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TABLE OF CONTENTS

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OBSERVATIONS ON WATERBIRDS IN CALIFORNIA[1]

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INTRODUCTION

We are continually reminded in California that availability of water is an element of first importance in the continued human occupation of this State. But we are apt to forget that a like problem exists for birds, especially ones that are dependent upon the aquatic or semiaquatic environment. And this area has always been an important one for North American waterbirds. When we so change the land that it is quickly drained, and when we store water and use it for special purposes, we can not expect these birds to find living places unless special provision is made for them. In making this provision it is necessary to remember always that aquatic habitats suitable for birds have many qualities besides the presence of water. Not only is each body of water a complex environment, but each kind of bird is fitted to make its own special demands upon this habitat.

This point was emphasized by Forbes (1925) in a classic essay originally prepared and read just fifty years ago, on February 25, 1887, in which he emphasized that conditions of life in a lake are primitive and that the system of organic interactions has remained unchanged from a remote geological time. According to him the animals in such a body of water are remarkably isolated, and are independent of the land and animals about them. Hence, a survey of aquatic life must consider the whole complex in order to understand any part of it. He wrote as follows:

"A lake is to the naturalist a chapter out of the history of a primeval time, for the conditions of life there are primitive, the forms of life are, as a whole, relatively low and ancient, and the system of organic interactions by which they influence and control each other has remained substantially unchanged from a remote geological period.

"The animals of such a body of water are, as a whole, remarkably isolated—closely related among themselves in all their interests, but so far independent of the land about them that if every terrestrial animal were suddenly annihilated it would doubtless be long before the general multitude of the inhabitants of the lake would feel the effects of this event in any important way. It is an islet of older, lower life in the midst of the higher, more recent life of the surrounding region. It forms a little world within itself—a microcosm within which all the elemental forces are at work and the play of life goes on in full, but on so small a scale as to bring it easily within the mental grasp.

[1] Submitted for publication, November 12, 1937.

"Nowhere can one see more clearly illustrated what may be called the *sensibility* of such an organic complex, expressed by the fact that whatever affects any species belonging to it, must have its influence of some sort upon the whole assemblage. He will thus be made to see the impossibility of studying completely any form out of relation to the other forms; the necessity for taking a comprehensive survey of the whole as a condition to a satisfactory understanding of any part. If one wishes to become acquainted with the black bass, for example, he will learn but little if he limits himself to that species. He must evidently study also the species upon which it depends for its existence, and the various conditions upon which *these* depend. He must likewise study the species with which it comes in competition, and the entire system of conditions affecting their prosperity; and by the time he has studied all these sufficiently he will find that he has run through the whole complicated mechanism of the aquatic life of the locality, both animal and vegetable, of which his species forms but a single element."

Concerning fluviatile lakes, which are situated in river bottoms, and which are connected with the adjacent streams by periodical overflows, Forbes wrote as follows:

"The amount and variety of animal life contained in them as well as in the streams related to them is extremely variable, depending chiefly on the frequency, extent, and duration of the spring and summer overflows. This is, in fact, the characteristic and peculiar feature of life in these waters. There is perhaps no better illustration of the methods by which the flexible system of organic life adapts itself, without injury, to widely and rapidly fluctuating conditions. Whenever the waters of the river remain for a long time far beyond their banks, the breeding grounds of fishes and other animals are immensely extended, and their food supplies increased to a corresponding degree. The slow or stagnant backwaters of such an overflow afford the best situations possible for the development of myriads of Entomostraca, which furnish, in turn, abundant food for young fishes of all descriptions. There thus results an outpouring of life—an extraordinary multiplication of nearly every species, most prompt and rapid, generally speaking, in such as have the highest reproductive rate, that is to say, in those which produce the largest average number of eggs and young for each adult."

In the summer of 1936 it seemed that anyone interested in birds should pay particular attention to the waterbirds. This was especially true in California for several reasons: There was wide divergence in the opinions expressed concerning the current status of waterfowl. The scarcity of permanently recorded facts concerning the recent history of waterbirds in California was becoming more and more evident. There was need for someone outside the agencies primarily concerned with game to keep in touch with faunal changes in the State. There were indications that at least in some sections the area of aquatic habitats was increasing. And finally, there was the possibility that 1936 might prove to be a critical year in duck numbers. In view of these circumstances the program of the Museum of Vertebrate Zoology was so arranged that I could spend some time in the field and in assembling information pertinent in the general problem. Chief objectives, then, were: to determine areas occupied by ducks, geese and other water-

Fig. 1. Ducks on one of the lakes on the Imperial Refuge. By actual count there were nearly 2200 ducks, mostly widgeon, in this area. Photograph by E. S. Cheney, November 23, 1935.

birds; to study seasonal occurrence and movements of each species; to learn actual numbers and relative numbers of each species; to study hunting practices and their effect on numbers of waterbirds; to study relations between ducks and agriculture; to collect specimens. It was planned to supplement rather than duplicate the kind of survey being carried on by State and Federal officials.

As a further definition of the attitude represented in this inquiry, it may be suggested that a distinction should be recognized between preservation and management when waterfowl are considered. Preservation, to me, implies the maintenance of all kinds of waterfowl found originally in this region in as nearly the former numbers and relative proportions as is consistent with other needs for the land required for them. Each season there may be a surplus which could be removed by shooting, without permanent harm to the permanent stock of birds. Contrasted with this, the management practiced usually appears to favor one or a few kinds of birds which may be maintained at shootable numbers while the other kinds are greatly diminished or completely absent. I assume that the kind of preservation defined above has greater justification on the basis of future human welfare than the type of management specified, but there is no good reason for not combining the two objectives involved. Moreover, it seems that permanent solution of waterfowl problems will require the practice of management for the preservation of all the kinds of animals in order to satisfy all recreational needs and not alone the desire for shooting.

The waterfowl problem in California is primarily one of aquatic habitats and of these in the seasons of migration and wintering. Understanding these involves not only an acquaintance with their present extent and handling but a consideration of their former extent and the modifications that have been imposed upon them. In California the water problem has been forced upon the attention of the State because of its intimate relation to human occupation of the area. The extensive and thorough surveys made in the study of the water resources and a coordinated plan for their development have been summarized in a long series of volumes. These contain much information needed for an understanding of the environment available for birds. Because they are not available generally and they seem not well known to naturalists, I have made extensive use of these reports in studying habitats of waterbirds and the history of their modification. The original bulletins and maps should be studied by every person who pretends to acquaint himself with the habitats of animals in California.

On account of the short time available to me for study in the field it was necessary to restrict my attention mostly to the low ground in the Central Valley. Most of the materials assembled and considered apply to that restricted area, but they should be useful also to some extent in other localities. In some ways the problem is more serious in the central part of the State because of the high specialization of agricultural practices there and the extensive system of improved roads which make all parts of it so easily accessible.

PHYSICAL FEATURES OF THE CENTRAL CALIFORNIA LOWLANDS

It is desirable to direct attention to some of the features of the central part of the State, which enter into its fitness for waterbirds. The districts will be considered from north to south. A more extended discussion of the Sacramento River Basin may be found in the report by Waddell (1931), from which most of this material was obtained.

The Sacramento Valley floor is a comparatively flat area of about 4800 square miles, extending for about 150 miles from Suisun Bay to Red Bluff, and averaging about 30 miles wide. Elevations range from below sea level to as high as 300 feet at the foothill line. From the Reconnoissance Soil Survey of the Sacramento Valley, California (U. S. Dept. Agri., 1915), we learn that the region is semi-arid. The rainfall increases northward and varies from 14.5 inches near the southern boundary to nearly 30 inches at the north. The rainy season usually extends from November to March, but it may begin in September and continue until June. Winter rains seldom last more than three or four days, but they may continue for a week or more. Precipitation is most often in gentle rains or showers interspersed with clear or foggy weather. Violent thunderstorms, hail and cloudbursts are rare. Snow is rare and seldom lies on the ground for more than a few hours. A low relative humidity accompanied by cloudless skies is usual in the summer season. Humidity is higher along the larger streams and poorly drained parts than on the higher slopes, and is about 10 per cent higher at the southern than at the northern end of the valley. Evaporation from a free water surface at Chico in normal years is reported to be about 63 inches. Heavy dew occurs in the rainy period and continues for a time beyond its limits. Only the low moist areas receive dew in summer and here it disappears early in the morning.

Fog is frequent in winter, but it decreases in density and frequency toward the north. In the south it is dense during the night and morning, but frequently lifts or disappears during the day, though sometimes it continues as high fog for several days. This has some significance for ducks, especially as it affects conditions for shooting.

The mean winter temperatures are about the same in all parts of the valley, but the mean summer temperatures show greater variation; that of Sacramento is 72.5° F., whereas that of Red Bluff is 82.1° F. High temperatures occur during July and August, with extremes frequently above 100° F. at midday or in the afternoon. Light frosts and thin films of ice frequently occur during the winter months in the northern part of the valley, while southward the cold diminishes somewhat on account of the greater frequency of fogs. It is rare that waterbirds are driven out on account of ice.

In the northern part of the valley the general air movement is from the north during the spring, fall and winter months. Normally the summer air movement is from the south or southeast. In the south end of the valley the spring, fall and winter winds are variable and light, but prevailingly from the southeast, and the summer winds mainly from the south. During this period ocean breezes enter the valley through Carquinez Strait and greatly temper the interior heat. In spring and fall, wind movement is brisk for the entire valley, and pronounced south winds in winter, if prolonged, usually result in rain. Occasional strong north winds, called "northers," occur irregularly and in the summer months are hot, dust laden and oppressive. Considerable loss of moisture occurs during these winds. The evaporation from plants is excessive, and vegetation generally has a drooping or

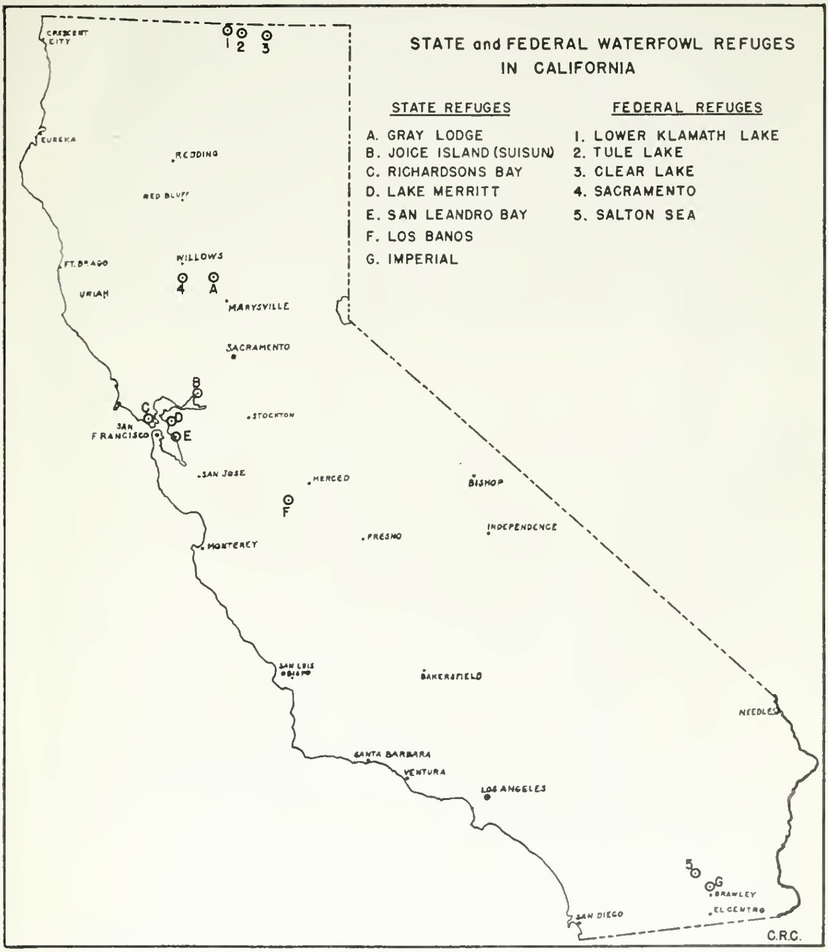

FIG. 2. Map of California, showing the location of the State and Federal Wildfowl Refuges. In addition to the twelve sanctuaries set aside primarily for water-birds, there are many general wildlife refuges where waterfowl find sanctuary. These include State Game Refuges, State Parks, National Parks, National Monuments and various city and county parks and reservoirs. Several of these, San Francisco State Refuge and Mission Bay State Park, for example, are very nearly as useful in waterfowl conservation as the regular wildfowl refuges.

wilted appearance. In fall, winter and spring the northers are cold and disagreeable. They attain a velocity of 20 to 25 miles an hour and blow for periods of about three days. When they occur in the shooting season, there are likely to be extra heavy losses to ducks and geese.

The Sacramento Valley lands have been divided into five classes, on a basis of their utility for agriculture (Waddell, 1931, p. 80). Class 3 contains extremely hummocky and hogwallow lands, with shallow soils, rough channel-cut lands and lands of steeply rolling topography. Under present conditions, where not included in organized irrigation projects, the development of these lands is likely to be long deferred. Where in organized irrigation projects, they are largely devoted to rice culture and gun clubs. Except for this use, practically all land in this class is pasture and range in large undeveloped holdings. Orchard or vine plantings previously made have been abandoned. This land is not adapted to grain production and if grain were grown, crop returns would be small.

Class 4 includes lands of extremely dubious agricultural worth because of alkali or deficient soil conditions. They are almost entirely used for pasture and gun clubs, although rice has been grown on some parts of flat alkali lands which are in organized irrigation projects. Rice growing has not been very successful on such heavily alkali lands and is not likely to continue except in periods of high prices. Gun clubs are established on a considerable area of this land where water is available.

Before the spread of agricultural development in the Sacramento Valley, a large part of its area was subject to annual or periodical overflow. This great floodplain, irregular in outline and varying in width from two to thirty miles, extended from the mouth of the Sacramento River almost to Red Bluff, a distance of about 150 miles, and comprised an area exceeding one million acres. A considerable part of this floodplain was covered by a dense growth of tule. Surrounding the tule lands lay belts of overflow lands known as the "rim-lands." With the advent of agricultural development, these rim-lands were the first to come under cultivation. The higher and more fertile lands extending from the river banks back to the tule, being less often flooded and more easily accessible to water transportation, were the first to be settled.

In 1850, the tule lands, designated as "swamp and overflow lands," were transferred to the State of California. Between 1855 and 1868, legislation was enacted for their sale to individuals who were obligated to reclaim them either individually or by the formation of reclamation districts. Within three years after 1868, practically all of the State's swamp lands had passed into private ownership, about one million acres being patented to individual owners.

In the early days the Sacramento Valley was devoted largely to the raising of grain and cattle. The area irrigated increased from less than 100,000 acres in 1880 to about 860,000 acres in 1929. The latter area is about 13 per cent of that of the total agricultural part of the basin and one-fifth of the net irrigable area. About three-fourths of the increase from 1880 to 1929 occurred in the last twenty years because of increase in orchard and rice plantings. Further increase will be controlled largely by the development of water supplies through the storage of winter run-off from the mountains.

Areas of crops and gun clubs each year in the Sacramento Valley under conditions of ultimate development, according to Waddell (1931, p. 121) would be as shown in table 1.

TABLE 1

Areas of Crops and Gun Clubs in the Sacramento Valley Under Conditions of Ultimate Development

Crop or use	Ultimate area	
	In per cent of total irrigable area	In acres
Citrus orchards	2.0	52,800
Olive orchards	1.0	26,400
Deciduous orchards	20.0	528,000
Vines	7.5	198,000
Grain	10.0	264,000
Alfalfa and sudan grass	20.0	528,000
Field crops	9.5	250,800
Pasture	6.5	171,600
Truck crops	10.5	277,200
Rice	10.0	264,000
Gun clubs	3.0	79,200
Totals	100.0	2,640,000

Unit allowances and uses of water in Sacramento Valley under conditions of ultimate development would be divided as indicated in Table 2 (*op. cit.*, p. 122).

TABLE 2

Unit Allowances and Use of Water in Sacramento Valley Under Conditions of Ultimate Development

Water used for	Acre-feet per acre per season		
	Allowance		Net use
	Gross	Net	
Citrus orchards	3.75	2.50	2.12
Olive orchards	3.00	2.00	1.60
Deciduous orchards	2.63	1.75	1.59
Vines, general	2.25	1.50	1.32
Vines, on shallow soils	2.63	1.75	1.34
Grain	1.50	1.00	0.80
Alfalfa and sudan grass, general	4.50	3.00	2.65
Alfalfa and sudan grass, on gravelly soil	7.50	5.00	2.75
Field crops	2.63	1.75	1.59
Pasture	1.88	1.25	0.82
Truck crops	3.00	2.00	1.85
Rice	9.00	6.00	5.05
Gun clubs	2.25	1.50	1.07

The San Joaquin Valley extends southward from the Sacramento Valley about 270 miles and averages 50 miles wide. The area of the valley floor is about 13,000 square miles, including part of the delta (436 sq. mi.) at the confluence of the Sacramento and San Joaquin rivers. The delta proper, or the low marsh and peat lands, was in natural condition subject to tidal overflow. The bordering alluvial rim-lands were subject to occasional inundation from flood waters. Of approximately 500,000 acres in this area several thousand are in existing waterways.

According to Jones (1931, p. 462) the "protection of the delta lands began early in the history of agriculture in the valley and has been in progress for over sixty years. During this period, practically all of the delta lands have been brought within levees which provide about the maximum degree of protection that can be obtained by this method of flood control. This degree of protection, however, would be far from adequate during a period of major flood occurrence. Levees as a rule follow the winding courses of river channels and connecting sloughs with the result that the delta is made up of a large number of islands. The levees around these islands have been built gradually to the limiting heights that their unstable foundations will support. Although the channels are many, their total flood carrying capacity is far less than the amount they may be called upon to carry in any season of major flood occurrence." Toward the head of the delta the total present safe channel capacity is only about 60,000 second-feet, or less than half the estimated discharge of the 1911 flood through this section of the valley.

Matthew (1931) in an extensive report on economic aspects of a salt water barrier gives many facts that must be considered in an appraisal of aquatic habitats of birds. Some of these may be summarized as follows: Adjacent to Suisun and San Pablo bays are about 130,000 acres of marshlands. In the Suisun Bay area, about 46,000 acres are leveed, of which only 5000 acres are farmed. In the San Pablo Bay area, there are also about 46,000 acres leveed of which 24,000 acres are farmed. Farming operations have not been very successful on account of saline conditions. At present, much of the marshland, especially in the Suisun area, is devoted to duck preserves and apparently is more valuable for this purpose than any other. These lands, if furnished with a fresh water supply might be completely reclaimed and brought into agricultural production. This would involve the building of levees and drainage works and removal of salt from the soil, all of which would be difficult and expensive. The cost of completely reclaiming these lands is estimated to be considerably greater than the average market value of fully developed and producing lands in the delta and of large areas in the San Joaquin and Sacramento valleys served with a water supply and ready to be farmed. Under present conditions, large expenditures for development of these marshlands would not be economically justified.

During the winter season, before reclamation, when large floods occurred, most of the marshland area adjacent to both bays was submerged for considerable periods of time. The quality of the water in the sloughs of the marsh area varied considerably in different periods of the year. In the Suisun Bay area, the winter floods from the Sacramento and San Joaquin rivers and the adjacent local streams usually provided fresh water in the marsh channels for a considerable period of each year. During the period of low stream flow, however, saline water from the lower bay gradually replaced the fresh water in these channels, generally resulting in the presence of water of considerable salinity for a period of five to six months or more each year. The amount of salinity was not uniform throughout the entire marsh area, but was greatest in the channels downstream near the lower end of Suisun Bay and gradually decreased upstream toward the confluence of the Sacramento and San Joaquin rivers.

Old time residents state that the original vegetation on the marsh areas consisted of aquatic plants (tules, cattails, sedges and wire grass), salt grass, pickle weed, and some red top and clover on the high lands bordering the sloughs. The aquatic plants generally grew where water was normally present continuously, whereas the salt grass grew on the higher ground not usually flooded and the pickle weed in isolated pockets lacking drainage. Salt grass was the predominating growth over most of the marsh area. Before any reclamation occurred, these marshlands were used for pasturing beef and dairy cattle except during periods of high water when they were inundated.

Although a large part of the marshlands is enclosed within levees, the provision of drainage works and the improvement of the soil for crop production is extremely variable and far from complete. In the Suisun Bay area, only 5000 acres, or 11 per cent of the land within levees, now are farmed. In the San Pablo Bay area a much larger percentage of the leveed land, amounting to 24,000 acres, or 52 per cent of the total within levees, now is farmed.

A large part of the Suisun marsh area is devoted to private duck preserves, which in 1930 occupied about 28,000 acres, or 60 per cent of the total area within levees. Although the first private duck clubs in the Suisun area were started many years ago, their rapid development and expansion has occurred largely during the past ten to twenty years. The splendid duck hunting in this area and its nearness to metropolitan centers, developed a situation wherein the bulk of the Suisun marshlands appear to be more valuable as duck hunting preserves than for any other purpose, but these are supplemented in some cases by cattle grazing. Most of these preserves are flooded by means of floodgates in August or September and remain flooded until the end of the duck hunting season and for a considerable period thereafter before they can be drained. The water used in the fall is usually rather heavily impregnated with salinity. Hence, this general practice of operation by the duck clubs probably has increased the saline content of the lands. In the San Pablo Bay area about 4500 acres are occupied by duck preserves (1930). These lands have gone back to the original salt marsh and whatever improvements might have been made by previous leaching operations have been entirely lost.

From the Reconnoissance Soil Survey of the San Francisco Bay Region, California (1917, p. 105) we learn further characteristics of this habitat. Tidal marsh consists of a few inches of gray or brownish-gray clay, silty clay or lighter textured material, underlain to a depth of many feet by bluish, dark-gray or black clay of sticky, plastic character. The lighter colored surface material may extend to a depth of several feet or may be entirely wanting, and the entire soil column consist of the darker colored clay. Content of organic matter is usually high and the type grades in places into muck and peat. Owing to water-logged conditions and lack of aeration it is usually in poor physical condition.

The most extensive development of tidal marsh is along the southern extension of San Francisco Bay and the northern side of San Pablo Bay. Besides this there are many detached areas along San Francisco Bay and its various estuaries.

Tidal marsh in its general surface and drainage features is remarkably uniform. It is flat and depressed, being, with the exception of muck and peat, the lowest lying soil material in the area. Its

TABLE 3

Present Crops and Natural Vegetation on Suisun and San Pablo Bay Marshlands

From Survey of August, 1930 (Matthew, 1931)

Type of vegetation	San Pablo Bay						Suisun Bay						Combined Suisun and San Pablo bays	
	North side		South side		Combined north and south sides		North side		South side		Combined north and south sides			
	Area, in acres	Area, in percentage of total	Area, in acres	Area, in percentage of total	Area, in acres	Area, in percentage of total	Area, in acres	Area, in percentage of total	Area, in acres	Area, in percentage of total	Area, in acres	Area, in percentage of total	Area, in acres	Area, in percentage of total
Cultivated crops—														
Grain and grain hay	23,780	41	130	6	23,910	40	3,680	6	40	0	3,720	5	27,630	22
Blue grass	----------	0	----------	0	----------	0	560	1	----------	0	560	1	560	0
Alfalfa	----------	0	----------	0	----------	0	10	0	----------	0	10	0	10	0
Asparagus	----------	0	----------	0	----------	0	500	1	----------	0	500	1	500	0
Corn	30	0	180	8	210	0	----------	0	----------	0	----------	0	210	0
Truck and field crops*	30	0	110	5	140	0	210	0	----------	0	210	0	350	0
Subtotal	23,840	41	420	19	24,260	40	4,960	8	40	0	5,000	7	29,260	22
Native vegetation—														
Salt grass	4,130	7	180	8	4,310	7	19,600	33	2,970	29	22,570	33	26,880	21
Pickle weed	10,120	17	1,090	50	11,210	19	11,180	19	3,200	31	14,380	21	25,590	20
Aquatic growths (tules, sedges, wire grass, etc.)	5,720	10	380	17	6,100	10	14,500	25	2,700	26	17,200	25	23,300	18
Foxtail	8,580	15	----------	0	8,580	14	3,250	6	180	2	3,430	5	12,010	9
Wild oats	2,670	4	----------	0	2,670	4	720	1	50	1	770	1	3,440	3
Miscellaneous	940	2	----------	0	940	2	660	1	110	1	770	1	1,710	1
Subtotal	32,160	55	1,650	75	33,810	56	49,910	85	9,210	90	59,120	86	92,930	72
No vegetation—														
Water surface (drains, pools, etc.)	1,400	2	90	4	1,490	2	2,380	4	160	2	2,540	4	4,030	3
Roads and bare land, levees and mud flats	1,200	2	40	2	1,240	2	1,450	3	790	8	2,240	3	3,480	3
Subtotal	2,600	4	130	6	2,730	4	3,830	7	950	10	4,780	7	7,510	6
Totals	58,600	100	2,200	100	60,800	100	58,700	100	10,200	100	68,900	100	129,700	100

*Includes all crops for human consumption, such as tomatoes, beans, cabbage, beets, onions, and celery.

general level is but a few inches above the water and its surface is marked by many winding tidal sloughs. At ordinary tides these slough ways are filled with water and the slightly more depressed parts of the marsh are submerged, at times of high tide there is very little of the type that is not flooded, and the soil is water-logged almost to the surface at all times.

Tidal marsh has been built up of clayey sediments deposited by the waters of streams and tidal sloughs. The material is now in process of deposition about the mouths of all the principal streams entering the bays, and in most instances the stream channels traverse several miles of tidal marsh before they reach the open water. The formation of tidal marsh is succeeded by the encroachment of low flat alluvial fan deposits superimposed upon its surface, and for this reason it is occasionally difficult to determine the exact boundary between tidal marsh and the heavier, darker-colored types of the various alluvial soils. Notable extensions of the tidal marsh are being built by the Sacramento River in Suisun Bay.

By far the greater part of the tidal marsh is unreclaimed and of no present agricultural value. It supports a fairly heavy growth of pickle-weed, salt grass and kindred vegetation, which yields some pasturage in those parts sufficiently stable to support cattle. Some other extensive areas have been reclaimed, notably on the north side of Suisun Bay and San Pablo Bay, southwest of Warm Springs adjacent to San Francisco Bay, and in other scattered areas. A large tract is occupied by salt works around the southern part of San Francisco Bay, notably in the region west of Alvarado. Salt pans, ranging in size up to a few acres, have been constructed and their total area amounts to many thousand acres. Most of the reclaimed tidal marsh has been diked and is devoted to the production of grain hay. Wherever possible, use has been made of fresh flood waters from year to year for flooding the surface to aid in leaching out the included salts and reclaiming the land.

Tulare Lake, in Kings County, receives the surplus flow of all streams south of Kings River. Naturally, Tulare Lake covered about 760 square miles in wet years. Levees now restrict the submerged area to small tracts under normal run-off conditions. The water storage district includes a gross area of 192,730 acres, of which 11,520 acres are set aside for reservoir purposes. Waters from the Kern, Tule, Kaweah and Kings rivers now reach the lake bed. Flood waters must raise the level from 179 feet elevation, the lowest point, to a level of 205 or 210 feet before they can escape northward into Fresno Slough and the San Joaquin River. Levees are constructed to an elevation of not over 195 feet. Under present plans for the reclamation of Tulare Lake lands, 260,000 to 350,000 acre-feet would be stored before additional lands would be inundated. These storage capacities are insufficient to store all of the water which would reach the lake under present conditions of development in the tributary drainage area (Jones, 1931).

Buena Vista Lake contains 25,459 acres. It is partly used as a storage reservoir and partly farmed. It is anticipated that during large floods Buena Vista Lake will be flooded, and the lands are reserved for this purpose. Water in excess will flow northward toward Tulare Lake (Jones, 1931).

Both these basins were flooded in the first half of the summer of 1937. John McB. Robertson visited Buena Vista Lake at the end of May, when the water was still rising, and he found several kinds of waterbirds already nesting, as well as many which were reported as nesting later (letter, September 13, 1937). No doubt these lakes in the future will provide aquatic habitats temporarily after seasons of extra flood. But these times are likely to be in years when other parts of the State also have water, and when there is less urgent need for marshes.

FIG. 3. Gray Lodge Refuge is visited by large numbers of waterfowl. Photograph by Gordon H. True, Jr., December 19, 1935.

AQUATIC HABITATS IN 1936

Aquatic habitats in central California, in the fall of 1936, were reduced to an extent much smaller than would be expected in an average year, even with the drastic practices of drainage and intensive cultivation of the land in recent years. In many localities the ground was drier than it had been in the memory of local residents. The previous spring had not been especially dry, but by the time ducks arrived there was no water in the valleys except where it had been flooded on purpose for the birds. These areas were mostly of two kinds—shooting grounds and refuges.

Shooting Grounds

Commercial

Commercial hunting clubs have long constituted an important factor in duck and goose shooting in California. Since 1927 they have been regulated by law and both the club and operator have been licensed. A license for such a club costs $25 ($100 for an alien owner), and for each operator $5 (alien $25). For several years the number of licensed clubs was around 65, but this number has now decreased slightly. Several important regulations have been imposed by law, among them the following:

1. Shooting days are limited to Sundays, Wednesdays and Saturdays, the opening and closing days of the season, and legal holidays.
2. Blinds must be no less than eighty yards apart, and not more than two hunters may occupy a blind at one time.
3. Clubs are prohibited from guaranteeing limits.

Many of these clubs are operated on ground that is cultivated or pastured at other times of the year. Usually they are flooded only during the hunting season and the aim is to attract birds only for shooting. Several of them occupy large acreages and on Sundays many hundreds of shooters may be accommodated on one. According to Hornaday (1934) the 67 commercial clubs in California in 1933, covered 58,248 acres.

Private

Since about 1900 an extensive system of private duck clubs has occupied the best parts of the marshes in the State. These clubs have come to dominate the duck shooting. There is great variation in these clubs as to number of members, acreages and methods of operation. On many of them the club owns the land and it is farmed or pastured to pay expenses or to make a profit. Others are leased for the duck season only. These organizations have the greatest part in the responsibility for maintaining numbers of ducks and marsh birds in the State.

Clubs that desire to, can provide permanent ponds and marshes where the birds may live at any time of year. They can thus not only provide nesting places, but at the same time, by improving the stock of aquatic foods and making their ponds attractive, they can have more birds and a greater variety of species in the shooting season. The results would no doubt be well worth the added expense necessary on such grounds although the same procedure might not be justifiable on the strictly commercial clubs where the professed aim is only to sell shooting tickets.

One report (Hornaday, 1934) gives the number of private duck clubs in California as about 433, with an average acreage of 540 or a total of 233,820 acres. The same authority gives 32 tons as the average amount of grain used by each club in a year for baiting when that practice was legal. Several years ago, Phillips and Lincoln (1930) estimated that the 200 or more large California clubs killed at least a quarter of a million ducks, or from one-half to one-third the annual total in the State.

Public

Practically no places are left in California where ducks may be hunted freely without paying a high fee for the privilege. In 1936, I was able to find one small bit of ground near Los Baños which was considered traditionally as a public shooting ground, but few ducks ever were shot there. Elsewhere there were a few stretches of public road where shooters congregated without disturbance by wardens or the owners of adjacent land. And there are a few spots where the land owner permits a shot at a duck.

One exception to this situation is the government operated public shooting grounds at Tule Lake in northern California. It is also

FIG. 4. When the hunting season opens, wildfowl seek sanctuary on the Suisun Refuge. Photograph by Gordon H. True, Jr., 1936.

possible to obtain poor duck hunting and fair brant shooting on the open water of various bays.

Refuges

General Considerations

Because refuges are likely to be the most important devices for permanent preservation of waterbirds in California, a general discussion of them seems to be warranted. A review of the duck refuges in the State shows the following important uses:

1. As sanctuary on shooting days for ducks and geese. This is of immediate concern and value.
2. As nesting places for aquatic birds of all sorts and for special kinds of land birds. This is the greatest permanent value. Much work is needed to insure variety of conditions and to prevent waste of resources by burning and grazing, and by drying, silting or filling of water-ways by plants.
3. As resting places at other seasons, especially during the annual molt—there are more important requirements than open water where guns are prohibited. Among the items desirable to attract waterbirds are: screen, variety in depth of water, quiet, logs, islands, mud-bars, and fresh water for drinking.
4. As feeding places—where it is desirable and possible to maintain variety and continuity in such features as the presence of water.

For most of the aquatic habitats at lower altitudes in California there can be little question as to the desirability of some degree of artificial management for they are no longer natural. Moreover, because the total area available for such purposes is small, it is necessary to crowd desirable features on it.

In consideration for the financial support of the present refuge program it seems desirable to dedicate all the refuges to the welfare of *wild* animals, but to give preference on them to native species that are shot.

We should work to maintain variety of species as well as large total numbers.

In order to insure the greatest value of the refuges it is necessary to allow no crop to be removed when that removal hinders use of the area by birds. Ordinarily this would require that there be no grazing, no harvesting and no burning.

It would be profitable on the refuges to discourage the presence of large fish, especially carp.

It is imperative that sedimentation in the ponds be delayed as long as possible. An important means of accomplishing this is to take into the ponds no more water than is needed.

There are many reasons why ponds should be kept filled with water as continuously as possible.

Effectiveness of the refuges no doubt would be increased greatly by preventing shooting on adjacent lands. This could be accomplished to some degree at many places, for example, at Los Baños Refuge and Salton Sea.

It seems a justifiable procedure on aquatic refuges in this State to trap carnivores when they congregate and take more than ordinary numbers of birds, but this would permit no trapping except by permanent refuge crews.

On small refuges it appears to be good practice to leave no strip of dry land more than a quarter-mile across. In Iowa, Bennett (1936, p. 494) found that of 340 "puddle duck" nests, 95.6 per cent were located on the land within 220 yards of the shoreline of the marsh, slough or pothole, even though the actual grass or suitable nesting area extended beyond that. The heaviest concentration of nesting ducks he found was one nest per acre. The average marsh had about one nest to 10 to 15 acres. His opinion was that a pothole of one-half acre was near the optimum for production of puddle ducks.

Whenever possible duck sickness should be counteracted by maintaining deep water rather than by an increase of current.

Planting of grains or of emergent vegetation on the refuges for duck foods may not be successful, on account of the blackbirds which are likely to harvest the seeds first—as they have on many occasions.

The feeding habits of the "river ducks" are summarized by McAtee (1918, p. 2) with the statements that they "rarely dive so as to disappear entirely beneath the water, but obtain their food in shallows by dipping the head and neck or by submerging all of the body but the tipped-up tail. Vigorous paddling with the feet is needed to maintain the latter position in the water. The food usually is obtained within 12 to 16 inches of the surface, and as a result river ducks obtain fewer of the underground organs of aquatic plants than the diving ducks. These root systems of the plants include the rootstocks, stolons, tubers, and winter buds, which are stocked richly with nutriment. However, the river ducks wax fat by their own way of living, and although they are distinctly successful foragers, expediency seems to be their rule, as they are more nearly omnivorous than any other ducks." This gives an idea of what kinds of conditions to provide on feeding refuges where only the shallow water ducks occur.

Federal Refuges

The welfare of waterbirds in California depends in large part upon what happens on the rest of the continent. Concerning the activities of the Federal Government in behalf of these birds, H. P. Sheldon, in April, 1937, told the 15th Annual Convention of the Izaak Walton League of America that, three years previously, approximately $20,000,-000 had been placed in the hands of the U. S. Biological Survey to establish a waterfowl sanctuary system. In the three years, nearly 3,000,000 acres were acquired by gift, purchase or Executive order. One-third of this amount was breeding area. In all, 217 wildlife refuges were under administration by the Survey.

The Tule Lake Wildlife Refuge in Siskiyou and Modoc counties, in extreme northern California, was established by Executive order on October 4, 1928, and enlarged on April 11, 1936. It contains 36,563 acres, of which 20,000 acres are used as a public shooting ground. The area is a Bureau of Reclamation project under secondary jurisdiction of the Biological Survey.

In the *California Conservationist* for July, 1937 (p. 21) the opinion of the Bureau of Game Conservation, Division of Fish and Game, was expressed that at Tule Lake when the duck season opened there would be approximately 43,000 acres covered with water to a depth of six feet, and that this would be ideal for duck shooting.

The following detailed report of a survey of crippled waterfowl at this place gives some notion of the extent of this drain upon the population of the birds (*Gull*, vol. 14, Nov., 1932):

"According to a report to the United States Department of Agriculture, made by Mr. H. M. Worcester, protector of the Tule Lake Bird Refuge, Siskiyou County, California, 1359 mortally wounded birds were given to local charity organizations for food during the 1931 open season.

"Wounded by hunters, 1865 crippled waterfowl flew into Tule Lake Bird Refuge and were rescued by refuge employees and volunteers aided by a spaniel trained to retrieve crippled birds. Beginning November 25, Mr. Worcester with deputies and volunteers gathered the birds daily until January 5. They were placed in a box on sled runners and taken by the men to nearby special pens on Link River, Klamath Falls, Oregon, where they were cared for and fed.

"The report states that 1173 ducks (723 pintail hens, 392 pintail drakes, 19 mallard hens, 21 mallard drakes, 12 widgeons and 6 gadwalls) were placed in the pens. There were also 685 geese (386 Hutchins' and Cackling, 209 Lesser Snow and 90 white-fronted) and seven Swans cared for. About 30 per cent of the ducks died, but there was only a 10 per cent loss of the geese.

"Eighty-five per cent of the geese received alive had broken wings, although less than 17 per cent of the recovered ducks were so injured. The wings of thirty-seven geese were shattered so badly that amputations were necessary. Of these birds twenty-two were still alive and doing well at the time of the report. Permanently disabled birds were distributed to parks and zoos for exhibition and breeding purposes.

"Mr. Worcester believes that many of the winged birds were injured by long-range shooting from hunters' blinds as the birds passed high in the air. The refuge is a 10,600 acre reservation and the officials permitted hunters to recover birds falling within the sanctuary, though they were not allowed to carry their guns inside. Many of the birds, however, sailed far into the refuge before they fell—some as much as half a mile. These were not recovered by the hunters and Mr. Worcester believes would have starved, frozen or become victims of meat-eating animals had it not been for the rescue work. Near the end of the campaign, it was estimated that about 200 eagles had gathered gradually, attracted to the refuge by the disabled birds."

Clear Lake Migratory Bird Refuge, in Modoc County, contains 25,300 acres. It was established by Executive order on January 13, 1912, and it remains a Bureau of Reclamation project. Recently a considerable amount of construction work has been done here by a Civilian Conservation Corps camp. This has included the making of nesting rafts, a telephone line, a truck trail and fences.

The Sacramento Migratory Waterfowl Refuge, formerly the Spalding Ranch, is south of Willows, Glenn County, and in the northern part of the Sacramento Valley. Its acquisition by the Biological Survey was announced early in 1937. The 10,775 acres are located especially well to contribute to refuge facilities for waterbirds in California. The press release contains the comment that, "Because the Sacramento Refuge is naturally attractive to waterfowl the Biological Survey plans little development work there. Marsh and hay lands used by the geese and ducks have a good supply of water. Small dams, dikes and levees will be constructed, however, to impound water from spring run-offs from higher areas. The ranch buildings will be remodeled for use in administering and maintaining the refuge.''

The Salton Sea Migratory Bird Refuge, in Imperial County, includes submerged and marginal lands at the southern end of this large lake which was formed by the Colorado River thirty years ago and the surface of which is now about 250 feet below sea level. On November 25, 1930, 15,733 acres of public lands were set aside for refuge purposes by order of the President. Intermingled with these lands were about 8982 acres under private ownership, which were purchased by the Government to make a refuge of 24,715 acres. A notable feature of this refuge is that it controls the two principal freshwater inlets to the sea. It is also on one of the main flight lines of migratory waterfowl.

Reports from game wardens (*California Fish and Game*, vol. 20, 1934, p. 168) summarize duck conditions in this vicinity as follows: In the southern end of the lake, baldpate and pintail (sprig) were about even in abundance (in 1933) and comprised 60 per cent of the duck population. The balance consisted of shovellers, 15 per cent; teal, 10 per cent; redheads, 5 per cent; other species, 10 per cent. At the Mecca section on the north end of the lake, private and commercial duck clubs took more ducks in 1933 than in the previous year. The kinds, in order of abundance, were pintail, baldpate, redhead and scaup.

A visit by me in April and May, 1937, to the near vicinity of the Salton Sea Refuge revealed a great many more ducks there than had been anticipated. The weather, up to late May, was exceptionally mild, and this may have accounted for more than ordinary numbers of ducks remaining until that late. Evidently members of several species were preparing to nest, but it was not certain that any of them actually would be successful. The coming of severe summer conditions, normal for Imperial Valley, might terminate nearly all the nesting activity.

The general conclusion after more than a month spent in this neighborhood was that it is desirable to develop the area for waterbirds. The nature of the land and the climate, and the amount of bird life that would be affected would surely be justification for the expense of more permanent and continuous improvements. The uncertainty of moisture conditions here, however, makes it essential that every change be made with the understanding and agreement of officials of the irrigation district. That organization really controls completely the fate of all life on the federal refuge.

Another obvious element in the problem here was the acute need for restoring local respect for the refuge. This was mostly lost because the refuge was not watched after being established and marked with boundary signs. There was good evidence showing considerable competition among certain persons who made a living by charging for ''shooting rights'' on refuge land.

State Refuges

The State of California made important provision for waterbirds when legislation was passed to provide for spending the money from one-third of the hunting licenses sold by the State during the period of ten years, commencing January 1, 1928, to acquire by purchase, lease or rental, and to maintain, develop, improve and administer lands and water rights within the State suitable for game refuges or public shooting grounds, or both.

Imperial Refuge, near the town of Calipatria, on the Alamo River, is south of Salton Sea in Imperial County. It consists of about 2000 acres purchased by the State in 1931 and 1932. Floods have eroded a wide river course and the stream now flows in a meandering channel through a mile-wide valley approximately 25 feet below the floor of the main valley. The river has built its own levee in this secondary valley, each successive flood adding sediment to the top of the levee.

FIG. 5. Another view of the waterfowl on the Suisun Refuge during the 1936 Season. Photograph by Donald D. McLean.

Between these levees and the main, high banks are the extensive flats that are flooded by irrigation drainage water for the refuge lakes. A problem here is the control of cattails which grow to a height of 20 feet. Islands of this plant growth are sometimes floated out by changes in the depth of the water. A greater problem is caused by the rapid silting of the ponds. The water level is so closely dependent on that of the Alamo River, and the level of that is so uncertain, that these ponds scarcely can be expected to last for many years even with the best care. Their usefulness would no doubt be greatly prolonged if greater effort were made to retard the deposition of silt in them. This could be done in part by reducing the amount of water taken in through the ditches, if that be possible.

Injury to levees and ditches on this refuge by muskrats is great enough to warrant constant attention to it. An occasional spell of trapping on a large scale will not necessarily provide the remedy. Moreover, unless these injuries are counteracted, there can be no justification for building levees and roads, for these would soon be destroyed.

The whole Imperial Valley is an area of rapid and extensive changes. Conditions for waterbirds appear to be so closely dependent upon the activities of the Irrigation District that any improvements for birds must be temporary. Conditions here are not conducive to development of permanent aquatic habitats. This applies especially to the State refuge where minor changes in the control of the water would bring great changes, even complete drying of the ponds.

The Los Baños Refuge, four miles northeast of Los Baños, Merced County, consists of 3000 acres purchased by the State in 1929. There were a few small ponds, behind temporary levees, that had been used by duck hunters. The land is rolling and it slopes toward a meandering slough which crosses the property from south to north for about three miles. The surface is interrupted by lesser drainage ways which made it possible to make many individual lakes, with a total area of about 1000 acres. In making these lakes more than 100,000 cubic yards of soil were moved; levees were made full road width. Water is delivered through irrigation ditches at four points, from which it is run through the ponds and lakes to the lower edge of the refuge. Precautions are taken to keep the water continually flowing.

Because water is not available for this refuge until irrigation needs in the district are satisfied, and because in dry years there is a shortage of water for the farms, there has been difficulty in getting sufficient water in the ponds when it is most needed in the summer. A pump has been installed which helps to compensate for this shortage of water in the ditches. It lifts water from Salmon Creek into Olson Pond.

Alkalinity here affects the water where it is not constantly freshened and it results in a less dense stand of vegetation than is present on some of the other refuges.

A count of waterbirds made on March 1, 1931, by Sumner (1931, p. 273) revealed the following numbers on this refuge: Coots (mudhens), 10,015; geese, 5019; ducks, 2727; total 17,761. By this time of year the ducks had begun to migrate from the refuge and there had been a tremendous invasion of coots.

Gray Lodge Refuge, consisting of 2541 acres, was obtained by the State in April, 1931. It is eleven miles southwest of Gridley, in Butte County, and it is close to the northeastern edge of the concentrated duck hunting area along Butte Creek. The ground had been developed and maintained at great expense as a duck club by its former owners. Although water from a drainage ditch has been available in large quantity, only about one-third of the refuge has been kept under water. It would be desirable to have a larger proportion of this land under water.

The Joice Island Refuge consists of 1711 acres in the Suisun marshes in Solano County. It is on an island bounded by tidal sloughs, and a high levee keeps it from being flooded at every high tide. Fresh water is available continuously in years of normal rainfall, but in years of reduced rainfall brackish water is used for late summer flooding. A problem here has been mosquito control in which it is thought necessary to maintain a constant water level. This naturally tends to make the ponds more salty, thus reducing the amount and variety of the vegetation. Visitors to this refuge in the shooting season of 1936 observed that the chief use made of it by ducks was to escape from shooters on hunting days.

A supplementary function of this refuge might well be the provision of suitable, protected habitat for the white-tailed kite. This bird is already present in the near vicinity and on the refuge, but its future welfare might be assured by putting out and maintaining stands of trees for it. The value of this land as a permanent refuge for the kites might turn out to be even greater than its value for waterfowl.

Other refuges have been established in the San Francisco Bay area. Notable among them are the ones which include the waters of San

FIG. 6. Female mallard and young. Photograph by E. S. Cheney, Los Baños Refuge, 1930.

Leandro Bay and of Richardsons Bay. These areas have been sought in recent years by increasing numbers of birds. In 1936 an impressive horde of ducks, mostly pintail, went to San Leandro Bay for safety on shooting days. Richardsons Bay serves as a haven for birds harried on other parts of San Francisco Bay and on San Pablo Bay.

Lake Merritt, in the heart of the city of Oakland, was made the first State Game Refuge in California by an act of the legislature in 1869 (*Gull*, vol. 15, March, 1933). It is a natural salt water lake of about 155 acres, the water level being controlled by electric flood gates on the canal leading to San Francisco Bay. Lakeside Park, the area between the two arms of the lake, covers about 150 acres.

A portion of the lake has been set aside by city ordinance as a refuge for waterfowl and boats are kept out of this area by a log boom. An artificial island was constructed in 1923 in this section as a possible breeding ground for the birds. It has been accepted as such, at least by the Canada geese. A freshwater fountain for the ducks at the feeding station was erected in 1920.

Ducks were fed first at the lake in 1915, when a flock of canvasbacks, heavily coated with oil, would have starved to death, had such measures not been taken. During the winter season ducks are now fed daily at the feeding station at 10 a.m. and 4 p.m., and at the embarcadero half an hour earlier.

Much material dealing with birds at this lake has been published, especially in the *Gull*.

KINDS AND NUMBERS OF BIRDS

Former Status

Accounts of waterbirds in California before extensive settlement agree in giving the impression of great variety and great numbers. It is impossible, however, to get any clear notion from them of the relative numbers or total numbers of the birds. Possibly the best substitute for records of the birds is the history of the physical change that occurred in the habitat with the settlement and use of the land through the past seventy-five years. Therefore this factor has been given special emphasis in this study. If we know something of the extent and nature of the habitat available for birds a century ago we may assume certain things about the populations of birds at that time.

Even if we do not know how many of these birds formerly occupied California, we can be sure about the obvious trends in their populations. A reduction in numbers took place so rapidly that some species were practically gone before the dangers were generally realized. Several species, however, among them the American egret, snowy heron, whistling swan and wood duck, are definitely more numerous now than they were early in the present century.

Present Status

The conspicuous waterbird population of California consists of those migratory species which formerly came in large numbers to the valleys in the fall. The facilities available to Lincoln (1935) for the study of this complicated problem have led him to conclude that the ducks and geese, by adhering more or less rigidly to any particular flyway, tend to perpetuate not only that ancestral route but also the groups of individuals that use it. For example, he cites that of more than 550 returns of ducks banded at Lake Merritt, nearly 97 per cent represent birds taken in the Pacific flyway. This may signify that if California is to continue to have ducks and geese in the fall and winter, there must be adequate provision of suitable habitat for them here; it is not enough to insure their preservation elsewhere in the United States.

When the winter flocks come and the amount of water surface is greatly expanded, it is difficult to know what happens to the waterbirds remaining from the concentrations so evident during the shooting season. It may be said that they scatter and stay in the same general region, and no doubt a great many do that. Some species are known to go no farther south than central California. These are especially the geese, which can feed by grazing and which are not so closely dependent upon feeding in the water as the ducks.

Phillips and Lincoln (1930) have indicated that there is among the ducks a drawing away from the interior of California after late November and December. But they did not know how far south these birds moved and whether they returned north through California or by some route farther to the east.

In the fall of 1936 I was able to spend twenty-two days in the field in central California, distributed according to months, as follows: October, 3 days; November, 15; December, 4. On these days full time was spent studying the waterfowl situation. This included giving attention to the location and nature of the existing aquatic habitats, to the kinds and numbers of waterbirds, and to shooting practices. The following accounts of selected species summarize the observations which seem worthy of permanent record.

White Pelican

Pelecanus erythrorhynchos

After a long account of the history and present status of the white pelican, Thompson (1932) summarized the situation for this State as follows: "California, with the exception of Clear Lake (Modoc County), can no longer be considered as a nesting ground of the white pelican." Considering the precarious status of this bird in its whole range, and especially in California, it is desirable to assemble definite records of its occurrence.

Records. Butte County: Gray Lodge Refuge, October 22 (6) and December 1 (3), 1936.

Marin County: Tomales Bay, February 10, 1937 (250±).

San Joaquin County: Holt, April 29, 1937 (8).

Stanislaus County: 5 miles northeast of Crows Landing, November 11, 1936 (50).

Merced County: 4½ miles southeast of Gustine, November 7, 1936 (3); 17 miles west of Merced, November 9, 1936 (28±).

Double-crested Cormorant

Phalacrocorax auritus

Because they have less sharply restricted nesting requirements than the pelicans, the cormorants of inland localities will probably continue longer to occupy aquatic habitats in central California.

Records. Glenn County: Packer Lake, November 30, 1936 (25±).

Butte County: Gray Lodge Refuge, October 22, 1936 (4).

Solano County: Joice Island Refuge, December 5, 1936 (6).

Contra Costa County: Richmond, October 24, 1936 (100+); San Pablo Reservoir, November 26, 1936 (2).

Merced County: Los Baños Refuge, November 10, 1936 (1).

American Egret

Casmerodius albus

Egrets apparently are helped a great deal by irrigation. The great increase in those birds in recent years seems to have resulted as much from the provision of suitable habitats by irrigation as from the extra protection given them.

Records. Glenn County: 9 miles southeast of Willows, October 20, 1936 (1); 2 miles west of Glenn, November 28, 1936 (14); 3 miles northwest of Princeton, November 28, 1936 (25); Packer Lake, November 30, 1936 (300+).

Colusa County: 1 mile north of Delevan, October 19, 1936 (30); 2 miles north of Delevan, October 21, 1936 (32); 2½ miles southeast of Delevan, October 20, 1936 (10±); 3 miles west of Princeton, October 21, 1936 (45); 6 miles east of Maxwell, October 20, 1936 (3); 6 miles west of Colusa, October 20, 1936 (11).

Butte County: 8-9 miles east of Butte City, October 21, 1936 (22); Richvale, October 21, 1936, 2 miles south (4), 5 miles west (12±), 7 miles northwest (177+); 8 miles west of Gridley, October 22, 1936 (19); Gray Lodge Refuge, December 1 and 2, 1936 (1).

Sutter County: 7 miles west of Yuba City, November 27, 1936 (8); Sutter By-pass, 13 miles southwest of Yuba City (25) and 20 miles southwest of Yuba City (9), December 3, 1936.

Solano County: South Hampton Bay, October 19, 1936 (1); ½ mile east of Cordelia, October 19, 1936 (1); Joice Island Refuge, November 20, 1936 (10).

Yolo County: 11 miles northwest of Knights Landing, October 23, 1936 (7).

San Joaquin County: 5 miles west of Lodi, November 7, 1936 (3); 9 miles northwest of Stockton, November 6, 1936 (4).

Stanislaus County: 5 miles northeast of Crows Landing, November 11, 1936 (7).

Merced County: 2 miles east of Gustine, November 9, 1936 (15); 7 miles southeast of Gustine, November 11, 1936 (50±); 4½ miles north Los Baños, November 8, 1936 (9); 3 miles south of Dos Palos, November 8, 1936 (3); ½ mile southwest of Brito, November 9, 1936 (65±); 17 miles west of Merced, November 9, 1936 (15±); 7 miles southwest of Merced, November 8, 1936 (35); 10 miles southwest of Livingston, November 11, 1936 (several).

Snowy Egret

Egretta thula

The small egret too has reached a stage of recovery where it is beyond immediate danger so far as California is concerned. The smaller number of records given here may be accounted for by the more southern distribution of this bird compared with the American egret.

Records. Butte County: Gray Lodge Refuge, October 22, 1936 (2), and December 1 and 2, 1936 (25±).

Sacramento County: 7 miles southwest of Sacramento, October 23, 1936 (1).

Solano County: Joice Island Refuge, December 5, 1936 (25±).

Merced County: 2 miles east of Gustine, November 9, 1936 (25±); 4 miles southeast of Gustine, November 7, 1936 (10±); 5½ miles north of Los Baños, November 8, 1936 (2); Los Baños Duck Refuge, November 10, 1936 (10); ½ mile southwest of Brito, November 9, 1936 (35±); 17 miles west of Merced, November 9, 1936 (25±).

Black-crowned Night Heron

Nycticorax nycticorax

Night herons have become so numerous at some places in California that they have been considered locally as pests. The species is much less common in winter northward than during the migrations or in summer.

Records. Glenn County: Packer Lake, November 30, 1936 (1).

Butte County: Gray Lodge Refuge, December 1 and 2, 1936 (2).

Solano County: Grizzly Island, November 20, 1936 (6); Joice Island Refuge, December 5, 1936 (many, sometimes 10 or 15, in sight at once).

Merced County: Los Baños Duck Refuge, November 10, 1936 (9); Brito, November 9, 1936 (1).

American Bittern

Botaurus lentiginosus

The duck marshes provide abundant wintering grounds for bitterns, and at some places they congregate in large numbers at this season.

Records. Colusa County: 4½ miles west of Princeton, November 29, 1936 (1).

Butte County: Gray Lodge Refuge, October 22, 1936 (2) and December 1 and 2, 1936 (50±).

Solano County: Road between Benicia and Cordelia, November 19, 1936 (1); Joice Island Refuge, November 20, 1936 (2) and December 5, 1936 (many).

Merced County: Los Baños Duck Refuge, November 7, 1936 (1) and November 10, 1936 (1).

White-faced Glossy Ibis

Plegadis guarauna

Flocks of glossy ibis have been seen in winter farther north than the localities listed here, but not commonly. This is another bird that has found improved conditions in irrigated fields and pastures. It is present in the central part of the State more regularly in summer than in winter.

Records. Merced County: 2 miles east of Gustine, November 9, 1936 (25); Los Baños Duck Refuge, November 7 and 8, 1936 (43); 7 miles southwest of Merced, November 8, 1936 (20+); 17 miles west of Merced, November 9, 1936 (3).

Whistling Swan

Cygnus columbianus

Whistling swans seem to be more numerous than they were a few years ago, but this may be merely the result of better means of transportation to fewer suitable habitats, thus making it easier for persons to find the wintering flocks.

Records. Colusa County: 4½ miles west of Princeton, November 29, 1936 (110±).

Butte County: Gray Lodge Refuge, December 1 and 2, 1936 (7 and 16).

Solano County: Joice Island Refuge, November 20, 1936 (8), and December 5, 1936 (11).

San Joaquin County: Victoria Island, November 6 (20+), 11 (2), 22 (many flocks, 56 in one), 1936.

Merced County: 4, 5, and 7 miles southeast of Gustine, November 7, 1936 (100+, 3, and 60±); 2 miles east of Gustine, November 9, 1936 (32±); Los Baños Duck Refuge, November 8, 1936 (50±); 17 miles west of Merced, November 9, 1936 (175+).

Canada Goose

Branta canadensis

The three common California races (Canada, Hutchins, and Cackling) are considered together. Most of the records apply to the two smaller forms. Fewer individuals were seen than I expected, but there were indications that there had been recent slight increases in numbers as a result of better protection.

Records. Colusa County: 4½ miles west of Princeton, November 28, 29, and 30, 1936 (a few small flocks, numbering up to 75).

Butte County: Gray Lodge Refuge, December 1 and 2, 1936 (abundant, mostly in small flocks up to 100; 3 forms detected, but only a few *canadensis*).

Solano County: Joice Island Refuge, December 5, 1936 (several hundred, apparently 3 forms on ponds in north part of refuge).

Contra Costa County: San Pablo Reservoir, November 26, 1936 (500± *canadensis*).

Merced County: Los Baños Duck Refuge, November 10, 1936 (1).

White-fronted Goose

Anser albifrons

Although present in small numbers compared with former times, this goose was sufficiently numerous to be found at many places in the Great Valley in winter and in good sized flocks. The tule goose is a large form of this species.

Records. Colusa County: 4½ miles west of Princeton, November 28 to 30, 1936 (2000± each day, usually in flocks under 100).

Butte County: Gray Lodge Refuge, October 22, 1936 (500 to 1000 in several flocks), December 1 and 2, 1936 (third in abundance among geese; 6± of large race).

Solano County: Joice Island Refuge, November 20, 1936 (1000±), December 5, 1936 (many flocks).

Merced County: 7 miles southeast of Gustine, November 7, 1936 (16); Los Baños Duck Refuge, November 7 and 8, 1936 (several hundred), November 10, 1936 (1000±); 10 miles southwest of Merced, November 8, 1936 (550± in flight in 2 flocks); 17 miles west of Merced, November 9, 1936 (7 in flight).

Snow Goose

Chen hyperborea

This was the most numerous of the geese at the places visited in the fall of 1936.

Records. Colusa County: 4½ miles west of Princeton, November 28, 29, and 30, 1936 (1000 to 1500).

Butte County: Gray Lodge Refuge, October 22, 1936 (2000 to 3000), December 1 and 2 (25,000+, most numerous of the geese).

Solano County: Joice Island Refuge, November 20, 1936 (possibly 5000, in many flocks), December 5, 1936 (most abundant goose).

Stanislaus County: 9 miles west of Turlock, November 11, 1936 (46 flying south).

Merced County: Los Baños Duck Refuge, November 7, 8, and 10, 1936 (1500±, mostly in 2 flocks).

Mallard

Anas platyrhynchos

Mallards were surprisingly scarce on the more open types of flooded ponds provided for duck shooting. This duck could be preserved in larger numbers in the interior of California by providing deeper ponds, with a more permanent supply of water, and a better stand of vegetation. Apparently the only really suitable winter habitat is on private hunting clubs, where the shooting is likely to be heavy. Of the supposedly common ducks, this one seems to be in greatest danger of diminution in California from continued heavy shooting.

Records. Butte County: Gray Lodge Refuge, October 22 and December 1 and 2, 1936 (most conspicuous kind of duck).

Solano County: 9 miles north of Benicia, November 19, 1936 (2); Joice Island Refuge, November 20, 1936 (50+), December 5, 1936 (numerous).

Alameda County: Lake Merritt, October 25, 1936 (250±).

Contra Costa County: Salt marsh north of Richmond, October 24, 1936 (8).

Merced County: 4 miles southeast of Gustine, November 7, 1936 (20±); Los Baños Duck Refuge, November 8 and 10, 1936 (most numerous duck); 17 miles west of Merced, November 9, 1936 (1).

Gadwall

Chaulelasmus streperus

After a study of the food of the gadwall, Mabbott (1920, p. 2) pointed out that it resembles the mallard, feeding either on dry land or in shallow water near the edges of ponds, lakes and streams, where it gets its food by "tilting" or standing on its head in the water. It feeds to a very large extent upon the leaves and stems of water plants, paying less attention to the seeds. Apparently the flooded areas are not suitable wintering grounds for this duck in California, for so few were seen that this species could scarcely be considered a shootable one.

Records. Butte County: Gray Lodge Refuge, October 22 (at least 2) and December 1 and 2 (about 10), 1936.

Merced County: 4 miles southeast of Gustine, November 7, 1936 (at least 6); Los Baños Duck Refuge, November 10, 1936 (12±).

European Widgeon

Mareca penelope

This duck has always been a rarity in the State and the changed conditions seem not to have affected it.

Records. Butte County: Gray Lodge Refuge, December 1, 1936 (1).

Alameda County: Lake Merritt, October 25, 1936 (1).

Baldpate (American Widgeon)

Mareca americana

According to Mabbott (1920, p. 2) the baldpate resembles the gadwall in feeding habits, feeding to a large extent on the leaves and stems of water plants, paying less attention to the seeds. The species was found in fairly large numbers in the fall of 1936.

Records. Butte County: Gray Lodge Refuge, October 22 and December 1 and 2, 1936 (several hundred).

Alameda County: Lake Merritt, October 25, 1936 (350±).

Solano County: 9 miles north of Benicia, November 19, 1936 (few); Joice Island Refuge, December 5, 1936 (several hundred).

San Joaquin County: Victoria Island, November 6 (2+) and 22 (1+), 1936.

Merced County: 4 to 6 miles southeast of Gustine, November 7, 1936 (50+); 5½ miles north of Los Baños, November 8, 1936 (small numbers); Los Baños Duck Refuge (few); 16 miles west of Merced, November 9, 1936 (10±).

Pintail (Sprig)

Dafila acuta

Mabbott (1920, p. 31) summarized his investigation of this species by saying that "in its general habits the pintail quite closely resembles the mallard, although it probably spends less time feeding on dry land remote from the water. It is not particularly adept at diving, but nevertheless obtains much of its food from under the surface and often from the bottom in shallow water, by tipping-up for it.'' The observations here summarized showed this to be the most common and most widespread duck in the central part of the State. Even the most unfavorable places, if covered with a shallow sheet of water, had pintail. Many thousands occurred on the bays along the coast. Most of the duck shooting observed was directed at this species.

Records. Colusa County: 4½ miles west of Princeton, October 20 and 21, 1936 (500±), November 28, 29, and 30, 1936 (a few small flocks and singles).

Butte County: Gray Lodge Refuge, October 22, 1936 (abundant), December 1 and 2, 1936 (less numerous than in October).

Solano County: 9 miles north of Benicia, October 19, 1936 (25±); Benicia to Cordelia, November 19, 1936 (100±); Joice Island, November 20, 1936 (100+), December 5, 1936 (abundant).

FIG. 7. Shovellers (spoonbills) and pintail (sprig) at Los Baños Refuge. Photograph by E. S. Cheney, 1933.

Alameda County: Lake Merritt, October 25, 1936 (600±); San Leandro Bay, November 18, 1936 (between 10,000 and 50,000); American Salt Company, west of Mt. Eden, November 18, 1936 (2000±); vicinity of Irvington, November 18, 1936 (several flocks in flight).

Contra Costa County: Salt marsh north of Richmond, October 24, 1936 (150±); 2 miles east of Martinez, November 6, 1936 (125±); San Pablo Reservoir, November 26, 1936 (25 to 50).

San Joaquin County: Victoria Island, November 6, 1936 (20,000+), November 22, 1936 (many small flocks flying high); 5 miles southwest of Lodi, November 6, 1936 (500+).

Merced County: 5½ miles north of Los Baños, November 8, 1936 (numerous in flight); Los Baños Duck Refuge, November 10, 1936 (third in abundance among ducks); 16 miles west of Merced, November 9, 1936 (1).

Green-winged Teal

Nettion carolinense

The green-winged teal, according to Mabbott (1920, p. 17) "feeds largely upon the seeds of pondweeds, bulrushes, and other aquatic plants, although it takes also a smaller proportion of such animal food as insects, small crustaceans, and snails. When much disturbed during the daytime, the flocks feed largely at night." Green-winged teal were shot in fairly large numbers, and they made a large proportion of the duck flights in the 1936 season.

Records. Colusa County: 4½ miles west of Princeton, October 20 and 21 (45±) and November 29 and 30 (several flocks), 1936.

Butte County: Gray Lodge Refuge, October 22 (third or fourth in abundance among ducks) and December 1 and 2 (less numerous), 1936.

Solano County: 9 miles north of Benicia, November 19, 1936 (31±); Joice Island Refuge, November 20 (25±) and December 5 (abundant), 1936.

Merced County: Los Baños Duck Refuge, November 8 and 10, 1936 (abundant).

Cinnamon Teal

Querquedula cyanoptera

The cinnamon teal is really a summer duck in California, and by the time the shooting season begins the bulk of the population has moved on to the southward. A few, however, were detected at various places. The continued welfare of this species in the State is obviously dependent on other factors than the shooting here.

Records. Colusa County: 4½ miles west of Princeton, October 20 (5) and November 28 (1), 1936.

Butte County: Gray Lodge Refuge, October 22 (25±) and December 2 (2), 1936.

Merced County: 4 miles southeast of Gustine, November 7, 1936 (6); Los Baños Duck Refuge, November 10, 1936 (25±).

Shoveller (Spoonbill)

Spatula clypeata

Although this was one of the more common of the protected kinds of duck, it was too scarce in 1936 to make an important element in the duck population. The fact that shovellers appeared to occupy only a few places and yet to be fairly numerous there, seemed to indicate that the usual kinds of duck ponds were not suitable for this species. Even so, the total number was too small to insure continued presence of the bird.

Records. Colusa County: 4½ miles west of Princeton, October 20 and 21, 1936 (7).

Butte County: Gray Lodge Refuge, October 22 and December 1 and 2, 1936 (25+).

Solano County: Joice Island Refuge, December 5, 1936 (100±).

Merced County: 4 to 7 miles southeast of Gustine, November 7, 1936 (200±); Los Baños Duck Refuge, November 8 and 10, 1936 (several hundred).

Wood Duck

Aix sponsa

The wood duck has been increasing slowly in California for several years. On October 21, 1936, at 2 p.m., I stopped at the bridge across Butte Slough, west of West Butte, Sutter County. After half an hour a male and female wood duck swam out from beneath the top of a tree in the water a hundred yards away. A few minutes later two females swam out from the other bank. Shortly after 3 o'clock I saw nine birds together in midstream, but they took alarm and hurried to cover. They began to come out again in half an hour, and about 4:15 I saw twelve together in open water. For nearly two hours one bird had been perched on an exposed log in open water. Some of them climbed out on dead limbs of trees that had fallen into the stream. Nearly half appeared to be in fully adult plumage. Finally, about 4:30 the group (10) moved off to the south in midstream. This observation illustrates the impracticability of trying to determine numbers in this species. In the daytime these birds were practically hidden, and it took three hours watching from one spot to detect them. It is impossible for a person to walk along the steep banks on account of the jungle of vegetation, and so many trees are in the water that it looks as if one could not take a boat far in the stream. However, it is reported that hundreds of wood ducks live in Butte Creek basin.

Record. Sutter County: Butte Slough west of West Butte, October 21, 1936 (12).

Redhead

Nyroca americana

The redhead was not detected at any of the places visited in the fall of 1936. Whether this means that the population which formerly wintered in the central part of the State has been too far reduced could not be determined. The species may continue to be a nesting duck in this area if suitable nesting ground is maintained. There seems to be little prospect now that it will ever be a common wintering bird.

Ring-necked Duck

Nyroca collaris

The ring-necked duck was found in only a few places, but I suspect that locality and type of habitat are more important than shooting in determining its status in California. Apparently it is much more common farther south in the State than at the places visited in this survey.

Records. Butte County: Gray Lodge Refuge, December 1 and 2, 1936 (200). Contra Costa County: San Pablo Reservoir, November 26, 1936 (20±). Merced County: 16 miles west of Merced, November 9, 1936 (1).

Canvasback

Nyroca valisineria

The main flight of canvasbacks did not arrive in central California until after the field work here reported was ended. This species came too late to be affected by the 1936 shooting. Even so, the numbers were disproportionately reduced compared with the former status, especially at interior localities.

Records. Butte County: Gray Lodge Refuge, December 1, 1936 (1).

Solano County: South Hampton Bay, November 18 and December 3 and 5, 1936 (50±).

Alameda County: Lake Merritt, October 25, 1936 (100±).

Contra Costa County: San Pablo Reservoir, November 26, 1936 (2).

Lesser Scaup (Bluebill)

Nyroca affinis

Practically no scaup were found in the valley areas in the 1936 study. This may mean only that there are no longer any suitable places for this species in that part of the State in the fall. However, this species arrived especially late that season.

Records. Solano County: South Hampton Bay, December 3, 1936 (2).

Contra Costa County: San Pablo Reservoir, November 26, 1936 (40±).

Merced County: Brito, November 9, 1936 (1).

Ruddy Duck

Erismatura jamaicensis

Ruddy ducks were observed more commonly than any of the protected ducks and in larger numbers than many of the ones not protected. Their rather narrow choice of habitat, and their habit of keeping well hidden under some circumstances, favored their continued presence even more than the legal protection, for many shooters showed no hesitancy in trying for them when they were in sight. Some persons even shot at them on the water.

Records. Colusa County: 4½ miles west of Princeton, October 20 and November 29 and 30, 1936 (up to 4).

Butte County: Gray Lodge Refuge, December 1 and 2, 1936 (100±).

Sacramento County: Sacramento River, 1 mile above Rio Vista, November 21, 1936 (1).

Solano County: South Hampton Bay, October 19 (110±), November 19 (500±), and December 3 and 5 (2000±), 1936; 8½ miles north of Benicia, November 19, 1936 (10+); Joice Island Refuge, December 5, 1936 (600).

Alameda County: Lake Merritt, October 25, 1936 (100±).

Contra Costa County: San Pablo Reservoir, November 26, 1936 (3).

Merced County: 2 to 5 miles southeast of Gustine, November 7, 8 and 11, 1936 (200±); 5½ miles north of Los Baños, November 8, 1936 (30±); Los Baños Duck Refuge, November 7 and 10, 1936 (10±).

Florida Gallinule

Gallinula chloropus

Not many fall and winter records are available for this bird in the Sacramento Valley area. Obviously this is one bird that has been aided, or at least not hindered, by the great development in irrigation systems. It can make use of the kind of aquatic habitat provided in the ditches and the waste marshy ground.

Records. Glenn County: 1½ miles southwest of Butte City, October 20, 1936 (2).

Sacramento County: 7 miles southwest of Sacramento, October 23, 1936 (13+).

Solano County: Joice Island Refuge, November 20, 1936 (1).

San Joaquin County: Victoria Island, November 6, 1936 (1).

Merced County: 2 miles east of Gustine, November 9, 1936 (2); 5 miles southeast of Gustine, November 7, 1936 (1); Los Baños Duck Refuge, November 7, 1936 (2); 18 miles west of Merced, November 9, 1936 (2).

SHOOTING PRACTICES

Number of Shooters

One item, important in any consideration of duck hunting in California, is the total number of shooters. Only approximate figures can be obtained, but these have some value. Reports for the 1934 season, when permits were required on baited shooting grounds, showed the number of hunters at such places in California to be 10,476 (*Pacific Sportsman,* September, 1935, p. 12). Hornaday (1934) gives the number of members of duck clubs in California as 6000 and of "outside duck hunters" in the State as 9000.

FIG. 8. Snow Geese on the Gray Lodge Refuge. Photograph by E. S. Cheney, 1933.

A tabulation of numbers of hunters whose kill was checked on the reservoirs in San Diego County shows 10,082 for the season 1928–29, 8410 for 1929–30 (*Calif. Fish and Game*, vol. 16, 1930, p. 167), and 9915 for 1933 (*ibid.*, vol. 20, 1934, p. 167). These represent man-days of hunting and not separate individual hunters.

A press release from the U. S. Department of Agriculture, dated February 9, 1937, contains information about hunting license sales. Sportsmen in the United States and Alaska paid nearly $10,000,000 for hunting licenses and Federal migratory bird hunting stamps in 1935. Of this, $446,919 was for the Federal stamps. A total of 5,988,064 resident and nonresident licenses were issued in 1935, approximately 70,000 more than in the previous year. Sales of the Federal hunting stamps were 188,425 less than in 1934, which was the first year they were sold. Approximately 90 per cent of proceeds from the stamp sales are turned over to the Biological Survey for establishing, maintaining and administering migratory bird refuges.

In California the 1935 hunting license sales were as follows: resident 188,290; nonresident 835; total 189,125; money return, $367,880. Waterfowl hunting stamp sales for 1936 were 44,570; for 1935 were 33,353; for 1934 they were 39,525. Thus, fewer than one-fifth of the hunters of California attempted to hunt waterfowl. It is probable that a great many persons bought the stamps who did no shooting.

Table 4, compiled from biennial reports of the California Division of Fish and Game, shows the fees collected by the Division from commercial hunting license sales. It shows the general trend of this form of hunting in late years, and indicates to some extent the variations in amount of duck hunting. Table 5 shows the number of hunting licenses issued in California from year to year.

TABLE 4

Commercial Hunting Club Licenses Issued in California

Year	Club licenses	Operators' licenses
1927–28	$1,475	$410
1928–29	2,025	575
1929–30	2,575	820
1930–31	2,110	620
1931–32	1,375	345
1932–33	2,075	565
1933–34	1,750	395
1934–35	1,225	265
1935–36	950	215

TABLE 5

Hunting Licenses Issued in California

Year	Number	Revenue
1926–27	253,532	$279,701
1927–28	257,738	285,362
1928	228,696	464,145
1929	241,709	488,638
1930	231,970	464,157
1931	214,577	424,188
1932–33	154,031	453,159
1933–34	171,139	334,746
1934–35	174,667	338,538
1935–36	189,125	367,880
1936–37	224,050	434,255

Kinds of Shooting

In this section I am not concerned with the technique of killing ducks, but I do wish to recount some observations on some of the conspicuous kinds of human behavior exhibited on commercial shooting grounds. These notes apply to places in central California where shooters congregate in large numbers, but they do not represent situations where the largest kills are made or where experts shoot. They represent the situation any hunter must expect who can not shoot on a private preserve.

For two hours, from 9 to 11 a.m., on November 8, 1936, I watched shooters on a pond on a large commercial club near Los Baños. About six men were stationed in blinds around this small pond, but from one to three of them were out in sight and moving about or wading in the pond almost all of the time. I could not count, or distinguish, the shots at this pond, but there must have been between 200 and 500, and I am sure that not more than 10 ducks fell. Many of the birds which came over appeared to be within easy range, but most of them were way out of range. Nearly all the shooting was at single birds. The shooters scarcely ever waited for the ducks to come near their decoys.

There was no screen about this pond except for one small cattail patch near its center. Over most of the surrounding ground there was little opportunity for cripples to escape or be lost unless they flew off out of reach. Coots, ruddy ducks and other birds (about 50) stayed on this pond all morning despite the frequent shooting, which seemed not to disturb them. Also it seemed strange to see many cattle and horses continue to graze in the near vicinity paying no attention to the shots. The ducks and geese took little note of automobiles on the nearby road, but they moved a little when the machines came out across the pasture.

Two weeks later I visited another shooting ground—one in the delta region—arriving at 6:50 a.m. after going through fog so thick visibility was not more than fifty feet. Most of the hunters were already in place, and they were shooting at about the same rate as they did later in the morning. Scarcely ever were there more than one or two seconds between shots. Until 9 o'clock the fog continued dense and close to the ground. All this time, swans flew over the flooded ground with loud calls. Once, when three swans flew close overhead, three hunters standing on the pavement fired eight shots at them. Hunters continually arrived and searched for their blinds, and from the fog came their constant calls—some giving instructions, some from shooters appealing to their lost companions, and some threatening neighbors. The threats became more numerous after it became light enough to see the birds and they included promises of human shooting and accusations of theft of birds. Many of the calls were in a foreign tongue.

After the fog cleared away, it was plain that most of the shots were aimed at pintails flying far out of range. Of course a great many more were killed than were seen to fall, but the total must have been small compared with the possibilities. Of the many shots directed at swans no hits were seen. Many shots were fired at coots, and I saw at least a dozen of these birds fall. About 9 o'clock three game wardens left in two cars; later two returned. Many poachers were seen while the fog was thick. Once the keeper left the grounds to drive away seven shooters lined up near the road shooting at coots. One paying hunter arrived at 11 o'clock.

Many of the shooters tired of standing in the blinds and waded around among the other stands, sometimes going close to half a dozen or more. This often resulted in loud protests. The largest strings of ducks seen were being carried by two Chinese boys who left early.

On the last three days of the duck season in 1936, I spent about fifteen hours watching shooters and birds from one place in the center of a large commercial club in the Sacramento Valley. The first day, Saturday afternoon, I saw about fifty hunters. Several took in good-sized strings of ducks. Some parties obviously were poachers. One man sent his boy over the fence where, after much shooting, he got two coots. Another man who was familiar with the country was looking for a place where he could slip in to shoot the next day. A party of four men circled a pond after 4 p.m. and scared up several ducks. After shooting about forty times, they got at least one duck.

The next morning, at the same place, shooting was fairly heavy for about three hours after 7 a.m.; then it ceased almost completely until 2 p.m. At first there were many automobiles along the road, and about twenty men were lined up outside the fence. One of these men got two teal. From the start few ducks were seen, but a good many geese went over, far out of range. Several hunters stopped near me. One of them who lived in the neighborhood explained how he and other local residents hunted by going along the road and by slipping in on unguarded land, but with little success except on the opening day.

One of the "herders" for the gun club came by; he had been putting out decoys for "de luxe hunters." He seemed to pay no attention to persons shooting from the road, but rather was competing with them. He had two ducks. Some patrons came along at 10 o'clock and complained a little at the absence of ducks. They went in to the headquarters. I was told that about 150 paying shooters were on the club that day, the last Sunday of the season, and I saw that many more on the road looking for open shooting ground.

One man, apparently a poacher, who shot all day close to the road, hid out of sight most of the time, except when disturbed by other shooters. He got about four jack rabbits, three or four ducks and a white-fronted goose. Another man with three boys was leaving at 4 p.m. They had four ducks (3 pintail and a green-winged teal). This man said the flight of ducks that day was the poorest he had ever seen. He did not believe there were too many shooters, but thought the season should be closed.

These brief sketches, along with many other similar accounts written in the field, give some basis for judging an important influence upon the welfare of waterbirds. Shooting provides the means for removal of a large part of the bird population each year, but it also indirectly provides some beneficial conditions for the birds. The shooters thus rank high among the active agents which determine waterbird status. To understand the extent of their influence, it is necessary to know the behavior of individual shooters as well as something of the combined result of their activity.

An important item to remember is that the behavior of shooters is not exactly the well-governed routine of behavior of the same persons at home in the cities. Now, more than ever before, waterfowl shooting is less truly hunting, but more a highly specialized and often commercialized form of recreation. The behavior of the shooters tends to become standardized, and even though the surroundings may be almost entirely artificial there is a certain aspect of adventure in the outing. The shooting trips are made infrequently, and many of the men are so unaccustomed to a gun that they not only fail to kill many birds, but they drive away the ones which might be killed by their more experienced neighbors.

Despite all these circumstances which tend to reduce the actual kill, the total number of shooters is so great that they remove too many birds. Duck hunters who want their sport to continue will not encourage other persons to take it up. They may even advocate more drastic regulations for shooting than have been in force in past years.

Regulations

The waterfowl regulations for the time this study was made (1936) provided for the complete protection in California of the redhead, canvasback, wood duck, ruddy duck, bufflehead, Ross goose and swan. Except possibly the ruddy duck, none of these could be considered as assured of preservation by such a regulation. However, I saw no evidence that many of any of these birds were killed. Most of them were not present where the shooting was done. If they had been, it is doubtful if many of the persons in the blinds could have identified them.

FIG. 9. The Los Baños Refuge is a favorite with the geese. White-fronted, Hutchins, Cackling and Snow Geese are to be seen here, as well as the ever-present Coot or Mudhen. Photograph by E. S. Cheney, 1932.

The established limits of 10 ducks and 4 geese, and possession limit of one day's bag was no doubt observed more often because not that many birds could be obtained than for any other reason. Except on the opening day not many shooters seemed to be able to bring in limit bags. Restriction of hours of hunting to the time between 7 a.m. and 4 p.m. was both hard to enforce and hard for a large group of eager hunters to observe. This was especially true after the opening day, when the ducks learned to hurry to the nearest refuge as soon as a single shot was fired.

The forbidding of live decoys and baiting provided some really effective contributions to the preservation of the birds, and this no doubt accounted for some increased survival of the birds. Restrictions against the use of sink boxes or batteries, and shotguns over 10 gauge or more than 3-shell capacity, could scarcely have been very effective under conditions in California.

Benefits from such imposed limitations to shooting as the ones just listed must come from voluntary respect for them as well as from vigilant enforcement by wardens. Repeatedly, observations in the field and reports by other persons showed a high degree of both of these influences in California in 1936.

RELATIONS OF WATERBIRDS TO AGRICULTURE

Relations of waterbirds to agriculture in California involve mainly three types of crops: rice, pasture and grain. Most of these relations involve some form of irrigation, but that practice is not necessarily entirely beneficial to the birds. In the valleys where drainage has developed along with irrigation the whole development is more likely to be harmful than beneficial. Reasons for this are mainly that care is taken to get as much use as possible from every bit of the water in the ditches and to run all surplus as quickly as possible to the sea. This means that only small amounts of water are likely to be exposed where they can benefit birds, and, most important, there will be long, annually recurrent periods of extreme drouth. These drouth periods, when they coincide and are nearly universal, as in the fall of 1936, are the critical times for most kinds of aquatic birds. They can not possibly occupy this area unless special provision is made for them at these times. Refuges established by the State and Federal governments have an important usefulness here.

The problem of protecting crops from damage by wildfowl was discussed by Kalmbach in a mimeographed leaflet issued in August, 1935, by the Biological Survey. For California he reported damage by geese to wheat, and damage by ducks to rice, barley, wheat and truck crops. It is pointed out in this leaflet that the farmer is obligated to modify his farming methods to reduce losses, and it is recognized that the government is obligated to heed the complaints that come from bird damage. The various methods used for crop protection are discussed.

Rice

Rice is usually considered the crop most closely connected with waterbirds in this State. The normal planting is probably about 130,000 acres (Weir, 1929, p. 3). The 1935 acreage was 93,988. An extra large crop was planted and harvested in 1936. Since the first commercial plantings in 1912 near Biggs, Butte County, many advances have been made in handling the land and crop. Nearly all these changes have tended to hinder rather than benefit waterbirds.

Because rice grows on submerged land, and because it is planted soon after the end of the rainy season, it was hard at first to dry out the land at any time of year, either for planting or for harvesting. Some lands, the ones naturally best suited for birds, proved too difficult to drain. The presence of the large numbers of birds, especially ducks, that were attracted to this new food source also caused much concern. Methods had to be devised to restrict the abundant growth of aquatic vegetation in the rice fields and in the canals.

These problems were met by shifting the crop to land that could be readily drained, by constructing elaborate works for quick and thorough drainage, by developing quick growing strains of rice that could be harvested before the rainy season, by devising planting schedules that would protect the young crop from birds, and by developing systems of rotation of other crops and fallow years, intended to kill out aquatic plants. As a result of all these the rice lands are no longer so favorable the year round for birds as they were at first. They still offer large areas of water at certain seasons, and large amounts of screen at some places, as well as an abundance of food for short periods, but these conditions are subject now to sudden and drastic changes which make the land unattractive to many birds. For example, in the fall of 1936, practically all of the rice land was completely dry after harvest time and a great deal of it was burned over or plowed. Outside the refuges, and the club lands flooded especially for birds, there was no place in the Central Valley where waterbirds could live through this three-months-long season.

Partly to compensate for this kind of situation, according to Weir (1929, p. 15), "as a part of the stipulation on rights of way through Butte Basin, the several districts have agreed to maintain for the benefit of the several gun clubs, a water level at an elevation between 47.3 feet and 48.8 feet above sea level. The districts have been required to build and control regulatory gates for this purpose." If, for any reason, these gun clubs ceased to maintain their property, as by a termination of shooting, this area might become much less favorable for waterbirds than it is now even with the heavy shooting which occurs each winter.

Pasture

In many districts pasturing is the agricultural use most profitably combined with duck shooting. Often this involves only the removal of the excess of each year's plant growth and on most of the land it would be the only profitable use even if there were no shooting. The land usually is poor soil to begin with and, on account of alkali or poor drainage, is not suited to raising cultivated crops. The main treatments needed to make shooting grounds out of these pastures are the construction of a few shallow depressions that will hold water, and flooding at the proper time. The aim usually is to flood as much surface, to as small a depth, as near the start of the shooting season as possible, in order to make use of the whole amount of plant and insect food available. This use does not necessarily interfere with the grazing which often continues right through the shooting days.

Grain

Large plantings of grain affect waterbirds in various ways. Sometimes in preparing the seed bed in the fall the ground will be flooded for several weeks. One such large field near Los Baños, which happened to be within a refuge established for pheasants, was under water through the 1936 shooting season. It was reported that ducks and geese congregated here on shooting days in just as great numbers as on the nearby state-owned refuge that had been established and maintained for that purpose.

Growing plants in the field are eaten, and the ripened grain before harvest and that left after cutting sometimes furnish a needed food source. Early fall rains may submerge whole fields of standing grain which then make good forage places for ducks.

After harvest, grain fields are sometimes flooded for shooting grounds.

Benefits to Farmer

The farmer or land owner where ducks congregate in the shooting season has opportunity to profit by selling shooting rights. No doubt some of the excess losses to waterfowl in recent years can be traced directly to this kind of desire for profit. Advertising and solicitation may have had a part in increasing the number of shooters.

With the recent reduced shooting seasons and greater restrictions, however, possible profits were so reduced that many purely commercial duck and goose shooting enterprises were abandoned. Some individual land owners, through continuance of shooting on a private basis, thereby profited from the birds.

Indirectly, certain types of farming may be benefited by duck shooting through the provision of water for irrigation. This may be utilized on the flooded shooting ground or it may be stored in the shooting ponds, later to be spread on the farmed land. In either instance the expense of irrigation is considerably reduced.

Effect of Agriculture on Birds

In general, waterbirds in California are benefited by farming through the provision of added food supplies, through augmented amounts of water, and through the greater sanctuary provided on farmed land. These beneficial effects, however, are not sufficient to offset the harmful ones which accompany intensive use of the land.

DISEASE

The disease most often discussed and most feared by persons concerned with ducks in California is the western duck sickness which was reported upon at length by Kalmbach (1934). The following items, extracted from his report, are important for this State. The malady is now recognized as a form of botulism, a disease caused by the toxin produced by a common saprophytic and anaerobic bacterium, *Clostridium botulinum*, type C. This organism, thriving under conditions of decay, and previously recognized as the cause of more or less localized outbreaks of limberneck among domestic poultry and forage poisoning in livestock, is simply a form of food poisoning. In general, the disease coincides with or immediately follows periods of hot weather. As a rule, outbreaks in central or southern California extend later into the fall than those in Oregon or Utah, and in the San Joaquin Valley in certain seasons the disease has persisted until December and January.

Duck sickness is intimately correlated with areas of shallow, stagnant water and mud flats. Where water depths of a foot or more are maintained, the disease is seldom in epizootic form. Hence, water levels in duck ponds should be reasonably deep (one or more feet near shore and greater in the center). Water temperatures should be kept below 80° to 90° F. during midday by circulation or change of the water or by increasing its depth. Shore lines should be kept well defined and clean.

SUMMARY AND CONCLUSIONS

Availability of water is an acute problem for certain birds in California just as it is for people. Moreover, the aquatic habitat is remarkably complex, and it must be studied from many angles if it is to be maintained for adequate use by wild animals. The present study was undertaken to determine what areas are available for waterbirds and to study the effects of shooting practices. It seems that permanent solution of waterfowl problems in California will require management of all the aquatic animals in order to satisfy all man's recreational needs and not alone his desire to shoot. The main problem regarding waterbirds seems to be what to do about restoration of numbers sufficient to preserve the species which have been so far depleted as to be in danger of extinction; it is not simply to provide birds of any sort to be killed.

The former extensive marshy areas in the central part of the State were so reduced by 1936 that by the time the wintering birds arrived there was no water available except where the ground had been flooded for the birds. These places were mainly shooting grounds and refuges. Refuges are likely to be the most important devices for permanent preservation of waterbirds in California. They serve as sanctuary, as nesting places, as resting places, and as feeding places. A satisfactory refuge program would permit no grazing, no harvesting and no burning. It would be desirable to delay sedimentation in ponds as long as possible and to keep them filled with water as continuously as possible.

Examination of several of the refuges already established revealed qualities especially suited to the birds and showed the nature of some possible improvements. More refuges need to be established if the State expects to have more wintering waterbirds.

The total number of waterfowl shooters is not exactly known, but hunting stamp sales might indicate that around 40,000 persons shoot at these birds each season in California. Apparently this is too great a number to allow continued existence of all the kinds of waterbirds. It is probable that more drastic regulation of shooting will be necessary than any in force in past years. Moreover, it seems certain that neither improvement of habitat nor stricter regulation of shooting, even prohibition of it, would solve the waterfowl problem satisfactorily. The final solution must be some combination of these. Also we must accept the general condition which makes it impossible now to have anywhere nearly as many waterfowl in California as were present when the country was settled by the white man.

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NOTES ON HATCHING AND REARING GAME BIRDS IN CALIFORNIA[1]

By August Bade
Superintendent of State Game Farms
California Division of Fish and Game

The California system of hatching and rearing upland game birds is considered by many to be the most advanced and up to date of any in the United States.

The idea of this system originated in the mind of the author several years ago when all game birds were reared with the domestic hen as a foster mother. To those who are acquainted with the domestic hen method, it is unnecessary to point out or dwell upon the many disadvantages encountered because of the introduction of domestic poultry diseases to the young birds.

About ten years ago it became apparent that the method of producing game birds must be changed. In the succeeding years changes have been made and today game birds are being produced in large numbers with a minimum of trouble from the standpoint of disease. Electric incubators are used to hatch all types of game bird eggs and the young birds are reared in electric brooders especially adapted to the needs of the various types of game birds being propagated.

For the purpose of incubation the ordinary types of incubators built for domestic chicken eggs are used. The only mechanical change in these machines that is necessary is in the size of the egg trays due to the small size of most game bird eggs. Both the force draft machine as well as the flat top type are being used successfully.

It is not the purpose of this article to show just how these machines are operated except in a general way. Artificial incubation in most cases is a local problem. By that we mean local atmospheric conditions will change the method of procedure. Most incubator manufacturers furnish a booklet telling how their particular machine should be operated. If these instructions are followed, especially in the particular locality in which the machines are built and tested, good results will be had. But when the machine is shipped into another part of the country where humidity and general atmospheric conditions are different, the machine may not function as well as the manufacturer indicated in his book of instructions. For that reason we say artificial incubation is a local problem and different conditions must be taken into account.

Generally speaking we have found that game bird eggs hatch best when they are dried down, or in other words when the moisture in the egg is evaporated and its actual weight reduced about 14 per cent. For many years it was generally agreed that 13 or 13½ per cent was sufficient for the successful hatching of domestic chicken eggs. But

[1] Submitted for publication, November 5, 1937.

our experience in handling large numbers of game bird eggs of all kinds leads us to believe that when the moisture in the egg is evaporated until it has lost about 14 per cent in weight and when ample moisture is added during the last three or four days of the hatching period, we get stronger chicks and a larger percentage of hatched eggs.

In speaking of the different types of incubators such as the force draft and the flat top, we should make this distinction: In the force draft machine the air is stirred mechanically, that is, by a fan or similar device, and the general temperature of the machine should be held at about $99\frac{1}{2}°$ F.; whereas in the flat top machine, where the heat is generated above the egg trays and there is no artificial stirring of the air, the temperature should be maintained at about $102\frac{1}{2}°$, with the temperature reading taken at the center of the egg.

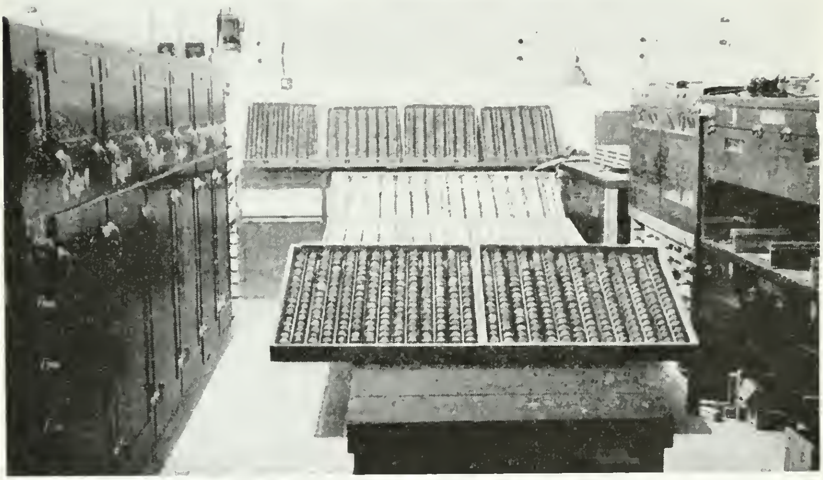

FIG. 10. The incubator room at the Yountville State Game Farm on egg setting day. The ten trays shown contain a total of 2600 eggs, or one-half of the weekly set. The capacity of the machine on the left is 24,000 eggs every 25 days. Photograph by August Bade.

In this machine, where ventilation is obtained only from the principle of warm air being lighter than cold air, the upper part of the egg, being closer to the source of heat, is from one to one and a half degrees warmer than the under side.

As a matter of actual practice at California Game Farms, eggs are incubated in force draft machines, but the hatching is done in flat tops. Two or three days before the actual hatching time, eggs are transferred from the force draft machines to the flat tops where additional moisture is added and the eggs are held until the chicks are hatched.

A very important factor in successful incubation is a well ventilated incubator room. By well ventilated we mean a room where air conditions are under control and excessive drafts are eliminated. If the general room temperature can be kept at about 85°, little or no trouble will be encountered. At that temperature it is an easy matter to secure proper humidity. Since warm air absorbs moisture easily, humidity will cease to be a problem in an incubator room in which the temperature can be held around 80° or 85°.

A slight variation between night and day temperature in the room will usually occur but if this difference is not more than four or five degrees it will have little effect on the general operation of the machines.

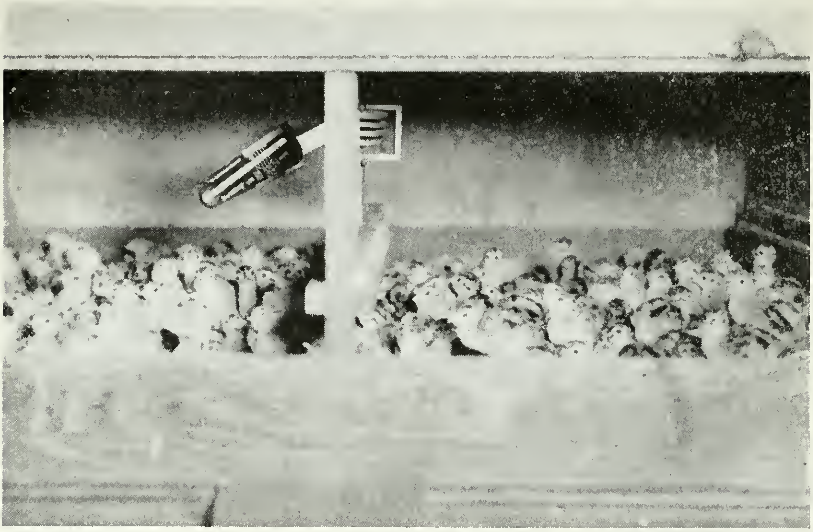

FIG. 11. One section of a hatching machine showing birds ready for the electric brooder. Photograph by August Bade, Yountville State Game Farm.

So far as incubation is concerned, only three factors are involved—heat, moisture and ventilation, or more properly speaking it is the right combination of these three factors that produces proper incubation. In the process of brooding we are concerned with only two factors. One of these is heat and the other is ventilation. The matter of moisture drops out of the problem here.

Where its use is possible we advise electricity because of its convenience. Electrical energy is probably one of the most dependable sources of power that we have. For that reason and the matter of the cost of equipment, its use is advisable.

Any brooding equipment to be effective should have ample power to furnish sufficient heat for the lowest temperature period, which usually occurs at night. If birds have proper heat and plenty of ventilation there should be little or no trouble during the brooding period.

As a general rule, and this applies to all game birds, more actual floor space is required per bird than is the case with domestic birds. From the very nature of game birds they seem to require more room and this characteristic is evident even in the brooding period.

In rating the capacity of a brooder, the sunshine space, or screened-in run, should be added to the actual brooder room area. In other words, the capacity of any given brooder is dependent upon the amount of sunshine run space connected to the brooder. Figuring the brooder room space, plus the sunshine run, we advise at least one and one-half square feet per bird. A brooder room 8 x 12 feet with a 6 x 12 foot sunshine run will accommodate approximately 100 pheasants.

With the development of adequate equipment for the hatching and development of game birds, the chief concern of the present day breeder is the matter of suitable food for young as well as older birds. We have ample facilities for the proper hatching of game bird eggs and good brooding equipment that meets the requirements of the day in every respect. But there is still much to be learned about the proper food for the birds at different stages in their growth, as well as the matter of food for the birds during the mating season in order to have a large number of fertile eggs.

In the last four or five years several commercial producers of feeds have turned their attention to the matter of game bird foods. For a long time, and before accurate records were kept, it was the common opinion that the same food that would meet the needs of domestic poultry would do for game birds. At that time no very accurate records had been kept and until a few interested breeders began to check up on the results they were getting from domestic poultry feeds, no particular progress had been made. Within a short time after experiments were started and accurate records kept, it was found that all game bird foods should contain more protein than was the case with poultry foods. Just how much protein game bird food

FIG. 12. Electric brooders and rearing pens operated by the sportsmen of Bakersfield. During the 1937 season, 3940 pheasants, quail and partridges were handled by the Bakersfield group, assisted by Game Warden Lester Arnold.

should contain was the problem to be solved. This experiment called for accurate records and much work for the laboratory.

From year to year the percentage of protein has been gradually increased until today many breeders are using a food that contains as high as 30 per cent protein. In most cases it has been found that as the percentage of protein is increased more and better birds are produced.

If we analyze the yolk of an egg it will be found to contain 32 per cent protein. Since the egg yolk furnishes the food for all birds during their first days, is it not logical to suppose that a starting food should compare favorably with the natural food or egg yolk?

In rearing any kind of game bird it is a good plan to stay as close as possible to nature. For years and years grated egg yolk has been the one starting food that seems to get results for every one. But even a good thing can be overdone and this can happen in using egg yolk as a starting food. Experiments have proven that egg yolk should be eliminated entirely at the end of ten days or two weeks. If continued over a longer period it may prove very harmful.

In bird farming the well-balanced ration is being given just as much consideration as the household economist is taking in the matter of a well-regulated menu for the table. Too much of any one food is to be avoided, and most particularly those foods that are the richest and at first may appear to be the most nourishing. A well-balanced ration for birds consists of foods that will produce muscle, bone, flesh and feathers in an even and methodical manner.

In the wild state birds have access to a variety of foods, and by choice as well as by instinct they seem to be able to get the necessary elements that make for a balanced ration. Insect life goes far to make up the necessary protein. From green foods they get the essential minerals, and additional carbohydrates come from seeds and grains. When birds are confined under domestic conditions it is essential to provide them with these various food elements in order to maintain their health and vigor.

Not only is it necessary to provide them with a balanced ration, but at the same time they should have ample room and adequate sanitation. As regards sanitary conditions, the matter of drinking water is an essential factor, as it is the immediate source of many diseases. In order to maintain a clean water supply, it is necessary to have proper equipment in the way of drinking vessels that are easily kept clean. There is no better source of infection than stagnant or unclean drinking water.

So far as our experience goes there is no royal road to success with game birds. Eternal vigilance, plus a work-a-day knowledge of sanitation and food values is the only way to achieve our goal—more and better game birds.

GRUNION IN SOUTHERN CALIFORNIA[1]

By FRANCES N. CLARK
California State Fisheries Laboratory
Division of Fish and Game

Who during the summer months in southern California has not been inveigled to a moonlight picnic by the promise of additional excitement in the form of a grunion run? And who has not gone to such a picnic for the first time with his fingers crossed assuring himself that he would be merely the sack holder in a snipe hunt? Do fish come up out of the ocean to dance and cavort on the beach as he has been told? It is a good story but can it be true? It mayhap that such a skeptic will return from his first, second or even third picnic still questioning. Grunion can not be depended upon to appear on every section of every southern California beach on the nights when grunion runs are due. That there is such a fish, however, is attested by figure 13, and somewhere on some southern California beach these fish can be found on certain nights during the spring and summer months. To know when, where and why grunion will appear, one must understand the life cycle of these strange, world-renowned fish.

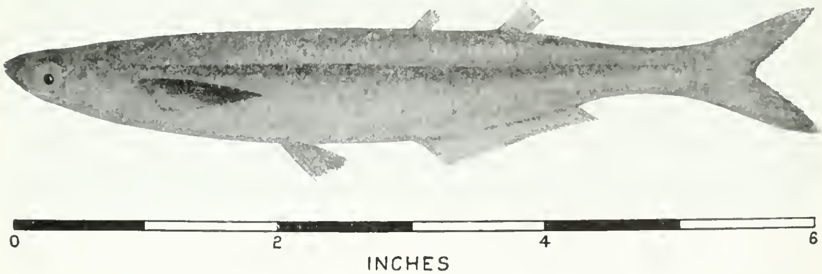

FIG. 13. The grunion, *Leuresthes tenuis*.

Grunion Habits

Distribution

Why these fish should occur in southern California only, thus giving this famous tourist region an attraction that her rival, Florida, can not boast is hard to understand. The grunion, known to scientists as *Leuresthes tenuis*, belongs to the family Atherinidae, or silversides. The silversides inhabit tropical seas and only a few species occur in subtropical waters. The grunion, decidedly limited in its habitat, is to be found only along the southern California coast from Point Concepcion southward to the northern portion of Lower California.

[1] Submitted for publication September, 1937.

Spawning

It is a shore dweller, spending its entire life near the sandy beaches where it makes its spectacular appearances every summer. The reason for these brief excursions out of the sea onto the shore was not clearly understood until 1919, when Thompson [2] studied successive runs and definitely established that grunion come up onto the beach to bury their eggs in the sand. The spawning season for the grunion extends from March to August and during these months the female ripens a batch of eggs at two-week intervals.[3] Thus spawning occurs only every two weeks and the time required to mature a batch of eggs is so mysteriously adjusted that the fish are ready to spawn only on the

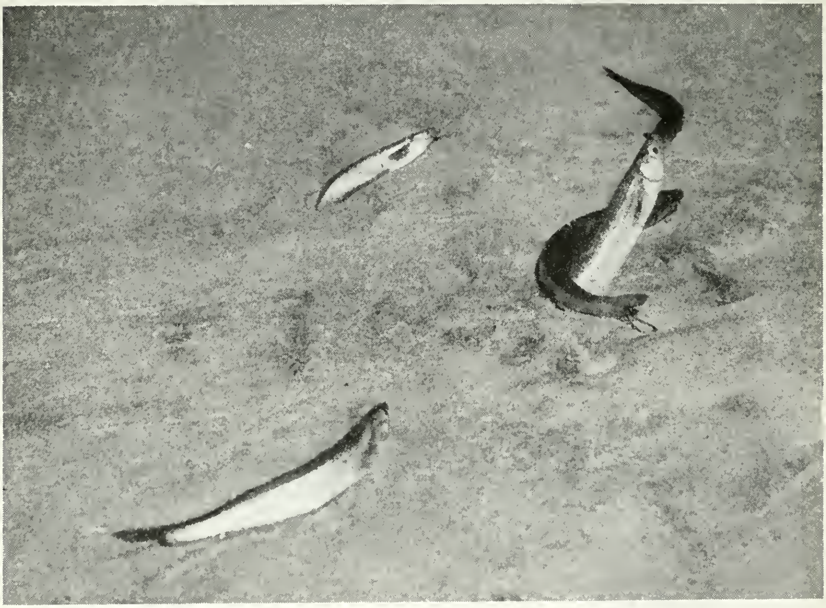

FIG. 14. Grunion spawning on the beach. Photograph by "Dick" Whittington.

three or four nights when occur the exceptionally high tides accompanying the full and the dark of the moon.

These spawning runs take place only at night and only on those nights when each succeeding tide is lower than on the preceding night. On any given night, the run occurs just at or somewhat after the turn of the tide and lasts for about an hour. The grunion are washed up onto the beach with the larger waves, the female quickly digs, tail first, into the sand for about half the depth of her body, then extrudes her eggs which are fertilized by the male as he lies arched around her. The male then flops away toward the water and the female, much exhausted, sways back and forth until she has freed herself from the

[2] Thompson, W. F., assisted by J. B. Thompson. The spawning of the grunion (*Leuresthes tenuis*). California Fish and Game Commission, Fish Bull. No. 3, 27 pp., 1919.

[3] Clark, F. N. The life history of *Leuresthes tenuis*, an atherine fish with tide controlled spawning habits. California Fish and Game Commission, Fish Bull. No. 10, 51 pp., 1925.

sand and is washed back to sea by the next wave. The whole process of egg laying takes about thirty seconds.

Incubation and Hatching

The pods of eggs lying at the upper limit of the tidal zone are buried deeper in the sand as the beach is built up by the succeeding series of lower tides. Here they lie in the warm, moist sand unmolested for two weeks until the next series of high tides again erodes the beach and digs the eggs out of the sand. As the eggs are freed from the sand the baby grunion hatch and are washed back to their natural environment, the sea.

Thus an extremely delicate adjustment between fish and tidal phenomena assures the perpetuation of a species of fish unique in its spawning behavior. If the eggs did not ripen at intervals corresponding to the occurrence of highest tides the grunion might spawn on a series of tides which increases in magnitude each night. This would result in the eggs being dug out and washed back to sea before hatching time had arrived. For the same reason if the grunion spawned on any given night before the turn of the tide the eggs might also be washed to sea. This mishap is avoided because the fish do not run up on the beach until the tide is on the ebb. They can be seen milling around in the surf for some time but it is seldom that a spawning run actually begins before the tide turns.

A further safeguard for the grunion is assured because the eggs do not hatch until actually dug out of the sand and also because the eggs can remain alive for at least a month after deposition. The first factor prevents the hatching of the eggs if there is no opportunity for the larval fish to return to the ocean, and the second enables the eggs to await their liberation for as long as a month if necessary.

An Interesting Experiment

Anyone interested in becoming an amateur naturalist can demonstrate these facts himself. All that is necessary is a small container, a spade, and the expenditure of a modicum of energy. Properly equipped, proceed to the beach on the days immediately following a series of high tides during the grunion season. Dig, not deeper than twelve to eighteen inches, in the upper portion of the tidal zone, look sharply and a pod of grunion eggs will be the reward. The eggs are salmon-pink in color and each is about the size of a small pinhead. Place the eggs in the container and cover with moist sand. For the next two weeks keep the sand moistened with sea water but not wet. At the end of two weeks gather interested friends, pour some sea water on the sand, agitate the container, and suddenly baby grunion will pop forth. Eggs can be kept thus for a month or more but the longer the time the eggs are held the less vigorous will be the hatching.

Life Span of the Grunion

The baby fish when washed back to the sea grow rapidly during their first summer and continue to grow, although more slowly, in their first winter. By the following spring they are about five inches long and ready for their first spawning. These young fish, spawning for the first time, do not spawn as early in the season as do the older grunion.

nor do they produce as many eggs, nor spawn as frequently. The older fish begin to spawn in March and each individual continues to spawn at two-week intervals until July or August. The younger fish start spawning in April and May but do not continue later than June. This means that almost the entire grunion population is spawning in April, May and June, but only part in March and in July and August. For this reason the largest grunion runs occur from mid-April to mid-June.

Grunion live to be two or three years old but only an occasional individual has been found that had lived for four years. The maximum size is about seven inches. The maturing of the sex products places such a strain on the metabolism of the fish that growth stops during the spring and summer months. This complete cessation in growth causes a scar to form on each scale and by examining a scale under the microscope and counting the number of these scars the age of the grunion can be determined.

Favorable Beaches

Grunion have been seen running on most of the beaches from Ventura County southward to San Diego. Certain beaches, however, appear to be more suited to grunion spawning and in these regions runs occur more frequently and are of greater magnitude. Such a favored section lies near Long Beach along Belmont Shore and thence south to Huntington Beach. A second locality where large grunion runs are frequently observed comprises the beaches near La Jolla. Why grunion should appear with greatest frequency on these beaches is not known.

Many have speculated about the homing instinct of grunion. Does each adult grunion return to its native beach when spawning time approaches? This question was unexpectedly answered in part for us through the need for recreational facilities at Los Angeles Harbor. During 1927 an artificial beach was constructed at the base of the breakwater protecting this harbor. By the spring of 1928 this beach was completed and during June and July of 1928 grunion runs were observed there.[4] This immediate appropriation of a new spawning ground by the grunion demonstrates that these fish can adapt themselves to a new locality and each individual does not necessarily return to spawn on the beach where it was hatched.

Dates of the Spawning Runs

From the early spring until late summer of each year the California State Fisheries Laboratory is bombarded with questions about the date and time of the next grunion run. To readily answer these questions, the laboratory staff prepares a grunion time table which is kept near the telephone all spring and summer. In addition this table is given to local newspapers and published frequently by them.

To the amateur the preparation of a grunion time table is very mysterious, but to the initiated very simple. A knowledge of grunion habits indicates that all the information necessary is the height and time of each nightly high tide. Because grunion spawn only at night the day tides can be disregarded. In figure 15 are shown the height

[4] Clark, F. N. Grunion on Cabrillo Beach. California Fish and Game, Vol. 14, pp. 273-274, 1928.

of the night tides from March to August of 1925 and 1937. These two seasons illustrate the way in which the height of the tide increases and recedes at fortnightly intervals. In some seasons each high-high tide is associated with the full of the moon and in some with the dark of the moon. The summer of 1925 represents the former and 1937 the latter condition.

The arrows pointing upward on the curves of figure 15 indicate the dates on which grunion runs were expected. In the latter half of March, the three nights immediately following the date of the highest tide are considered the most probable dates for the grunion run. This same method is followed through April and May. By June the second night following the highest tide is considered the more probable date of the

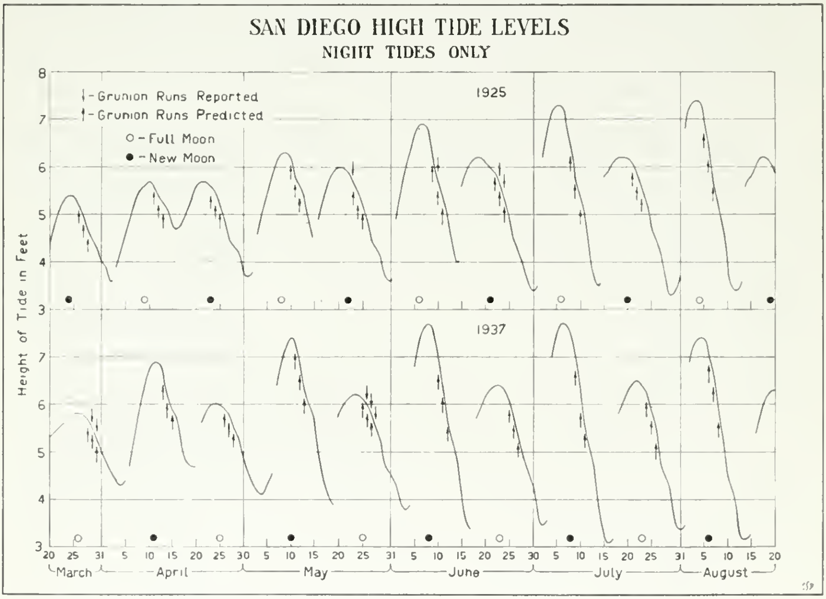

FIG. 15. Highest levels reached by tides each night (6 p.m. to 6 a.m.) at San Diego, California, March–August, 1925 and 1937. The arrows pointing upward indicate nights on which grunion runs were predicted; arrows pointing downward show the nights on which grunion were reported. No attempt was made to follow every run. Tidal data from Pacific Coast Tide Tables, U. S. Coast and Geodetic Survey.

beginning of the grunion run and this method is continued throughout the remainder of the season. The reason for this change is the fact that the grunion tends to require fifteen days to develop a batch of eggs, and as the high-high tides occur at approximately fourteen-day intervals, there is a slight lag between the date of the highest tide and the onset of the spawning run.[5] The arrows pointing downward in figure 3 indicate the dates on which grunion runs were actually observed. No attempt was made to follow every run in either of these seasons.

The hour on which a grunion run will occur on any given night is determined by the simple expedient of assuming that spawning will

[5] Clark, F. N. The conservation of the grunion. California Fish and Game, Vol. 12, pp. 161-166, 1926.

begin about fifteen minutes after high tide. For example, if the tide is high at nine o'clock, grunion should run at about a quarter after nine.

Abundance

In comparison to our important commercial species, the original abundance of grunion along the southern California coast does not appear to have been great. Fortunately these fish have never been subjected to an intensive commercial fishery. On the other hand the number of grunion taken by amateurs is surprising. No one individual takes a vast quantity but the total number of people who go "grunioning" each season produces a heavy amateur catch. This was especially true before a law was enacted which prohibited the taking of these fish in the surf with seines or other contrivances. Now that the fisherman must pick the grunion up on the beach with his hands, the odds for the grunion are much better and the sport of grunion catching greatly enhanced.

By 1926 the grunion population appeared so decimated that a closed season was enacted for the protection of this unique fish. This law prohibits the taking of grunion by either amateur or commercial fishermen during the months of April, May and June of each year. This legal protection plus efforts made to overcome pollution in our southern California waters appear to be bearing fruit. The grunion runs of 1937 were reported as exceptionally good. Because the grunion spawns when only a year old, its population can be restored to a former abundance more quickly than could that of a species first spawning at an older age. If the present promise of population increase is fulfilled and the increase continues, the closed season may be safely shortened to two months, April and May. Because each individual fish spawns more than once, the closed season should always apply to the early part of the spawning season. Thus each fish can spawn unmolested two or three or more times before it has to run the gantlet of the fishermen during its later spawnings.

RED WATER, ITS CAUSE AND OCCURRENCES[1]

By PAUL BONNOT and J. B. PHILLIPS
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California Division of Fish and Game

Everyone who has taken an ocean voyage is familiar with the phenomenon known as "phosphorescence." This is caused by a great variety of organisms—bacteria, plants and animals. Some of these are very minute, most of them even microscopic. When the water is disturbed, these organisms give off tiny flashes of light or they continue to glow for some time. In most cases, especially in temperate waters, the phenomenon is caused by some species of dinoflagellate.

Dinoflagellates are single celled organisms having one anterior whip-like flagellum and a second flagellum encircling the body like a girdle. Most of these organisms are marine and some are luminescent. They range in size from 7/1000 of a millimeter (3/10,000 of an inch) to 2 millimeters (8/100 of an inch) and are either armored or unarmored. The armored type has a definite outer cell-covering of cellulose or a similar substance. Many dinoflagellates exhibit animal-like feeding habits, taking as food small diatoms or even smaller dinoflagellates, while others manufacture their own food, like plants. Some forms have yellow, orange or brown pigments. The cumulative effect of sheer numbers of such organisms gives the water a discolored appearance due to the reflection of light from these minute pigments.

The distribution of dinoflagellates is widespread throughout the sea. They are found at or relatively near the surface. In the temperate zone, they reach the height of abundance when the water is warmest, as during summer or early fall. On the Pacific Coast, five genera of dinoflagellates are usually responsible for red or brown water conditions: *Gonyaulax*, *Gymnodinium*, *Ceratium*, *Cochlodinium* and *Peridinium* (see Fig. 16). In the Atlantic Ocean, *Noctiluca* is commonly associated with a red water condition. *Gonyaulax* has most frequently been associated with red water in California.

Like all organisms in a natural environment, dinoflagellates live in a well-balanced world. Factors which are favorable for their increase, such as increased temperatures and more abundant food, are counteracted by cold, decreased food supply and increases of natural enemies. As soon as the balance is disturbed the organisms either increase in numbers to an enormous extent or decrease to the vanishing point, until conditions become adjusted again. Once in a while favorable conditions along the California Coast lead to a great increase and the result is patches of "red water," which sometimes cover the sea for many square miles.

These organisms are commonly found in our plankton but under normal conditions are no more noticeable than other plankton forms. It is when conditions become favorable that they increase in such tremen-

[1] Submitted for publication, November 15, 1937.

dous numbers as to discolor the water and become what may be termed a plague. When dinoflagellates are so numerous as to give the water a reddish or brownish color, shellfish and fish are sometimes killed along beaches or in coves or bays where such life can not move away from the affected areas. The loss of shellfish and fish is not due to direct poisoning by the dinoflagellates. In the case of shellfish, it appears that death has been due to suffocation. In the case of fish, death may be due to toxic by-products of the decay of countless numbers of dinoflagellates or, more likely, due to the sudden decrease in the oxygen content of a localized water area. In some instances, the washing up onto beaches of countless millions of these dead organisms has produced a terrible stench.

Nightingale (1936) reports a number of cases of red water occurrences in different parts of the world, dating back to 1871. During some of these outbreaks, fish and shellfish were killed. Some of the cases in which this mortality occurred were at Port Jackson, Australia, 1891; Narragansett Bay, Rhode Island, 1900; Southern California,

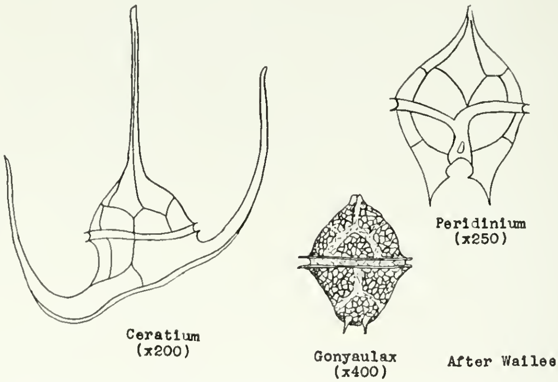

FIG. 16. Three common forms of dinoflagellates.

between Santa Barbara and San Diego, 1902; Southern California, between San Pedro and San Diego, 1907. Gokasho Bay, Japan, center of a pearl oyster industry, has been most consistently hit by the red water plague. In 1893, 1904, 1910, 1926 and 1933, red water plagues in Gokasho Bay resulted in great losses of pearl oysters, and in some instances fish and bottom life. The 1933 plague was the greatest, causing a loss of pearl oysters valued at approximately $7,000,000. In this case, the damage was found to have been caused by masses of dinoflagellates of the genus *Gymnodinium*. The Japanese call the phenomenon "red current." The report of the commercial attache at Tokyo says: "The organism is normally present in Japanese inland waters and has a wide range of distribution, occurring also along the Pacific Coast of the United States. It is a matter of record that its intensive development, causing 'red current,' occurs in Japan at more or less regular intervals of from 8 to 10 years usually remaining about 3 weeks. * * * it is not poisonous, but when occurring in enormous numbers smothers or suffocates the oysters."

Miyake, a Japanese scientist, developed a method of treating sea water with copper sulphate which rapidly destroyed the offending dinoflagellates. The copper sulphate method is also used to destroy growths of algae in municipal water supplies. Nightingale has made an intensive study of red water occurrences in Puget Sound, center of the Pacific Coast oyster industry, but in none of the cases of such occurrence has the mortality of the valuable shellfish resources of that region been nearly as costly as in Japan.

Torrey (1902) reports the occurrence of red water off Tomales Bay in the early 70's and it was also noted for the first time at San Pedro in the same year. Of course, red water is frequently present in small quantities, increasing to a maximum during the warm months; indeed, it may be that there is red water present in quantity every year but when it occurs in relatively small patches it is not reported. The recorded occurrences in California are, besides the two instances mentioned above: 1911, 1917, 1924, 1927 and 1933.

During the last three weeks in August and the first two weeks in September, 1937, the ocean water from Pt. Sur to Pt. Reyes was affected in varying degree with red water. It was not distributed uniformly throughout the above region but appeared in streaks and patches. It was first noted in Monterey Bay about August 11, appearing as a streak paralleling shore. This streak was about 100 yards wide and commenced approximately 200 feet offshore. Later this was scattered over a wider area, apparently by tide and wind. Other streaks and patches appeared farther offshore. Fishermen reported seeing this discolored water as far south as Pt. Sur and as far north as Pt. Reyes. Areas of red water were also reported in the San Pedro region by W. L. Scofield, so it appears that other localities along the Pacific Coast were affected at this time. The presence of red water in the Monterey region during the above period was the most extensive and persistent plague recorded for this area.

The organisms responsible for the red water epidemic in the Monterey-San Francisco region during August and September, 1937, have been identified by H. W. Graham of the Carnegie Institution, Washington, D. C., as of the genus *Gonyaulax*, species *G. catanella* or a very similar form.[2]

In the early part of the season this abnormal water was found inshore, whereas later, before disappearing entirely, it was found at some distance offshore. Captain Walter Engelke of the California Division of Fish and Game boat *Bluefin* reported that on a 300-mile cruise due west of Monterey Bay on August 20-22, red water was noted only inside Monterey Bay. Ten days later, on a 50-mile trip on the same course, no red water was observed in Monterey Bay, but it was noted from just outside the bay to about 35 miles west.

On September 15, 1937, Captain Lars Weseth of the California Division of Fish and Game boat *Albacore* made a cruise southwest of Pt. Reyes in quest of sardines and albacore. He reported that red water was present for eleven miles of this course, and although no schools of sardines were seen while traveling through the discolored area, a few schools were seen just outside of it. Bait men in southern

[2] Discoloration of the water was not due to waste liquors, such as net tanning solution, being released into the bay, as some persons suspected.

California reported that sardines confined in live boxes died when subjected to the red water. However, during the recent epidemic of red water in the Monterey and San Francisco regions, no loss of marine life was noted.

The luminescent property of this form of *Gonyaulax* is attested to by R. L. Bolin of the Hopkins Marine Station, Pacific Grove, who, upon returning to Monterey Harbor from an offshore cruise on the *Bluefin* in the fall of 1937, noted the remarkable luminescence of the propeller wash when the boat passed through an area of red water. Dinoflagellates are responsible for a great deal of the luminescence which is observed in our waters at night. In fact, our sardine industry, which depends almost entirely upon luminescent fishing, would be hampered by the complete disappearance of these organisms from our waters.

Many of the smaller pelagic animals live on such organisms as dinoflagellates and diatoms and it therefore follows that when any one species is very predominant it would furnish the largest proportion of food for the plankton feeders. When *Gonyaulax* is the predominating organism it would constitute the bulk of the food of such animals as sardines, anchovies and mussels. Very few of these animals seem to suffer any inconvenience from the toxin contained in the dinoflagellates and the few found dead are probably individuals that are possibly already in a weakened condition before feeding. If the toxin was universally potent, we would expect to find whole schools of sardines or anchovies dead and all the mussels on the shore adjacent to the larger patches of red water periodically killed. This does not occur. However, it is dangerous for people to eat the internal organs of animals that have fed on *Gonyaulax*. In eating fish, the gut is removed and thus as far as man is concerned, even sardines that have been feeding on *Gonyaulax* are eaten with no ill effects. In the case of mussels, however, the condition is different. Mussels are eaten just as they come from the shell, gut and all. Cooking does not affect the potency of the toxin and if enough of it is ingested it will kill even human beings. In 1927 in California over 100 people became sick after eating mussels and six of them died. Red water was reported from several places along the coast in immediate proximity to the "poison mussel areas" just previous to this epidemic. The Indians of the California Coast recognized the connection between red water and toxic mussels, and when the red water appeared and the breakers along the beaches were highly luminescent at night, the mussels were taboo until some time after the phenomenon had passed. The coast Indians set guards at various places along the shore to warn off any inland people who might attempt to gather mussels during this time.

The Hooper Foundation for Medical Research at the University of California has been working on the problem of mussel poisoning since the outbreak of 1927, which was fatal in several cases. Their findings include the clinical history of the victims and the chemical researches in relation to the cases. The chemical work did not lead them very far. The toxin was found to be very elusive and even in the cases of the people who died of eating mussels, it left no trace that could be detected in the stomach or intestine. In connection with this problem, W. Forest Whedon of the Hooper Foundation instituted a series of studies on the relative abundance of the various species of dinoflagellates in relation to mass abundance. His researches show that the genus *Gonyaulax* gradually assumes the dominant position of abundance among the various types of organisms which constitute the red water and that four days after this particular organism comes to its peak of abundance the fish and mussels in the immediate vicinity show a high degree of toxicity. This is not conclusive proof, but as it has happened for three consecutive years, it can hardly be considered a coincidence. In view of these findings, despite the fact that they can not as yet be considered final, it would be an unwise proceeding to eat mussels during the time that red water is in evidence.

Since the outbreak of 1927 the California State Board of Health has quarantined mussels during the summer months, allowing none to be sold and posting warnings against their use by tourists and picnickers. During 1933 red water was generally noticeable for the first time since 1927. It was first reported from Santa Cruz on August 3. At San Francisco about September 5 the fishermen were reporting dead fish offshore in patches of "dirty brown stinking water," and from Fort Bragg to Crescent City between September 12 and 19 the same condition was observed. On September 25 a local newspaper reported the death of a boy in Oregon "from eating mussels." This northward movement may be in direct relation to the temperature which would rise slightly during the summer months, the rise occurring later to the northward. For several weeks after the occurrence of the red water on the northern coast, the trawlers working out of Eureka continually scraped up from the bottom of the ocean a layer of loosely packed, vile smelling effluvia, presumably the bodies of the millions of dead microorganisms.

Although increased water temperatures have been closely associated with outbreaks of red water in temperature zones, there are undoubtedly other less evident factors which may be equally important.

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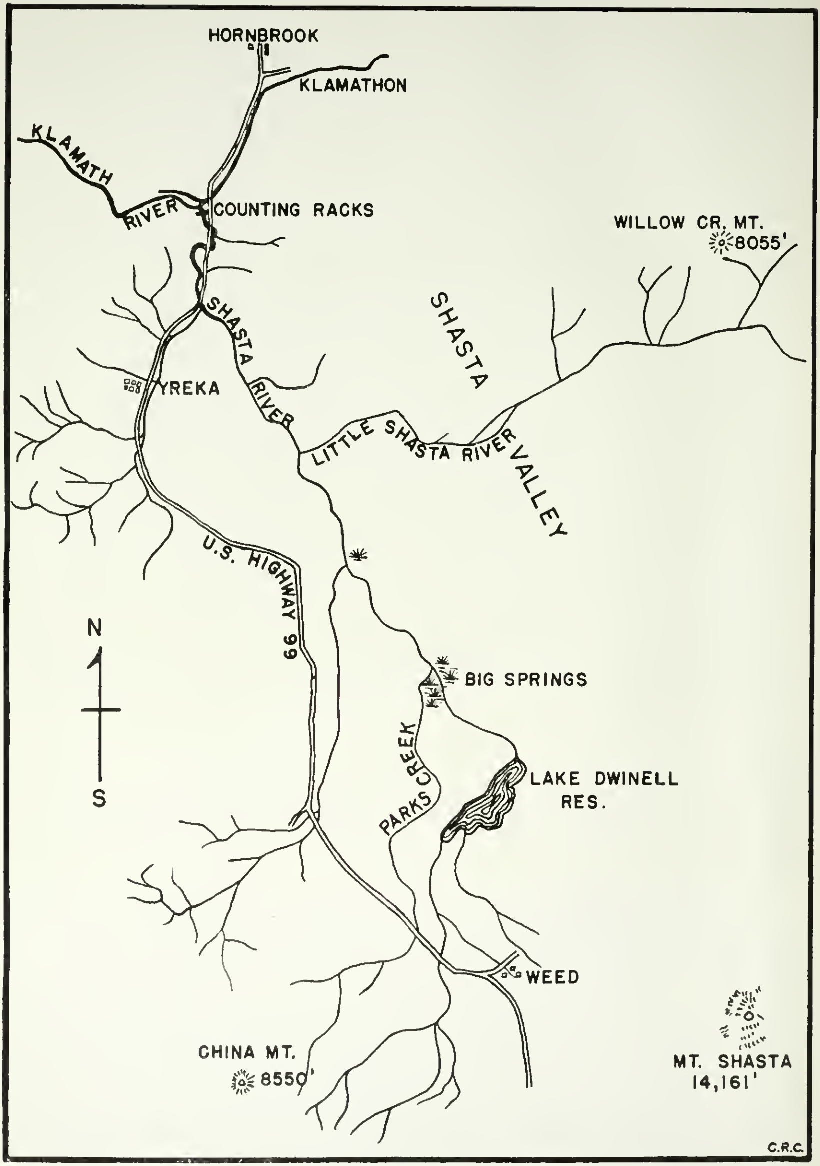

FIG. 17. Map of the Shasta River and tributaries.

THE SALMON MIGRATION IN THE SHASTA RIVER (1930-1934)[1]

By MERRILL W. BROWN
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California Division of Fish and Game

This report is a preliminary account of the general salmon investigation being conducted on the Shasta River by the California Division of Fish and Game and under the direct supervision of the Bureau of Fish Conservation.

As part of the general investigation the Division has conducted an annual census of the spawning migration of king salmon, *Oncorhynchus tschawytscha*, in the Shasta River, and this paper is a summary of the data collected during the fall months of 1930 to 1934, inclusive.

FIG. 18. The Shasta River in the Upper Shasta Valley.

The Shasta River, a tributary of the Klamath drainage system, was chosen as a site suitable to carry on these investigations regarding the king salmon for the following reasons:

1. It is a river of suitable size for investigation and control.

2. It is a representative river of the Klamath system in that the usual obstacles, such as irrigation dams, ditches, etc., are found along its course.

3. It is a natural spawning stream of the king salmon, and even now the salmon spawn there in considerable numbers.

[1] Submitted for publication, November 19, 1937.

4. No artificial propagation of salmon has been conducted in the Shasta River.

5. The stream is accessible along its entire course.

The Shasta River (fig. 17) originates from Lake Dwinell Reservoir and from several large springs located in the upper Shasta Valley, just north of Mt. Shasta. Thence it meanders in a generally northwesterly direction the length of the Shasta Valley until it drops suddenly into

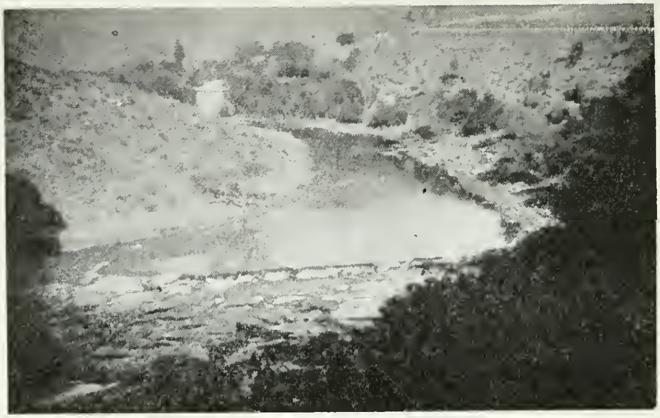

FIG. 19. Large spawning area found in the Shasta Canyon.

the Shasta Canyon, five miles north of the town of Yreka. In the valley the stream, for the most part, is sluggish and for long stretches the bottom is covered with silt and mud. Suitable areas for spawning are found only in the vicinity of Big Springs and in the tributaries known as the Little Shasta River and Parks Creek. In the canyon, however, a considerably different situation is found. Here, the stream is a typical and ideal spawning area in that it possesses gravelly riffles and bars with intermittent waterfalls and deep pools.

As mentioned before, one feature of the salmon investigation is an accurate census of the salmon entering the Shasta River from the Klamath on their spawning migration. For this reason, all fish were allowed to proceed upstream as they entered the mouth of the Shasta.

In order to secure this accurate census of the spawning migrants a counting rack (fig. 20), similar to those used by the United States Bureau of Fisheries, was constructed across the Shasta, just above its confluence with the Klamath.

The construction of this counting rack, as now in use on the Shasta is as follows: A strongly constructed weir is built across the stream. Built into this weir are two sliding gates which can be raised or lowered to any desired position. Before each gate is placed a broad strip of white canvas or white painted galvanized sheeting. These white aprons are so placed that migrating fish must swim over them, and as they do this the observer can easily distinguish and count the different species as they pass upstream.

By the use of this counting rack an accurate enumeration of migrating fish is made possible. The relative number of grilse or small males, the time and other particulars of the migration are also determined.

During the seasons under discussion (1930–1934), the salmon commenced their migration from the Klamath and up the Shasta, as a rule, during the first two weeks of September. Frequently they appeared considerably in advance of the arrival of fish at the Klamath Egg Taking Station, located but a few miles up the Klamath from the junction of the Shasta River. As the season advances, the run increases in a series of higher mounting successive waves until the peak is reached, generally between the second and third weeks of October, after which the run decreases rapidly until the end is reached during the latter part of November.

It was interesting to note that most of the fish migrated during the afternoon. But few fish were counted through the gates in the morning, and at night the migration was always at a standstill.

However, it was noticeable that a rise in the stream level, with resultant muddy water, invariably resulted in a sudden rush of salmon into the Shasta from the Klamath, where the fish had been loafing in a large pool just below the confluence of the two rivers.

The magnitude of the spawning migrations or escapements for the years 1930 through 1934 are shown, by weekly totals, in table 1. Upon examination of this table and also of figure 21, it can be seen that the run of 1930 was small, totaling 19,362 fish of which 12,082 or 63.5 per cent were grilse. In contrast to 1930, the migration of 1931 was large, totaling 81,848 kings, 20,037 or 24.48 per cent being young males. The

FIG. 20. Shasta counting rack.

outstanding feature of the 1932 escapement, which totaled 35,592, was the fact that only 5058 or 14.21 per cent of the salmon were grilse. In 1933 the count was noticeably small. Only 11,586 fish went upstream. However, 6886 or 59.43 per cent of the upstream migrants were young males. The census of 1934 showed that 48,421 immigrants traveled up the Shasta, 21,807 or 45.05 per cent of which were the precocious males.

TABLE 1

Weekly Escapements of King Salmon up the Shasta River, 1930-1934

Date	1930			1931			1932		
	Adults	Grilse	Total	Adults	Grilse	Total	Adults	Grilse	Total
August 30				7		7	3		3
September 6				12	1	13	20		20
September 13	3	11	14	37	33	70	23		23
September 20	54	204	258	4,306	1,697	6,003	1,512	189	1,701
September 27	102	363	465	9,503	3,170	12,673	6,104	869	6,973
October 4	431	1,586	2,107	16,480	4,817	21,297	2,956	1,021	3,977
October 11	2,052	2,474	4,526	22,160	7,800	29,960	12,661	2,133	14,794
October 18	2,262	3,315	5,577	5,652	1,881	7,533	4,608	542	5,150
October 25	2,082	3,760	5,842	2,436	473	2,909	2,027	250	2,277
November 1	234	240	474	808	128	936	557	45	602
November 8	43	68	111	391	37	428	54	9	63
November 15	14	32	46	19		19	3		3
November 22	2	8	10				6		6
November 29	1	4	5						
December 6		16	16						
December 13		1	1						
Totals	7,280	12,082	19,362	61,811	20,037	81,848	30,534	5,058	35.592

Date	1933			1934			Average		
	Adults	Grilse	Total	Adults	Grilse	Total	Adults	Grilse	Total
August 30							2.0		2.0
September 6				2		2	6.8	0.2	7.0
September 13				5	1	6	13.6	9.0	22.6
September 20	11	10	21	126	73	199	1,201.	434.	1,636.
September 27	1,443	2,554	3,997	6,024	3,578	9,602	4,635.	2,106.	6,742.
October 4	1,593	2,835	4,428	5,846	4,057	9,903	5,461.	2,863.	8,324.
October 11	987	1,080	2,067	8,904	6,630	15,534	9,352.	4,023.	13,376.
October 18	526	352	878	4,127	5,042	9,169	3,435.	2,226.	5,661.
October 25	113	53	166	1,319	2,178	3,497	1,595.	1,342.	2,938.
November 1	27	2	29	235	229	464	372.	128.	501.
November 8				14	19	33	100.	26.6	123.
November 15				1		1	7.4	4.4	11.8
November 22				3		3	2.2	1.6	3.8
November 29				8		8	1.8	0.8	2.6
December 6								3.2	3.2
December 13								0.2	0.2
Totals	4,700	6,886	11,586	26,614	21,807	48,421	26,187.	13,174.	39,361.

Until additional data, now on hand, have been correlated and future counts of the migration are obtained, I do not deem it wise or possible to draw any conclusions from the results of the salmon census as shown in this report. There is an indication, however, that knowing

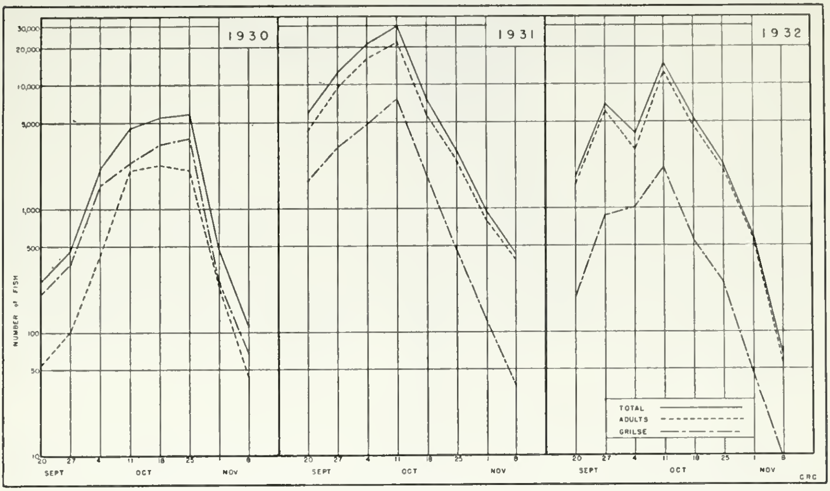

FIG. 21. Weekly escapements of king salmon up the Shasta River, 1930–1932.

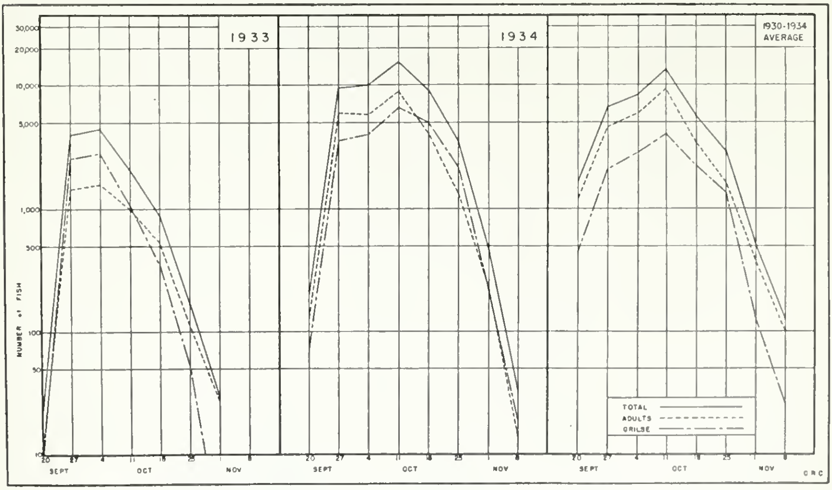

FIG. 22. Weekly escapements of king salmon up the Shasta River, 1933 and 1934, and average for 1930–1934.

the grilse count for any given season, we possibly could predict the size of future migrations. But until more figures are assembled it is not possible to draw definite conclusions. Further summaries will be presented from time to time in *California Fish and Game*.

BATHYLAGUS WESETHI, A NEW ARGENTINID FISH FROM CALIFORNIA[1]

By Rolf L. Bolin
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During the night of May 5, 1937, while engaged in collecting lantern fishes aboard the California Division of Fish and Game boat *Albacore*, I secured three specimens of an undescribed species of *Bathylagus.* I take great pleasure in naming this new fish for Captain Lars Weseth of the *Albacore* in slight appreciation of the helpfulness and cooperation which he unfailingly extends to scientists working on board his vessel.

Bathylagus wesethi, new species

Body slender; deepest at about vertical of pectoral base; tapering evenly from this point to caudal peduncle except for very slight expansions under the median fins. Dorsal profile of head very gently curved, almost flat above the eyes; anterior part of snout steep, forming an angle of 143° (136°-152°) with frontoparietal region; bluntly pointed from dorsal view. Interorbital space, measured to edge of the thin lamellar expansions of frontals, about as wide as diameter of orbit; channeled by a broad, shallow, longitudinal groove. Eye moderate in size; upper edge of orbit entering into dorsal profile of head; pupil oval, markedly elongated anteriorly. Mouth small, terminal, oblique, most of its gape anterior; maxillary short and broad, failing to reach vertical of anterior orbital border by a space about equal to anterior width of iris, its upper edge covered by preorbital. Nostrils double, the anterior larger and more median, borne on a lateral dermal elevation evident only from dorsal view. A close set, regular series of 20 or 21 lanceolate teeth, truncated at the base, extending along each dentary; 9 similar teeth forming a curved transverse series across front of vomer, the outer ones and the one on each side of the median tooth slightly enlarged; no teeth on premaxillaries or palatines. Upper end of gill opening on a level about 1.5 times as far removed from ventral margin of body as from dorsal margin; edge of gill cover formed by a thin transparent membrane, difficult to distinguish; its upper part extending downward and backward in a gentle concave curve which merges into a bluntly convex curve posteriorly. Gill membranes united at a distance in front of pectoral base about equal to or slightly greater than long diameter of pupil; free from isthmus; supported by 2 branchiostegals. Gills 4; pseudobranchiae well developed; gill rakers long and slender, 8+1+16 on first arch.

Fin formula: D. 13 (12-13); A. 15 (14-16); P. 10 (10-11); V. 10 (9-11). Dorsal origin slightly behind, sometimes almost directly on a

[1] Submitted for publication November 15, 1937.

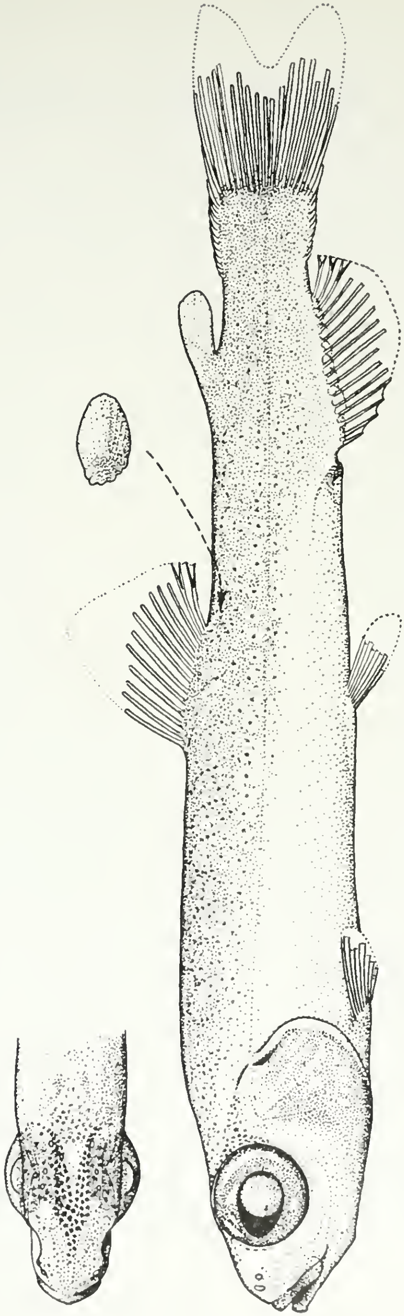

FIG. 23. *Bathylagus wesethi*, new species.

vertical midway between tip of snout and caudal base; length of dorsal base equal to or slightly greater than depth of body at anal origin. Adipose fin rather far posterior, the end of its base over 10th, 11th, or 12th anal ray. Anal origin on a vertical about midway between ventral base and caudal base; anal base equal to depth of body somewhere under dorsal fin. Dorsal and ventral rays of caudal numerous, the ventral rays extending forward to within 0.5 peduncular depth of end of anal base, dorsal rays extending very slightly farther anteriorly. Anterior end of pectoral base under or very slightly in advance of posterior edge of opercular margin, fin placed low near ventral body margin. Ventral base under 5th or 6th dorsal ray. Counting the urostyle as one, a paratype has 46 vertebrae.

MEASUREMENTS IN PER CENT OF STANDARD LENGTH

Length of head	28.0	(26.2-30.0)
Diameter of orbit	9.6	(9.0-10.1)
Length of snout	6.9	(6.8- 7.0)
Interorbital space	9.8	(8.4-10.4)
Depth at pectoral base	16.2	(15.3-16.9)
Depth at ventral base	13.5	(12.3-14.9)
Depth at anal origin	11.0	(10.4-11.6)
Depth of caudal peduncle	7.2	(6.8- 7.6)
Snout to dorsal origin	53.8	(51.0-56.0)
Length of dorsal base	11.5	(11.0-12.3)
Snout to end of adipose base	87.1	(85.6-88.8)
Snout to anal origin	79.9	(77.8-82.2)
Length of anal base	12.3	(11.7-13.0)
Snout to pectoral base	29.0	(27.0-31.1)
Snout to ventral base	57.2	(54.3-61.2)

Scales large, one from the dorsal region just behind the dorsal fin is .75 diameter of orbit. Most of the scales are lost on the three available specimens but, estimating from distinguishable scale pockets, they number between 25 and 30 in a longitudinal series.

Color in alcohol: upper surfaces of body dark brown, fading out ventrally at the lateral line anteriorly but extending well below it on the posterior part of the body. Cheeks and ventral abdominal region silvery; opercles and gill membranes metallic lead color. Lips blackish. Peritoneum and lining of mouth and gill cavities jet black.

Holotype: a specimen 45.5 mm. in standard length from off the mouth of Monterey Bay, Lat. 36° 40′ 30″ N., Long. 122° 06′ 00″ W., taken at night between the surface and 50 fathoms. Paratypes: two specimens from the same plankton haul, 36.6 and 35.7 mm. in standard length, the latter specimen now in fragments due to a rather unsuccessful attempt to clear in potassium hydroxide and to subsequent partial dissection. The type material has been deposited in the Natural History Museum of Stanford University.

This species appears to be most closely related to *Bathylagus nigrigenys* Parr and *B. argyrogaster* Norman, but differs from both in its more slender form and fewer scales.

EDITORIALS AND NOTES

VOLUME 24 JANUARY, 1938 Number 1

TAG RECOVERIES FROM THE FIRST THOUSAND SARDINES

When the California State Fisheries Laboratory initiated its program of marking sardines by the use of an internal tag, the staff decided to try out the plan on a small scale to see how much harm would be inflicted upon the fish by inserting a serially numbered magnetic metal strip, and to determine whether or not it would be possible for a sardine so marked to wander up and down the eastern edge of the Pacific Ocean and ever find his way back to one of our canneries after mingling with millions of his schoolmates. Some of us even had mental reservations as to the ability of an electro-magnet to pick such a small bit of nickeled steel out of the flood of fish meal in a reduction plant conveyor. Believing the supply of sardines in the ocean to be huge, we supposed it would be necessary to mark at least several hundred fish if we expected to recover one or two tags on any one of the few magnets then installed. It was therefore decided to try marking one thousand fish before the close of the 1935–36 sardine fishing season.

The first sardines were tagged on March 9, 1936, at Santa Monica Bay in southern California. Eight hundred and eighty-one marked fish were liberated on that day, and later, on April 29, 83 fish were marked, making a total of 964 fish in this trial sardine tagging. We hoped, rather than expected, to recover one or two of these tags, and the more optimistic among us thought that we might be lucky enough to get back as high as three or four from this original 964.

It is not our purpose here to record the results from this original marking, as they are fully reported elsewhere nor can we adequately describe the excitement when the first tag was picked up by one of the magnets in the late spring of 1936. The fishing season soon closed but we held high hopes that the 1936–37 season would yield three or four more tags. The expected three or four tags arrived, closely followed by others throughout the whole season and even a few during the following autumn of 1937, so that by the end of November, 1937, a total of 67 tags had been recovered from the original 964, or a return of practically 7 per cent. Tags were recovered over a wide time interval at San Francisco, Monterey and San Pedro. Occasionally a recovery was made at San Francisco and only a few days later another would be returned at San Pedro. We have given up speculating on how many more of these tags will be recovered and how long it will be before the last comes wandering in.

Certainly these initial tagging results have caused some of us to scale down our ideas about the vast numbers of fish in the sea and to recognize that the fishery for sardines is far more intensive than was formerly supposed. Also, the scattered returns indicate that these sardines have not remained in one compact school for long periods but suggest rather that the tagged fish have joined different schools. Another unforeseen consequence of this trial marking has been that some of us have gone so far as to estimate the ocean population on the basis of this return of 7 per cent. If 7 per cent of the tagged fish were caught, then the total commercial catch of sardines over a like period represents 7 per cent of the sardines in the sea, within a smiliar range of fish sizes. The theory is sound but the practice is as yet wild speculation because of the small number of fish tagged and returned and because so many unknown quantities are involved, such as estimates of the number of tags that passed over magnets without being caught, the number that passed through plants without magnets, the possible abnormal death rate resulting from the surgical operation of tagging, not to mention the error in reducing weights to numbers of fish of various sizes. In spite of these recognized errors the method may give some rough estimate of the population remaining in the ocean and future estimates should come closer to the truth as the approximate magnitude of some of the error is determined.

These questions of intensity of the fishery, schooling habits of the fish and estimates of the size of the ocean population are really by-products of the experiments in sardine tagging, which were originally undertaken for the purpose of giving us additional information on the migrations of these fish along the coast. As recoveries are made from subsequent taggings, the results will be tabulated in such a way as to demonstrate all that they reveal as to migrations. In the meantime we keep a weather eye open for another lagging pioneer from the initial 964 marked in the spring of 1936, although we realize that some of the returns from later markings may in the long run prove to be far more significant.—*W. L. Scofield, California State Fisheries Laboratory, November, 1937.*

NORTHERN RECOVERY OF CALIFORNIA SARDINE TAGS

The sardine tagging program carried on by the various fisheries agencies along the Pacific Coast continues to yield interesting results.

During the summer and early fall of 1937, 30 California sardine tags were recovered in regions to the north of California. Of these, British Columbia cannery and reduction plants accounted for 21 tags, Washington plants 5 tags, and Oregon plants 4 tags. All of the fish bearing these marks were released off southern California during January, February and March, 1937.

Of the tags recovered in British Columbia, one was out only 103 days; the longest period was 208 days. The average for all California tags recovered in British Columbia was 169 days.

Since most British Columbia catches were made off the coast of Washington, these fish traveled a minimum of 1000 nautical miles, or an average of about six miles per day. The fish bearing these tags may have lingered off our southern coast before starting north, and they may have been in northern waters at least a short time before being caught. Hence the above estimate of their rate of travel is quite conservative.

There is a striking absence in the northern recoveries of tags put out off California before January, 1937. This may be accounted for in two ways. In the first place, practically all sardines tagged off southern California before that time were small fish. Returns are therefore in accord with the theory that small sardines make shorter migrations than large ones. Excellent recoveries were made from these fish in California. Secondly, recoveries from fish tagged off central California in 1936 have been disappointing. Early tagging methods tried in this area proved to be harder on the fish than those used in the south, apparently resulting in an extremely high mortality (see *California Fish and Game*, vol. 23, no. 3, pp. 190–204).

It is a pleasure to acknowledge the cooperation extended to the State Fisheries Laboratory of the California Division of Fish and Game by reduction plant operators and fisheries authorities in British Columbia, Washington and Oregon who have diligently watched for our tags and turned them back to us.—*John F. Janssen, Jr., California State Fisheries Laboratory, November 23, 1937.*

SMALL SARDINES TAKEN OFF OREGON

The California State Fisheries Laboratory has at hand an unusual group of baby sardines collected off the Oregon coast in a unique way. The fish were included in a sample of feed taken from albacore stomachs by Captain Conrad Svenson of the *Enterprise*. The albacore were caught between 30 and 35 miles off the mouth of the Columbia River on September 23 and 24, 1937. Mr. J. F. Funsten of the Pacific Marine Products, Astoria, Oregon, forwarded this sample to California.

The sardines or pilchards, *Sardinops caerulea*, twenty in number, varied from 34 to 53 mm. standard length, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches, total length. It is rare indeed to have a definite record of sardines as small as these taken from waters as far north as Oregon. This collection adds further evidence to that already at hand indicating that sardines do spawn in these northern waters, in some seasons at least, and that such spawning may take place well off shore. In addition, the small size of these fish caught late in September, suggests that spawning in these more northern waters occurs later than off the California coast where the peak of spawning takes place in April and May, or that the northern sardines experience a slower rate of growth. The smallest sardine ever recorded from California waters in September was 58 mm., standard length, and the average size for September fish of the 0-group is about 85 mm.

Sardines may spawn off the Oregon coast every season, or only in seasons when the waters are exceptionally warm. The answer to this question will have to await the time when someone can attempt to collect eggs and larvae in these waters over a period of years. Likewise the problem of the magnitude of these spawnings can only be solved by such consistent research.—*Frances N. Clark, California State Fisheries Laboratory, November 19, 1937.*

FISH BULLETIN NO. 50 ON SARDINE SIZES

A further contribution to the study of the California sardine is Fish Bulletin No. 50, by J. B. Phillips, which was issued recently by the California State Fisheries Laboratory of the Bureau of Marine Fisheries. It deals with the "Sizes of California sardines caught in the different areas of the Monterey and San Pedro regions." The results are obtained from an analysis of extensive data on the sizes of sardines appearing in the cannery catch over a period of seven fishing seasons from the summer of 1929 through the spring of 1936. The results are of importance to the industry in demonstrating the average size of sardines to be expected in each local area each month of the fishing season. Also, this study furnishes additional evidence indicating a southward movement of sardines along the California coast during the winter months.

In the Monterey fall fishery, the smaller sardines occur in Monterey Bay with larger sizes to the north and the largest off San Francisco, whereas in the San Pedro fall fishery there is little size difference in the various local areas. In all areas of both regions the average size of fish increases during the winter fishery due to incoming larger "winter" fish from the north. This increase is evident first in the north and appears progressively southward with a time interval of one to two months between San Francisco and San Pedro. When the large winter fish reach San Pedro there seems to be a general dispersion throughout the local areas, as these adults have arrived in the region where they will spawn the following spring.

An earlier Fish Bulletin, No. 43, describes the sizes of sardines caught in different localities, but gives special attention to the kind of gear used and reaches the conclusion that no gear (purse seine, ring net or lampara) shows any greater tendency toward size selection than does any other of the three nets. Fish Bulletin No. 47 describes the changes in sardine sizes within a season and from one season to another without contrasting small local areas, but rather from the standpoint of the proportion of sizes in the catch due to the presence or absence of dominant age classes. Fish Bulletin No. 48, "Fishing localities for the California sardine," is concerned with volume rather than sizes of fish, and has special reference to distances from shore and ocean depths at the various fishing grounds. These four bulletins, Nos. 43, 47, 48 and 50, give a comprehensive survey of fishing localities and the significance of the sizes of sardines in the catch along the California coast.—*W. L. Scofield, California State Fisheries Laboratory, November, 1937.*

CHARLES M. BOUTON

In the death of Charles M. Bouton, the Division of Fish and Game has lost one of its most beloved employees.

Mr. Bouton was born in Oakland on March 11, 1878. He went to work for the Fish and Game Commission on January 1, 1916, spending practically all of the time since then on the bay and river patrol in the vicinity of San Francisco. He was a most efficient launch operator, keeping his vessel in good running order at all times, despite the make-shift type of machinery with which some of the boats in his charge were equipped, particularly the *Quinnat II.* His last command was the fine new speed boat *Quinnat III.*

Charlie was an ardent fisherman, spending most of his days off in angling. His favorite sport was trout fishing on the Pit River, near Big Bend where he spent many of his vacations. I do not think anybody ever found Charlie in an unfriendly mood. He was so good natured that law violators almost seemed to enjoy being arrested by him. He was always a most pleasant person, even during the last few months of his illness. He went on sick leave January 21, 1937, and died in the United States Marine Hospital in San Francisco on July 11, 1937.

C. M. BOUTON

The Division of Fish and Games wishes to take this opportunity to express its sympathies to Mrs. Bouton.—*E. L. Macaulay, California Division of Fish and Game.*

McPHERSON LOUGH

Warden McPherson Lough died suddenly on November 9, 1937, at Palo Alto from a heart attack.

He entered the service on September 1, 1918, with headquarters at Eureka, where he was stationed for approximately ten years. He was later transferred to Palo Alto where his patrol district included the northern portion of Santa Clara County and the southern part of San Mateo County.

For the nearly twenty years that he was with us, Warden Lough was a steady, conscientious worker, respected and well liked in the community in which he worked. He leaves a widow, to whom we wish to express our sympathy.—*E. L. Macaulay, California Division of Fish and Game.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1937, to September 30, 1937, of the Eighty-ninth Fiscal Year

Revenue for Fish and Game Preservation Fund:		
Current Year:		
License Sales:		
Angling licenses, 1937	$222,151 55	
Commercial hunting club licenses, 1937-1938	100 00	
Commercial hunting club operators licenses, 1937-1938	5 00	
Deer tags, 1937	41,797 00	
Fish breeders' licenses, 1937	30 00	
Fish importers' licenses, 1937	20 00	
Fish packers and wholesale shellfish dealers' licenses	865 00	
Fishing party vessel permits, 1937	125 00	
Game breeders' licenses, 1937	65 00	
Hunting licenses, 1936-1937	18,903 50	
Hunting licenses, 1937-1938	124,419 00	
Kelp licenses, 1937	10 00	
Market fishermen's licenses, 1937-1938	27,150 00	
Trapping licenses, 1937-1938	79 00	
Total license sales		$435,720 00
Other income:		
Court fines	$13,880 04	
Fish packers' tax	22,783 47	
Fish tag sales	1,072 24	
Game tag sales	55 77	
Interest on bank balances	712 73	
Kelp tax	30 22	
Lease of kelp beds	331 86	
Miscellaneous sales	530 83	
Salmon tax, Chap. 1015-35	16,071 73	
Total other income		$55,468 89
Grand total current year		$491,188 94

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to September 30, 1937, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Operating Expenditures—89th Fiscal Year:					
Administration:					
Executive	$1,249 98				$1,249 98
General office	1,410 00	$234 77	$257 62	$42 65	1,945 04
Printing, general		29 15			29 15
Automobiles		—83	255 95		255 12
Traveling			690 09		690 09
Postage			1,219 01		1,219 01
Telephone and telegraph			756 53		756 53
Freight, cartage, express			235 08		235 08
Rent			2,413 70		2,413 70
Accident and death claims			300 04		300 04
Department administration pro rata	2,500 00				2,500 00
Librarian	450 00	1 71	34 24	38 20	524 15
Legal			1,627 20		1,627 20
Publicity			552 34		552 34
State fair			1,200 00		1,200 00
Sales tax on sales			—8 09		—8 09
Temporary help	300 00				300 00
Total Administration	$5,909 98	$264 80	$9,533 71	$80 85	$15,789 34
Patrol and Law Enforcement:					
Executive	$3,555 00				$3,555 00
General office	1,200 00	$1 92	$3 28	$4 70	1,209 90
Automobiles		5,659 86	3,953 08	6,221 86	15,834 80
Traveling			14,178 82		14,178 82
Postage			195 84		195 84
Telephone and telegraph			994 13		994 13
Freight, cartage, express			1 87		1 87
Rent			160 00		160 00
Heat, light, water and power			1 50		1 50
Captains and wardens	51,732 60	51 63	1,098 81	267 00	53,150 04
Launches	3,347 59	2,806 36	3,273 45	165 17	9,592 57
Premiums on bonds			42 50		42 50
Temporary help	344 28				344 28
Assistant fish and game wardens, seasonal	5,775 26				5,775 26
Printing		194 60			194 60
Total Patrol and Law Enforcement	$65,954 73	$8,714 37	$23,903 28	$6,658 73	$105,231 11
Marine Fisheries:					
Executive	$2,610 00				$2,610 00
General office	2,043 00	$17 87	$12 44		2,073 31
Printing		86 71			86 71
Automobiles		119 22	23 03		142 25
Travel			1,883 70		1,883 70
Telephone and telegraph			140 09		140 09
Freight, cartage and express			20 45		20 45
Rent			30 00		30 00
Heat, light, power and water			84 34		84 34
Research (oyster)	570 00	19 60			589 60
Laboratory	8,214 52	687 28	44 28	56 43	9,002 51
Fish tags		177 98			177 98
Statistics		21 63	584 67		606 30
Temporary help	300 00				300 00
Terminal Island grounds	300 00	2 55	1 60		304 15
Fish cannery auditing			795 00		795 00
Total Marine Fisheries	$14,037 52	$1,132 84	$3,619 60	$56 43	$18,846 39

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to September 30, 1937, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Bureau of Fish Conservation:					
Executive	$1,590 00		$19 52		$1,609 52
General office	1,197 41	$7 79	2 15		1,207 35
Automobiles		4,144 25	1,256 33	$9,980 33	15,380 91
Traveling			6,311 99		6,311 99
Postage			66 10		66 10
Telephone and telegraph			319 64		319 64
Freight, cartage and express			102 74		102 74
Rent			195 00		195 00
Heat, light, water and power			657 58		657 58
Research		17 51	5 19	36 22	58 92
Fish planting		133 63			133 63
Hatcheries	28,002 48	22,248 49	1,345 66	497 56	52,094 19
Fish cars	450 00				450 00
Cooperative research	942 00	53 63	24 04	33 41	1,053 08
Statistical	570 00		286 50		856 50
Temporary help	24 00				24 00
Special field	3,350 00			5 72	3,355 72
Fish rescue	480 00				480 00
Assistant fish and game wardens, seasonal	13,229 71				13,229 71
Total Bureau of Fish Conservation	$49,835 60	$26,605 30	$10,592 44	$10,553 24	$97,586 58
Bureau of Hydraulics:					
Executive	$2,130 00				$2,130 00
General office	480 00	$44 12		$147 31	671 43
Automobiles		35 72	$20 45	667 67	723 84
Traveling			640 68		640 68
Telephone and telegraph			1 15		1 15
Blue printing			28 70		28 70
Photography		3 09	2 66		5 75
Fish screens		31 83		1 64	33 47
Tools				52 44	52 44
Total Bureau of Hydraulics	$2,610 00	$114 76	$693 64	$869 06	$4,287 46
Bureau of Game Conservation:					
Executive	$5,407 49				$5,407 49
General office	1,215 00	$35 98	$9 27	$103 06	1,363 31
Automobiles		1,363 74	330 77	632 78	2,327 29
Traveling			1,944 88		1,944 88
Telephone and telegraph			88 31		88 31
Freight, cartage and express			12 77		12 77
Heat, light, water and power			1,422 60		1,422 60
Maintenance of game farms	3,608 30	4,515 95	86 33	346 43	8,557 01
Predatory animal control	1,116 90		936 60	18 44	2,071 94
Statistics	272 74	39 45	275 80		587 99
Maintenance of game refuges	600 00	345 94	94 87	119 11	1,159 92
Temporary help	10,161 13				10,161 13
Total Bureau of Game Conservation	$22,381 56	$6,301 06	$5,202 20	$1,219 82	$35,104 64
Bureau of Licenses:					
General office	$3,796 34	$4 12	$89 08	$4 44	$3,893 98
Printing		71 38			71 38
Traveling			61 78		61 78
Postage			1,125 75		1,125 75
Premium on bonds			2,277 50		2,277 50
License identification buttons		3,204 86			3,204 86
License commissions			13,340 58		13,340 58
Total Bureau of Licenses	$3,796 34	$3,280 36	$16,894 69	$4 44	$23,975 83
Total 89th fiscal year, expense paid from support appropriations					$300,821 35

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to September 30, 1937, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Expenditures for additions and betterments:					
Permanent improvements:					
Purchase of game refuges and public shooting grounds, and C.I.E., Chap. 157-37	$36 00	$241 36	$1,199 27	$17 07	$1,493 70
Contributions to Employees' Retirement System					5,283 88
Total current biennium					$307,598 93
Prior biennium appropriations, eighty-ninth fiscal year and eighty-eighth fiscal year:					
Special Item—Construction of Russian River jetties, Chap. 989-33, 88th fiscal year					$365 84
Special Item—Expenses of California Code Commission, Chap. 645-33, 89th fiscal year					37
Total 89th fiscal year and 88th fiscal year					$366 21
Support:					
88th fiscal year				$51,503 58	
87th fiscal year				3 12	
Total Support					$51,506 70
Special Item—Predatory animal control, 88th fiscal year					3,426 15
Expenditures for additions and betterments—Permanent improvements, purchase of game refuges and public shooting grounds, and C.I.E., 88th fiscal year					18,138 07
Total expenditures for additions and betterments—permanent improvements, purchase of game refuges and public shooting grounds, and C.I.E.					
Total prior biennium appropriations					$73,437 13
Grand total					$381,036 06

SEIZURES OF FISH AND GAME

July, August, September, 1937

GAME:	
Antelope	1
Bear	1
Beaver pelts	2
Deer	34
Deer meat, pounds	520½
Doves	866
Ducks	5
Grouse	1
Nongame birds	14
Pheasant	37
Quail	21
Rabbits	49
Spotted fawn	5
Trap	1
Tree squirrels	2
Woodpeckers	2

FISH:	
Abalone	88
Barracuda, pounds	3,672
Bass, black	168
Bass, striped	122
Bluefin tuna, tons	3
Catfish, pounds	40
Clams	3,052
Crabs	165
Frogs	141
Grunion, pounds	10
Lobsters	113
Perch	30
Salmon	5
Trout	247
Trout fillets	27
Trout spawn	2 rolls
Yellowfin tuna, pounds	356

GAME CASES

July, August, September, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Bear; closed season	1	$25 00	
Beaver pelts; possession	1	150 00	
Deer; closed area, season; killing, possession doe, fawn, spotted fawn, spike buck; failure to fill out, attach, validate deer tag; failure to retain hide and horns; mutilating tags; dogs running deer; possession another's tags; selling venison	153	5,644 00	544
Doves; closed season; overlimit	69	1,947 50	
Ducks; closed season	5	150 00	25
Firearms in refuge	22	620 00	
Hunting; at night; in refuge; no license; using another's license; failure to show license on demand	111	2,171 00	80½
Illegal shooting	37	535 00	
Mammals; illegal taking, possession of	6	125 00	
Nongame birds; killing, possession of	3	100 00	
Pheasant; closed season	22	1,105 00	
Protected birds; possession of	6	240 00	
Quail; closed season; trapping	12	375 00	
Rabbits; closed season	14	330 00	
Spotlight hunting	16	325 00	145
Trapping; no license	17	83 00	
Trespassing	3	5 00	
Totals	498	$13,930 50	794½

FISH CASES

July, August, September, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone; overlimit; undersize	21	$365 00	
Barracuda; overlimit; undersize	2	25 00	
Bass, black; overlimit; undersize	9	70 00	
Bass, striped; overlimit; undersize	29	475 00	
Clams; overlimit; undersize	38	590 00	22½
Commercial fishing; failure to register boats; no license	63	630 00	12½
Crabs; closed season; mutilating; undersize	6	85 00	15
Fishing; at night; closed area; failure to show license on demand; making false statement to procure license; too near dam, ladder; using another's license; using prohibited gear	187	4,065 00	36
Frogs; overlimit	1	25 00	
Grunion; closed season	3	15 00	
Lobster; closed season; undersize	8	390 00	4
Pollution	14	1,475 00	
Salmon; killing with rocks	1	10 00	
Trout; overlimit; snagging; using fresh spawn; taking with explosives	13	680 00	
Totals	395	$8,900 00	90

FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES FOR JULY, AUGUST AND SEPTEMBER, 1937

Compiled by Division of Fish and Game, Bureau of Commercial Fisheries

Species	Landed in Region 70, Los Angeles	Landed in Region 80, San Diego	Total pounds
Barracuda	90	168,244	168,334
Cabrilla	9,290	6,045	15,335
Grouper		948	948
Halibut, California	13,000	147,119	160,119
Mackerel, Pacific		14,226	14,226
Mackerel, Spanish	264	486	750
Perch		37	37
Rock Bass		11,080	11,080
Rockfish		21,182	21,182
Sea-bass, Black	273,544	82,122	355,666
Sea-bass, White		154,595	154,595
Shark		1,488	1,488
Sheepshead		191	191
Smelt		41	41
Swordfish, Broadbill		28,433	28,433
Tuna, Albacore	953,300		953,300
Tuna, Bluefin	595,868	445,074	1,040,942
Tuna, Bonito	661,440	308,659	970,099
Tuna, Oriental	280,354		280,354
Tuna, Skipjack	9,494,690	16,410,236	25,904,926
Tuna, Yellowfin	8,606,625	21,265,259	29,871,884
Whitefish		563	563
Yellowtail	208,579	2,231,774	2,440,353
Miscellaneous Fish	650		650
Total pounds	21,097,694	41,297,802	62,395,496

*These importations are included in the tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

FRESH FISH IMPORTATIONS BY POINTS OF ORIGIN* FOR JULY, AUGUST AND SEPTEMBER, 1937

Compiled by Division of Fish and Game, Bureau of Marine Fisheries

Species	Gulf of California	West Coast Lower California	International waters south U. S. boundary (definite origin unknown)	Mexican mainland, Central and South America	Japan	Total pounds
Barracuda		168,244	90			168,334
Cabrilla		6,045	9,290			15,335
Grouper		948				948
Halibut, California		147,119	13,000			160,119
Mackerel, Pacific		14,226				14,226
Mackerel, Spanish		486	264			750
Perch		37				37
Rock Bass		11,080				11,080
Rockfish		21,182				21,182
Sea-bass, Black		82,122	273,544			355,666
Sea-bass, White		154,595				154,595
Shark		1,488				1,488
Sheepshead		191				191
Smelt		41				41
Swordfish, Broadbill		28,433				28,433
Tuna, Albacore					953,300	953,300
Tuna, Bluefin		585,889	455,053			1,040,942
Tuna, Bonito		616,899	353,200			970,099
Tuna, Oriental					280,354	280,354
Tuna, Skipjack	847,404	14,410,156	8,202,990	131,481	2,312,895	25,904,926
Tuna, Yellowfin	441,948	10,265,559	13,012,425	5,354,835	797,117	29,871,884
Whitefish		563				563
Yellowtail	670	2,344,869	94,814			2,410,353
Miscellaneous Fish			650			650
Total pounds	1,290,022	28,860,172	22,415,320	5,486,316	4,343,666	62,395,496

*These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

CALIFORNIA FRESH FISH LANDINGS* FOR JULY, AUGUST AND SEPTEMBER, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Region 10, Del Norte	Region 20, Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds
Anchovy				28,100	840		1,389		30,329
Barracuda						53,090	428,040	369,442	850,572
Cabezone				850	2,993	70			3,913
Cabrilla							9,290	6,045	15,335
Carp			1,012						1,012
Catfish			60,690						60,690
Cultus, Pacific	1,715	58,788		267,917	18,546	46	122		347,134
Dolphin							1,524	469	1,993
Eel				36	15				51
Flounder, Starry				511,682	222				511,904
Flying Fish							27,934		27,934
Grouper								948	948
Hake				22,191	40				22,231
Halibut, California				611	1,754	86,431	47,866	149,409	286,071
Halibut, Northern	361	104,719		37,545					142,625
Hardhead			920						920
Herring, Pacific					220				220
Kingfish				2,372	10,723		107,499	371	120,965
Mackerel, Horse					17,622		1,947,715		1,965,337
Mackerel, Pacific				3,801	1,176,622	9,235	28,743,323	457,396	30,390,377
Mackerel, Spanish							264	486	750
Mullet								685	685
Perch		30		8,410	6,230	1,942	28,998	2,105	47,715
Pompano, California							2,300	17	2,317
Rock Bass						3,866	39,147	84,550	127,563
Rockfish	3,494	32,532		305,674	464,021	67,038	34,237	50,508	957,504
Sablefish		181,190		47,412	259	10	2,681	154	231,706
Salmon	633,370	2,407,858	800,969	638,918	97,862				4,578,977
Sand Dab				122,656	5,881		1,579		130,116
Sardine			12,232,900	38,865,856	30,854,100	316	11,682	773	81,965,627
Sculpin							42,772	279	43,051
Sea-bass, Black					23	1,960	275,722	83,614	361,319
Sea-bass, Short-fin								249	249
Sea-bass, White				11,418	19,749	17,838	22,320	182,998	254,323
Sea-trout, California					37				37
Shark		565	1,717	21,915	8,523	25,040	53,129	27,129	138,018
Sheepshead						884	4,272	271	5,427
Skate				66,030	665	7,872	1,348		75,915
Smelt		4,176		80,926	42,701	3,137	57,744	41	188,725

Sole		163		2,332,995	18,750	72,312	1,372	12	2,425,604
Split-tail			628						628
Swordfish, Broadbill						91,079	195,792	145,854	432,725
Swordfish, Marlin						157	3,402		3,559
Tuna, Albacore					462,083	83	2,156,856	73,750	2,692,772
Tuna, Bluefin					10	8,024	3,566,710	1,110,606	4,685,350
Tuna, Bonito					20	16,070	2,270,285	1,115,139	3,401,514
Tuna, Oriental							280,354		280,354
Tuna, Skipjack							9,990,380	17,637,793	27,628,173
Tuna, Yellowfin							8,754,846	21,297,498	30,052,344
Turbot				14,172			17		14,189
Whitebait	250	10,893		983	175				12,301
Whitefish						871	766	677	2,314
Yellowtail							237,798	2,292,108	2,529,906
Miscellaneous fish		5,254		33,926	130	424	1,608		41,342
Crustacean:									
Crab	5,714	67,974		48,336	6				122,030
Crab, Rock				142					142
Prawn					157				157
Shrimp				479,693					479,693
Mollusk:									
Abalone					639,750	507,167	100		1,147,017
Clam, Cockle				242			5,874		6,116
Clam, Gaper		432		1,262					1,694
Clam, Pismo					352	68,915			69,267
Clam, Soft-shell				24,425					24,425
Clam, Washington		2,179		958					3,137
Octopus		68		517	3,981				4,566
Oyster, Eastern				77,744					77,744
Oyster, Japanese				112,041					112,041
Oyster, Native				5,536					5,536
Scallop				100					100
Squid				175	101,635		90		101,900
Total pounds	644,904	2,876,821	13,098,836	44,177,567	33,956,697	1,043,877	59,359,147	45,091,376	200,249,225

*Importations of fresh fish from foreign countries included. See foreign importation tables.

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TABLE OF CONTENTS

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TROUT FISHING IN SOUTHERN CALIFORNIA STREAMS—INSTRUCTIONS FOR THE BEGINNER [1]

By DONALD H. FRY, JR.
California State Fisheries Laboratory
Division of Fish and Game

INTRODUCTION

There are many people in southern California who would like to go trout fishing but who know absolutely nothing about the subject. Many such show up at the stream side with surf tackle, black bass outfits, or other equipment totally unsuited to the work at hand. The only thing they ever catch is a case of poison oak. Others throw themselves on the mercy of a tackle salesman and reach the stream with gear which is suited to the work at hand but with absolutely no ideas on how to use it. Such people often fish industriously for hours without getting a nibble or seeing a fish, and finally convince themselves that there are no trout in the stream. Three of the most pathetically bewildered beings I have ever seen were in that frame of mind when a big kid strolled around the bend and went past them on the far bank of the creek, pausing every few steps to extract another trout. He caught eight almost under their noses and strolled on, around the next bend. Such experiences are apt to be heartbreaking and make the beginner give up in despair. The affair savors of black magic; the expert produces trout from an empty stream like a conjuror taking rabbits out of a hat, and the beginner has no trace of an idea how he should act in order to do likewise. What he should do is to make friends with some really good trout fisherman who will take him out, show him what to do, what not to do, and explain the why of each. A rank beginner whose every move is being coached by a real expert will often get more and bigger fish out of a stream than a fairly good fisherman who is on his own. What is even more important, a beginner under proper guidance will soon learn enough to give him a good start so that he can keep on learning—and learning fast—when he is alone.

Many beginners have no expert friends, and this article is an attempt to do for them with words and pictures what a teacher would do for them with words, demonstration and pointing.

This article will confine itself primarily to bait fishing because in southern California a beginner will do far better to confine himself to bait until he has at least learned the rudiments. There are a few times, particularly during extreme low water, when flies may produce better results, but at such times flies must be handled very expertly. The beginner who starts by using bait will learn a lot about streams and trout and will probably pick up some knowledge of fly fishing by watching others. Then he can graduate into fly fishing if he desires.

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[1] Submitted for publication, February, 1938. All photographs by the author.
The author wishes to express his appreciation to Mr. Lawrence Spooner of the New York Hardware Trading Company, Inc., Los Angeles, who read the manuscript and offered valuable suggestions.

Many experts will have methods which they prefer to the ones given here. The methods given do not pretend to be the ultimate, but they work excellently in southern California and will do reasonably good work in similar streams almost anywhere.

Obviously, in a paper of this size, it is impossible to do much more than cover the rudiments for a fairly limited set of conditions. Any one who wishes to make a real study of trout fishing can find many good books on the subject. One excellent book which goes into nearly all phases and yet is easy reading for a beginner is "Just Fishing," by Ray Bergman (Penn Publishing Co., Philadelphia, 1932).

TROUT TACKLE

The tackle required for fishing a trout stream is essentially very different from that used for trolling, bait casting or ocean fishing. The beginner who uses a surf rod, for example, is so handicapping himself that he is doomed to certain disappointment. He would be far better off using a flexible piece of willow.

When a beginner buys his outfit he should by all means go to a store which has a really large assortment of tackle. Such places have salesmen who know tackle from A to Z and many of whom are really expert in its use. Buy your tackle some time when there is no crowd in the store (**not** the day before the season opens). Ask for a salesman who knows trout fishing and tell him you are a beginner. Most real tackle salesman are the sort who will regard that as a compliment and will gladly spend an hour or so giving excellent help and advice on tackle, how to use it, where to go, and how to get there. Occasionally you will get a salesman whose only interest (if he has **any** interest) is in selling you something. When this happens go to another store.

The cost of trout tackle can be fitted to almost any purse. You can spend over $60 for the rod alone, or you can get an entire outfit for $5. An excellent outfit for a beginner can be purchased for $20-$25.

License

Properly speaking, this isn't fishing tackle but don't forget to buy one if you are over eighteen years of age. The cost is $2 for citizens who are residents of California, $3 for nonresident citizens and $5 for aliens. The license entitles you to fish in fresh or salt water any place in the State that has not been specifically closed; it is good until December 31 of whatever year purchased.

Rod

The rod is the most important piece of equipment and is the one on which the least skimping should be done.

The only really suitable type of rod for trout fishing in small streams is a single-handed fly rod. Such a rod is long, slender, and has the reel mounted below the handle.

The best rod material is split bamboo. In the standard type of construction, six triangular strips of bamboo are glued together with the enamel or skin side out and are thus made into a rod of hexagonal cross section.

Besides split bamboo there are rods made of steel and various solid woods. For trout fishing these materials are decidedly second choice except for one special set of circumstances. When fishing a very brushy stream, a telescoping steel rod is nice. It is heavy and its action is terrible but you can shorten it down to a three-foot length, bull your way through a thicket and lengthen it out again to fish the next pool. Incidentally, such rods are very cheap.

The cost of a fly rod may be anything from $2 to $60 or even more, and the great worry of most of us is how much to pay. A really high class instrument will cost $30 or more, will last a life time, and will be much nicer to use than a cheaper rod. However, a beginner will not be able to pick one he would like to use the rest of his life, and until he gets used to carrying a rod over rough country, there is always a chance he may break it. For a beginner to whom $30 is a lot of money, the logical thing would be to get a cheaper rod and learn how with it. There are good rods to be had for as little as $6 or $8, but there is also a lot of junk for sale in that price range, so be careful when you make your selection.

A good rod to use for stream fishing is one which is from eight to nine feet long and which has a fairly stiff (dry fly) action. Such a rod will probably weigh from four to seven ounces. Longer rods are not so satisfactory for small or brushy streams, and those which are shorter than eight feet are usually either stubby affairs or very light fairy wands. The stubby type is fairly satisfactory for small streams, but not for much else, and the very light rods (1 to 3½ ounces) are suitable only for use by an expert and only for fly casting.

The rod should be husky enough to lift ashore fish up to eight or nine inches long. Theoretically no fly rod should be subjected to this strain, but most southern California streams are of a waterfall and pothole type, and if you are standing near the head of a pool when you hook a fish you will often scare everything else in the pool while doing some wild scrambling to get to a place where you can beach or net your catch. So get a rod heavy enough to stand lifting them out, because you will be doing it anyhow.

Rods are made in various degrees of stiffness and that stiffness is by no means entirely dependent on weight. Get one which has the proper "action" and don't worry too much about how much it weighs. Rods in the eight- to nine-foot class can be purchased with wet fly or dry fly action and some nine-foot ones are designed for bass flies. The typical wet fly rod is too limber for dry fly, bait or spinner use, whereas bass fly rods are too stiff for best use on small streams. The dry fly rod is the best all around instrument for trout fishing and a well made nine-footer will do good work on bass or steelhead as well.

When you select your rod ask to see and feel the action of some of the really fine ones—they will give you an idea of what to look for in whatever price range you decide to patronize. To select a rod, put it together and point it horizontally. Does it bend slightly in an even graceful curve? If not, don't get it regardless of price. Revolve it slowly. Does it keep the same curve or does it bend more in some positions? The guides may stiffen one side very slightly, but if there is any other unevenness, don't buy it. Tie a light weight (an ounce or so) to the tip so as to bend it more and repeat the above tests. Point the rod where there is no danger of hitting anything with it and snap your wrist a trifle to bend the rod. Does it ooze back into position or does it come back with a snap you can feel? A rod which oozes back is too flexible for general use. Stiffness, or backbone, is hard for a beginner to gauge properly—you will have to rely on another person to some extent. Does the rod feel right? (You can tell this better if you put a reel on it.) Look at the ferrules (joints). Do they slide into each other firmly but smoothly? Do they come out with a decided "plop"? Are they well fitted to the wood? The better rods have ferrules which are split at the ends and these splits are lashed down with silk windings. This lets the end of the ferrule spring slightly with the wood and greatly reduces the chances of a rod breaking at the joint. You will probably get a rod which is in three sections. Be sure there is a spare tip. The reel seat may be of wood or metal and the clamping band may screw or slide into place. Try a reel on it and see if it holds the reel firmly. Line guides should be large, so the line will pass through them easily. The first guide (nearest the handle) should be a ring of steel or agate. The rest should be light steel. If the tip guide should be of agate, be sure it is well guarded with metal—an exposed agate is sure to get chipped, and a chipped agate will ruin a line in short order.

Line

When using a fly rod on a lake or large stream it is important to have a line which properly matches the rod. On small streams you can get by with a mismatched outfit—but why try to?

When casting any distance with fly, bait or small spinner, it is the weight of the line which carries the leader and lure. The line must be heavy enough to do this, and must be heavy enough to bring out the action of the rod. When using a well-balanced outfit, the rod throws the line much as a bow shoots an arrow. At the start of the forward cast, the inertia of the line bends the rod backward, then the wood snaps straight and flips the line forward with far more speed than you could possibly get with wrist action alone. Too light a line will not bring out this action and one that is too heavy is simply too much of a load for the rod.

To pick a line of exactly the right weight is a job for an expert, but a beginner can come fairly close by using the following table:

Rod	*Level Lines (Untapered)*	*Tapered Lines*
8–8½ feet flexible (wet fly)	G or F	H F H
8–8½ feet stiff (dry fly); 9–9½ feet flexible (wet fly)	F	H E H
9–9½ feet stiff (dry fly)	E	H D H
9–10 feet very stiff (bass and steelhead rods)	D	H C H

Most manufacturers use the letter system to denote fly line sizes, and although the sizes of various manufacturers do not always correspond, they are usually close enough to the general average. Tapered lines are small at both ends and large in the middle. An HEH line, for example, is size H at each end and size E in the center.

The amount of line you will need is very little. Fly lines are usually sold in coils of 25 yards, 30 yards, or 100 feet. One coil of 25 yards is all you will need.

Fly lines are made in three finishes: oiled silk, hard enamel and soft enamel. The soft finish lines are often known as "oil impregnated lines" but must not be confused with oiled silk.

Oiled silk has nothing to recommend it except price. You can get one for 25 cents, but don't.

Hard enameled lines are made of silk with a hard smooth enamel on the surface. Sooner or later this enamel begins to crack and peel off, but a good line may last several seasons. The price varies with size as well as qualtiy. The lightest you should ever try to cast with (size G) will probably cost from $0.50 to $1.25 for a 25-yard coil. Heavier lines cost a bit more—in size D the price range is roughly from $1 to $2.

Soft enameled (oil impregnated) lines are the most expensive, but if you are lucky you may get one which will last a life time. They are made with a soft smooth finish which penetrates clear through the silk, so there is nothing to crack or peel, but there is one disadvantage which the hard finish does not have. Some soft finished lines will get sticky in spite of anything you can do and such a line is an abomination. Never buy one which shows the faintest trace of this ailment—it will always get worse, never better. A soft finished level line of the highest quality will cost from $1.75 to $3.50.

Recently some manufacturers have made cheap soft finished lines to sell at about the price of hard enameled ones. The finish is soft, but as you can easily tell by a close examination it is more of a surface finish than that found on the highest grade products. When compared with hard finished lines, these new products show less tendency to crack and peel, but some of them turn sticky. On the whole they seem to be a slight improvement on the hard enameled lines.

Tapered lines have some advantages over level ones, but for a beginner who intends to do most of his fishing in small streams they hardly seem worth the added cost. The ends of tapered lines are fine, so they can be cast more delicately and the extra weight in the center makes it possible to do extremely long distance casting with them. With moderately light rods, such as are used in small streams, the line which matches the rod is not heavy enough so that there is any real need for a tapered end, and there is almost never any occasion to do any long range work.

If you do decide to get a tapered line get a good one, with the best type of soft enameled finish. It will cost from $5 to $10 or even more. **Don't** get a cut-rate product. You would be far better off with a good level line costing half as much.

To test a line before buying it: loop the end and pinch the loop. Don't buy it if the enamel cracks or discolors or the line shows a tendency to bend more readily in that place. Take a few turns off the coil of line and throw the length out straight onto the counter. A high priced line should lie flat in whatever position it hits and not try to re-form the loops. Less expensive lines should not be expected to lie perfectly flat and straight, but don't buy one which acts like a watch spring.

Reel

Trout reels are used primarily to hold line and to balance the rod. They do not need to be expensive, and there are many nice ones on the market for as little as \$2. You can get a beauty for \$3.50 to \$5, and even for the heaviest steelhead and bass fishing there is absolutely no need to spend over \$8. The reel should be a single action one, and the handle knob should be on the side of the line drum itself. The line is less apt to catch on a reel of this design than on any other. Narrow reels of large diameter are the easiest to use. With this shape, the operator can reel in rapidly and he does not have to pay any great attention to make sure the line spools evenly on the drum. Be sure the reel is large enough to take the size of line you are planning to put on it and have room to spare. A tightly filled reel is an abomination.

To make casting easier and thus save wear and tear on the wrist it is important to have a reel which balances the rod. To do this, it should weigh in the neighborhood of $1\frac{1}{2}$ times as much as the rod. When put together, the outfit should balance at the upper end of the cork grip or within six inches above that. Hang your coil of line on the reel handle while checking the balance; then remove the coil and see if the outfit **feels** right. Some experts claim the above method is false and deceiving—but the beginner need not worry about being too badly deceived by it.

It is easy to get a trout reel which will balance a $7\frac{1}{2}$-$8\frac{1}{2}$ foot rod, but most reels (especially the lower priced ones) are too light for a longer rod. This difficulty can usually be overcome by the judicious use of a little lead. If the reel arbor (hub) is small and solid you can wind a narrow strip of sheet lead around it. If it is large and hollow, fill it with shot and use a piece of adhesive tape to keep the shot in place.

There are two ways of mounting the reel on a fly rod. The more common one requires that the reel be mounted right handed for use by a right handed person. The reel is placed so that the handle is on the **right** side when the reel is hanging under the rod. When the outfit is assembled this way the rod is held in the right hand for casting and is switched to the left hand when reeling in.

The other system seems far more satisfactory to the writer. It requires that the reel be mounted left handed for a right handed person. The handle is on the left, the rod is always held in the right hand and the reel is operated by the left hand. There is no switching of the rod from one hand to the other just as the action starts.

The clicks on most cheap reels are so designed that they offer about equal resistance to reeling in or paying out. Such reels can be mounted either right or left handed. On some medium priced and expensive instruments, the click lets the line come in much more easily than it goes out. On some models this can be easily reversed for left handed mounting. You may like a reel on which the click can not be reversed, or one which has a line guide. If so, be sure you know whether you want a left or a right handed reel.

A trout reel is mounted below the rod handle where it can't readily be thumbed and thus kept from over-running. For this reason most such reels are made with a click which is on at all times. If you can turn your click off don't do so while fishing—it is courting disaster.

Enameled line should not be wound in a very tight coil, hence if the reel has a very small arbor it should be partly filled with some old line. Cotton or linen will do. **When you wind the line off the coil turn that coil as though it were a spool mounted on an axle**—this method takes longer, but it doesn't twist the line.

If you plan to hold the rod in your right hand and reel in with your left put the line on by turning the reel counter clockwise.

Leaders

A leader, as used in trout fishing, is a length of some inconspicuous substance which is placed between the line and the hook in the fond hope that the trout will not notice it.

Most beginners on southern California trout streams use leaders which are too short and far too heavy. All too often a 3-foot leader of 10-15 pounds breaking strain is used where a 6-foot one of less than two pounds test would be necessary to get results.

Trout leaders are made of silkworm gut or of imitation gut. Each has its advantages and disadvantages.

Imitation gut can be obtained in any desired length. It is very cheap, and can often be purchased in 5- to 40-yard coils for as little as a cent per yard. It is a little stronger than the natural gut. When wet, it is too sloppy to cast nicely. In quality, it varies from excellent to worthless and it is hard to know which you are getting. Try soaking a piece in water overnight and test it the next morning. If it is still strong you won't need to worry. Another disadvantage of imitation gut is that when wet it is so slippery that special knots have to be used in tying it. **Remember that.** The size of imitation gut is usually given as so many pounds breaking strain—a very convenient method. In appearance, imitation gut is translucent and silky.

Natural gut has a clear glassy luster. If you examine it closely you can be sure of getting good quality. The gut itself comes only in short lengths (up to 18 inches). The tackle maker knots these sections together to make a leader. A 6-foot, high quality, natural gut leader will probably cost you 50 or 60 cents. Such a leader is nicer to cast than one of imitation gut, as even when wet it has a faint springiness which tends to keep it from landing in a mass. Its superiority in this respect is important only in fly fishing.

The sizes of natural gut are usually listed by name instead of by breaking strain. Regular, fina, and refina, testing respectively about 5, 3 and 2 pounds are the only ones that need interest a beginning trout fisherman. Drawn gut (passed through a die and drawn to a finer size) is listed differently. Size 2x tests about $2\frac{1}{2}$ pounds, 3x tests about $1\frac{3}{4}$ pounds, and 4x (not recommended for beginners) tests about $1\frac{1}{4}$ pounds. All of these breaking strains are only approximate—different manufacturers do not agree closely.

Tapered leaders are made by carefully graduating the thickness of the pieces of gut knotted together. Such leaders have two advantages: They are easier to cast with and the inevitable snag usually takes only the last section. Short lengths of gut (called tippets or leader points) can be carried for repair purposes.

A good leader for most southern California use is a 6-foot one, either of natural gut tapered to refina (2 pounds), 2x ($2\frac{1}{2}$ pounds) or 3x ($1\frac{3}{4}$ pounds), or else of imitation gut, untapered, and testing 2 to 5 pounds.

In general the longer your leader the better your chances, but for bait fishing in southern California streams there is seldom any need for a leader longer than six feet and if you are fishing a very brushy creek you may find that even six feet is more than you can handle, thanks to low overhanging limbs. In such streams a 3-foot leader is usually long enough to fool some fish and short enough to enable you to reach under the limbs. If there are just a few bad brushy spots you can manage by reeling part of a long leader through the upper guides of your rod, but before you do this remember that the leader is apt to catch and refuse to pay out again until you coax it out by hand.

The color, if any, of a leader is not important so long as it is not conspicuous.

All leaders must be soaked in water before use. A new one may require a full half hour's soaking, but after being used it will soften up in a few minutes. You can soak your leader in a dish of water or by placing it between two moist pads.

Natural silkworm gut comes from Spain. There is already a serious shortage, thanks to the Spanish civil war. By the opening of next season (May 1, 1938) most of us may be using imitation gut regardless of our choice in the matter. The imitation gut, by the way, all comes from Japan.

Flies

A beginner who is teaching himself will do well to learn how with bait, but a few artificial flies are always handy. The following patterns should be enough: Royal Coachman, McGinty, Gray Hackle, Black Gnat, Mosquito, and one or two designs of nymphs or creepers. Size 12 is best, or sizes 10, 12 and 14 if you want an assortment. By all means get eyed flies, *i.e.*, ones on which there is a metal loop on the hook itself to which the leader can be tied direct. Snelled flies (the other alternative) have a short length of gut, to which the leader is fastened. Usually this snell is too heavy for best results, and in addition it usually deteriorates and breaks off long before the fly is past using.

Spinners

A spinner is a blade of metal, shaped much like the bowl of a teaspoon. When dragged through the water it spins like a small propeller. In fairly large pools, or in lakes, it is often very successful. For stream use get one with a blade about a half-inch long. Silver, copper, brass and hammered bronze are all excellent. In southern California streams, spinners are usually a last resort rather than a first choice, but by all means have two or three with you. The "Colorado" type is probably the best.

A combination that works well at times is a spinner to which a gaudy fly has been fastened.

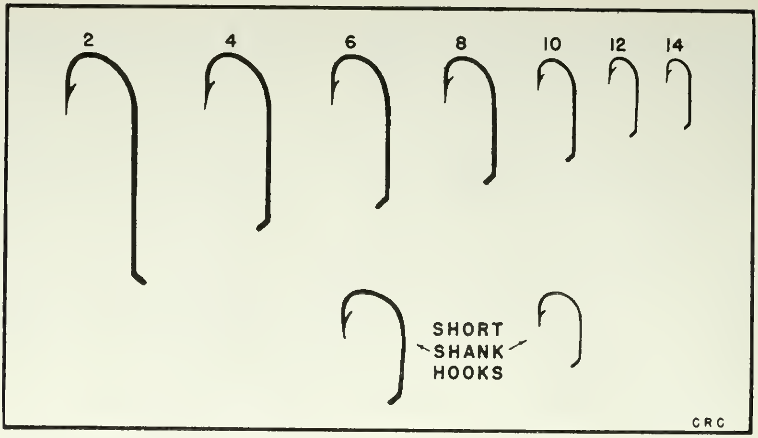

Fig. 24. Hooks, shown actual size. The longer shanked hooks shown here are a good shape for most bait fishing. The No. 2 has an up-turned eye, the rest have down-turned eyes. The two short-shanked hooks are shapes preferred by some for live bait fishing. The smaller short-shanked hook is an excellent size and shape for salmon egg fishing. Different makers' hook sizes do not agree perfectly. For example, some firms label as No. 14 a hook which is as large as another maker's No. 12.

Hooks

Hooks, like flies, can be purchased either eyed or snelled. If the attached snell (piece of leader) is long and fine the combination may be satisfactory, but in general, eyed hooks are better. Either up-turned or down-turned eyes are satisfactory, but ringed hooks (with a large eye not turned either up or down) are not. The writer prefers upturned eyes. Good hooks cost about 25 cents a dozen. Don't get the 15 cent a hundred kind; they are not at all satisfactory in the sizes used for trout fishing. Figure 24 tells more about the best shape than words could.

The sizes which are most useful are No. 14, 10 and 8. Two No. 14 hooks (one on the end of the leader and one an inch above it) make an excellent rig on which to drape a worm. Another good worm rig is a No. 8 or 10 with a No. 14 above it. (See Fig. 27.) A No. 10 by itself is excellent for either worms, salmon eggs or grubs. For salmon eggs a short shank hook is best. A few larger hooks, such as sizes 6, 4 and 2, are handy if the stream contains large trout and the fisherman has ideas involving the use of less conventional baits such as minnows, frogs or water beetle larvae.

Sinkers

In general the less lead you can get along with the better, but there are many times when it is needed. Split BB shots are the usual form in which it is sold to trout fishermen but thin sheet lead is far better. Cut the sheet into strips weighing as much as seems necessary and fold or twist them around the leader a foot or two above the hook. The equivalent of one or two BB shot is usually enough.

Landing Net

This piece of equipment is omitted by about 99 per cent of southern California fishermen. The writer is in the other one per cent, but does not insist that the net is absolutely necessary. Southern California fish run small and if you do get a big one you can usually beach it. If you are laying for a big one, you had better take a net along.

Fishing Basket or Creel

Fish do not keep well in a sack or on a string. Get a creel. You can get one that will do for less than a dollar or a really nice one for \$2.50. A strap (if you want one) will cost \$0.35 to \$1.50 more, but some fishermen prefer to carry the creel in one hand and set it down when going into action.

Tackle Box

Get a tackle box small enough to carry in your creel or pocket. Aside from that, let your conscience be your guide. A few aspirin boxes kept in a small jar will do nicely.

Leader Box

By all means have a box or pouch in which to keep spare leaders and leader tips. Moist felt pads will keep the leaders wet enough for immediate use. The box should be of some nonrusting material, since rust ruins leaders. Price, from 25 cents up.

Clothes

A trout fisherman who starts up stream at daylight has two alternatives. He may dress warmly—and have that extra sweater on his hands for three-fourths of the day, or he may shiver for the first hour or two. The choice is yours.

Suit yourself in the matter of dress—but wear something that won't be too conspicuous against a neutral colored background of leaves, dirt and rocks. **Don't** wear white.

Don't wear shoes that water will damage. Tennis shoes are excellent if you don't mind wet feet, but ones which have smooth soles or crepe soles will slip on wet rocks. Waterproof hiking boots are excellent. You probably won't need to go in far enough to run water over the top of a 14- or 16-inch boot. Rubber boots are out—you have to walk too far.

And don't forget to carry a knife.

Care of Tackle

Rod

Don't leave your rod standing outside overnight in the dampness.

Dry the rod before you put it away.

Don't seal the rod in an air-tight case if it or its cloth bag is the least bit damp.

If the rod develops a "set" (bend) put it together and hang it up by its tip and leave it till the next time you want it.

Keep your rod well varnished—once a season is usually plenty. Repair any defective silk windings before varnishing. Any good tackle salesman will sell you varnish and silk, and tell you how to use them.

Don't store a wooden rod near a steam pipe, register or stove. The heat will ruin it.

Line

Don't leave the line on your reel between trips. Coil it up in a moderately loose coil and leave it in a cool dry place.

Reel

Clean and oil your reel once in a while.

Keep it out of the sand while fishing.

Leaders

Don't store leaders with hooks on them. The hooks may rust and ruin the leaders.

Don't get oil on your leaders.

Throw away any leaders (or parts thereof) that are frayed and fuzzy, or cracked.

Leaders which are new or in good condition at the end of one season, will be in perfectly good condition the next season. That statement will be regarded as rank heresy by tackle dealers but it is true.

Flies

Keep flies where moths can't find them.

Dry them out so rust won't spoil them.

Steam will fluff out matted flies.

Hooks

Make sure the points are needle sharp before you start fishing. A hook hone or a small sharpening stone will enable you to put a good point on a hook in a few seconds.

A little care will prevent rust from starting in a box of hooks. Dry hooks off before putting them away, and keep used ones separated from new ones.

Knots

Special knots are needed for tying leader material. (See Figs. 25, 26 and 27.) It is very slippery and with some knots it has a tendency to cut itself. Imitation gut is the worst; it is so slippery that a square knot or a sheet bend, for example, will not hold it at all. Hence, the need for some special knots that **will** hold.

Both natural and imitation gut must be thoroughly soaked before any knots are tied in them.

Pull all knots tight before using them. Pulling on the ends that are to take the strain usually tightens a knot tied in natural gut, but imitation gut often slips instead of tightening, even when it is pulled up moderately tight to start with, so pull firmly on **all** the ends and make sure the knot **is** tight.

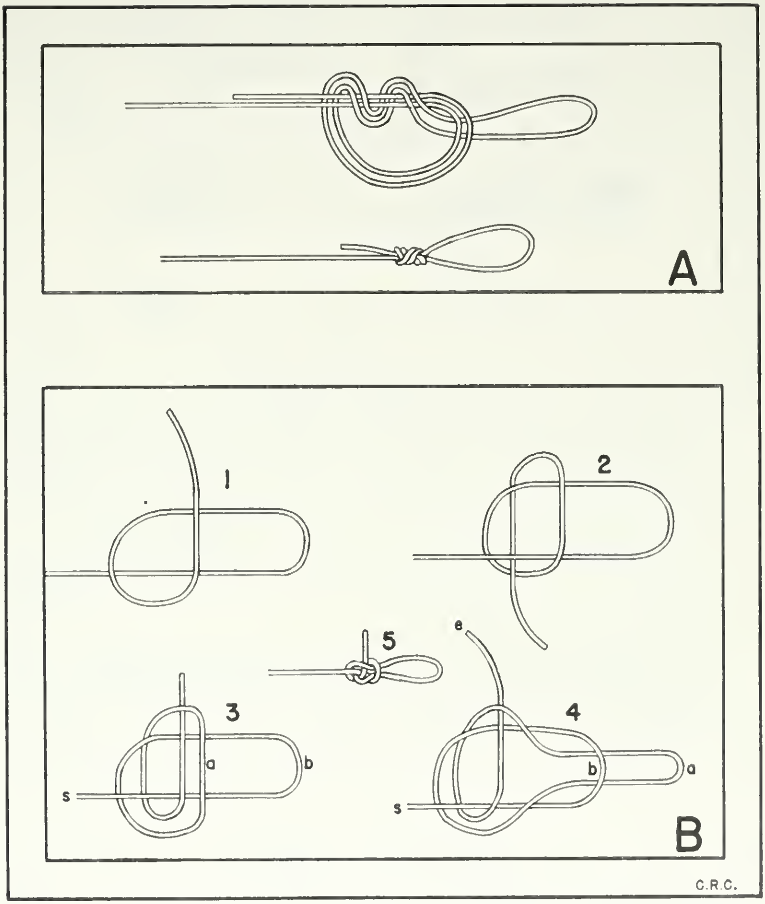

Fig. 25. Loop knots. Both are suitable for either natural or imitation gut.

A. Loop the end of your leader, tie an ordinary overhand knot with the doubled part, then pass the doubled end through the loop a second time and pull tight.

B. When you reach stage 3, hold as much of the knot as possible between thumb and forefinger to prevent slipping, then grasp loop "a" and pull under "b," thus reaching stage 4. Continue to pinch between thumb and forefinger and take up slack by pulling on standing end "s," then tighten by pulling on loop "a" and short end "e."

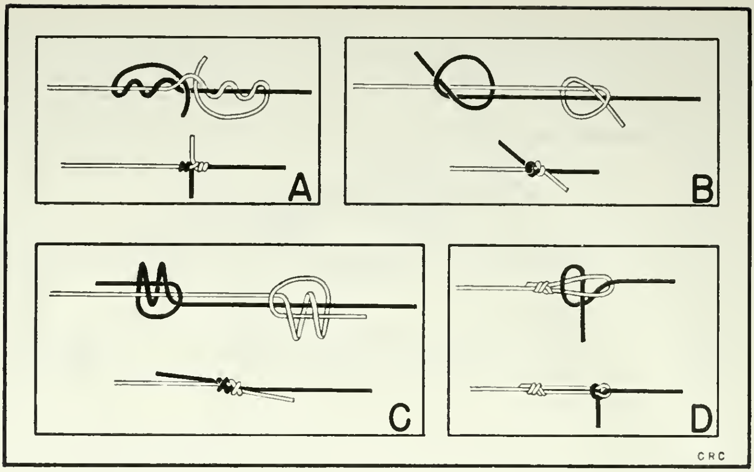

Fig. 26. A. Blood knot. This is the best knot you can use for tying together two pieces of natural or artificial gut. Its advantage is that the short ends of gut point at such an angle that they do not pick up stray bits of pond scum or rotted plant fibers. Its disadvantage is that in a dim light with half-frozen fingers you may not be able to tie it. You don't need to tie the blood knot exactly as it is shown here—an extra turn or two won't hurt anything.

B. This is a very easy knot to tie, but the short ends will pick up pond scum, etc. The knot is perfectly satisfactory for natural gut but not for imitation.

C. This is essentially the same knot as "B" but has an extra turn on each end. It is perfectly satisfactory for natural gut and with care can be used for imitation gut. When tying this material be sure to pull all ends tight and then pull hard on the long ends to make sure the knot is holding.

D. This knot is used to fasten the line to the loop in the end of your leader.

Rigging Your Tackle

The steps are as follows:

1. Put the leader to soak. This should be done some time in advance.

2. Put the rod together. Take the bottom two sections, line up the guides accurately and slip the ferrules together. If the guides of the two parts are not in line, pull the two sections apart and try again, but never under any circumstances twist a split bamboo rod. When the bottom two sections are together, rest the butt on the ground and slip the tip into place.

3. Attach the reel and make sure it is turned so the handle is on the side where you want it.

4. Thread the line through the guides and make sure that you don't miss any guides or take a turn around the rod with the line. This sounds like superfluous advice but it isn't, as can be testified by any one who has put his tackle together in that icy period just before dawn.

5. Uncoil the leader (this requires patience) and tie it onto the line.

6. Fasten on your hook or lure.

7. Bait up and get busy.

Taking the tackle down should be done in the exact reverse order. If your rod joints stick together get some one else to help you pull if

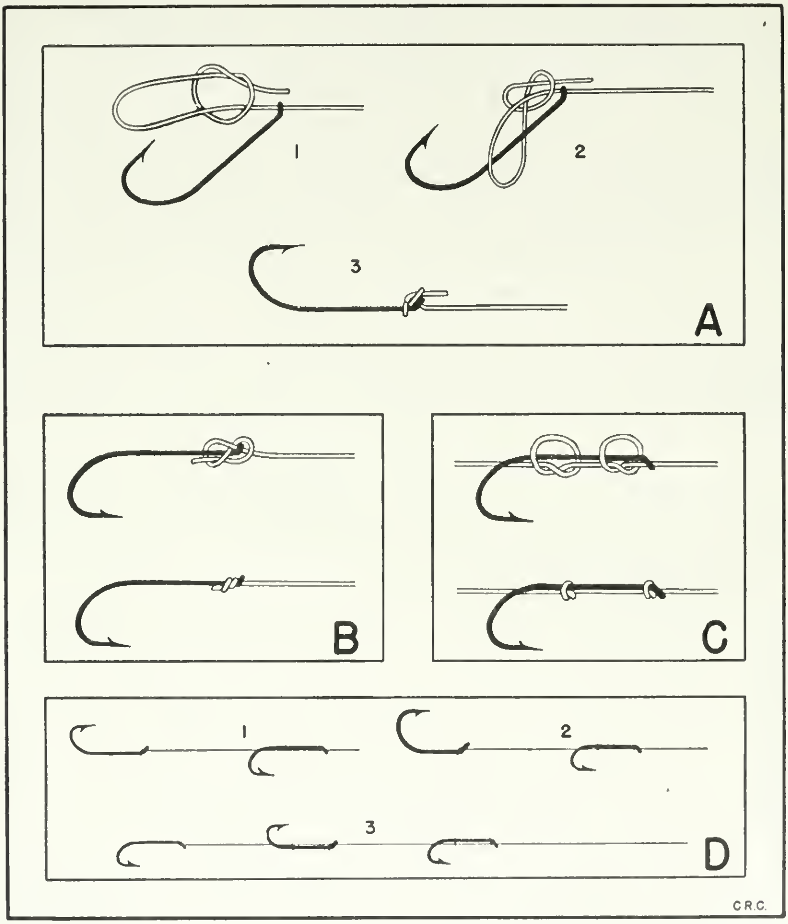

Fig. 27. A and B. Both these knots are satisfactory for tying an eyed hook to the end of a leader. They will hold either natural or imitation gut.

C. This knot serves to hold a hook above the end of a leader and is used in making up two- and three-hook rigs such as those shown.

D. Two- and three-hook worm rigs. No. 1 is probably the most generally useful. If your worms are very large you can space the hooks farther apart than shown here. No. 3 is a very deadly rig indeed but is not recommended unless you are fishing for some expert bait stealers, as ordinary unsophisticated trout will usually swallow the bottom hook. As a general rule, the more hooks you use the more snags you will catch.

necessary, but remember, **don't twist.** Sticking joints can usually be cured by applying a trace of grease or oil to the ferrules before putting them together. Rubbing the male ferrule against the side of your nose will usually be enough.

LEARNING TO CAST

Put your outfit together and go out on the front lawn—oh, all right, the **back** lawn then, if you are that sensitive about it.

Drop or Underhand Cast

Hold the rod in one hand, the bait in the other, and have the line from bait to rod tip sag just slightly. Point the rod at the horizon. Now drop the bait and simultaneously lift the rod tip. The bait should swing away from you, first down and then up. As it starts to rise, drop the rod tip and the bait will keep on going and land on the lawn somewhere in front of you. Practice till you can drop your bait exactly where you want it nearly every time. On the stream you will have to hit the spot you are aiming at, and will have to miss limbs and snags in order to hit that spot. This is the simplest of all casts, but for bait fishing it is by all odds the most useful. On a small moderately brushy stream at least 90 per cent of your casts will be of this type.

The Overhead Cast

This is **the** standard cast for fly fishing. You can get real distance with it when using a fly or small spinner. You can cast bait fairly well, but are all too apt to snap the bait off the hook. It is a last resort bait cast for that reason.

Flip your line as far in front of you as you can, then lift the rod tip to vertical with a bit of a snap. Your line will fly out behind you. Just as it comes tight in mid-air, snap the rod forward again, the line will land on the lawn in front of you. Now strip a yard or so of line off the reel and hold it in your left hand. Make another cast just as you did the last one, but when the line is flying forward let go of that yard or so you have in your hand. The momentum of the moving part of the line should pull this extra three feet out through the guides; if it does, feed it another yard on the next cast, and so on.

The trick to overhead casting is in the timing; you must learn to start the forward cast just as the line comes tight behind you. If you start just as the momentum of the line springs the rod tip backwards, the line will get flipped forward by the spring of the rod in a way no amount of power on the swing can duplicate. To learn the proper timing, watch your back cast—it shouldn't take you many minutes. If you start too soon you will "crack the whip" with your leader and may ruin it. If you start too late there will be a double jerk as you cast, and the cast will lack power. The first jerk is the line coming tight behind you and getting flipped weakly forward by the rod alone; the second jerk comes when your swing takes up the slack.

A few hints on the overhead cast: Use your wrist, not your arm. Remember the cast goes as far behind you as it does in front—so make sure there is plenty of room. When you make your back cast, remember to stop the rod when it is vertical, or a very little past that; many self-taught fishermen never do learn to cast properly because they persist in swinging the rod back till it points almost horizontally behind them. Try to keep the line high in the air on your back cast. When you want a fly to land with great delicacy, don't cast at the spot you want to hit, cast at a spot two feet above it and let the fly settle to the surface.

Side Cast

When there are trees low overhead you can often use a side cast. Except that the rod is swung to one side the method is a duplicate of the overhead cast.

Special Casts

There are several other casts designed to get distance without the need for a lot of space behind you. They are not used often and the beginner will do well to really learn the casts just described before he starts worrying about anything more complicated.

HABITS OF TROUT

Trout are found in cool or cold fast-rushing streams and in clear lakes. They are not found in sluggish lowland rivers or in excessively warm and weedy ponds and lakes. They must have cover; they like to hide under rocks, under banks, in log jams and among roots. Unless there are such hiding places available trout will not thrive. In California most of the trout streams which are under 4000 feet in elevation, are in shady canyons and almost all canyon streams which flow the year around contain trout. In the higher elevations there are open meadow brooks which provide excellent sport, but in the lowlands such streams are usually too warm and sluggish. There are some streams which cut across the narrow coastal plain and empty into the ocean. If the river bottom contains boulders and gravel and the water forms pools and riffles, there may be good trout fishing right down to the ocean, but there will be no fishing at all in the lower reaches of the river if the bottom is sandy and the water is smooth flowing and of uniform depth.

California streams have a tremendous seasonal change in rate of flow, and many that are rushing torrents in February are nice looking trout streams in May, and by August are reduced to strings of pools with no water at all flowing above ground. In such streams, the isolated pools are often teeming with trout. Of course, when all the streams vary so much in flow there are many which dry up entirely—make sure the one you are planning to try out is not one of these. Southern California streams are more prone to dry up than those in other parts of the State.

Food Habits

In California, stream trout feed primarily on aquatic insects and insect larvae, crustaceans (shrimp, etc.), mollusks (clams and snails), land insects which have fallen in, and to some extent on small fish. Some large trout, usually brown or Loch Leven, feed largely on small fish and do not hesitate to include any small trout that may stray within reach. In most southern California streams, aquatic insects and insect larvae form the bulk of the food, and the caddis worm is probably the commonest single item. This creature is the larva of the caddis fly. Most caddis fly larvae live in cases which are made of bits of wood, sand grains, etc. These cases are quite conspicuous and abound in most trout streams. The fish frequently eat the ''worm'' case and all.

Trout food is most abundant under stones, logs and other obstructions in the rapidly flowing parts of the stream, and the trout himself is essentially a fast water feeder. A feeding trout will usually be in or near fast water and will also be in or near a good hiding place. In a large stream, he may be in the open riffle if it is not too fast but he is more apt to be where a boulder breaks the current. He may be under a bank, or in the deep water at the head end of a pool, but wherever he is he will be watching the fast water and will be waiting to grab whatever the current brings him. In a small brook the riffles are usually too shallow for safety or comfort and the trout will probably be at the upper end of a pool, watching the fast water flow in. Wherever he is in a large stream or small, if there is any current he will be facing into it. If he is in an eddy, that may result in his facing down stream—remember that when you sneak up on him. A trout in the middle of a large quiet pool is usually loafing. He is not overly hungry and tends to be very critical of all offerings, and as the water is clear, the surface is unbroken, and the visibility is excellent, he usually shows unerring judgment in separating free offerings tossed in to whet his appetite from those which have a hook in them.

During the legal fishing hours (one hour before sunrise to one hour after sunset) trout seem to feed best in the morning and evening. The middle of the day is quite slack by comparison, but it is by no means useless to fish at midday. The big cannibalistic trout seem to prefer the hours of darkness for their depredations, but even they will occasionally bite at noon. Probably one thing that helps make the trout **seem** to be off their feed at noon is the excellent light which makes even a fine leader stand out all too clearly.

Size of Southern California Trout

Small streams contain small trout. In most southern California streams even the larger pools are seldom much over 30 or 40 feet long. In such creeks, a six-inch fish is the most usual, anything over eight inches is a good one, and anything over ten inches is something to crow about.

Some of the larger streams have deep pools over a hundred feet long. In such places there are sometimes a few trout as large as 20 to 22 inches, but as far as the beginner is concerned, they are there for ornamental purposes only. They didn't reach that size by being careless, and until he learns how to look for them the beginner may not even see them.

Wherever you fish in the southern part of the State, any stream trout over a foot long is a beauty—and you needn't be ashamed to keep the six-inchers.

If you get a really small one and wish to throw him back, notice first if he is bleeding at the gills. If he is, **keep him** regardless of size.

If he is not injured, you can often turn him loose by holding the hook upside down and shaking it. If this won't work, wet your hand and hold him gently while you unhook him. If you do this properly he will live to grow up—or, more likely, to go into the creel of some one who is less particular.

Steelhead

There are a few southern California streams, such as the Ventura River, which have good trout water right down to the ocean, and there are some others which have a good flow down to the ocean in the winter time. During flood periods, such streams are ascended by large sea-going steelhead trout which usually spawn and return to salt water long before the fishing season opens. However, there are often a few steelhead which do not get back during high water and which are forced to spend the summer in the stream. Such fish are sometimes over 30 inches in length and 10 pounds in weight. Don't expect to catch one—but don't drop dead if you see one! Southern California is the extreme southern limit of the steelhead's range. If you really want to catch one go north at least as far as the Eel or Klamath rivers. Incidentally a steelhead is a trout—any trout—which has gone to sea. It is **not** a separate species even though it does look it.

BAIT

Worms

The most time honored of all baits is the old reliable earthworm. Its reputation is well deserved—it works very well indeed. Earthworms can be purchased at almost any sporting goods store in southern California. If they are kept reasonably cool and are occasionally sprinkled with a few drops of water, they usually stay alive for two months or more. Even if you plan to dig your own, it will pay you to look at and into a can of "store" worms. You will probably get some ideas on how best to keep your own alive.

Garden-dug worms should be starved for a day or two before use. This cleans them out and toughens them up a bit. A good method is to pack the worms in damp (not wet) moss or shredded paper towels. Put a lid on the can but have a few small air holes in the lid.

Warning! When you take worms to high altitudes don't leave them outside at night. It may freeze and kill them. Wherever you are don't leave worm cans in the sun, close to the motor or exhaust line of your car or any place that will overheat the worms.

When you put a worm on a single hook, put the hook through him once or at most twice and let most of his length dangle. **Don't** get him so firmly onto the hook that he can't even wiggle and don't thread him onto the hook. It is not necessary to hide the hook clear inside the worm, but if snags abound where you are fishing it is advisable to cover the point. When a trout bites give him a few seconds to get the entire worm in his mouth, then strike. If you strike too soon, you will probably donate him half the worm.

If you are using one of the two- or three-hook rigs, shown on figure 27, drape your worm over the hooks without putting any sort of a loop in him. When you get a bite, strike immediately.

Salmon Eggs

In this State canned salmon eggs are even more commonly used than earthworms. They will keep until the can is opened, but will start to mould not many days after that. In the writer's estimation they are not nearly as good a bait as worms, but they do have one great advantage for a beginning fisherman: They are so conspicuous that it is very easy to watch the course of one through the water. This enables you to keep track of your bait and to learn much more quickly what that bait is apt to do in different types of currents and eddies.

The best hook for a salmon egg is a short-shanked one which nearly fills the egg. Too small a hook is apt to jerk out and leave the egg in the fish's mouth. Size 10 is best for average sized eggs.

Insects and Insect Larvae

If you run out of the two standard baits, don't hesitate to use grubs, caddis worms, stone fly larvae, grasshoppers, or anything else you can find. Most such baits are quite small, but don't let that bother you—it won't bother the trout. Use a small hook and don't insist upon hiding it in your bait. If the bait is very small, very fragile, or has a very tough shell it is best to leave the point and almost the entire bend of the hook exposed.

Fishing with grubs *et al* is a very complex game and to do it really well requires a great deal of skill and experience, but it will often catch fish when nothing else will work at all. The beginner may not do it properly but even so he may get reasonably good results while learning.

Those funny looking inch-long bundles of sticks or sand grains that you see in the stream are caddis worm cases. Extract the worm and use him for bait.

The best place to look for bait is under rocks in shallow water which is moving fairly fast.

FISHING

How to Approach the Stream

All too many fishermen walk up to a trout pool with no more care than they would use in going to the corner drug store, and wonder why they never even see a fish. Move as carefully as though you were stalking game and you will have much better "luck."

If the water surface is glassy smooth, stay back of a bush, rock or tree. If you can't do that stay in dense shade and move slowly. If there is no shade creep up on hands and knees, or at least contrive to have something besides sky for a background. If there is no cover of any sort stand well back from the stream. **Never let your shadow fall upon the pool.** If you are so dressed that you harmonize with your background you can often stand in full view of well educated trout without frightening them—but you will have to move very slowly to do it.

If the water surface is ruffled you do not need to be nearly so particular, and if the water is white with bubbles or is muddy, about all you have to do is to avoid casting a shadow on the place where you are fishing.

Remember that trout face into the current. A trout is less likely to notice you when you are behind him.

Often, in spite of every care you can take, you will frighten the fish. When this happens it is usually best to move on, but sometimes the frightened trout are worth waiting for. Get yourself into a comfortable position and wait quietly. Usually the life of the pool will return to normal within five to fifteen minutes and you can get results.

Talk, shout or sing all you please, but **walk** quietly. If the stream is quiet and unbroken take every precaution to step lightly, and remember that the ground carries sounds for long distances. A stream with under-cut banks is the very hardest to approach. In such a place even your best efforts may not be enough. In places where the water is tumbling noisily along you do not need to be nearly so careful.

In general, don't wade southern California streams while fishing. In very large streams it is often necessary to wade in order to reach the fish with a reasonably short line, but there are very few places in southern California where the practice is in the least desirable. If you **do** wade while fishing be sure to move slowly enough so that you don't splash at all.

Offering Bait to a Trout

Use one bait—not more. A second hook and bait is apt to alarm a suspicious trout and will transform the rig into an excellent snag collector.

A hungry trout in a flowing stream is usually watching for anything edible that the current may carry within his reach, so let the current carry your bait past places where a trout is likely to be waiting. Drop your bait a few feet up stream from the place you hope to get action and let the current carry it along on a moderately slack line. Too tight a line will not permit the bait to act naturally and too much slack will make it hard to tell when you have a bite. If possible move the rod tip along above the bait. This insures a slack line and yet makes it possible to use a very short line. The drag of the current on a long slack line sometimes keeps the bait from acting naturally, particularly if you are casting across the stream.

Remember that a loose worm, salmon egg or grub will usually drift along pretty close to the bottom, so make your bait do likewise and your chances will be far better than if it stays in the upper layers of water.

Where there is a waterfall dropping into a pool toss your bait into the fall and let it drift around in the pool. If the current carries it along one edge of a pothole, let it drift to the lower end (if it will) and then throw it into the fall again and steer it so that it will go across the middle or along the other edge. You may have to pull it a bit to get it started in the direction you want, but slacken your line as soon as the current starts taking it where you want it to go. The less pulling you do the better. There may be an eddy in the pool. Let your bait drift into this eddy.

When you come to a riffle flowing into a pool drop your bait at the upper end of the riffle if it is short or a few feet up if it is long, and, if possible, follow the bait with your rod tip till it is well into the pool.

If a long riffle is shallow and contains no pockets of deeper water, it should be passed up.

A long riffle which averages more than knee deep and has boulders scattered through it is often an excellent fishing place. Drift your bait into all the pockets back of the boulders. In a large stream you can often get excellent fishing in the riffles when everyone else is fishing the pools and getting nothing.

Whenever it is feasible, do your fishing with a short line but don't be afraid to use a long line if it seems advisable. Simply strip line off your reel and let the current take it out through the guides. If the current is not strong enough to do this, you can make line go through the guides by switching the rod tip back and forth. Sometimes when you want the bait to sink quite deep and drift quite a distance it is advisable to drop the bait, leader and a few feet of line in the water right at your feet and then switch your rod and feed line through the guides faster than the current will take it. In this way, a very long and very slack line will be sent down the stream. It will sink deep and often a naturally drifting bait will be presented to a trout which could not be reached by any other method. However, remember that a long slack line is very apt to hang up on a snag—so look the water over first.

Use of Sinkers

In general the best rule for the use of lead to sink your bait is **don't.** However, when the current is very swift there are many times when you simply can't get your line to sink. In such cases, pinch a tiny piece of sheet lead (or one or two split shot) onto the leader a foot or two above the bait. If more is necessary use more. By all means use enough to get to the bottom of a good looking hole, but when you move on to a place where the lead is not needed take it off. Bait will not drift naturally if it is dragging too much weight, and you will catch far fewer snags if you take that weight off.

How Long to Fish in One Place

One of the major worries of a beginning trout fisherman is whether he should spend two minutes or two hours at that nice looking pool. The following is an attempt to give a rough idea of about how long it is worthwhile to fish in one place **if you don't get any strikes.**

A narrow glide, three or four feet wide, or a pocket back of a rock should never need more than two or three well-placed casts.

A pool, 20 feet long, 10 to 15 feet wide, and 2 or 3 feet deep, can usually be well covered by drifting the bait through it a half dozen times.

A larger pool in which most of the lower end is flat and shallow can be disposed of about as quickly. Fish the deeper water at the upper end and forget about the rest of the pool.

A deep and turbulent pothole, 10 to 15 feet across, is often worth a bit longer stay. Drop your bait in and let it drift around in the eddies or rest on the bottom for a minute or so after each cast. Four to six such casts should do.

Waterfalls which are 10 feet high or more will often drop into large deep potholes. Such places are excellent. Let your bait drift around for a total of at least five minutes and don't feel that you are wasting your time if you spend fifteen. There is apt to be a big suspicious trout who will be startled even by a careful approach, but who will quit worrying if you sit quietly in one place for five or ten minutes.

When really big pools are fished where the water rushes into them, they are treated much like a smaller hole. Let the current carry the bait in several times, let that bait drift as far as it will and leave it for a minute or two after it stops moving. If you need a rest, leave the bait there several minutes, then pull it in gently and be ready for action. Often a trout will swallow your bait and won't be noticed because of the slack line. Should you get no results you had better move on if fishing has been at all good. If fishing is poor or you are tired, you may decide to fish the middle of the pool. The cards are stacked against you, but you may get a beauty.

Climb to a spot where you can see well into the pool. Thirty to fifty feet up a steep bank will give you an excellent view and if you use a little care you won't frighten any fish. Look carefully. There may be a veritable school of trout loafing in the deepest water. Throw in a free sample of bait. If the response is a scramble for the bait, your chances are good, but if there is a scramble for cover you may as well move on. Chances are you won't get either extreme. Probably a trout will swim up to your bait—maybe he will take it, maybe he will let it settle to the bottom, perhaps while he is making up his mind a smaller one will sprint in and grab it. Having found out where the fish are and what the general attitude is, sneak up to a good spot where you can see what is happening and make yourself comfortable. Throw in a free sample and drop your real bait nearby. Perhaps some trout will make a mistake—odds are that if the fish are at all large they will take free samples and nothing else. Let your bait and leader settle to the bottom and rest there for some time. There is an excellent chance that after a short while some good trout will pick it up—probably because the leader is so much less conspicuous when on the bottom.

No matter whether you are fishing a tiny riffle or a huge hole, if you get a strike try again. If a fish gets your bait without being hooked, he is almost certain to bite again. If you hook a nice one and lose him try again right away—the danger may not have registered on him. If he is frightened, stop fishing for him and try again later. Fishing for an alarmed trout only serves to confirm his suspicions. If a fish strikes several times and then stops, move on but remember the place and try again later. If you land a fish try the same spot again. You may have frightened all the others in the pool—and you may not. It is a common occurrence to fish a quarter-mile of stream without a bite and then to get three or four out of a hole that looks no better than average. After you catch one fish, it is often a good plan to wait a moment or two before trying for the next one. One expert carefully cleans each fish as soon as it is caught, buries the entrails, and then tries for the next one. He finds that the cleaning operation takes him just about the right length of time—and in addition it gets the fish home in excellent condition.

A general rule on how fast to fish a stream: If fishing is fair or good you can usually catch the most fish by covering the stream rather rapidly, but by a slow and careful working of the better looking spots you will probably get larger fish. A good compromise method is to rapidly cover all but a few of the very best spots and spend some little time at each of them. If fishing is very poor you will probably do best to fish rapidly until you see some good trout and then use all your patience and ingenuity on them.

Hooking and Landing a Trout

Whenever you drop your line into the water watch the bait if you can do so without showing yourself to your proposed victims. If the bait suddenly vanishes without any apparent reason, it was probably grabbed by a trout. An eight-inch trout is often far harder to see than a salmon egg or even a worm. If you can't see your bait, watch your line. If it starts to move erratically, you probably have a bite. This movement may be anything from a faint twitching to a steady march against the current. An inch or less of white or red string tied to the upper end of the leader will often be a help in detecting a bite—watch the string for erratic movement. **Even if you have no reason to suspect a bite be ready for action whenever you pull in slack line.** All the time your bait is out keep your finger tips alert. Feel for a faint rapping as well as for a more violent bite. If you think you do have a bite, pull in your line gently but fairly rapidly until you feel your fish, **then** set the hook. If you strike while there is several feet of slack line in the water you will warn the fish and he may be able to spit the bait out before you get the line tight. When you do strike be gentle, remember you are not trying to throw him over your shoulder, you are only trying to drive in that tiny needle-sharp hook. A jerk that will sail a six-inch trout through the air will snap a fine leader if the victim is 11 or 12 inches long. When your fish is hooked, pull gently and keep pulling. If he is a small one you will lift him out. If he is fair-sized he will probably start to go places. Let the line slide through your fingers or off the reel with enough pressure to put a good arc in your rod, **and keep that rod bent.** Its spring is the best safety device known against sudden stunts by the victim. If the fish heads for a brush pile or some other place that spells disaster tighten down on him and stop his rush. If he is a really big one, and you can't stop him without danger of breaking the leader, let him run. A trout tangled in a brush pile is not hopelessly lost. The biggest stream trout I have seen taken in southern California was hooked by a friend and was finally netted by the writer in a mass of roots in about six feet of water. Due to too hasty shedding of underwear there were buttons scattered all over the bank. The trout was worth it—just over three pounds. If your trout doesn't reach cover or come unhooked he will soon be lifted to the surface by the steady pull of the rod. Then, if he is under eight inches lift him ashore. If he is over 10 inches, find a bit of beach to slide him up on. If he is over 12 inches, don't beach him till he is thoroughly exhausted. If there is no beach get him completely fought out and use your creel or your hat for a landing net or grab him by the gills. It is a good idea to spread a handkerchief over your hand before grabbing—cloth which is free of fish slime won't slip at all easily on a fish. If by any chance you **do** have a landing net, you can use it much earlier in the game than it would be safe to use a creel or hat.

Rudiments of Fly Fishing

The beginner who really wants to learn fly fishing should by all means get some one to teach him, but if he just wants to do a little experimenting with a fly between spells of bait fishing the following should be of some help.

One of the most important differences between fly and bait fishing is that when a trout grabs a fly he immediately realizes that something is wrong and spits it out. This means that a fly fisherman must always be prepared to strike instantly. One trick (frowned upon by fly purists) is to put about an eighth of an inch of worm on the hook of your fly. A trout will hesitate an instant before spitting this out and you will have a bit longer in which to strike, but even with a baited fly the strike must be fast and any amount of slack line is out of the question.

Nymph and creeper flies are excellent for a beginner's use. They are made to represent the aquatic larvae of insects, and can be fished much like bait. Let them drift around near the bottom just as you would bait, but keep your slack down to a minimum, watch your leader like a hawk and strike at the first faint twitch. Other types of flies can be drifted near the bottom in this same way but are more commonly used on or near the surface. Surface work has to be done much more skillfully but you do have the advantage that you can usually see your fish coming. When you do see a fish dart for a fly don't wait for him to hit it but strike right then. The lag of your reflexes and the slack in the line will give him time to reach the fly.

If your drifting fly, nymph or creeper doesn't get any action retrieve it slowly with a faint twitching motion. This will often attract a fish that had failed to notice it. Try to make it act like an insect struggling against the current or swimming across quiet water.

Cast into the base of a waterfall and twitch your fly away from there like a half-drowned insect trying to reach shore.

Cast across the current and let the force of the water against your line whip the fly downstream and across. Try moving your fly along the surface of still water at a speed of one or two miles per hour. Pull it against the current, but do this very slowly.

Dry fly fishing consists of floating the fly on the surface and letting it drift naturally with the current. The method is most effective at low water. In general dry flies should be cast upstream or up and across and allowed to drift down. Pick up the slack as it comes toward you.

To float properly a fly must be dry. If it gets soaked blot it and then make a few false casts (casts which do not touch the water) to finish drying it. A few false casts after each real cast will usually keep the fly dry enough to float. Use of fly oil is also a help in this matter.

Often when everything else fails you can make a trout strike by letting your fly dangle below the rod, lowering it till it just touches the water, then letting your hand tremble faintly. This makes the fly seem to flutter on the surface. The method is most valuable at extreme low water.

A fly fisherman will usually cover a stream a bit more rapidly than a man using bait. This is because the drifting of bait on a long slack line takes more time than any sort of fly cast.

Use of Spinners

In some regions, such as the coastal area from central California north, a well used spinner is murderous. In other places the trout just don't seem interested enough to strike hard. They will swim up and nudge the spinner but seldom get hooked. In southern California most of the streams are in the latter category and in addition many of them are so small that it is very difficult to fish a spinner properly. Some of the lakes in southern California are quite different—spinner fishing is excellent.

Spinners are fished by dragging them slowly through the water. The best speed is the very slowest one which will keep the blade turning properly. Spinners should be allowed to sink and then fished deep. An eighth-ounce or more of lead is often a great help in keeping one close to the bottom. As a general rule, fishing across the current is best but you can fish up stream or down if the current isn't too swift. A spinner doesn't have to pass as close to a trout as does a bait or fly. Its glittering blade will often attract fish from 10 or 15 feet away, thus making it possible to cover a large stream very rapidly. In small streams, on the other hand, a spinner is not satisfactory because it has to be moved rather rapidly to keep it turning, and it is clear across the pool before a trout has had time to decide whether or not he wants it.

Spinners are often useful at noon or during some slack part of the day when the fish are not taking bait.

Fish which are striking half-heartedly can sometimes be induced to hit harder by dangling a small piece of bait on the hook of the spinner.

Spinner fishing is the fastest of all methods of covering a stream. A fish that is in the least interested will nearly always come out and look at a spinner on the first or second cast, and if nothing appears you may as well move on.

ILLUSTRATIONS OF DIFFERENT TYPES OF TROUT POOLS

The text up to this point has been rather general. The following pictures with their captions are an attempt to be as specific as possible in telling a beginner where to fish.

To show the approximate size of two of the pools the writer's dog was induced to pose in the picture. She appears in a third on her own initiative. Perhaps this would be a good place to bring up the subject of dogs on trout fishing trips. No dog is an asset, and everyone's fishing will be utterly ruined by a hysterical pup that insists on dashing ahead and into every pool. A dog that will mind and can be made to stay away from the creek is not too great a handicap if you and he really enjoy each other's company.

Fig. 28. This is a typical small waterfall and shallow pothole combination. The best place for a bait fisherman is behind the rock "A." Drop your bait just above the waterfall and let it drift clear across the pool. Three or four casts should be enough. Steer your bait so that each cast drifts along a different route. Be sure to drift a bait along the base of rock "A."

Don't pass up the fast water at the foot of the pool. If you decide to fish it from rock "A" be sure the upper end of the pool is fished out before you start—a trout dragged the entire length of a pool is liable to frighten everything in it.

Spinner or fly fishermen would do better to stand below or to the left of the part shown in the picture, but back far enough so the fish won't notice them. Drag spinners clear across the pool just fast enough to keep them turning. Drop flies near the waterfall and let them drift. If that doesn't get results, try working the flies across the pool.

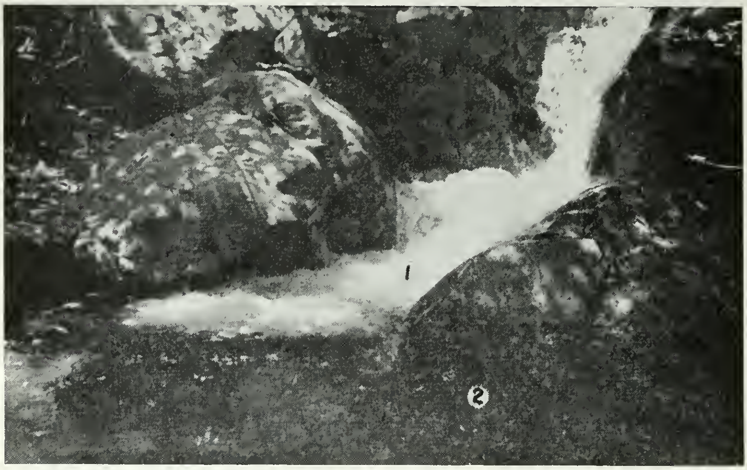

Fig. 29. This is a deeper hole than shown in Figure 28. It is an excellent place for bait but not very good for spinners. Drop the bait at "1" and let it drift through the hole three or four times. Make sure it goes deep and that on one or two casts it goes around the corner past "2."

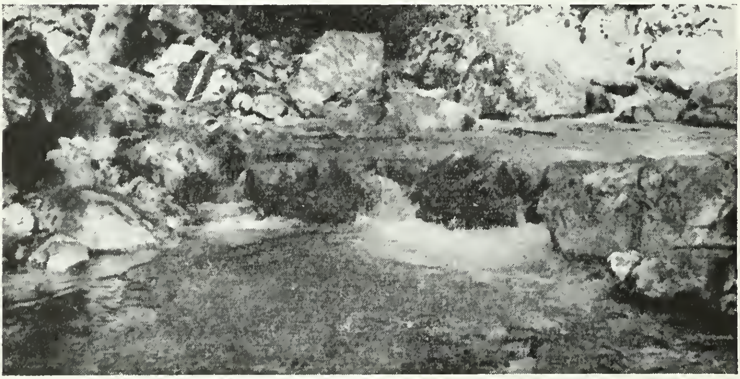

Fig. 30. Trout may be anywhere under that large area of foam, so drop your bait in three or four different places, and each time let it drift across the pool by a different route. Let the bait boil around under the foam for a minute or so if it will stay there.

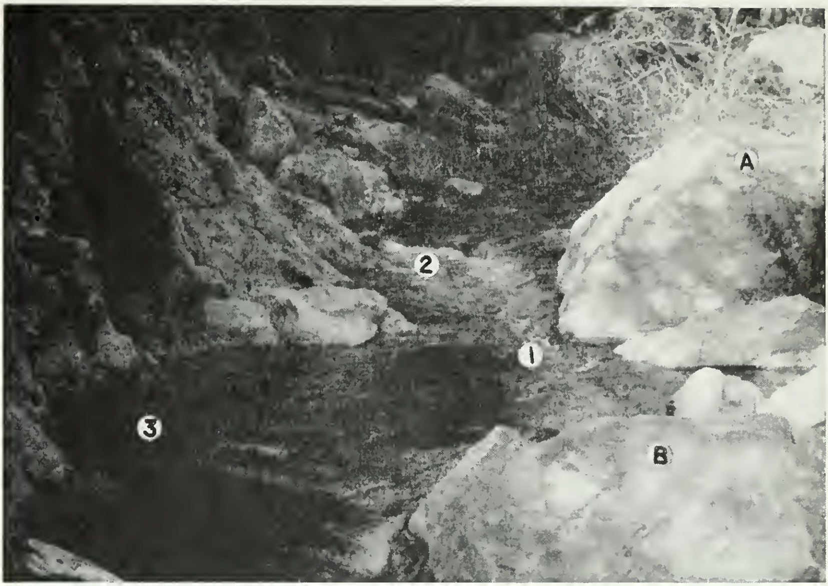

Fig. 31. Riffle and small pool. The best place for the fisherman is behind rock "A" because from that position he can easily keep any small trout hooked in the riffle from getting into the pool and disturbing other fish. Any fish much above "1" will probably be small and will be there because a bigger one has taken the best spot somewhere below him. Drop your bait in at "2," and follow it with your rod tip to let it sink deep before it reaches "1." Pay out as much line as is needed to let your bait drift the entire length of the pool. Make four or five casts and try to steer at least two of them into the eddy which flows from "3" toward "1." This will be hard and instead you may have to cast over to "3" or beyond in order to accomplish the same result. A bait which hits a rock and slides or falls in will be far less likely to disturb trout than one which lands in smooth water with a loud smack. If there were no cover at "A" the fisherman would be far better off fishing from behind "B" than standing or kneeling in the open at the upper end of the pool.

Fly fishermen should fish the pool in a way much the same as that just given. Drift flies with the current, then work them across and finally against it. Don't try to drift a fly to "3"—cast it.

Spinner fishermen will have no trouble fishing below "1" but the riffle looks too fast and too narrow for proper use of a spinner.

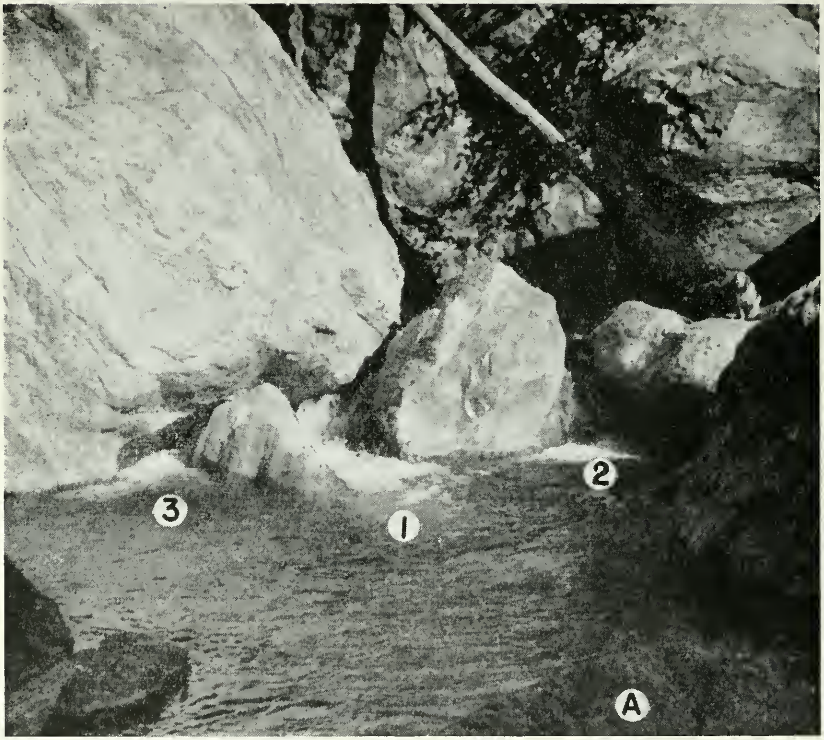

Fig. 32. This is a beautiful type of trout pool and one at which the fisherman could well afford to spend ten minutes or more, especially if he knows there are big fish in the stream. "A" is the best position from which to fish. "1" is the most likely looking place to drop a bait or fly, "2" is the next, and "3" is a bad third. Spot "1" should be fished first because anything hooked there can be led away without disturbing either of the other two. Try "2" next. Trout are apt to be anywhere in this pool, so cover it slowly and carefully. Let bait drift around all over the bottom; this process is apt to hook a good fish several minutes after all other action is over.

Spinner fishermen should use plenty of lead and keep the blade near the bottom. This is something which is always hard to do in steep-sided pools such as the one shown. Cover such pools thoroughly with a spinner, but do not bother to keep casting for minutes on end. Any fish that wants it will nearly always take it in the first eight or ten casts.

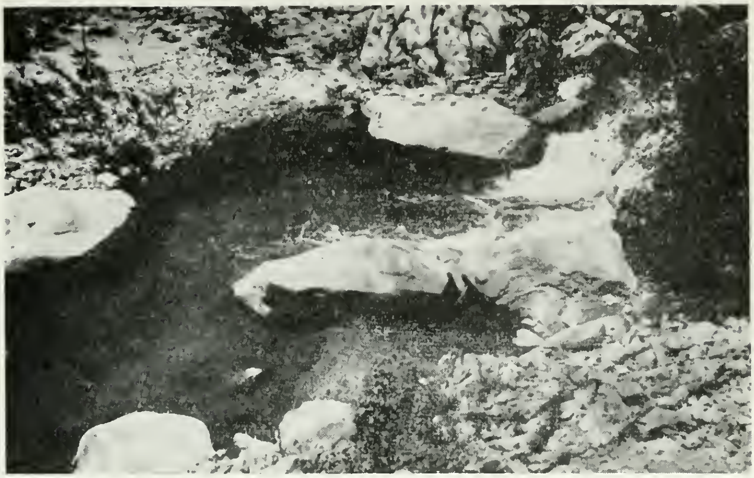

Fig. 33. This type of pool must be approached with great care. Water is running fast and smooth for its entire length. Trout may be anywhere and from most places they will have an excellent view of any careless fisherman.

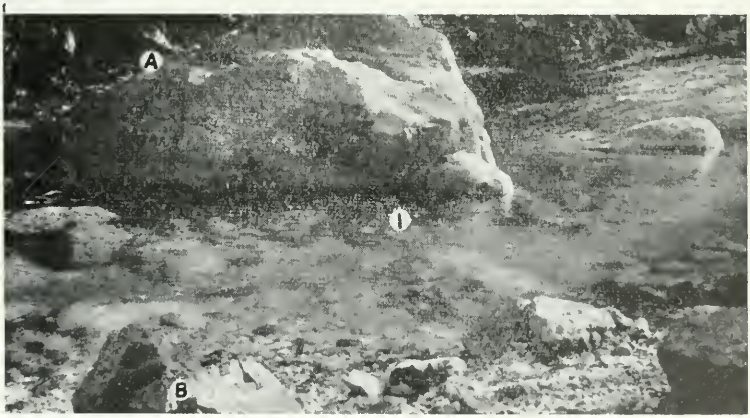

Fig. 34. This pool is another which must be very carefully approached, but it does have one advantage: you can watch your bait, fly or spinner and will have plenty of warning before a fish strikes.

If you are on the far bank start operations near "A." Try "1" first—there will probably be a trout loafing in the shadow—but he won't stay long if you show yourself.

If you are on the near bank crawl to "B" and stay down. Cast bait or fly well up stream from any trout you see and let it drift well past the fish before you pick it up. Cast a spinner up stream from and well beyond your fish—if you can do so cast it clear into shallow water near the far bank so the splash will be a long distance from the fish.

Fig. 35. The trout will be under the roots, so drift your bait close to the bank. If a fisherman gets on top of that bank his footfalls may frighten the fish and if he does hook one of any size, it is apt to be back among the roots in a flash. A safer bet would be to crawl up to the rocks "A," cast into the white water and let the bait drift close to the steep bank. Then a fish can be led away from the roots as soon as he strikes.

Fly or spinner fishermen should work from "A" or stand well back on the right-hand bank. Cast close to the roots, but don't overshoot and cast into them.

Fig. 36. This is the sort of place where trout may be anywhere but are more apt to be nowhere. A fly or spinner fisherman could cover this place fairly quickly by cross-current casts, but a bait fisherman would take much longer drifting his bait into each pocket. If you don't want to waste time doing this, try using an inch-long piece of worm and work it across the current like a fly. The trick often works on unsophisticated fish in shallow water.

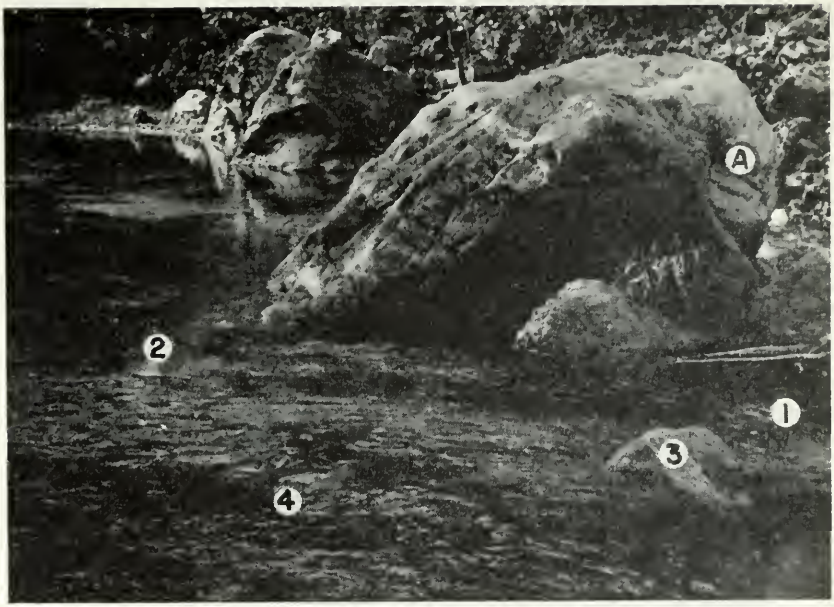

Fig. 37. This is another place where staying out of sight is of prime importance. Trout are apt to be anywhere in the smooth run between "1" and "2," below rock "3" or submerged rock "4." If you are fishing from near "A" cast your fly or bait up stream (above "1") and give bait plenty of slack so it will settle in the deep water near "2." Work close in behind rock "3." Let your line drift down stream from "4."

The current at "1" looks too fast for good spinner work, but if you are using a spinner try some short cross-current casts to make sure. Make these casts long enough so the splash is well beyond the place you want to fish. Cast up stream and across and retrieve fast. Make some long casts and let the drag of the current on your line whip the spinner down stream and across. Hold your rod tip high enough so the line passes over rock "3"; it will probably wash over "4" without any trouble. Make three or four long casts down stream from "2." If necessary, crawl onto the big rock "A" to do this but don't stand up.

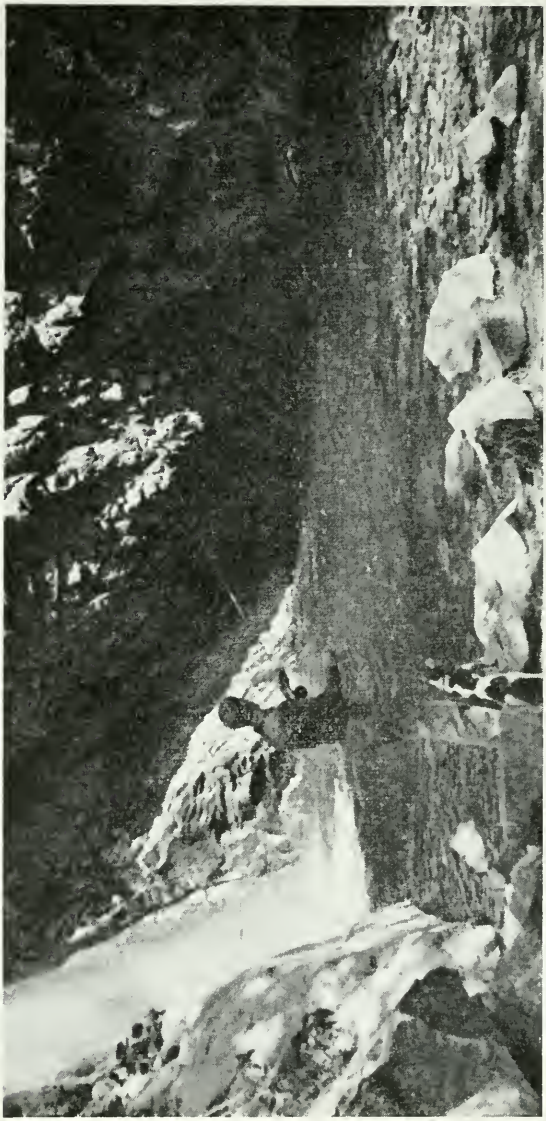

Fig. 38. This is an excellent pool for bait or fly, and is a spinner fisherman's delight. The water surface is ruffled enough so that extreme caution is not required. When this picture was taken the fisherman (an expert) had finished working the nearer part of the pool from a place farther back on the bank and had moved quietly forward to fish the deep water along the far edge. Results were excellent. When a pool of this type can be fished from the upper end it is a perfect place to let a bait drift for a long period, but when you cast from the lower end, the current with a long slack line to work on will usually drag the bait right out of the deep water.

A LIST OF TROUT STREAMS

This list does not pretend to be complete, but it does include a majority of the consistently good streams in southern California. Most of these streams have one or more forks which also provide good sport. With a few exceptions these branches have not been named separately.

Santa Barbara County

Santa Ynez River. Long stretches of this stream flow through cattle ranches, the owners of which do not permit fishing on their property.

Ventura County

Ventura River. This is a trout stream clear down to the ocean.

Sespe Creek.

Los Angeles County

San Gabriel River and all its branches. Due to diversion of water it is necessary to drive up the canyon almost to the junction of the West Fork.

Santa Anita Creek. Fish above the dam.

San Dimas Creek. Fish above the dam.

Little Rock Creek.

San Bernardino County

San Antonio Creek. Partly closed. All or nearly all of the closed part is in Los Angeles County.

Deep Creek. This stream is good clear down to the junction with Mojave River, but the fish are very well educated.

Holcomb Creek.

Santa Ana River. Good in the mountains—the lower reaches are barren.

Bear Creek City Creek	Apt to be closed in midseason on account of fire hazard.

Riverside County

North Fork San Jacinto River Strawberry Creek	Apt to be closed in midseason on account of fire hazard. Enquire first.

HOMING INSTINCT AND STRAYING AMONG STEELHEAD TROUT (*SALMO GAIRDNERII*) AND SILVER SALMON (*ONCORHYNCHUS KISUTCH*)[1]

By A. C. Taft and Leo Shapovalov
Bureau of Fish Conservation
California Division of Fish and Game

Indisputable evidence obtained through marking experiments carried out by various scientific workers in this and other countries has established as a fact the homing instinct among anadromous members of the salmon family. Briefly, young salmonids which descend from fresh water to the ocean return to their "parent stream" for spawning purposes (young fish artifically hatched and liberated return to the stream in which they were liberated, not to the stream to which their parents returned or in which they were hatched).

The present writers have had an excellent opportunity to study not only the homing instinct but also straying as exhibited by steelhead trout (*Salmo gairdnerii*) and silver salmon (*Oncorhynchus kisutch*) in California. Experiments in the marking of salmonids are not new to California. However, past work has been confined entirely to the king salmon (*Oncorhynchus tschawytscha*). These experiments are described in various papers appearing in *California Fish and Game* from 1916 to 1928.

Scott and Waddell Creek Experiments

Figure 39 shows the location of weirs maintained in three adjacent streams in Santa Cruz County by the California Division of Fish and Game, at which all steelhead trout and silver salmon (the only salmonids regularly present in the three streams) are examined. Young seaward migrants are regularly marked at both Scott and Waddell creeks,[2] so that the amount of straying between streams can be noted. The reader should note that upon descending to the ocean the young fish do not simply remain near the mouth of the stream of liberation, but may wander great distances. Marked salmon from Waddell Creek have been caught in the ocean off Fort Bragg, two hundred miles to the north (Taft, 1937). Incidentally, marked king salmon from both the Klamath and the Sacramento river systems, hundreds of miles

[1] The experiments described in this paper were in large part conducted in cooperation with the U. S. Bureau of Fisheries, as part of the program of the California Trout Investigations. We are indebted to Mr. Theodore J. Hoover for the use of Waddell Creek for experimental purposes, to Stanford University for laboratory space, and to Dr. P. R. Needham, of the U. S. Bureau of Fisheries, who is in charge of the cooperative investigations. Submitted for publication, December 31, 1937.

[2] For a description of the trout and salmon marking work carried on in California, showing numbers and sizes of marked fish planted, see Shapovalov (1937). In the present paper, the term "marked fish" refers to fish marked by clipping fins; "tagged fish" are those to which tags have been applied.

apart, have also been caught off Fort Bragg, and also in Monterey Bay (Snyder, 1921, 1923, and 1924), yet we shall see how accurately the homing instinct operates. It should also be noted that in general character, character of terrain, temperatures, chemical conditions, and rainfall, Waddell and Scott creeks are very similar.

Table 1 shows the various groups of fish marked and liberated at Waddell and Scott creeks, respectively, and the number returning to the parent stream or straying to the other stream. All of the salmon die after spawning once, so that no marked individual returns more

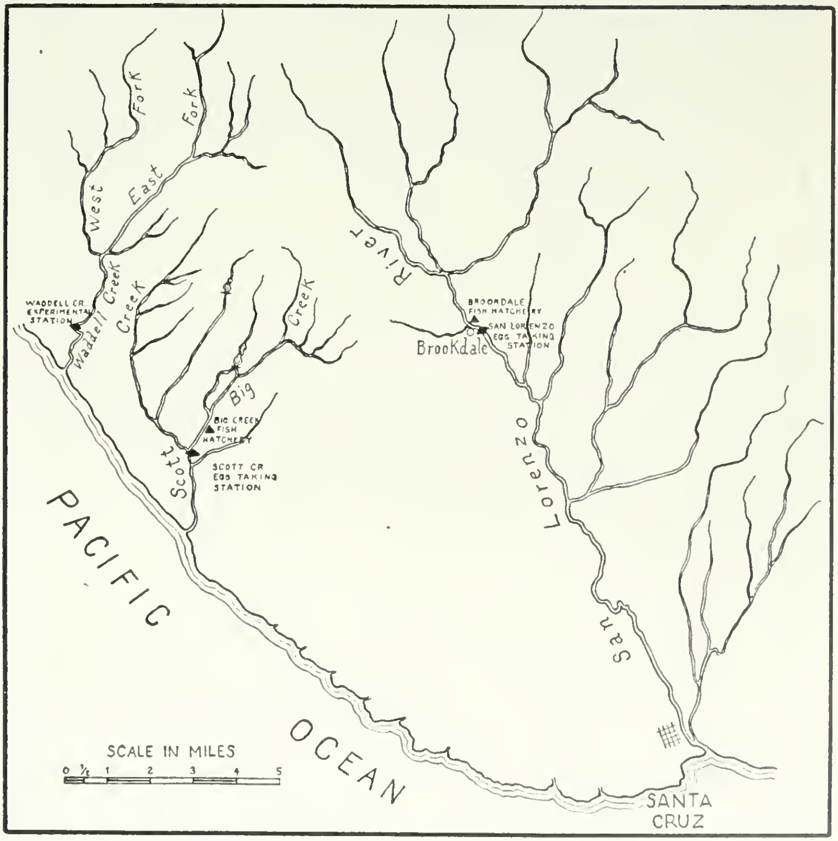

Fig. 39. Map of streams in Santa Cruz County, California, on which the California Division of Fish and Game maintains weirs.

than one time. Among the steelhead, the same marked individual may occasionally be present in successive years, but the number of such fish is quite small. Males and females have been grouped together in the table, since no significant sexual differentiation has been revealed in the straying fish as compared with those of the same year-class returning to their parent stream. The fish at Scott Creek are hatchery-reared, whereas those at Waddell Creek are naturally spawned. No "planting" of fish is done in Waddell Creek. For a description of the Waddell experimental station see Taft (1936).

TABLE 1

HOMING AND STRAYING OF MARKED STEELHEAD TROUT AND SILVER SALMON IN SMALL COASTAL STREAMS

Steelhead Trout

Season marked	Mark	Returned to Waddell Creek				Returned to Scott Creek			
		1933-34	1934-35	1935-36	1936-37	1933-34	1934-35	1935-36	1936-37
Waddell Creek—									
1931	Ad-LV	3 (100%)	3 (100%)			0	0		
1932									
1933-34	Ad-RP		66 (98.5%)	63 (98.4%)	15 (100%)		1 (1.5%)	1 (1.6%)	0
1934-35	Ad-LP			17 (100%)	39 (100%)			0	0
1935-36	Both P				27 (90.0%)				3 (10.0%)
1936-37	Ad-RP								
Scott Creek—									
1932-33	Ad-RV	0	0	0		9 (100%)	39 (100%)	4 (100%)	
1933-34	Both V		0	1 (1.2%)	0		38 (100%)	79 (98.8%)	10 (100%)
1934-35	Ad-LV			1 (0.5%)	5 (2.7%)			197 (99.5%)	177 (97.3%)
1935-36	Ad-RV				0				0
1935-36	Ad-Ant½D				0				6 (100%)
1935-36	Both V				0				0

Silver Salmon

Season marked	Mark	Returned to Waddell Creek 1933-34	1934-35	1935-36	1936-37	Returned to Scott Creek 1933-34	1934-35	1935-36	1936-37
Waddell Creek—									
1931	Ad-LV	17				0			
1932									
1933-34	Ad-RP		7	20 (83.3%)			Poor records during 1933-34 and 1934-35	4 (16.7%)	
1934-35	Ad-LP			15 (78.9%)	98 (78.4%)			4 (21.1%)	27 (21.6%)
1935-36	Both P				0				0
1936-37	Ad-RP								
Scott Creek—									
1932-33	Ad-LV	2	0			3			
1933-34									
1934-35									
1935-36									

Ad=adipose fin; P=pectoral fin; V=ventral fin; D=dorsal fin; L=left; R=right; Ant=anterior.

From Table 1 it is seen that over a period of four years among the returning steelhead, 233 (97.9%) of the fish marked at Waddell Creek returned to their native stream and only 5 (2.1%) strayed to Scott Creek; and of those marked at Scott Creek, 559 (98.8%) returned to their native stream and only 7 (1.2%) strayed to Waddell Creek.

Among the returning salmon (during the two years for which good records for Scott Creek are available) 133 (79.2%) of the fish marked at Waddell Creek returned to their native stream and 35 (20.8%) strayed to Scott Creek. Salmon have not regularly been marked at Scott Creek, so the amount of straying from there for them can not be recorded for the present. Some straying does take place, as shown in Table 1 by the two fish of the 1932-33 Scott Creek marking that were taken at Waddell Creek during the season of 1933-34. However, since the Scott Creek salmon records for 1933-34 and 1934-35 are poor, the three salmon of the 1932-33 marking which returned to Scott Creek in 1933-34 may not represent total returns and consequently homing and straying in this instance are not listed in terms of percentages.

TABLE 2

HOMING AND STRAYING OF TAGGED STEELHEAD TROUT IN SMALL COASTAL STREAMS[a]

Year tagged	Returned to Waddell Creek				Returned to Scott Creek			
	1932–33	1933–34	1934–35	1935–36	1932–33	1933–34	1934–35	1935–36
Waddell Creek—1933–34	Station not operated	----------------	3 (100%)	(0)	-------	---------	(0)	(0)
Scott Creek—1931–32	- -	1(?)="hole in rt. opercle, probably 1932 Scott Creek tagged fish" (20.0%?)	(0)	(0)	83	4[b](80.0%?)	(0)	(0)
1932–33		1=No. 87932 (4.2%)	(0)	(0)	- -	23[c](95.8%)	3[d] (100%)	(0)
1933–34		-- -- ----- --	(0)	(0)		- ---	30[e](100%)	(0)

[a] None of the tagged fish returning were marked fish.
[b] Three of these 4 are included in the 23[c] tagged in 1932–33.
[c] Three of these 23 are included in the 4[b] tagged in 1931–32.
[d] All of these 3 are included in the 30[e] tagged in 1933–34.
[e] Three of these 30 are included in the 3[d] tagged in 1932–33.

Table 2 shows the homing and straying of tagged fish. Adult steelhead were tagged with individually numbered tags at Scott Creek in 1931-32 (strap tags) and 1932-33 and 1933-34 (disk tags), and at Waddell Creek in 1933-34 (disk tags). At Scott Creek the fish were tagged immediately after being spawned, whereas at Waddell Creek they were tagged before spawning, on their upstream migration. The fact that all fish tagged were adults means that they had all spent one or more years in the ocean. All returns on tagged fish, then, are on fish that had made at least two spawning migrations into fresh water and are not directly comparable with returns on fish with clipped fins, which are marked previous to their first trip to the ocean. One difference is that in the case of the tagged fish the parent stream is not known and homing or straying must be considered only in relation to the stream in which tagging took place. Also, the fish tagged being adults, the returns on these groups are not as large as on the small, marked fish and might alone be inconclusive, especially in view of the possible loss of tags. However, they support fully the results of the marking experiments and are included as supplementary data .

From Table 2 it is seen that, over a period of three years, 60 (96.8%) of the fish tagged at Scott Creek, returned there and only two (3.2%) strayed to Waddell Creek and of those tagged at Waddell Creek three returned there and none were taken at Scott Creek. During 1932-33, 83 fish tagged at Scott Creek in 1931-32 returned there, but since the Waddell Creek station was not yet operating that year the amount of straying can not be recorded and these 83 fish are not included in the above percentages.

The limited degree of straying is emphasized by the fact that no salmon or steelhead marked at Scott or Waddell creeks have been seen at the San Lorenzo Egg-Taking Station since it began operations at the beginning of the 1934-35 season. However, one of the steelhead tagged at Scott Creek in 1931-32 (No. 16088) entered the estuary of the San Lorenzo River during the following year and was caught there in January by an angler. It was a female, 69 centimeters long when tagged and 30 inches (76 cm.) long, weight $9\frac{1}{2}$ pounds, when caught.

Especially in view of the slight amount of straying among the steelhead it is interesting to note one remarkable case of straying and return to parent stream within the same spawning season.

The fish in question was hatched at the Big Creek Hatchery during the spring of 1934 and marked by having its adipose and left ventral fins clipped off. It was one of a group of 5608 fish so marked and liberated about one mile below the hatchery, in Scott Creek, on February 11-12, 1935.

Of this group the great majority that returned to spawn returned to their parent stream, Scott Creek. But the fish under discussion strayed to Waddell Creek, and was checked through the dam there on February 5, 1937. A scale sample was taken from the left side and the dorsal fin half-clipped as a temporary mark to show that the fish had been marked and measured at the Waddell Creek dam. It was unusual, but not extraordinary, for this fish to stray to Waddell Creek. But on February 10, five days later, the same fish was found in the tanks at the Scott Creek Egg-Taking Station. The area from which scales had been removed was clearly evident and the half-clipped dorsal fin was conspicuous. Upon examination the scales taken at the time appeared identical with those taken at Waddell Creek. The remarkable feature is that this fish had turned into one creek from the ocean for a distance of one and one-half miles, had then returned to the ocean without spawning, proceeded along five miles of coast line to the neighboring stream, and had migrated two miles up that stream, where it was again trapped within five days.

Klamath River Experiments

The Scott Creek and Waddell Creek experiments revealed to us the operation of homing and straying in small streams entering the ocean directly. The Klamath River experiments show the operation of these processes within a large river system, the mouth of which flows into the ocean.

The Klamath River, next to the Sacramento-San Joaquin, is the largest and most important of California's rivers. Figure 40 shows the Klamath and its principal tributaries to the Oregon boundary, exclusive of the Trinity River. On this map are shown Copco Dam, an impassable barrier 197 miles above the mouth of the Klamath, and the region below it, including the streams in which marked steelhead were liberated and the egg-taking stations at which they were recovered.

Table 3 shows the various lots of marked trout liberated in Fall and Beaver creeks and the number returning to these streams or entering Bogus and Camp creeks. The "Kosk Creek rainbows" are suspected of possessing nonmigratory tendencies and are not included in

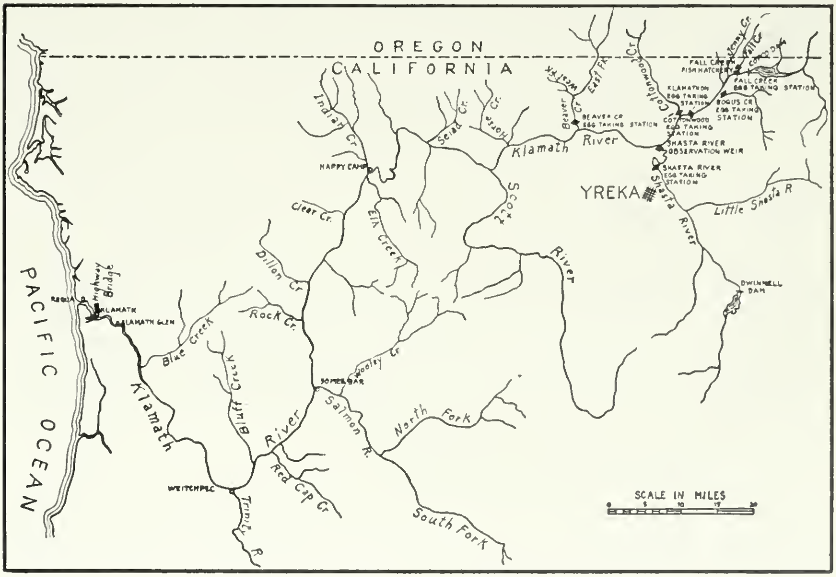

Fig. 40. Map of Klamath River and its principal tributaries to the Oregon boundary, showing streams in which marked steelhead were liberated and recovered.

the main table, especially since scale readings of the returning marked fish of this lot indicated that none of them had descended to the ocean. The fish listed as steelhead are all offspring of races or strains of fish which regularly descend to the ocean. Several other marked steelhead of various sizes returned to their parent stream but are not included in the table, since scale readings indicate that they had not descended to the ocean.

During the seasons of 1934-35, 1935-36, and 1936-37 all of the fish handled in the egg-taking operations at the four above-mentioned stations were examined for marks. These did not include all of the fish entering these streams but did constitute a fair sample. Returning marked sea-run fish for the season of 1936-37 are listed in the table. No marked sea-run steelhead were recovered at any of the stations during the two previous seasons.

From Table 3 it is seen that during the 1936-37 season, 45 (100%) of the marked fish liberated in Fall Creek returned there and none were taken in the other streams. Of the marked fish liberated in Beaver Creek 71 (95.9%) returned there, one (1.4%) strayed to Cottonwood Creek, one (1.4%) to Bogus Creek, and one (1.4%) to Fall Creek.

TABLE 3

HOMING AND STRAYING OF MARKED TROUT WITHIN A RIVER SYSTEM

Steelhead Trout

Season marked	Mark	Returned to Beaver Creek 1936–37	Returned to Fall Creek 1936–37	Returned to Cottonwood Creek 1936–37	Returned to Bogus Creek 1936–37
Beaver Creek—					
1933–34	Ad-RV	70 (95.9%)	1 (1.4%)	1 (1.4%)	1 (1.4%)
1934–35	Both V				
1935–36	Ad-LV				
Fall Creek—					
1933–34	Ad-LV	0	45 (100%)	0	0

Stream Type Fish (Kosk Creek Rainbow)

Season marked	Mark	Returned to Beaver Creek 1936–37	Returned to Fall Creek 1936–37	Returned to Cottonwood Creek 1936–37	Returned to Bogus Creek 1936–37
Fall Creek—					
1933–34	Ad-Both V	2	3	0	0

It thus appears that even within a large drainage basin, such as that of the Klamath River, the amount of straying among sea-run steelhead is not much greater than between the small coastal streams, such as Waddell and Scott creeks. That there should be some straying is to be expected, for otherwise the fish could not readily have dispersed and eventually come to occupy all of the streams favorable for their existence.

Conclusions

The answer to the question of whether certain fishes of sporting or commercial importance, such as the steelhead trout and silver salmon, return to their parent stream is one not only of great scientific interest but also of much practical importance. It has a direct bearing on the methods to be employed in maintaining and increasing the runs of these fishes. It is quite apparent that if the amount of straying is as small as these experiments have shown it to be then each stream, so far as the production of a particular species is concerned, must be handled as a separate unit. We can not count on the planting of one stream or tributary to have much effect on the rest.

One of the greatest difficulties which arises in connection with increasing or even maintaining the runs of steelhead trout and silver salmon is the fact that they are not only caught as adults but are also taken by anglers in great numbers as young fish previous to and during their migration to the sea. If such young fish are all caught in any one stream it will certainly mean that within a very few years there will be practically no adults to return to that stream. This applies to both naturally reared and planted fish.

Depletion of the runs of adult fish through the killing of large numbers of young fish is, of course, equally effective whether the young fish be taken by anglers or lost in unscreened irrigation ditches, power turbines, or streams drying up through the diversion of water. Conversely, the loss of adult fish at impassable dams will just as certainly affect the production of young fish.

It is a problem that we must treat at both ends. It is also a problem that we must treat separately in each trout and salmon stream, for the run of fish returning to it is dependent almost entirely upon the number of young fish that are allowed to reach the ocean.

The fact that homing operates within a river system contradicts the theory advanced by Huntsman (1937) that a true homing instinct does not exist and that the fish return to their parent stream only when they do not leave the neighborhood of the river mouth and thus the influence of the fresh water from that stream. It is to be emphasized that in the Klamath River experiments the tributaries in which the marked steelhead were liberated and to which they returned after spending at least a year in the ocean are great distances above the mouth of the river. Beaver Creek is 160 miles above the mouth, Cottonwood Creek 182 miles, Bogus Creek 189 miles, and Fall Creek 196 miles. It is indeed inconceivable that the fish could have felt the influence of their particular small stream during their sojourn in the ocean, 160 to 196 miles or more away, even if they did not leave the neighborhood of the river mouth.

Although proof that steelhead do not in any way have to remain under the influence of the water of their parent stream in order to exercise homing seems to be amply demonstrated in the above situation, it might be added that the mouths of most California trout and salmon streams are closed by sand bars during the summer months and that in some cases the lower courses of the streams are entirely dry, so that no fresh water reaches the ocean.

Just what it is that guides the fish in its return from the ocean to the river system which it left and then into its parent stream is an intriguing problem that has caused much discussion but is still unanswered. Accurate knowledge of movements in the sea, sadly lacking, would certainly be desirable and might shed light on this question. But the fact that homing does exist, though truly remarkable and overwhelming, is by no means surprising in view of its existence among widely separated groups of animals. It operates not only among highly developed vertebrates, such as birds, but also among invertebrates, for example, among mollusks.

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PROGRESS REPORT OF TROUT FEEDING EXPERIMENTS, 1937 [1]

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Dry plant and animal meals have come into widespread use in this country as fish food wherever the cost of fresh meats is high. There is little question but what a judicious use of meals will produce good growth and health at considerable saving, but there is great variation in the kinds of meals used throughout the country, and too little is known about their comparative value in trout culture. Equally great variation exists in the methods of preparing and feeding meal-meat mixtures. It is the writers' opinion after four years of extensive feeding experiments that preparation and feeding of these mixed foods are equally as important and a much more difficult problem to solve than the choice of ingredients.

Preparation of food for large fingerlings and older fish is not as difficult as preparing meal-meat mixtures for smaller fingerlings. Nevertheless, it offers many obstacles to the producing hatchery and considerable ingenuity is needed to surmount them. The writers wish to acknowledge the help of Mr. Ralph Ledgerwood of the Mt. Shasta Hatchery who has spent a great deal of time during the last two years straightening out the difficult problems which constantly arise in food preparation for the older pond fish.

The cleanest and most economical method of combining meals with meat or using meals alone is to moisten them sufficiently and grind them through an ordinary meat grinder as outlined in last year's progress report.[2] By this method the food is formed into spaghetti-like strands which can be broken up into "pellets." One requisite for practical pellet manufacture is an electric motor or engine of about five horsepower and a large grinder. An outfit which would be large enough for grinding liver or other fresh meats would not be powerful enough to withstand the greater strain incident to pellet manufacture. Large pellets made through a half-inch plate are much more easily formed and are softer and consequently better for the fish. However, if the trout are not large enough to eat food in such large particles a smaller plate must be employed. When it is necessary to use a quarter-inch plate or smaller, there is great danger of getting the pellets too hard. In fact it is almost impossible to use certain combinations of meals and certain meats in pellets this small. As still smaller pellets are attempted, the choice of ingredients must be even more exacting. To illustrate some of the restrictions discovered in making small pellets we might mention

[1] This is the fourth report of experiments which are being conducted at the California Division of Fish and Game Experimental Trout Hatchery located at Mt. Shasta; submitted for publication December, 1937. See also previous reports issued in CALIFORNIA FISH AND GAME: vol. 21, no. 2, pp. 110-124; vol. 22, no. 2, pp. 111-117; vol. 23, no. 2, pp. 138-144.

[2] Calif. Fish and Game, vol. 23, no. 2, pp. 138-144, 1937.

that lungs make very hard quarter-inch pellets though half-inch pellets with lungs are satisfactory. Liver and fish can be used in the quarter-inch size, and canned sardines being heavy with oil are especially good. The grades of meal are important. Powdered milk makes a much harder pellet than flaked milk. In fact the best combination of meals which we have found for very small pellets (5/64 or 1/8 inch) is about two-thirds salmon egg meal and one-third flaked milk by weight. If it is impossible to make the desired size of pellet with the fresh meal incorporated, it is sometimes advisable to make the pellets of meals alone and feed the meat separately. Thus for young fish, two feeds a day of pellets and one of meat is a satisfactory diet. For adult fish, pellets of straight meal can be fed five times a week and meat twice. One commercial hatchery in the State feeds straight meal pellets five days a week, then lungs one day, and on the seventh day no food is given.

At Mt. Shasta the brown trout brood fish are fed pellets composed of about three-fifths meal and two-fifths fish or meat. The meal mixture is equal parts by weight of salmon carcass meal, dry skim milk and wheat mill run. The fresh fish is spawned-out salmon and condemned canned sardines, and the meats are fluky liver, heart or lungs. The kind of meat used is varied by the market supply.

As we have pointed out, the task of pellet manufacture is filled with difficult problems, especially when the ingredients can not always be the same, nevertheless it should be kept in mind that there is some combination which will work with any ingredients used and by experimentation this desirable combination can be found.

Fingerling Experiments

The principal object of the 1937 set of experiments with trough-reared fingerlings was to determine the minimum percentage of fresh meat for practical hatchery feeding and to determine if possible some practical method of feeding large numbers of small fingerlings on a combination with a high meal content. The senior author also wanted to determine what pathological changes might occur when trout had been fed on dry meals without any fresh meat supplement. Heretofore we have employed about 50 per cent meal and 50 per cent meat in our experimental diets. Most such combinations were satisfactory from a nutritional standpoint but somewhat difficult to feed rapidly enough to make them practical in large hatcheries.

We wanted first to repeat the experiments of numerous workers who have tested the fresh meat requirements of trout and determine the minimum fresh meat percentage which is practical under the conditions of our work. In so doing we felt that the difficulties involved in preparing and feeding such low meat combinations would become evident and a solution might be discovered. However, several unexpected difficulties were presented and the course of our experiments had to be partially altered.

Method

The experimental hatchery located at Mt. Shasta contains 22 regulation California troughs, 16 feet long, 16 inches wide and with an average water depth of 7 inches. The eggs were received in the eyed stage, hatched in the regulation baskets, and kept in the troughs until the end of the experiments. Records were kept of the daily loss in each trough and of the weights of random samples every two weeks. In so far as possible the care given the fish was similar to that given fingerlings throughout California. Approximately 15 gallons of water a minute entered each pair of troughs, coming in at the top of the upper trough, running through it and falling into the lower trough and so on to the waste pipe. The temperature during the experimental season ran from 36° to 58° F.

Brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and rainbow trout (*Salmo gairdnerii*) were used in the experiments. The brook trout were from Mt. Shasta brood stock (from Vermont selected fish). The eggs averaged 308 per ounce. The brown trout eggs were from Mt. Shasta brood stock and averaged 168 per ounce. The rainbow eggs were from Shackleford Creek, a tributary to the Klamath River, and therefore these fish might better be called steelhead than rainbow as most of the fish caught at this spawning station have been to sea. These eggs averaged 176 per ounce. At the start of the experiments, 23,000 brook and brown fingerlings were placed in each trough, but in the rainbow experiments only 20,000 fingerlings were placed in a trough.

The brook and brown trout started to feed on February 18, 1937, and the rainbow started on May 23. The experiments were continued in the brook and brown until August 24, 1937, and continued in the rainbow until October 1, 1937. Thus the brook and brown trout experiments lasted for approximately six months and the rainbow experiments lasted for five months and one week.

We also had a pond with about three thousand yearling brook trout which we fed an experimental diet of 100 per cent meal. This meal was a commercial balanced dog food, supposedly containing all the elements necessary for health and good growth of dogs. We wished to see if such a diet would be equally healthful for trout. This diet was continued for over six months but the mortality rose in these fish before the end of this time.

Foods

Beef heart was fed to all the experimental groups for the first six weeks. At the end of this time the fish were considered large enough to start on meals and the following diet groups were arranged. The number of fish given for each group represents those which started the feeding trials. Whenever it became evident that the troughs were overcrowded they were thinned down. Thinnings were made as uniformly as possible so that the factor of population density would not affect health and growth to any considerable extent.

1. 46,000 brook and 46,000 brown trout were fed 100 per cent meal for two months. The mortality was so high that the diet was changed to 80 per cent meal and 20 per cent liver for three weeks. The mortality remained high, so 100 per cent liver was fed for two weeks. By this time the fish were improving and were large enough to take pellets, so meal pellets were fed twice a day (65 per cent) and liver once a day (35 per cent) until the end of the experiment.

2. 46,000 brook and 46,000 brown trout were fed 90 per cent meal and 10 per cent liver for eleven weeks. The mortality was then so high that 50 per cent meal and 50 per cent liver were substituted. In two weeks the fish had improved and were large enough for meal pellets, so these were fed twice a day (65 per cent) and liver once a day (35 per cent) until the end of the experiment.
3. 46,000 brook trout were started on a diet composed of 90 per cent commercial dog food meal and 10 per cent liver. This was changed to 50 per cent of the meal and 50 per cent liver, but by the end of sixteen days it became evident that this meal was too coarse and would not stick together well enough to feed small fingerlings, so the diet was changed to 90 per cent sardine meal and dry milk and 10 per cent liver. This was fed for two months. The sardine meal was exhausted, so 50 per cent salmon egg and dry milk and 50 per cent liver were substituted. In two weeks the fish were large enough for pellets so two feeds a day of pellets (65 per cent) and one feed a day (35 per cent) of liver were given until the end of the experiment.
4. 80,000 rainbow trout were fed 75 per cent meal and 25 per cent liver for three weeks, when the oxygen demand from the food pollution plus a decrease in the water supply to about 10 gallons per minute per trough made it necessary to change the food to 100 per cent beef lungs. This was fed to the end of the experiment.
5. 80,000 rainbow trout were fed 50 per cent meal and 50 per cent liver for three weeks, when the same difficulty arose which affected the preceding diet group. The meal was discontinued and 100 per cent beef heart was substituted and fed until the end of the experiment.
6. 80,000 rainbow trout were fed beef heart for six weeks, after which they were given 100 per cent beef liver until the end of the experiment.

At the start, the meal fed most of these fingerlings was composed of dry skim milk and salmon carcass meal in equal proportions. The salmon meal contained bone particles which killed a number of fingerlings and it was necessary to substitute sardine meal which is much more finely ground. This sardine meal, manufactured in California by a vacuum process, was very satisfactory and is perhaps safer than flame-dried meal.

The commercial dog food meal which we tried on the fingerlings and on the yearling brook trout was too coarse for the fingerlings, and as its protein content was low we changed to a balanced mink food meal manufactured by the same company. This has a higher protein content (37 per cent) and we believe that it may find a place in the list of trout foods. It must be supplemented with fresh meat, however.

Summary

Diets of 100 per cent meal (sardine and milk) and 90 per cent meal and 10 per cent liver (by weight) proved to be inadequate when fed to brown and brook trout fingerlings. The trouble undoubtedly lies in the deficiency of the fresh meat factor sometimes called "Factor H."

Fish affected by this lack displayed the following symptoms: emaciation, sluggishness, and loss of appetite; they became dark and often lay on the bottom of the trough although during feeding they rose to the surface and swam listlessly. This last symptom may be aggravated by a decrease in the oxygen attendant to food pollution. Another condition was also displayed by certain fish. These fish appeared large and healthy, but would suddenly dart about entirely without sense of balance and then come to the surface and float motionless, belly up. When removed to a separate trough they would recover in about 75 per cent of the cases, and the remainder would die.

The viscera of the fish which became thin and sluggish showed but one definite and constant abnormality—the kidney tubules were always filled with large hyaline casts. These casts were so conspicuous that they could easily be seen with the medium power of a dissecting microscope. The casts were more apparent in the brook trout than in the brown trout fingerlings. The writers feel that these symptoms characterize an avitaminosis, although this interesting subject should be checked to exclude the possibility that some subtle disease was operating in conjunction with the lack of the fresh meat factor.

There seems little doubt but what 10 per cent liver by weight will not furnish enough of the factor to assure health. When the diets were changed to give 35 per cent liver the results were satisfactory and it seems probable that the minimum level of fresh beef liver in the diet lies around 20 to 25 per cent by weight, as McCay and others have shown.

The principal difficulty encountered in feeding these low meat diets to fingerlings in the producing hatchery lies in the pollution of the water and the resultant oxygen depletion. This was well illustrated in our tests with rainbow fingerlings. We wanted to feed 75 per cent and 50 per cent meal in two diet groups; however, the water temperature was relatively high (56° F.) and the flow of water was unavoidably decreased to 10 gallons per minute in each pair of troughs. The pollution by the meals therefore reduced the oxygen level, which was already low, to the lethal point and the fish were partially suffocated at each of the three feedings a day. As a result the gill filaments became badly swollen and respiration increasingly more difficult. The losses of fish rose alarmingly and we changed the diets to straight meats.

Earlier in the year we had experienced little difficulty in feeding high meal foods to the brook and brown trout fingerlings, but it seems pobable that is was due to the water being colder and more plentiful (15 gallons per minute) and because the brook and brown trout are more resistant to low oxygen levels.

Therefore we must conclude that high meal combinations can not be recommended unreservedly until a method is found whereby they can be prepared as efficiently as in pellet form. In the last annual progress report of these experiments [3] it was pointed out that pellets can not be prepared for fish smaller than 25 per ounce, and we see that the feeding of fish which are smaller than 25 per ounce presents a very serious problem. In California a large part of our hatchery fish must be liberated while still quite small, and if these fish could be fed com-

[3] *loc. cit.*

binations involving high percentages of meal a very appreciable reduction could be made in the cost of food.

Hatcherymen in the State of Washington [4] have used an electric blower to combine meal and liver in a form which is superior to that accomplished by other methods. The present writers have not tried this method, but think that it might be one solution of the problem. Until this method or some other has been tried and found to work successfully, it will be practically impossible to feed trout fingerlings which average smaller than 25 per ounce a meat-meal combination which involves more than 25 per cent meal by weight, and even that percentage must be handled with care.

When the rainbow groups became seriously affected by the meal pollution, the diets were changed to straight beef heart and straight beef lungs, and the third group was left on a diet of straight beef liver. Very little difference was noticeable in the health and growth of the fish given these different meats. It was thought possible that there would be a difference in red cell counts in the blood of fish fed these different meats but averages showed:

Food	*Red cells per cubic mm.*
Lungs	1,346,000
Heart	1,300,000
Liver	1,122,000

We do not feel that these differences are significant.

Earlier in this paper mention was made of the brook trout yearlings which were fed a straight diet of commercial dog food which was supposedly balanced for dogs. The protein content was low, the carbohydrate content high, and the minerals and vitamins were supposedly sufficient for health, growth and reproduction. This may be adequate for dogs but we wanted to see if the mineral and vitamin content would maintain health in trout. We knew that the low protein content would give little growth. It is probable that these fish obtained an appreciable amount of aquatic and aerial organisms in addition to the food we gave them, otherwise it is doubtful if they would have lived as long as they did. The 100 per cent meal diet was started in January, 1937, and continued for six months, at which time the mortality was so high the food was changed to 100 per cent beef liver for two weeks. The liver caused a rapid decrease in the mortality and added evidence that the loss was from anemia. A blood count was taken for seven fish on March 5 and showed 1,125,000 red cells per cubic millimeter. Another count taken on July 22 showed 508,000 per cubic millimeter. The gills of these fish during the latter stages of the test period were pale and this symptom should be useful in diagnosing anemia. We therefore conclude that a diet containing elements adequate for the health of dogs need not be adequate for trout, and that fresh meat, in this case liver, quickly restores the red count to normal.

Conclusions

1. Brook, brown and rainbow trout fingerlings were used in experiments to determine the minimum proportion of liver which could be used with meals in the producing hatchery. It was shown that about

[4] Washington Hatcheryman, vol. 1, no. 2, p. 2, 1937.

25 per cent liver by weight is a satisfactory minimum providing that the combination is properly prepared and fed. However, no method was used which proved satisfactory in feeding high meal combinations to fingerlings smaller than 25 per ounce. Fingerlings which are larger than 25 per ounce can be fed straight meal pellets twice a day and meat once a day. Unless some method is found whereby liver and meals can be combined and fed without serious water pollution it will be impractical to feed small fingerlings more than 25 per cent meal with the balance liver. This is an unfortunate situation as the writers feel that a considerable saving of money could be made if it were possible to use about 75 per cent meal plus 25 per cent meat.

2. We also wished to see exactly what took place when fish were fed straight meal or a combination involving very little meat. The symptoms were found to be of two types. In one, the fish lost appetite, became dark, sluggish and emaciated and developed hyaline casts in the kidney tubules, whereas in the second type, large, apparently normal fingerlings would suffer a nervous disorder, lose equilibrium and dash wildly about and then quickly recover in 75 per cent of the cases whereas the remainder died. No gross pathological symptoms were found other than the kidney casts in the first type of disease.

3. At the start of the experiments a salmon carcass meal was used but this contained bone fragments which killed a number of fingerlings. A vacuum dried sardine meal was substituted; this was finely ground and proved to be a valuable fresh meat supplement for fingerlings and undoubtedly for older trout.

4. Beef heart, beef liver and beef lungs were fed as straight diets to three groups of rainbow fingerlings. It was found that there was very little difference in health and growth and that the red cell count remained approximately the same in each.

5. A pond of approximately three thousand yearling brook trout was fed a commercial dog food for six months. This dry meal was fed alone without any fresh meat additions but it is probable that the fish obtained more or less aquatic and aerial organisms. Supposedly this dog food contained all the minerals and vitamins necessary for health and growth of dogs but we found that in about five months the fish became seriously anemic and that by the end of six months the losses were so heavy from anemia that it was necessary to change the diet to beef liver. In about two weeks on 100 per cent liver the mortality ceased.

6. We have verified the findings of previous workers who have shown that fresh meat contains a factor which is necessary to the health and growth of trout.

QUAIL RANGE EXTENSION IN THE SAN BERNARDINO NATIONAL FOREST—PROGRESS REPORT, 1937 [1]

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INTRODUCTION

The studies made during 1936 and 1937 on a quail range extension project in and adjacent to the San Bernardino National Forest in southern California are presented in this report.

The project, initiated in the summer of 1936, was prompted by the development of a watering device perfected by James Moffit and used successfully by the California Division of Fish and Game within its established quail refuges. The U. S. Forest Service became interested in this device because of the 3,000,000 acres of foothill and woodland areas within the national forests that are either actual or potential quail range and which could perhaps be made more suitable for quail by their use. Many thousands of acres of this area are waterless during the summer and the present studies are aimed at securing and building the factual and biological foundation on which the actual field work of quail range extension, particularly through water development on these waterless areas, might proceed.

During 1937 the work was under the direction of E. E. Horn of the U. S. Biological Survey and under the Division of Wildlife and Range Management of the U. S. Forest Service.

Objective of Quail Range Extension Project

The objective of quail range extension is simply to establish quail on woodland and semidesert lands where they are lacking due to the absence of some environmental factor. A good quail range is assumed to be made of the following constituents:

1. Roosting and loafing types of vegetation (heavily foliaged trees or brush at least 10 feet high).
2. Nesting types (usually grasses intermingled with short brush).
3. Food types.
4. Cover or escape types (usually compact brush from 30 to 36 inches high).
5. Water in some form (usually the limiting factor in southern California).

The presence, concentration and interspersion of these factors determine the feasibility of occupancy by quail of any particular range. The absence of roosting, nesting or cover types of vegetation would remove an area from consideration, but there is a possibility of manipu-

[1] Submitted for publication, February, 1938. Published by permission of the United States Forest Service. Photographs by author and Fred W. Johnson of the U. S. Forest Service.

lating the food and water factors. The first is a costly measure but could be accomplished by clearing and seeding with desirable food species. The second, usually the limiting factor in southern California, can be accomplished by placing water tanks on the area. The experiment on the San Bernardino National Forest deals with this factor. It is believed this form of management will produce results well worth the money and effort expended.

In order to determine the biological as well as the economical limitations of quail range extension, the project was started in 1936, in cooperation with the California Division of Fish and Game.

Problems Involved in Quail Range Extension

After careful inspection of numerous areas on or adjacent to the northern boundary of the San Bernardino National Forest, the area selected was chosen because it was typical of much of the higher elevations of our unreserved public domain and the juniper woodland within the national forests. It was known that during the winter and spring, adult quail spread out into this country and usually remain until the green vegetation disappears, at which time the lack of water apparently makes it necessary for them to seek natural springs higher in the mountains. If the quail nest early, the broods survive and also migrate to the mountains. Very likely, if the clutches occur late in the spring, many broods perish. As has been pointed out, general conditions in the study area were not adverse to quail livelihood or development, with the exception of the water factor. Because very young birds can not travel far to water, and since dew, succulent plants and water in any other form are conspicuous by their absence, the matter presented a severe problem.

June to October is the critical drought period. The problem was therefore not only to afford sufficient water on this range during those months but also to obtain proper distribution of water with regard to:

1. Watering the greatest number of birds possible.
2. Spacing the water tanks in such a manner that the young birds would have a continuous water supply in water sources one mile apart.
3. Securing use of all the good quail range.

In placing water on this area, an unnatural factor was established. What would be the effect on the general biotic complex? Rodents such as rabbits, gophers, ground squirrels, desert wood rats, kangaroo rats and white-footed mice were numerous. Would they be attracted to the water sites? Would they compete with quail for food? What would be the vegetative trends on the area under heavy concentration of birds and rodents? The rodents might be greatly beneficial if they act as buffers, thus taking a great load of predation off of the birds. Would predators increase around the water in proportion to the animal life, and what would be the general effect on the quail?

If quail were attracted to the sites, when did use first start? When did the peaks of use occur and when did use cease? Cost studies would necessarily have to be made, and the efficiency of the units improved.

Many of the problems were solved. The solution of the others which were studied will require subsequent observations over a period of years.

DESCRIPTION OF THE PROJECT AREA

History

The history of this area is one of excessive development of marginal farms and their subsequent abandonment. About 1917 much of this public domain was filed upon and many small tracts were cleared in developing the land. Natural soil catchment basins were constructed to water live stock during the summer months. Water for domestic purposes was caught on the roofs and stored in large cisterns. The

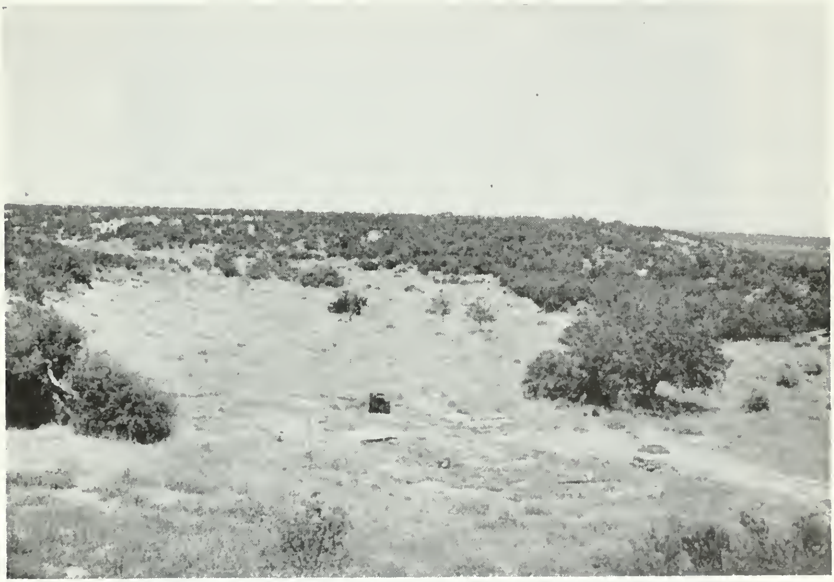

Fig. 41. A deserted homestead with remnants of house and orchard. Wild buckwheat is gradually pioneering into the grass and weed zone.

presence of water and more abundant food in the clearings created an environment particularly suited to quail and rabbits. In a few years quail were plentiful. Many of the homesteaders remarked on having seen thousands of quail in large coveys. In many cases, the ranchers in their semi-isolated situation, depended upon quail and rabbits for their meat supply. Some time after 1917, the "bubble" of their agricultural expansion burst and the ranches were abandoned. The fields of grain and alfalfa and the orchards of pears and apples were allowed to return to brush. Through a period of years, all of the houses were either burned or stolen and the orchards taken as firewood. Nothing remains of the original settlement but open cisterns, fire-scarred chimneys or foundations, and an occasional gutted dwelling. (See Fig. 42.)

Many of the property owners still hold the deeds to their land in the hope that oil will be found on the area. Much of the property has reverted to State ownership because of unpaid taxes.

Location, Topography and Climate

The area selected for this study lies on the desert north slopes of the San Bernardino Mountains and on the southern extremity of the Mojave Desert at an average elevation of 4,000 feet. The topography is considerably broken, especially adjacent to the mountains, by long, shallow, dry canyons and flat narrow mesas. The country flattens out three miles from the mountains into a gently sloping topography, drain-

Fig. 42. A deserted ranch site. The cistern and a few remnants of the house are all that remain of a $7,000 investment.

ing toward the desert and the Mojave River. Moisture in the form of dew and water is present only during winter and spring. The mountain range creates a definite barrier for the storms coming from the Pacific Ocean, and differences in rainfall, within a few miles, range from five to twenty-five inches annually. Rains seldom occur more than once a month during the rainy season and usually are of short duration. During the summer and the dry part of the year, the temperature varies from 65 to 110 degrees F., usually averaging about 95 degrees. Low humidities ranging from five to thirty-five per cent prevail. Wells have been drilled on the area to a depth of 600 to 800 feet before water was found. Only one spring is to be found on the range. This comes from an old mining tunnel half a mile from our watering site No. 6. The only natural water is found in a series of springs lying along a fault approximately five to seven miles from any of the sites. Many species of food plants, such as lupine, trefoil, four-o'clock, mustard and filaree, remain green and succulent until the latter part of July.

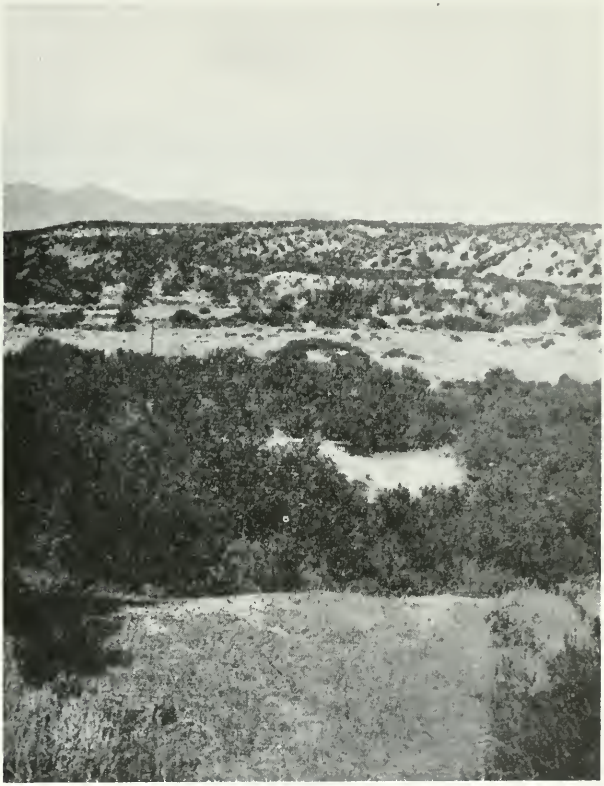

Fig. 43. Typical view of study area, showing roosting type of vegetation in foreground and food type in distance.

Vegetation

Two life zones are represented on the area. The Upper Sonoran is found close to the mountains and the climax vegetation is mesa oak (*Quercus dumosa*), chamise (*Adenostoma fasciculatum*) and manzanita (*Arctostaphylos*). This type breaks suddenly into the Lower Sonoran Zone, with the climax vegetation composed of juniper (*Juniperus californica*), sagebrush (*Artemisia*) and Joshua trees (*Yucca brevifolia*). Food types (weeds and grasses) are present, but the quail carrying capacity of these areas as to food supply is yet to be determined.

As soon as the range was homesteaded, the plow and fire broke up the climax cover into an excellent interspersion of heavy brush, light brush and clearings. These clearings are now in a successional stage

Fig. 44. Typical quail roosting area of juniper, interspersed with Joshua trees, wild buckwheat, trefoil and sagebrush.

Fig. 45. Watering site No. 10, showing the observation blind in left foreground.

and are gradually reverting to the climax type. The cover on these openings at the present time is characterized by trefoil (*Lotus*), lupine (*Lupinus*), filaree (*Erodium*), mustard (*Brassica*), California buckwheat (*Eriogonum*), wild plum (*Prunus*), sumac (*Rhus*), annual brome grasses (*Bromus*), and various other kinds of grasses. Most of these are excellent food species for quail. The irregular and spotty nature of these areas now affords quail edgings, food and nesting types. Roosting, escape and loafing cover are to be found in the adjacent climax types. The whole range is in a zone of tension between the Lower and Upper Sonoran life zones. As erosion affords no problem, it appears there is a place for clearing in creating additional food types. Sagebrush, wild buckwheat, grass and some perennial leguminous plants will establish themselves readily.

USE AND INSTALLATION OF WATER TANKS IN QUAIL RANGE EXTENSION

Description and Installation of Water Tanks

In August, 1936, R. M. Tullar was assigned the task of installing water tanks in known waterless areas where quail ranged during the early part of the year, but were absent during the dry periods.

By September, 1936, seven sites had been established. Because of the lateness of the season all were not filled with water, and no detailed records of use were kept. At least two of the sites had use. Site No. 6, even at that late date, was visited twice daily by 45 mountain quail. On June 10, 1937, five additional sites were located and all tanks were filled and were operating.

At each site, 8 to 10 feet from the water, a blind was carefully constructed of light wood, burlap sack and brush. From this vantage point, photographs were taken of birds, quail, rodents and snakes using the water.

Fig. 46. Water site No. 8; water trough at right, observation blind at left.

Hawk traps were placed on posts at several of the sites to obtain a measure of the hawks and owls that were attracted to the sites.

The cost of installation of the standard trough unit (see Fig. 47) included $2.50 or less for materials and two man-days of labor.

The labor and material costs for the "dew-dropper unit" (see Fig. 49) were both considerably less.

The maintenance of these units required but little time. The troughs were cleaned out from time to time or were lowered or raised as their condition warranted. In our case, the hauling of water to make the refills required the greatest amount of time and energy. If a tank truck could have been used it would have taken but a day and a half to fill the tanks at all 12 sites.

For the most part, the apparatus used by the Forest Service was similar to that used by the California Division of Fish and Game in their quail refuges. A slight modification was devised in 1936 by R. M. Tullar to suit our conditions. The apparatus used in the first installation differs from the others, mainly in the fact that it was fence-enclosed to exclude live stock. In subsequent installations a simple cover was devised over the watering trough to protect it from cattle. (See Fig. 47.) The cover is more efficient than the fence since it also discourages use by coyotes. Coyotes and dogs, however, by thrusting their muzzles sideways through the iron rods, were occasionally able to obtain water.

In general, the apparatus consisted of:

a 50-gallon drum (12-gauge)
$\frac{3}{8}$-inch pipe connecting the drum to the trough
2 unions (to facilitate moving)
1 trough (24-gauge galvanized iron)
2 redwood planks, 2 x 8 x 24 inches
20 iron bolts

A constant water level is maintained in the trough by making use of "negative pressure" in the drums (in principle like the watering apparatus used in chicken pens).

With regard to the operation of the units, several points should be mentioned. The drums are made air-tight by the use of leather washers and some petroleum water seal. The copper tube acts as an air feed; as water flows from the drum into the trough, air must enter into the drum through the tube. When the water in the trough reaches a depth of $2\frac{1}{2}$ inches, it is level with the end of the copper tube in the drum, and this level is then hydrostatically maintained. The water level in the trough can easily be altered by merely lowering or raising the trough. The air-tight chamber of the trough is formed by two incomplete partitions which just cut the water's edge. In the front partition, the remaining space is filled by a strip of window screen to prevent any trash from getting back into the cleaning chambers and thence clogging the pipe. The back partition is left incomplete so that, from time to time, both chambers may be cleaned of any fungus or dead insects that may be present by removing the lid and reaching in.

The placing of sharp-pointed staples in the trough to prevent lapping animals from drinking is a waste of time and hinders adequate cleansing of the screen. These staples in no way discourage dogs from obtaining water.

The trough is set in cement. Within the cement and extending into the ground for a depth of ten inches to a foot, is a continuous strip of chicken wire to prevent rodents from undermining the trough and destroying the level. Into this cement are set twenty 8-inch bolts to

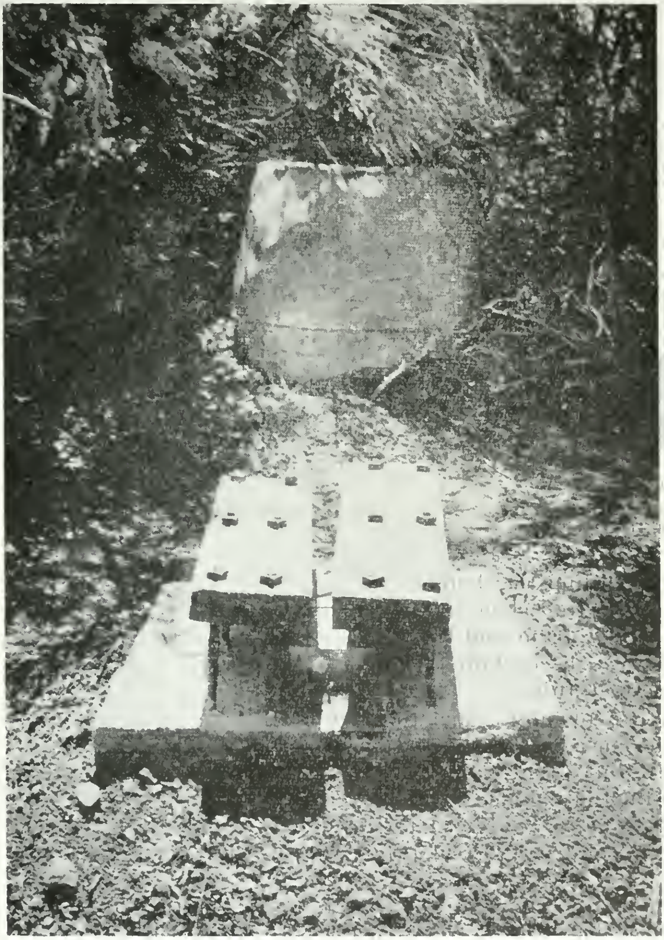

Fig. 47. Standard quail watering unit; tank in background, trough set in concrete with wooden protector to keep cattle out.

support the cover, this consisting of two separate boards 2 x 8 x 24 inches. The distance between the top of the trough and the bottom of the cover is 5 inches. The two halves of the cover are not placed farther than $1\frac{1}{2}$ inches from each other, and parallel. The $\frac{3}{8}$-inch pipe is buried, mainly to prevent trampling and to prevent disturbance of the set-up, were the pipe to be jarred.

The following precautions should be exercised in manipulating this equipment:

1. In setting up or removing, be especially careful when screwing the pipe into (or out of) the soldered bushings.

Fig. 48. Quail watering trough used by California Division of Fish and Game. This open type should be enclosed by a fence in cattle country.

2. In refilling the drum, always first screw on the refill cap in the trough, otherwise, when the refill bung is removed, all the water will flow out of the drum and trough.

3. Always be certain that the drum is absolutely airtight except for the copper tube.

4. When picking a spot to place the drum, either place it in solid shade and encase in an insulation of dirt, or if the slope is sufficient, completely bury the drum. If this is not done, expansion from temperature fluctuations may be sufficient to cause the trough to overflow. Fluctuation of the water in the trough is in direct proportion to the temperature and in indirect proportion to the amount of water in the drum.

A radically different watering unit was used at one of the sites, and to date has proven very successful. (See Fig. 49.) It merely consists of a single pipe leading out of the drum and into which are screwed small brass "alemite-like nipples" approximately one foot apart. The small ball-like valve is bright and the quail readily peck at it, obtaining a few drops of water each time. A small drop of water usually is suspended there and the sunlight glinting on this drop also serves to attract the birds. According to Sumner [2] quail frequently satisfy their water requirements by utilizing small dew drops found on vegetation. A small tin trough is placed beneath the nipples to

[2] Sumner, E. Lowell. A life history study of the California quail, with recommendations for conservation and management. CALIFORNIA FISH AND GAME, vol. 21, no. 3-4, pp. 167-256, 277-342, 1935.

catch any waste drip. There is always a small amount of water in the trough and the birds drink partly from the unit and partly from the trough.

Individual quail develop their own technique for using the nipples. Many quail hold their open bills against the valve and drink without moving their heads; others will seize the valves vigorously each time. The majority turn their heads sideways and merely peck lightly at the bright brass valves, obtaining a drop or two at a time.

This unit apparently has many advantages:

1. Efficient means of dispensing water.
2. Other animals can not manipulate the valves.
3. Quail readily learn to manipulate the valves.
4. Drum need not be air-tight.
5. No insulation required.
6. Inexpensive installation (approximately 20 cents per foot of pipe).
7. Minimum evaporation because there is no exposed water surface.

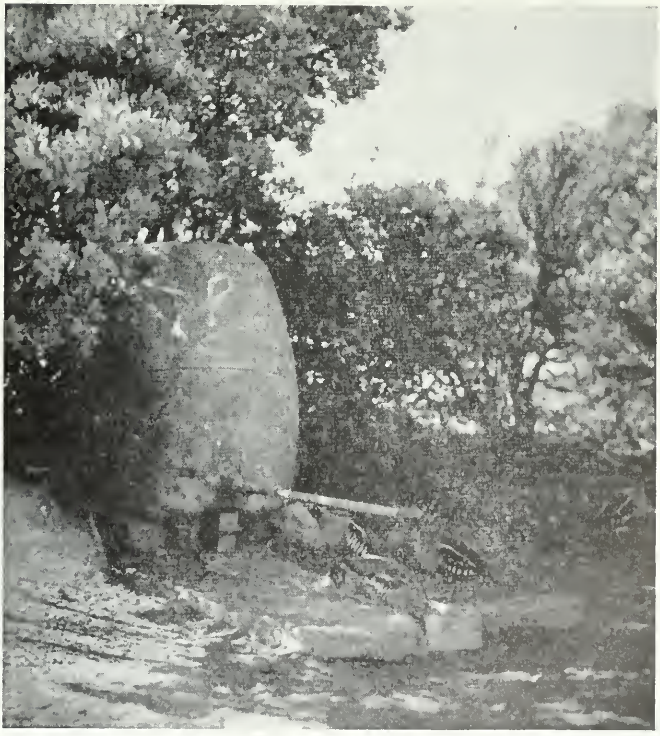

Fig. 49. Mountain quail drinking at the "dew dropper" unit—one from nipple and one from trough.

There is a possibility that dirt in the water would cause the valves to remain open and allow the water to escape. This has never happened to this particular unit. Highly mineralized water might cause a precipitate to form around the valves, not allowing them to seat themselves evenly. This could be remedied by cleaning off the valves with sandpaper at the beginning of each summer season.

An important factor to remember when installing this unit is to keep the water pressure as low as possible. High pressures are conducive to wastefulness—when a bird trips the valve, water will shoot out under high pressure conditions.

As previously mentioned, the extreme fluctuation of the length of exposed water surface in the trough was a continual source of water waste. This was caused by the expansion of air within the drum. If the trough were adjusted to adequately supply the quail with water during early morning and late evening, by mid-day the trough would overflow. If adjusted during mid-day, no water would be exposed in the early mornings when the birds usually watered. An attempt was made to reduce this daily fluctuation by insulating two drums with dirt. This resulted in a reduction of almost 70 per cent in the daily fluctuations.

Factors Influencing the Supply of Water in Tanks

The following study concerns the loss of water from the 50-gallon tanks through evaporation, use by animal life, and overflow of trough due to high temperatures.

TABLE 1

AVERAGE AMOUNT OF WATER LOST THROUGH EVAPORATION

Film length (inches)	Average number cubic centimeters evaporated per day (24 hrs.)	Average number of gallons evaporated per month
2	90	0.7
4	162	1.3
6	174	1.37
8	133*	1.0
10	180	1.4
12	240	1.9

* Taken under high humidity conditions.

TABLE 2

DATA TO BE USED IN ACCOUNTING FOR WATER UTILIZATION PER MONTH

1. Amount of water evaporated per month (average of 6 levels)	1.3	gallons
2. Use per quail per month (3 waterings daily)	0.237	gallon
3. Bees (large apiary) per month	43.0	gallons
4. Birds, rodents and overflow	Great	

From tables 1 and 2, one can account fairly accurately for the water utilization at any particular site. It is difficult to say exactly how much water will be used at any one site, for they all have varying intensities of use by bees, rodents and birds. Some tanks have a large daily fluctuation in film lengths and will overflow during extremely high temperatures; several gallons of water may be lost daily during a severe heat wave.

The two-inch level is the distance which loses the least water through evaporation; there is but a slight difference in loss between the 4-inch and 10-inch levels. At any rate, if the troughs are kept filled, we can expect to lose little over two gallons per month through evaporation.

Water Requirements of Quail

Until some effort is made to tag or mark the birds, it is difficult to determine the exact water requirements of quail. In numerous controlled experiments, it was found that mountain quail utilized between 9.5 and 10 cubic centimeters at a watering, with an average of about 9.8 cubic centimeters. There appears to be no established number of watering periods during the day. The habits of the coveys are vastly different and even the coveys themselves are very inconsistent. If it is warm and dry, they will visit the water two and three times daily. If moisture in the form of dew is available they are likely to water only once every two or three days. At times they will be at the water at the break of day or in the evenings when it is too dark to see them. Again, they will visit the sites at mid-day and remain for several hours around the tank, drinking, loafing, and dusting.

Table 3 and the following data indicate the amount of water required by each site from June 10 to December 1, 1937, ten days less than six months. The drums were all filled or nearly so at the conclusion of the experiment.

TABLE 3

WATER USED AT EACH SITE JUNE 10-DECEMBER 1, 1937

Site No.	Amount of water (gallons)	Remarks
1	182	Medium use by quail; heavy bird use
2	123.5	Very light use by quail; heavy bird use
3	188	Very light quail use; heavy bee use
4	280	No quail use; heavy bee use
5	146.5	Medium quail and rodent use
6	188	Very heavy quail use (dew dropper)
7	194	Medium quail use; bees
8	193	Early, heavy quail use Later, light quail use. Bees and rodents
9	188	Early, heavy quail use Later, no quail, heavy bird and rodent use
10	211	No quail use; heavy bee use
11	171	Heavy quail use
12	270	Very heavy quail use
Total	2335.0	

Data pertinent to utilization:

1. Period of use	Approximately six months
2. Average amount of water required by all 12 sites	194.6 gallons
3. Most representative site under constant use by quail alone	Site 6, which used 188 gallons
4. Average amount of water required per month per site	32.6 gallons
5. Average length of time one tank would last	1.4 months
6. Maximum used by any site	Site 4: 280 gallons. No quail use; many bees
7. Minimum used by any site	Site 2: 123 gallons. Very few quail; many birds; insulated to allow a constant short film of exposed water.
8. Range between maximum and minimum	156 gallons
9. Two sites most efficient at any time during the summer	Site 2: average 9 gallons per month during last 3 months. Little or no quail use; many birds Site 6: average 15 gallons per month under use by 50 to 75 quail. (Dew dropper)
10. Most inefficient sites at any time during the summer	Site 10: used 45 gallons per month when apiary operating; no use by quail Site 4: used 45 gallons per month; no quail use; large apiary present
11. Heavy use by 50 quail	Used about 12 gallons per month

THE EFFECT OF WATER DEVELOPMENT

The Quail of the Study Area

Three species of quail are found in the San Bernardino National Forest. The most abundant species in the study area is the mountain quail (*Oreortyx picta plumifera*), which comprises 74 per cent of all

Fig. 50. Gambel (desert) quail, adults and fledglings, drinking at site No. 9.

the quail at present. Next in abundance (23 per cent) is the valley quail (*Lophortyx californica vallicola*). Desert or Gambel quail (*L. gambeli*) are rather scarce, composing but 3 per cent of the quail population.

The mountain quail thrive mainly in the Transition Zone, but not abundantly. Odd as it may seem, these birds were the ones found on the range in the largest numbers, and consequently were the ones observed in this study. The desert environment is not adversely suited to their welfare, for they are frequently found near water in the dry, barren hills east of Victorville and Barstow, 40 to 100 miles into the Mojave Desert. These birds do not seemingly stand up well under present hunting regulations, and their presence in the San Bernardino Mountains can be attributed to the dense brush in which they are usually to be found during the hunting season. They are great rangers and can readily be attracted long distances if the various factors conducive to their welfare can be found. The water tanks proved to be very attractive to mountain quail.

The desert quail ranges for the most part outside of the forest boundary, except perhaps in the vicinity of Palm Springs. Many of these birds are found in Coachella Valley and around Barstow where they are found preponderantly in the mesquite association. It is entirely possible that these birds are not dependent upon water in its physical state but can use that found in succulent plants to just as efficient advantage. However, during the course of this study, they were actually seen and photographed at one of the watering sites. (See Fig. 50.)

Biota in General and Its Relationship to Quail

California jays are abundant and there is a possibility that they are important as regards quail egg destruction. No evidence was found that they are detrimental. They drink considerably at the sites, but are timid around the quail. The quail fledglings react rapidly to the alarm calls of the ever vigilant jays. Many times broods at the water troughs were observed to scurry to cover at the jays' wild screeches, to be well hidden when a hawk approached.

Horned larks, thrashers, thrushes, sparrows, flickers and doves all are present in moderate to abundant numbers. They visit the sites and drink several times daily and are only important in that they utilize and waste water. The thrashers, sparrows and jays bathe continuously, and frequently the ground is wet for a distance of two feet on all sides of the trough as a result of their ablutions. All of these birds are apparently timid and respect the stolid mountain quail.

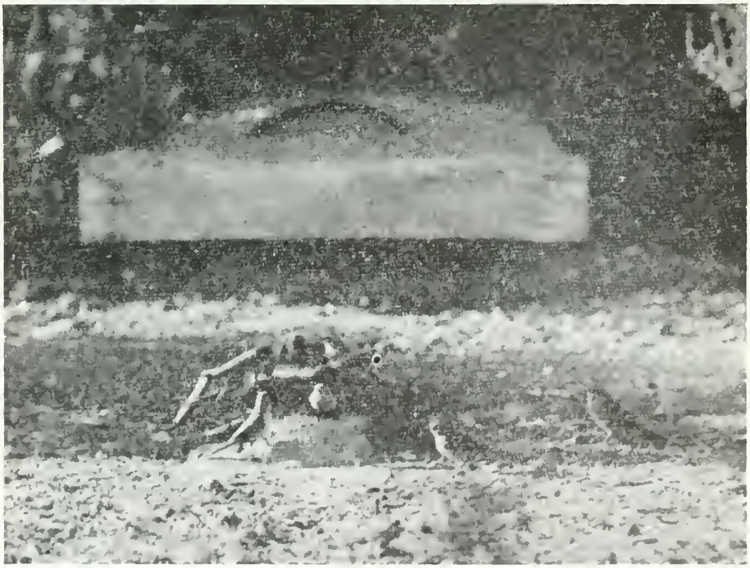

Fig. 51. Sparrows drinking and bathing at site No. 1. This is an uncovered trough, protected from cattle by a fence.

Sharp-shinned and Cooper's hawks are fairly abundant on the study area. These two hawks are definitely predators of quail, but it is difficult to determine to what extent. In four cases they were seen to kill quail at the watering sites. Several were caught in the hawk traps.

Horned owls are plentiful on the range and probably take some quail. Five were caught in the hawk traps. On examining the pellets from these birds, we found no evidence that quail had been taken; only the remains of wood rats, kangaroo rats, rabbits and small snakes were found.

The tracks of skunks were never seen, and bobcats are apparently scarce. There are about two coyotes to the section, and they frequently

Fig. 52. Part of a covey of mountain quail watering at site No. 8. Note how the birds are crowded around the trough.

visit the water troughs. I do not believe that they are of any great importance as quail predators, as indicated by stomach and scat examinations. These coyotes are great rangers as grapes were frequently found in the feces and there are no vineyards or grapes closer than seven miles from the range. Their diet consisted almost entirely of rabbits and other rodents.

Deer are frequently seen in the area during the winter months. Live stock occupation is seldom and slight.

Rodents are numerous and consist mainly of rabbits, gophers, California ground squirrels (scarce), antelope ground squirrels, desert wood rats, kangaroo rats and white-footed mice. These animals are competitors with quail for food, and if attracted to the sites, might create complications. A measure of the rodent concentration was made by running two transects of traps across one of the sites before water was installed. The initial study showed no trends, *i.e.*, rodents were not particularly more abundant near the sites than at a distance. On October 4–7, 1937, the height of the drought period, another sample was made, and still no trends were in evidence. (See Table 4.) Another trapping should be made in June, 1938, which would be comparable to the initial survey.

TABLE 4

NUMBER OF RODENTS CAUGHT (INCLUDING TRAPS SPRUNG OR LOST) AT WATER SITE No. 8 BEFORE AND AFTER WATER WAS AVAILABLE

Distance from water (feet)	June 11–19, 1937, before water was available	October 4–7, 1937, after water was available
5	1	7
20	3	4
35	1	1
50	3	2
65	3	3
80	2	3
95	4	0
110	3	1
125	2	3
140	0	4
155	2	5
170	0	0
185	3	1
200	1	3
215	4	1
230	2	0
245	1	3
260	4	2
275	2	1
290	3	4
305	4	1
320	2	1
335	2	2
350	2	6
365	1	1
380	3	6
395	0	1
410	3	2
425	4	1
440	2	2
455	4	-
Totals	71	71

It is quite possible that water, in its physical state, has no attraction for these desert rodents. They may obtain sufficient moisture from the taproots of desert plants or by a chemical breakdown of the carbohydrates. Of the diurnal rodents, ground squirrels (both antelope and California) drink frequently. Numerous photographs have been taken of several of them drinking at the same time. There is a possibility that these rodents are important as regards clutch destruction; valuable information could be obtained by making a study during the nesting cycle.

Rattlesnakes, racers and other snakes are attracted to the water. They have been observed drinking on numerous occasions. The stomach contents, when examined, never disclosed quail or their eggs; rabbits were found frequently.

Fig. 53. A cleared mesa with filaree, trefoil and mustard. An old homestead.

Study of Vegetation by Quadrats and Transects

In order to measure vegetative trends around the sites, quadrats were established and should be re-observed from year to year. This study was carried on at site No. 8. Meter-square quadrats were placed at different distances on four axes, 25 and 200 feet on the north, 135 and 386 feet on the west, etc.; six of this type were located. Two stakes were driven into the corners of each quadrat to facilitate realigning the plots when the examination is again made; distances and compass bearings were also taken. The vegetation upon each quadrat was charted to a scale of 16 square inches to a square meter. Plant colonies were mapped to scale and an appropriate letter abbreviation of the species placed within the area. Symbols were used for isolated and individual species. Too often there is a tendency to adopt methods of obtaining such information from established practices, such as grazing. At times, in this work, the methods should be altered to garner the desired results. The effect of quail and rodent utilization can not be compared with that of deer or cattle. For this reason another method was adopted in which random sampling was sacrificed. Milacre quadrats were established in belts parallel to and extending out from the water troughs. One belt was 20 feet from the water, another 80 to 100 feet. Care was exercised to place these plots in food types (filaree, mustard, etc.) and in areas of similar species and densities.

Two quadrats were placed in the burned area west of sites Nos. 1 and 2. This fire occurred in a climax type of oak and manzanita. It is hoped that the quadrats will aid in determining the successional trends of vegetation after burning. It is possible that spot burning, to create an interspersion of food and cover types, has a place in quail management. From casual observation of the hills north of the railroad, repeated small fires have improved this area for quail range.

In order to gain a better understanding of the area as a whole, a 3000-foot transect was made across a typical portion of the range. Three photographs made along this transect (Figs. 43, 53 and 54) give a better idea of the topography and interspersion of plant types than a written description.

GENERAL OBSERVATIONS ON THE QUAIL RANGE

On or about June 1, 1937, actual work started on the range. Pairs of quail were frequently seen; approximately 25 pair were spotted, but more could have been found if a detailed survey had been made. All available time was utilized in installing the water sites as rapidly as possible. Several coveys were located at this time, the fledglings being from two to six weeks of age, indicating that some broods had hatched in April. The nesting sites were well distributed over the range; it

Fig. 54. East end of line transect; deserted ranch and feed type of vegetation in foreground, brushy mesa in background.

did not appear as though the presence of the previously installed water sites had influenced the locations of the nests. Fog, dew and succulent vegetation were present, and water in its physical state was evidently not essential.

The cocks were heard daily, uttering their calls from the tops of the junipers. They were not, in all cases, unmated males. Frequently upon approaching them, nesting hens were flushed nearby. This habit of the cocks continued until after the broods were hatched. Several small coveys of fledglings were located by following the calls of the males. No utilization of the water sites took place until the fledglings were well feathered out and able to fly short distances. The success of the clutches was markedly good; many broods were in evidence, and all contained from 12 to 15 fledglings, which is quite high.

The use of the respective units is indicated in table 5. The peak

Fig. 55. Mountain quail watering at site No. 8. Note the chipmunk at left of trough.

of use occurred from August 1 to September 1, and closely corresponds to the high temperatures and the disappearance of the succulent vegetation. The continuation of use so long past midsummer was probably caused by the long dry fall which was characterized by infrequent light rains and frequent dry north winds.

The tabulation of water utilization presents several problems which are difficult to answer unless a trapping and banding study should be made, together with a life history study of the mountain quail on this area. Apparently the usual habit for these quail was to spread over the area during the winter and spring, nest, and return to the mountains when drought conditions became critical on the desert. This casual migration was partially halted by the installation of water, but some migrations continued. Site No. 10 was spotted in an isolated locality because of the presence of one pair of mated quail. During the course of the summer many coveys ranged across this site toward the east and southeast and did not visit the water. This area was thoroughly searched for nests or mated birds, and with the exception of the one pair, none was found. Evidently these coveys were making their annual pilgrimage to the mountains or the Mojave River. Site No. 10 was not desirably situated; an apiary was located close by and the trough was always literally swarmed over by bees. From other observations, we know that the quail are nervous and jumpy around the bees and are often reluctant to drink in their presence. This trough received but one visit during the summer, but quail tracks were usually found within 20 to 50 feet of the water.

The fact that some sites received immediate regular visits by quail, and others only periodic visits months later, is another problem. Possibly crop analyses taken at definite times would reveal the answer. At Site No. 5 quail were always seen around the site, but they did not start to use water until a month or six weeks after several of the other sites. At sites Nos. 8 and 9, the first heavily used units, the visits ceased altogether by September. There could have been several answers for this action. Predators might have depleted the coveys, a migration might have taken place after flocking, or they might have moved to other sites. The last explanation would explain the observed increase at other sites.

The survival of the fledglings was exceptionally good until they were three-quarters grown. At that time, the coveys began to be severely depleted. At sites Nos. 5, 7, 9 and 12, I found evidence where sharp-shinned and Cooper's hawks had taken the quail while they were watering. It appears that the greatest danger from predators occurs with mountain quail when the birds are almost mature. Evidently they do not react as quickly to the alarm calls of the parent birds; they are larger and afford better targets for hawks; they are more careless and wander from the covey. This predation occurred in the space of a month. In some cases, only 4 or 5 birds remained out of an original covey of 15. It is believed that toward the end of the summer many of the larger coveys were really flocks composed of the remnants of smaller coveys.

Daily observations and photographs were made from the blinds adjacent to the water sites, and much was learned about the habits and reactions of mountain quail. The maximum number of quail using the sites was approximately 637, with an average for the whole summer of about 313. The intensity of use corresponded closely with weather conditions. During rainy or cloudy periods, they would water irregularly, every day or two. Otherwise the frequency of their visits probably was controlled in many cases by the interspersion of the various habitat factors. It was noted that where all the factors, food, cover, roosting sites and water, were compactly distributed, the coveys ranged very little, not often exceeding one-half mile. At site No. 6, which was located a mile or more from the feeding grounds, the quail ranged considerably. I have observed them covering this distance in rapid time because of their eagerness to reach the water. Valley quail also ranged consider-

TABLE 5

WATER UTILIZATION BY QUAIL, JUNE 10, 1937-JANUARY 30, 1938

Site No.	June 10	June 15-June 30	July 1-July 15	July 15-July 30	Aug. 1-Aug. 15	Aug. 15-Aug. 30	Sept. 1-Sept. 15	Sept. 16-Oct. 31	Nov. 1-Dec. 1	Dec. 1-Dec. 15	Dec. 15-Jan. 1	Jan. 1-Jan. 15
1	0	0	Regular 2 coveys (30-40)	Regular 3 coveys (40-50)	Regular 3 coveys (40-50)	Regular (25-30)	Periodic (20-25)	Periodic (10-15)	Periodic (40-50)	Periodic (40-50)	0	0
2	0	Periodic *1 covey	0	0	Regular 1-2 coveys (15-20)	Periodic (15-20)	0	Periodic (25-30)	0	0	0	0
3	0	0	0	0	*Periodic 1-2 coveys (15-20)	Periodic (15-20)	0	0	1 visit (25-30)	0	0	0
4	0	0	0	*Periodic 1 covey (12-15)	Periodic 1 covey (12-15)	Periodic 1 covey (12-15)	0	0	0	0	0	0
5	0	0	0	*Periodic 2 coveys (25-30)	Regular 2 coveys (25-30)	Regular 2 coveys (12-15)	Regular (8-12)	Regular (8-12)	0	0	0	0
6	0	0	*Regular 4 coveys (50-60)	Regular 4 coveys (50-60)	Regular many coveys (150)	Regular (150)	Regular (150)	Regular (50-75)	Regular (50-75)	Periodic (25-30)	Periodic (25-30)	0
7	0	*Periodic 1 covey (10-12)	Periodic 1 covey (10-12)	Periodic 1 covey (10-12)	Regular 2 coveys (25-30)	Regular (20-25)	Regular (35-40)	Regular (12-15)	Periodic (25-30)	Periodic (25-30)	0	0
8	0	*Periodic 3 coveys (25-30)	Regular 2 coveys (25-30)	Regular 3 coveys (35-45)	Regular 3 coveys (35-45)	Regular 3 coveys (25-30)	Periodic (45-50)	Regular (15-20)	0	0	0	0
9	0	*Regular 2 coveys (25-30)	Regular 2 coveys (25-30)	Regular 3-4 coveys (35-45)	Regular 3 coveys (35-45)	Periodic (15-20)	0	0	0	0	0	0

10	0	0	0	*Watered once, 1 covey (10)	0	0	0	0	0	0	0	0
11	0	0	*Periodic 2 coveys (15-25)	Periodic 2 coveys (15-25)	Regular 3 coveys (30-45)	Regular (25-30)	Regular (35-40)	Regular (35-40)	Regular (35-40)	Periodic (25)	Periodic (25)	0
12	0	*Periodic 1 covey (8-10)	Regular 3 coveys (35-40)	Regular 4 coveys (40-60)	Regular many coveys (75-200)	Regular (75-200)	Regular (75-200)	Regular (75-150) Some dew and fog	Regular (75-150) Rain, fog and dew	Periodic (50-75)	Periodic (50)	0

* Indicates—Fi st use.
Covey—Family (hen, cock, fledglings).
Number—Number in covey.
Periodic—Irregular visits (3 to 4 days apart).
Regular—Daily or twice daily visits.
Sites 1, 2, 3, 4, 6, 11, 12 installed in 1936.
Sites 5, 7, 8, 9, 10 installed in 1937.

ably if these various factors were widely distributed, but they tended to remain more in the same locality. No observations were made on the desert quail because of their scarcity.

The watering habits of the three species are essentially different. The mountain quail are more stolid; observations and photographs were easily made. The Gambel and valley quail are very alert, especially the Gambel. Often a slight movement by the observer or the click of the camera shutter would frighten the whole covey.

Mountain quail are great loafers and spend considerable time dusting, playing and pluming themselves in the shade of the junipers or

Fig. 56. Mountain quail at the "dew dropper" unit, site No. 6.

manzanitas. If they water in the early mornings, they remain at the site from 20 to 45 minutes. If they visit the site during the heat of the day, they are likely to remain from two to four hours. They drink periodically during this time, but the majority of the covey would be found loafing and dusting.

The parent birds are ever alert for danger, and have definite positions for guarding while the fledglings are watering. In two coveys that were carefully observed, the cock and hen always took definite positions. The cock, in one covey, always mounted the wooden covering of the water trough. The cock in the other covey always first circled the entire site and took his position on a small hillock 25 feet from the trough and in the open. In many cases, the adults did not drink until the fledglings had finished and frequently, during the first of the summer, never touched the water. During the course of a twenty-minute drinking period, the fledglings would scurry to the adjacent protective brush cover several times; this was always done at the warning calls of the parents or blue jays. For this reason the water should always be located under some protective brush cover.

Many roosting sites were found, and in only one case was a mountain quail found roosting on the ground. This bird was injured and unable to follow his mates, spending the night at one of the sites and on the ground. Coveys were found roosting in manzanitas, mesa oaks and junipers. The birds perch on the limbs about 16 inches apart. A few birds were observed near the top and bottom, but the majority were near the center of the crown. On one occasion a covey spent the night on the wooden rails of a fence that enclosed one of the sites, completely exposed to owls and other night predators.

These quail rarely or never drank immediately after leaving their roosting sites in the mornings. As soon as it began to get light, a few birds would fly to the ground, ruffling their feathers and stretching their legs and wings; soon they were followed by the others. They would immediately start feeding in a sort of "skirmish line" formation and in the general direction of the water site. The lateness of their watering on the previous night apparently determined the time of morning that they drank. They seldom used the same roosting site twice, but would invariably approach the watering sites from the same direction. After watering, they would feed considerably around the site and would frequently return to drink two or three times. They scratch and feed in the patches of filaree and lotus, but will continue moving even though they range into an area where food is scarce. They may cross the food patch several times, but do not tend to linger and satisfy their hunger in any one place.

During the hunting season, the hunting effort was observed in different types of cover of varying densities. It was interesting to note that on areas with cover of a density similar to the project area, limits of valley quail were scarce. This species will survive well if the cover affords half a chance to escape. Adjacent to the range, several limits of mountain quail were checked. The hunters claimed that once the coveys were located, they encountered no difficulties in getting a limit of birds. Mountain quail shooting in our heavy brush areas, the typical mountain quail country, was poor. The quail were present but the dense brush restricted hunting.

A survey of the area, the reaction of landowners to the study, and whether or not to close the study area to hunting presented serious problems and considerable thought was given to the subject. Two alternatives presented themselves at the beginning of this study:

1. Should the area remain open to hunting to determine how well the quail could increase under open shooting conditions?

2. Should the area be closed to hunting to facilitate the study of quail under natural conditions—then, when the range was adequately stocked (two or three years), close only small areas around the watering sites?

The latter alternative was adopted. It was then necessary to survey and map the area and accurately locate each site, tying it into the Public Land Office survey. This done, the ownership was determined from the tax records and each property owner was contacted and requested to sign temporary agreements, allowing us to close their property to hunting and permit us to make the study.

The majority of the landowners were sympathetic and signed the agreements. A few persons were opposed to signing their names to any agreement, fearing some hidden clause. They did not object to the study or the closure but were afraid of tying up their property.

In any extensive quail range extension project on these desert lands, the attitude of the owners of deserted homesteads is the most important single factor. They are holding the land for speculation, oil or otherwise, and the best meant explanations and agreements are useless against their stubborn refusal to sign their names to any agreement unless some monetary remuneration is offered.

CONCLUSIONS

It was expected that the installation of water on our desert range would attract valley quail; instead, about 75 per cent of the birds using the water troughs were mountain quail. In any area where the brush cover is such that the hunters consider it "good hunting country," it is believed that the mountain quail will not stand up under even medium shooting. They are large, slow moving targets and have such strong terrestrial instincts that they are difficult to flush. They will stand stupidly around and be shot on the ground. On this forest, it is believed, they owe their present survival to the exceptionally heavy brush stands where they are to be found during the hunting season. If valley quail can not be attracted to the area, an experiment in artificial planting is recommended. If and when the area is opened to hunting, the brunt of the shooting should not be borne by the mountain quail. The extension of mountain quail range is not recommended.

This study is not complete, and the accomplishments to date should be taken as a progress report. The objective—attracting and holding quail on this waterless area through the use of water tanks—has been successful. The total effects of a study as intricate and far reaching as this can not be started and completed within a few short months. The natural environment of this area has been disturbed by the introduction of a foreign factor, water. Natural trends and changes occur slowly; it may be years before the actual effects can be observed. However, the preliminary studies show that quail range extension is feasible and that the biological consequences would not be detrimental. Continued observation over a period of years should be made. The opportunity for stocking with desert and valley quail is excellent. Increases in population could be made together with the determination of population levels in this type of country.

The hunting areas in the more populated sections of southern California are becoming limited. More hunting clubs, private property and "no hunting" signs, are seen yearly; the sportsmen will soon demand more public hunting areas. In our Public Domain and desert wastelands lies the solution to the problem. Thousands of acres of this land lie unproductive and idle, ready to be changed from a wasteland and scenic curiosity to a valuable shooting ground.

THE MUSKRAT AS NATIVE AND ALIEN: A CHAPTER IN THE HISTORY OF ANIMAL ACCLIMATIZATION [1]

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The muskrat (*Ondatra zibethica*) is one of the characteristic and conspicuous rodents of North America. Its native range includes a large part of this continent. From the early days of settlement down to the present day the muskrat has occupied a position of major economic importance in the fur trade. Its wide geographic range, its abundance numerically and the ease with which it may be trapped have resulted in the taking of millions of pelts. Records from Canada indicated an annual take from 1919 to 1924 of between two and three million annually. The number of muskrat pelts used by American furriers in 1919 was estimated to be over eight million. Despite this heavy and continued levy, the muskrat, unlike the beaver and some of the carnivores, has maintained its range and general population level, largely because of its fecundity. During recent years, interest in fur farming has resulted in the escape and transplantation of the muskrat in many areas where it was not native, in western North America and in various parts of Europe and Asia. In time the muskrat will probably be the most widely distributed single species of fur-bearing mammal in the world. Its spread in western Europe during the past 30 years constitutes the most outstanding instance of successful acclimatization among wild mammals in the present century.

Over most of its native range the muskrat is considered an asset, by reason of its value as a fur-bearer, with few or no detrimental aspects. Such is the case in many of the marshy areas of the eastern United States and in Canada.

In regions where canals are necessary for irrigation or for drainage, muskrats, when present, constitute an adverse factor since their burrows may lead to breaks in the banks of such canals.

Original Distribution

Under primitive conditions the muskrat occupied the greater part of Canada and the United States. It was and is more generally distributed in the East and North, while in the arid West its distribution is discontinuous by reason of the localization of marshes and other suitable habitat. The species is lacking from certain seemingly favorable areas in the Southeastern and Gulf states. Muskrats probably reached some of the now isolated waters of the West during a period

[1] Contribution from the Division of Zoology, College of Agriculture, University of California, Davis, California. Reprinted (with some changes by the author) from Journal of Mammalogy, vol. 18, pp. 443-460, 1937.

when aquatic and palustrine habitats were more widespread, in late Pleistocene or postglacial times. With subsequent contraction of habitat, stocks were reduced and isolated, since when limited subspecific differentiation has occurred. Parallel cases are known among amphibians and fishes in the western states.

In California the muskrat was native only to the Colorado River, along the Arizona boundary, and in scattered localities affording suitable habitat on the arid east side of the Sierra Nevada, from northern Mono County to central Lassen County. It was not present in the interior (Sacramento and San Joaquin) valleys, nor in the Modoc plateau. Newberry (1857, p. 62) was the first observer to comment on the suitability of these areas and their lack of occupancy by muskrats.

Some of these gaps in the original distribution of the muskrat are puzzling, since the species occurs in essentially similar habitats but a short distance away. Thus, in northeastern California the native occurrence at Eagle Lake, in Lassen County (of subspecies *mergens*), is less than 50 miles from suitable territory on Pit River in Modoc County. Parts of the Pit River drainage, as detailed beyond (Fall River Valley, Shasta County), have since proved eminently suitable. If muskrats had, in times past, reached the Pit River in northeastern California, they could very well have reached the Sacramento-San Joaquin basin, as they bid fair to do in the near future. Such gaps in distribution, where a species should occur "logically," only reflect our imperfect knowledge of the factors controlling animal distribution and emphasize the importance of the study of transplanted stocks.

Transplantation

Transplantation of animals to new localities has been a feature of man's activities since before the dawn of recorded history. The dogs of the American Indians, several domesticated animals, and the rabbit and pheasant in parts of western Europe, are early instances of transplantation and acclimatization. Transfer of the muskrat to new localities began, so far as available records indicate, after 1900. The first conspicuous transplant was that into Bohemia in 1905. One instance in California apparently dates back at least to 1911. A majority of the records, however, are more recent, following the development of fur farming. Interest in the possibility of farming muskrats probably arose from emphasis on the general decline in stocks of wild, fur-bearing animals, the success in the artificial rearing of silver foxes, and the development of the American fur markets following the World War. During the decade 1900–1910, little was said, in the literature, regarding depletion of the wild fur supply. Attention was focussed on the subject during the next decade, when numerous articles and books stressed the ever increasing market for fur, the decline in wild stocks, and the possibilities of fur farming as a means of augmenting the supply. At the beginning of the century, owners of a few marshlands in eastern states had already recognized the value of the muskrats thereon, and such areas were treated as preserves, or "wild farms," from which a regular annual yield was obtained. In 1917, Lantz stated that the commercial value of muskrat skins individually was so low as not to warrant attempts at purely artificial production. Despite this and other similar statements, there developed, subsequent to 1920, a large popular interest in the possibilities of breeding muskrats under various artificial conditions. The matter, being new, was subject to little or no legal regulation. Interest in the capture, production, and sale of "breeding stock" increased. Fur journals carried advertisements of allegedly fancy breeding stock, offered at obviously fancy prices. The history of this endeavor has not been written fully and the extent to which wild stock of various subspecies was mixed is unknown. One farm in California was reported to have obtained stock from Colorado, North Dakota and Ohio, thus possibly involving at least two subspecies; Alaska and Quebec muskrats are stated to have been crossed, and other admixtures are hinted, but whether these attempted hybridizations were successful is unknown. In several instances the original animals or their descendants have escaped or have been liberated in various localities. Whether "dealers" trapped their "selected breeding stock" from local marshes or obtained it by purchase or exchange from other dealers is unknown. Little of a definite nature can be said concerning the muskrats now abroad in some localities, and future monographers of the genus may be puzzled by specimens from such areas. Inferences on subspecific differentiation in nature must depend on such material as was available to Hollister in 1911. For a few transplants the exact source is known; those that survive will show whether or not such introduced stocks will respond to new environmental conditions by change in characters.

A complete record of muskrat transplantations probably can never be written, since continued inquiry brings reports of a multiplicity of introductions and transplants. The stock in Germany, Austria and Czechoslovakia is presumed to have descended from not more than two small introductions. If such actually be the case, it constitutes a record of successful acclimatization unequaled, as to smallness of original stock by the alien rats of seaports, the European rabbit in Australia and New Zealand, or by the European house sparrow in North America. Furthermore, the results of the European transplant should serve, as do some other alien transplants, thoroughly to discount the theory of decline by inbreeding so dear to the minds of many sportsmen.

Transplant and Spread in Europe

Details of the introduction and spread of muskrats in continental Europe are available to American readers in part through a recent article by Mohr (1933). A voluminous literature already is in print on the subject in Germany, clues to which may be gained from the article just mentioned, and from the books by Toldt (1929) and Ulbrich (1930). Several papers [2] provide information for England, France, Germany and Scotland.

For many details regarding muskrats in Europe I am indebted to officials in charge of rodent control operations in the several countries here discussed. Through conversations in 1934, by literature supplied then and subsequently, and by answer to later inquiries, I was aided by Mr. E. C. Read in the Ministry of Agriculture and Fisheries at London; Mr. T. Munro and Mr. Hyslop, Scottish Department of

[2] See literature cited at end of this paper: Chappellier (1930, 1933); Hinton (1933); Pustet (1928, 1933, 1936); Munro (1931, 1935); Warwick (1934), and others.

Agriculture in Edinburgh; Dr. Martin Schwartz, Biologische Reichsanstalt für Land- und Forstwirtschaft, Berlin-Dahlem; Dr. A. Pustet. Bayerische Landesanstalt für Pflanzenbau und Pflanzenschutz, Munich; and Dr. A. Chappellier, Service des Vertébrés. Centre Nationale de Recherches Agronomiques, Versailles. Mr. M. A. C. Hinton of the British Museum (Natural History) aided my studies in England.

Beginning at Dobrisch, about 25 miles southwest of Prague, Bohemia, in the spring or autumn of 1905, a few (2.5 to 10) pairs of muskrats from Canada were released. From this center the species has

Fig. 57. Spread of the muskrat in central Europe. Original introduction in 1905, southwest of Prague in Bohemia (now Czechoslovakia). Areas occupied in succeeding years are outlined. Regions freed of muskrats in 1935-36 in western Bavaria and Saxony surrounded by dotted lines. Adapted from Ulbrich (1930) and Pustet (1936).

spread in ever-widening range, like the ripples from a pebble thrown into a pond, until now this alien rodent occupies an enormous territory covering Czechoslovakia, much of Germany (fig. 57), Belgium, Holland, and parts of Austria and Poland. Muskrats have been captured on at least one occasion in Switzerland and a center, from a separate source, has been established in eastern France near Belfort.

Under the more rigid economic limits of life and sustenance for people in central Europe, the interpolation of any new element arouses concern. As early as 1912 attention was directed to the potentialities of the muskrat for harm. The countries of western Europe with much rainfall have extensive drainage systems to dispose of excess water. The principal damage by muskrats involves burrowing in canal banks, railroad fills and earthen dams. Culture of carp and other fish in ponds is an established industry in Germany, and muskrats have damaged such ponds and caused holding dams to break with consequent loss of water and fish. In a few instances they are reported actually to have eaten carp.

Germany

The entrance of the muskrat into Germany was a natural consequence of the spread from Bohemia. There are no sharp biological barriers and the waterways crossing international boundaries afforded every opportunity for spread of muskrats. Ulbrich's (1930) chart shows clearly that the increase of territory occupied was a natural spread. By the time control measures were instituted in Bavaria the species already occupied a wide extent of waterways. The work in Bavaria (1917) was, so far as I can ascertain, the first major attempt at control, and time was lost in development of suitable methods and administrative procedures. In addition, publicity was needed to arouse the interest of farmers and other people on the land regarding the potentialities of the muskrat. It seems evident, from perusal of the German literature of the period, that no hope was held of being able actually to exterminate the muskrat, but early in the work a defense line (Sperlinie) was established (München, Regensburg, Nürnberg, Bamberg, Lichtenfels) along which it was hoped that trappers might resist advance to the west. Despite considerable expenditures (for example 34,671 RM or about \$8,668 in 1927) this proved impossible, and muskrats spread beyond the line. The world-wide economic depression reacted unfavorably on the control program by decreasing the funds available in subsequent years for payment of trapping premiums and employment of trappers, while interest on the part of private trappers declined with reduction in pelt values. In 1927 muskrat pelts brought the trappers 5 to 7 RM (\$1.25 to \$1.75) each, while in 1929 this declined to a figure as low as 1 RM, rising then to 2 or 3 RM. In 1934, when I visited Munich, work was still in progress, at a cost of from 30,000 to 35,000 RM annually (A. Pustet, personal communication, March 20, 1934). Meanwhile, interest in the spread of the muskrat through Germany continues, and each year there appears in an issue of the "Nachrichtenblatt für den Deutschen Pflanzenschutzdienst," issued at Berlin-Dahlem by the Biologische Reichsanstalt für Land- und Forstwirtschaft, an article summarizing the yearly change. This information is kept down to date on a spot map in the Biologische Reichsanstalt. Each year's article includes a map of the current distributional situation and notations regarding new records of muskrats in the various states of the Reich. It is my impression that the agricultural officials are now reconciled to the continued presence of the animal and that future effort will endeavor to hold the numbers down by official trapping and by continued stimulation of public interest. It now seems impossible that the countries of central Europe can ever hope actually to rid their lands of the muskrat. The species will not only hold much of the territory already occupied, but may continue to spread and, in time, to occupy most of continental Europe suitable for its existence.

When interest was aroused in Germany over the possibility of damage by muskrats to earthworks, numerous state and local governments passed laws placing the animal in the nuisance category and making conventional stipulations regarding notification of presence and control by landholders. Many of these are reprinted by Ulbrich (1930).

In Bavaria, Prussia and Thuringia, trappers have been paid by the State; in Saxony the hunters have been under State license and were paid only bounties but were allowed to sell the pelts taken for their own account. Bounties there in 1934 were 30 to 50 pfennigs per animal, and more where muskrats were scarce. Trappers wear a distinctive armband. Officials have to guard against trappers leaving small "nuclei" of muskrats for future breeding. A total of 137 licensed trappers was operating in Saxony during 1934. The annual damage in the Reich was estimated at 70,000 RM, these costs being borne by the Ministries of Agriculture, Railways and Public Works (Ernahrung [incl. Landwirtschaft], Eisenbahn und Verkehr) because railroads, embankments, road structures, bridges and waterways all are state-owned. Many applications were made earlier, especially by small landholders, for permission to establish muskrat farms, but these were refused and the law now provides penalties for keeping muskrats in captivity. Entry of muskrats through customs now is prohibited by law, but due to ignorance of the species by customs inspectors, difficulties are experienced in enforcement; muskrats have, at times, even been declared as rabbits or guinea pigs. Control operations in Germany were conducted by the individual states until 1935, but in that year operations were consolidated for the Reich and Dr. A. Pustet, earlier in charge of work in Bavaria, undertook direction of the general program (M. Schwartz, letter, March 17, 1937).

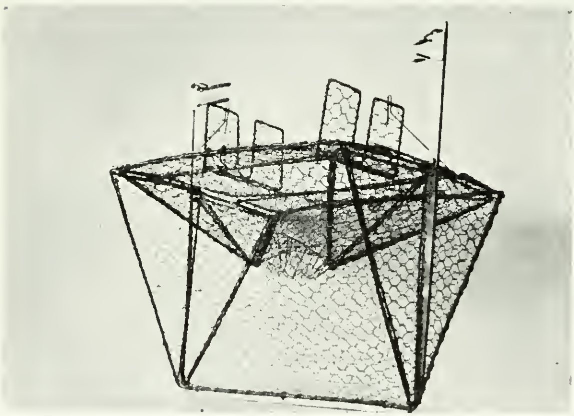

Fig. 58. A collapsible wire-screen trap to be set in the water on the route of swimming muskrats; used in Germany.

In Bohemia, muskrats are believed to have reached an equilibrium as to numbers. The animals do less damage to waterways there, since many of the structures are reinforced with stone. In Germany, many waterways are earth-lined; hence greater damage is possible (M. Schwartz, April 13, 1934).

Other Continental Countries

Muskrats have appeared in other countries of Europe, including Austria and Hungary. In France, muskrats escaped from a farm near Belfort and in the Department of Ardennes (A. Chappellier, January 15, 1934). In 1937, the territories of Belfort and Bas-Rhin were occupied; trapping had been employed to hold the animals in check and experiments with virus were being conducted (A. Chappellier, letter, March 15, 1937).

The species has been introduced into Finland in Kronoby near Wasa (1922), and in Ylivieska and Tuulois (1923). This is a region of many lakes. The annual spread of 30 to 40 km. has been aided by trappers and already a number of pelts have been taken. Thus far the benefits outweigh the damage (Mohr, 1933, p. 62).

In Poland, muskrats first appeared during the winter of 1929-1930 in Oberschlesien, in the Kreissen of Rybnik, Teschen, and Pless. By 1933 they were in Wojewodschaff Kielce, in former Russian Poland. First efforts at control were made in 1932, and in that year a law was passed against human aid in spreading muskrats, with a fine of 2000 zlotys or 6 weeks imprisonment. (Dr. Christiana *in* Nachrichtenblatt für den Deutschen Pflantzenschutzdienst, vol. 13, p. 108, 1933.)

There is one report of a few muskrats having been taken in Switzerland on or near Vierwaldstätter See, but no statement of further occurrence has been noted for that country. There has been a serious invasion in Belgium (C. Elton, letter, February 8, 1938; Mayné, 1935).

In 1934 van Poeteren indicated that the Netherlanders were then concerned over the potentialities for harm by this rodent to the all important dikes and dams of their country. The species was then only 58 miles away, and has since "arrived" in Holland (C. Elton, letter, February 8, 1938; Kluyver).

Muskrats have been introduced into several places in Russia, but full details as to the current status of the species in that country are not available. Eyerdam (1932, p. 281) reported a shipment of muskrats from Ontario, Canada, to Petropavlovsk, Kamchatka, in 1928. Lavrov (1933a) states [3] that muskrats were introduced "in the Solovietskyi and Karaghinskyi Islands, in the Kol'skyi Peninsula, near Archangel and Volodga, in the Ural Province, West Siberia, and the Iakut, A. S. S. R." A total of roughly 486 was imported, 1928–31, from Canada and Finland. In another paper (1933b) Lavrov mentions visiting muskrat farms at Solovietsk, Slobodsk and Kostroma and says that in 1930 "the rodent was set free in many northern regions." Some of the animals were confined in cages for study of food habits while others were in fenced enclosures. By the end of 1932 the population had grown to "several thousands."

British Isles

In the British Isles, muskrats were introduced into Scotland in 1927, and into England in May and June, 1929, at Shoeburyness, Essex. But an even earlier introduction is reported at Great Missenden, Buckinghamshire. In Ireland, muskrats were imported to County Tipperary

[3] Details of the work in Russia with muskrats have been made available to me through translations of Lavrov's articles by Mr. M. Dobrynin of the WPA translation bureau in the University of California at Berkeley.

in July, 1927. Early in 1930, M. A. C. Hinton and E. C. Read had 76 records (including some unconfirmed reports) of places where muskrats were or had been kept. At first, according to Mr. Read, certain government officials considered that muskrat farming constituted a new and useful industry meriting encouragement. Soon, however, this viewpoint was reversed, due to the escape and rapid spread of the rodents, coupled with adverse opinions by Messrs. Hinton and Read and other mammalogists conversant with the potentialities of the muskrat for harm, as hitherto demonstrated in Germany. On March 17, 1932, the Destructive Imported Animals Act was passed by Parliament. This placed the importation and keeping of muskrats under control of the Minister of Agriculture and Fisheries in England and the Secretary of State for Scotland. A Statutory Rule and Order (No. 153) promulgated by these officials, effective May 1, 1932, in England, Wales and Scotland, provided for licensing of muskrat owners and conferred on officials the right to destroy muskrats found at large. Penalties were provided for noncompliance, and owners as of June 24, 1931, who were refused licenses, were given permission to apply for compensation for loss of investment. Only 14 licenses were issued. In March, 1933, an order effective April 1, 1933, prohibited absolutely the importation or keeping of live muskrats in Great Britain. Similar laws were passed for the Isle of Man and by the Irish Free State (E. C. Read, May, 1934; Warwick, 1934, p. 251).

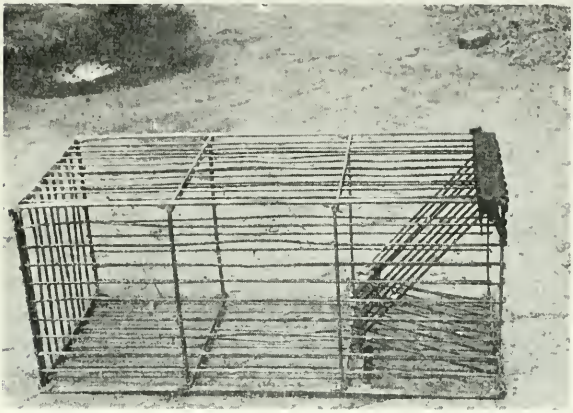

Fig. 59. Cage trap with "door" of individual wires at right; set at mouth of burrow to catch muskrats driven out by probing in the bank; used in Shropshire, England.

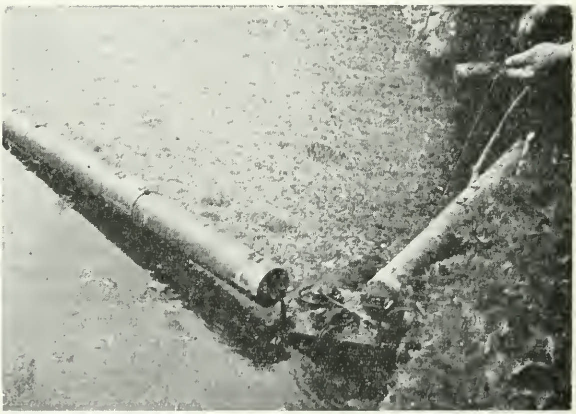

Fig. 60. Floating trap set at margin of quiet stream; the floats are metal tubes sealed at the ends; used in Surrey, England.

Warwick (1934) had record of 76 places in England, one on Isle of Man, 10 in Scotland, and one in Irish Free State where muskrats had been kept. Animals escaped from 12 of these and centers of infestation developed in five localities, namely: Shrawardine, Shropshire; Farnham, Surrey; Pulborough, Sussex, England; Feddal, Perthshire, Scotland; and Nenagh, County Tipperary, Irish Free State.

Governmental control campaigns were instituted in 1932 and 1933 in all these places. Field crews were organized, Herr Roith, the highly successful Bavarian trapper, was "borrowed" to demonstrate field techniques, and a thorough-going program looking toward actual elimination was instituted. In England, the crews were equipped with motor trucks capable of carrying a boat, and general reliance was placed upon trapping. The Roith technique ("Stöberfang"), involving use of a probe inserted from above ground on the bank containing a burrow, with wire catching cage at the burrow mouth, was used in part. A special type of burrow-entrance trap was developed (fig. 59). In addition, two ingenious types of floating traps were developed, use of which was chiefly to indicate presence of muskrats rather than as a means of extermination (fig. 60).

In England, prior to 1932, an estimated 1500 muskrats were taken by private individuals. The official campaign there resulted in the capture of muskrats as follows:

	Shropshire (Salop)	*Pulborough, Sussex*	*Farnham, Surrey*
1932	1,531	---	--
1933	1,064	144	39
1934	181	8	12
1935	7	1	1
1936	1	0	0
Totals	2,784	153	52

The annual costs (financial year ending March 31) were:

1932–33	£2,913	
1933–34	£6,519	
1934–35	£4,200	(estimated)
1935–36	£2,750	
1936–37	£1,050	(£100 recoverable by sale of equipment)
Total	£17,332	[=$84,580]

Each muskrat taken cost $28.29. The campaign was terminated on March 31, 1937 (E. C. Read, letter, March 17, 1937).

Similarly, the control of muskrats in Scotland involved:

	Expenditures		*Muskrats Taken*
1932–33	£840	1932	51
1933–34	2,600	1933	764
1934–35	2,900	1934	154
1935–36	2,240	1935	7
1936–37	1,100	1936	2
1937–38	200	1937	--
	£9,880 [=$48,610.80]		978

Each muskrat taken, therefore, cost $52.43. The Scottish campaign was to be closed before June 30, 1937 (T. M. Munro, letter, April 14, 1937).

The campaign in Scotland showed some of the problems involved in efforts actually to rid an area of a pest; the area was small and subjected to careful scrutiny, so the numerical details probably are quite accurate. Governmental operations began in October, 1932. During 1933, the staff of trappers was increased from 4 to 13 and a supervisor, remaining thus through 1934. The animals taken were:

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
1933	14	47	72	51	51	57	40	78	135	104	62	53	764
1934	27	19	13	11	17	19	9	5	10	4	13	4	154

Early in 1933 there were not sufficient trappers to control natural increase; as the staff increased and became more efficient, the population was far reduced. Only three family groups were taken in the latter half of 1934; all others were stragglers. In 1933, rats were taken in 38 squares of the Ordinance Map; in 1934, in only 23 squares. Yet at the end of 1934 it was considered that rats might occur anywhere within an area of 400 square miles. With decrease in physical labor of trapping, fewer men were employed, but need for even more careful scrutiny and inspection increased. Motorcycles were provided to aid this phase of the campaign (Anonymous, Scottish Jour. Agric., vol. 18, pp. 175-178, 1935).

The difficulties involved in a final clean-up were illustrated in an artificial pond, Loch-an-Erie, at Gleneagles Golf Course. In March, 1933, Herr Roith, the Bavarian trapper, saw a burrow there, but trapping produced no results. This burrow was watched and in August, 1934, evidence of occupancy was noted; again trapping was unfruitful. There was no sign in late October. A flood then occurred on River Earn, after which the loch froze over. On November 8, another trapper saw bubbles beneath the ice, indicative of muskrats. Five muskrats were subsequently caught in the loch (Munro, 1935, p. 12). Whether the pond was continuously occupied or reoccupied with the flood was not known.

The need for continued scrutiny of old burrows is obvious. Control workers in England preferred not to collapse such burrows but to leave them; fresh occupancy by rats missed earlier could then be detected more readily. When muskrats obtain food from under water and eat or store it in deep burrows, or when they feed at a distance from the burrow, detection is difficult.

During the campaign in Scotland a considerable variety of other animals was taken in the trapping operations, including (up to September 29, 1934) 1745 brown [Norway] rats, 2305 water voles, 57 weasels, 36 stoats, 2178 moorhens, 113 ducks, and miscellaneous other birds such as 23 seagulls, 13 each of curlews and redshanks, 28 snipes, 15 European blackbirds, and one eel—a total of 6587 animals, including both harmful and beneficial species (Munro, 1935, pp. 11-16).

For the Irish Free State, exact details are not available, but "several hundreds" of muskrats have been taken (E. C. Read, letter, March 17, 1937).

Current Status in Europe

In summary, according to information now in hand, it seems entirely probable that muskrats have been or will be entirely exterminated in England and Scotland. Success, if attained, will be due to the relatively small areas involved, to the nature of the terrain, to the adequate financial support of the government, and to the industry and persistence of the personnel involved. In continental Europe, the muskrat probably will remain as an acclimatized alien of dual importance, useful as a fur bearer but harmful in varying degree to earthworks, water channels and fish ponds. A review of the efforts to date in Germany shows that earlier, despite earnest endeavor with moderate financial support, spread of the species beyond the Sperlinie established in Bavaria had not been checked. Under concerted action in 1936, however, slight reductions were made in extent of territory occupied (Pustet, 1936).

Transplants in North America

Turning to North America, details as to spread of the muskrat by the aid of man are available for British Columbia and for California.

British Columbia

Muskrats were native to the mainland of British Columbia but not on Vancouver Island. In 1923, small numbers were liberated on the Island in the Cowichan Lake district by the Provincial Game Commission. Their status in subsequent years was briefly as follows: 1925—increasing; 1926—also in Somenos Lake and sign on Saanich Peninsula; 1927—increasing; 1928—also near Port Renfrew; 1929—several reports of muskrat damage to crops and lands in Cowichan and Saanich districts; 1930—increasing rapidly, many damage complaints, special trapping permits issued to farmers; 1931—catch of muskrats on Vancouver Island about 9000 pelts; 1932—on increase, many permits to farmers during closed season; 1934—many taken for fur, farm complaints lessened; 1935—few farm complaints and fewer taken by fur trappers. (Summarized from Reports of Provincial Game Warden, later Provincial Game Commission, 1923-1935, inclusive.)

It is also reported that muskrats were planted at Miller Creek, Forbes Landing, close to Campbell River, 6 in 1923 and 6 in 1924. Creeks and swamps south of this locality subsequently became well populated and crop damage due to muskrats was reported in 1931 (Ronald M. Stewart, B. C. Police, Atlin, letter, December 4, 1931). In 1933 they were reported north to Comox and also as introduced on Denman Island (T. Pearse, Courtney, June, 1933).

Muskrats were also planted on Graham Island, in the Queen Charlotte Islands, in 1924 or 1925, near New Massett and probably elsewhere. In 1933, at a site fully 30 miles from the place of introduction, a muskrat made nightly visits to catch fry of pink salmon at an experimental counting screen. Dikes in Tlell River, erected to hold back salt water, were reported to have been damaged (Pritchard, 1934, p. 103).

California

The first important translocation of muskrats in California followed as a natural consequence of building (1901) the International Canal carrying water from the Colorado River to the then desert Imperial Valley. While earlier there may have been occasional muskrats in the region (cf. Mearns' observations in 1894), the construction of more

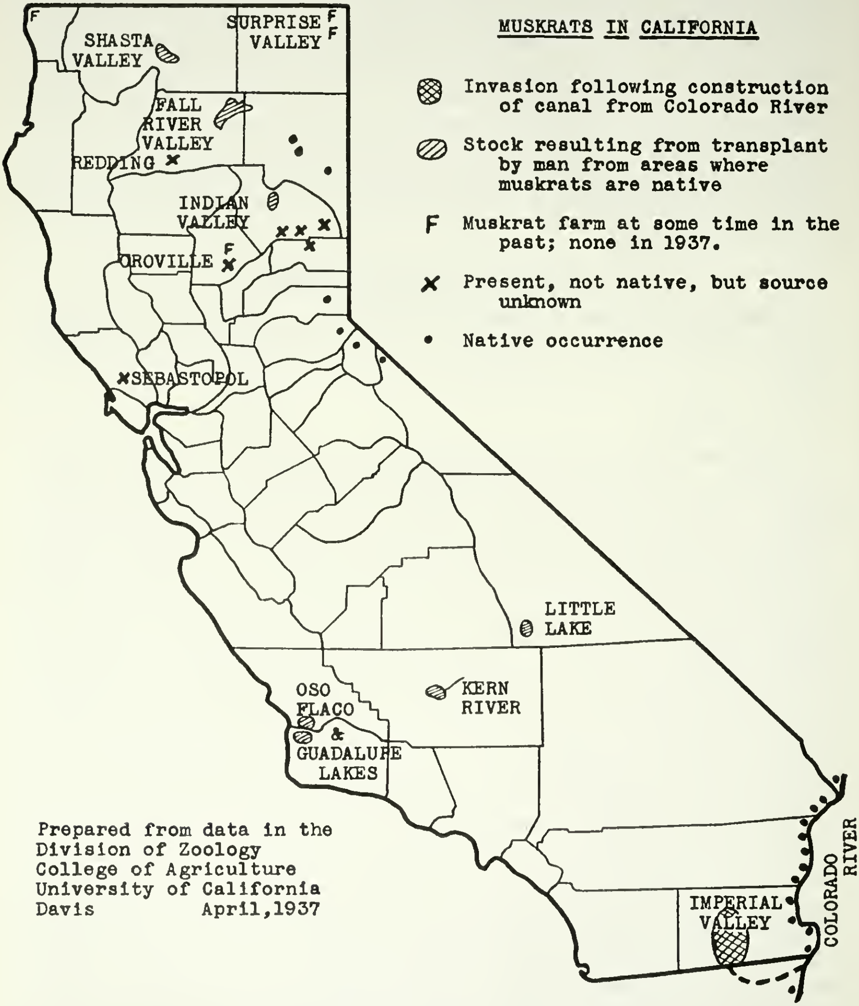

Fig. 61. Muskrats in California, 1937

than 300 miles of mainline canals and numerous small ditches, with subsequent inevitable growth of aquatic vegetation, provided an admirable extension of habitat for this species. The first were noted about 1905. E. A. Goldman saw many holes in irrigation banks in June, 1907, and in 1915 L. J. Goldman said damage had been caused and the irrigation district was paying bounties of 50 cents to $1.00 per head. In 1921, Joseph Dixon studied the muskrats in the valley and obtained reports of 20 to 40, and exceptionally 200, muskrats per mile of canal. He concluded that the pocket gophers, which had also increased, were responsible for more damage, by burrowing in canal banks, than the muskrats (Dixon, 1922). Nevertheless, the officials of the Imperial Valley Irrigation District considered that muskrats caused damage by burrowing in banks between adjacent parallel canals and around headgates (where wire mesh had to be inserted to check burrowing and the gnawing of wooden gates). From 1925 to 1932 the district paid \$33,204.50 in bounties on 139,012 muskrat tails at 12.5 cents (to mid-1927), later 25 cents each. Some unrecorded bounties had been paid earlier. The system was abandoned in 1932 because of financial difficulties. One break in the canal system cost \$5000 to repair (MS data from District Manager, 1935). Under favorable conditions of fur prices, as in 1919–1920, Dixon figured that 25,000 muskrats (estimated to be half the local population) were taken annually in the valley at \$1.25 per pelt, yielding \$31,000; this would amount to far more than the damage (Dixon, 1922). Damaged structures, however, must be repaired at the expense of the district, whereas income from muskrat furs accrues to private trappers. Furthermore, private trappers have less incentive to work during seasons of low prices, and always prefer to trap where animals are abundant rather than in critical areas where smaller numbers of the rodents may be causing damage. Replacements in the population are rapid, breeding being reported in Imperial Valley for every month in the year, but especially from about February 15 to October 30, with possibly 3 broods averaging 6 (3 to 9) each.

As previously mentioned, under original conditions in California, muskrats occurred only on the east side of the Sierra Nevada in scattered localities, and in the Colorado River. Transplantation or escape of captives has now resulted in establishment of muskrats in several places west of the mountains. Some of these localities are so isolated from other drainage basins that there is little likelihood of the animals radiating and establishing new centers; other colonies are on tributaries of the Sacramento-San Joaquin drainage system. The known transplants in California are:

Colorado River at Needles, San Bernardino County.—William Pugh reports that he introduced 75 muskrats (subspecies unknown) purchased from dealers in Oregon, Montana and Ohio, in 1930 to 1933. These were darker animals, planted in the hope that they would hybridize with the local *pallidus* (=*bernardi*) and result in pelts of higher fur value (E. R. Hall, Mus. Vert. Zool. field notes, February 1, 1934).

Kern River and Buena Vista Lake, Kern County.—Muskrats, presumably of subspecies *mergens*, were introduced in 1911 or earlier. The actual date, source and means are unknown. The population increased and considerable numbers are reported as taken for fur; later control measures were used against the animals. In the winter of 1936–1937, it was stated that few or none were left; the lake had been dry for several years and irrigation canals at Bakersfield, formerly occupied, had been dry for a long period. Later in 1937 the lake was partially filled with water.

Guadalupe and Oso Flaco lakes (west of Santa Maria, Santa Barbara County).—W. N. Morrison in 1927 introduced 149 individuals of the race *pallidus* (=*bernardi*) from Imperial Valley into Guadalupe Lake at Betteravia. At first the animals multiplied, but with a succession of dry years the lake dried up. Some muskrats migrated to pools and swamps at the outlet of the lake and the Santa Maria River. Black Lakes, south of Oceano, San Luis Obispo County, also were planted with muskrats to reduce the growth of tules. The Santa Maria Valley is irrigated from wells, only excess water appearing in surface ditches, and the drainage basin is far removed from other streams. No damage to agriculture has resulted; a few hundred pelts were taken in 1936; predators are reported to capture migrating muskrats, and some were run over on highways by automobiles.

Little Lake, Inyo County.—William Bramlette imported individuals of the race *pallidus* (=*bernardi*) in 1928 to reduce cat-tails in the lake, which they have done; some have migrated along a connecting stream that sinks in the adjacent desert. No damage has occurred and the animals are far from other water or agricultural areas.

Lagoon near Sebastopol, Sonoma County.—Two animals were trapped in the winter of 1935–1936; no further information is available.

Taylorsville, Plumas County.—W. H. Stanfords established a muskrat farm in Indian Valley in 1925, using native animals (subspecies *mergens*) from Honey Lake Valley, Lassen County. Some are known to have escaped into Indian Creek by 1929 (Dixon, 1929, p. 359).

Sierra Valley, Plumas and Sierra Counties.—Present at least since 1934 in the vicinity of Blairsden, Vinton, Loyalton; source unknown.

Coutélene, Butte County.—Ten pairs obtained from Colorado in 1929 were confined in a pen. Reported to have been taken by predators; none present in 1931 and no sign found on adjacent Little Butte Creek in January, 1936.

Oroville, Butte County.—Reported as present in one place on the Feather River in 1935; sign and animals seen in fair numbers during January, 1936; no evidence of muskrats found either above or below this locality.

Live Oak, Sutter County.—In January, 1938, a report was received of a muskrat having been shot near Live Oak, adjacent to the Feather River.

Princeton, Colusa County.—Four from McArthur were released here by H. G. Boyes about 1930 but "failed to make a start."

McArthur, Fall River Valley, Shasta County.—A muskrat farm was established in 1930, four miles north of the town, on Mud Lake, by Mount Shasta Fur Farms. The valley contains a network of creeks and canals connected to the Fall and Pit rivers. Muskrat stock from Ohio, Colorado and North Dakota (according to employees of the farm) was first bred in pens. In 1931, 228 were released into a mesh-wire fenced enclosure and in 1932 others were added to a total of 599 (of these 374 were females). Muskrats were first reported outside the fence in 1933 but later inquiry brought reports of escapes in 1932 and possibly even in 1931. Five trappers employed by the California State

Department of Agriculture took 1818 muskrats in May and June, 1933, when funds for the work were exhausted; appeals for additional appropriations at a special session of the State Legislature were unavailing. Employees of Shasta County and a local power company took an additional 1148 rats that autumn, 496 of these within the fence. In the winter of 1933-1934, commercial fur trappers and a CWA project accounted for about 1800 more in the valley. Later trapping produced 4812 muskrats in 1934, and 3476 in 1935 that are of record. Muskrats, presumably from this source, are reported in Hat Creek, a southern tributary of Pit River, some miles to the west. Dams around springs and small levees about fields in the Fall River Valley were perforated by numerous muskrat burrows in 1933.

Redding, Shasta County.—Two animals were trapped adjacent to Sacramento River in 1935; subsequent search in 1936 of Pit River, which connects Fall River Valley with Sacramento River, failed to indicate muskrats in intervening territory.

Fig. 62. Perforations due to muskrat burrows in dike about spring used for irrigation; Fall River Valley, Shasta County, California.

Shasta Valley, Siskiyou County.—About 1925 or 1926, muskrats were planted above Big Spring near Shasta River in the vicinity of Mayten. By 1931, muskrats had already spread down stream and were causing some damage to small dams on farms; one entered the intake of a water pump, which had to be overhauled in consequence! The Shasta River is tributary to the Klamath River.

Surprise Valley, Modoc County.—Two muskrat farms were established, one at Lake City (1926), another north of Fort Bidwell. By 1932 or earlier, muskrats had escaped to adjacent wet meadows and streams and caused minor difficulty by undermining temporary dams constructed to spread water on the sloping meadows. This area is separated by the Warner Mountains from the headwaters of Pit River.

Details given here, where not otherwise acknowledged, are from field observations by the author, supplemented by personal and written communications from federal, state and county agricultural officials concerned with rodent problems in California. Northern records for 1936 were secured by a trapper-observer employed by the State Department of Agriculture. W. C. Jacobsen, in charge of rodent control for the department, has aided greatly in the accumulation of records. To him and the other collaborators the author here expresses gratitude for the help rendered.

For many years the California quarantine law has contained a clause prohibiting entry of animals detrimental to horticultural or agricultural interests, and the game laws contain a provision that fur farmers should obtain annual licenses from the Division of Fish and Game; but these two laws were not rigidly enforced with respect to alien vertebrates. The muskrat situation in the Imperial Valley and reports of these animals in Kern County served to focus attention on the potentialities of the species. On May 15, 1929, notice was given by the Division of Fish and Game, at the suggestion of the State Department of Agriculture, that no permits would be granted for muskrat farming west of the Cascade-Sierra Nevada mountain system. Yet in February, 1930, a permit was granted for the Fall River Valley farm, on representation that adequate fencing would enclose the animals. Within two years (possibly less) muskrats were scattered over the valley.

In 1933, the State Legislature (Chap. 312) incorporated the regulation of 1929 in the California Fish and Game Code (Sec. 1323):

> "It is unlawful to import or transport into, or possess any live muskrat (genus Ondatra) in the region west of the crest of the Cascade-Sierra Nevada mountain system, and west and south of the Tehachapi, Liebre, San Gabriel, San Bernardino, San Jacinto, Cuyamaca, and connected mountains south to the international boundary, or in any water shed tributary to or draining into the Pacific Ocean, except the drainage basin of the Klamath River. It is unlawful to import or transplant live muskrats into any part of California outside said region, except under permit issued by the [California Fish and Game] Commission. A county agricultural commissioner, fish and game deputy, or State plant quarantine officer may enter upon lands or waters where muskrats unlawfully exist, and remove or destroy muskrats thereon or therein."

The principal facts relating to introduction and spread of muskrats in California were brought to the attention of the general and agricultural public in meetings and through newspaper articles and radio broadcasts, without significant result.

In 1937, a bill (Senate 719) was introduced into the California Legislature proposing Fish and Game District 100 to comprise all inland lakes in Tehama County not having an outlet into any stream. Section 2 of this bill read, "Nothing in this code prohibits the raising of muskrats in the waters in district 100 * * *." The intent was to permit "farm" rearing of muskrats in this special district which is within the prohibited area of Sec. 1323 cited above. The bill failed to become a law.

Agricultural officials of the State and counties are aware of the problems arising from the presence of muskrats in irrigated regions, but, lacking public interest and financial support, no sustained attempt at eradication has been possible. Trappers and furriers consider the new supplies of muskrats advantageous.

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WEIGHT AND AGE DETERMINATION OF STRIPED BASS [1]

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Many striped bass anglers are interested in knowing the age of the fish they catch, as evidenced by the numerous calls for the report by E. C. Scofield, "A Simple Method of Age Determination of Striped Bass."[2] This paper is now out of print so it was thought advisable to reconstruct the work, adding more material [3] and changing the form of the chart somewhat. The bass angler can determine the approximate weight and age of his best fish by simply knowing the length of the striped bass from the snout to the fork of the tail, by using the accompanying chart, figure 63.

Usually you anglers carry a pocket rule so that you may measure your bass from the snout to the fork of the tail, to the nearest quarter-inch. Then take the chart, figure 63, find the inch scale on the left, corresponding to the measurement of the fish, and trace a course with your finger to the right on the same line until the curve is reached. There you will note between what ages the fish size falls. Then by following down to the pound scale, you can read the weight directly, so that you have obtained both age and weight in one simple operation. To illustrate, suppose your fish was 21 inches long. Then, by following out from left to right at the 21-inch mark, you hit the curve at a point just above the 5-year line; then tracing down to the pound line you find that the weight of the fish is about 4½ pounds. The chart works just as well in the other direction. If you know the weight—say 30 pounds—you find this number on the pound scale, follow it up to the curve where it strikes midway between 14 and 15 years old, then follow to the left and read the length at 42 inches.

Remember that this calculated curve and the age groups by sizes are averages and it may happen that your individual fish will be above or below average in age, weight or length, or perhaps it may be above average weight and below average length. These averages are based on large numbers so that they will give you approximate values for weight, length and age in the field where you have no scales available or no scientist to determine the exact age for your specific fish.

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[1] Submitted for publication, December 29, 1937.

[2] California Fish and Game, vol. 18, no. 2, 1932.

[3] We are indebted to the *Oakland Tribune* for the weight and length material which they furnished from the finals of their last two striped bass derbies in 1936 and 1937. All weights were used to the nearest quarter-pound, all lengths to the nearest half-inch measured over the body from snout to the fork of the tail. The weight-length curve was calculated from the formula $\log F + (\log L)\, x = \log W$, where F and x are constants determined from the data, L is the length and W is the weight. Little material was available beyond 25 pounds, but the calculated curve seems to fit what data we have. The age determinations are for average size of each year group from E. C. Scofield's work ("Striped Bass of California," Calif. Div. Fish and Game, Fish Bull. no. 29).

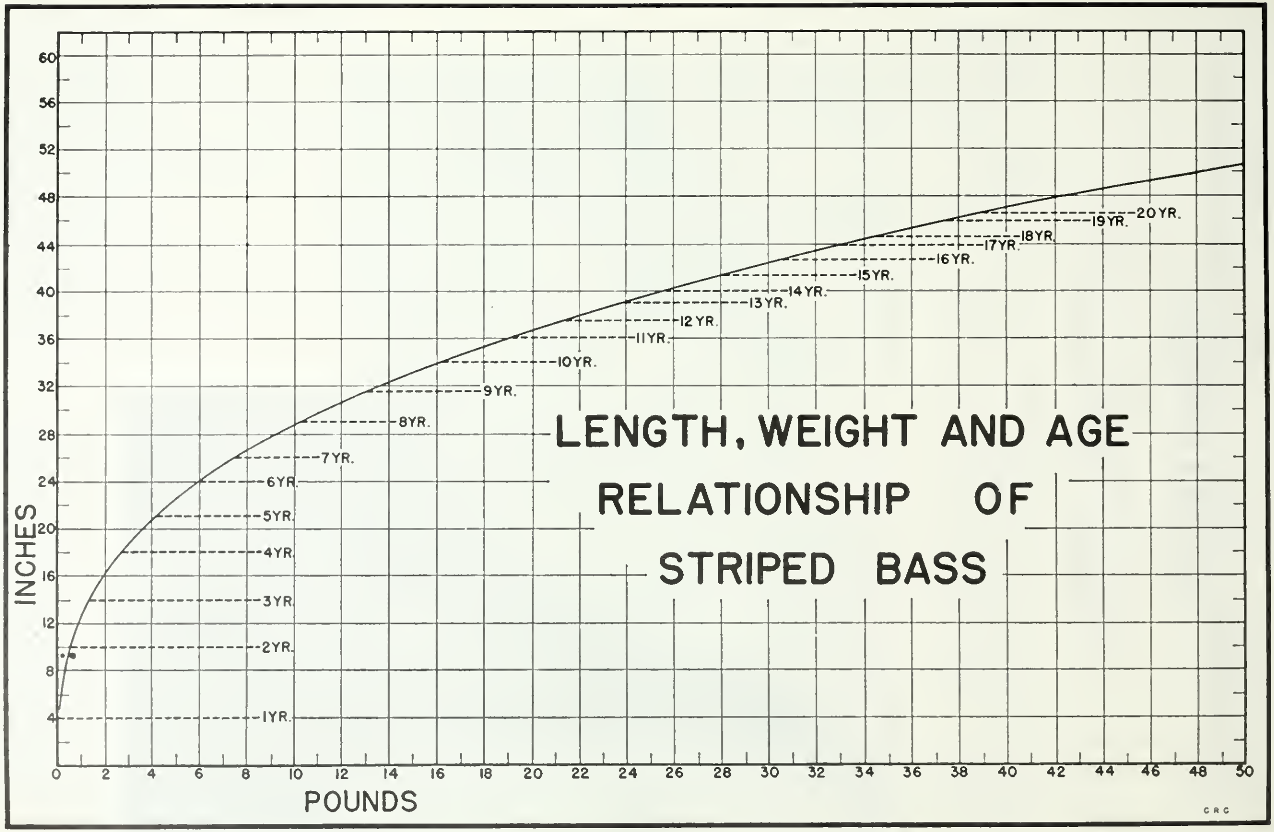

Fig. 63. The length, weight and age relationship of the striped bass of California. If you know either the length or weight of your fish, this chart will enable you to determine the other measure of size, as well as the approximate age.

"CHRISTMAS TREES" IN THE CALIFORNIA SARDINE FISHERY [1]

By John F. Janssen, Jr.
California State Fisheries Laboratory
Division of Fish and Game

Since the opening of the present sardine season on August 1, 1937, there has been an apparent abundance of small sardines off central California. Young sardines are always present in these waters, but this year the fishermen have encountered greater numbers than usual.

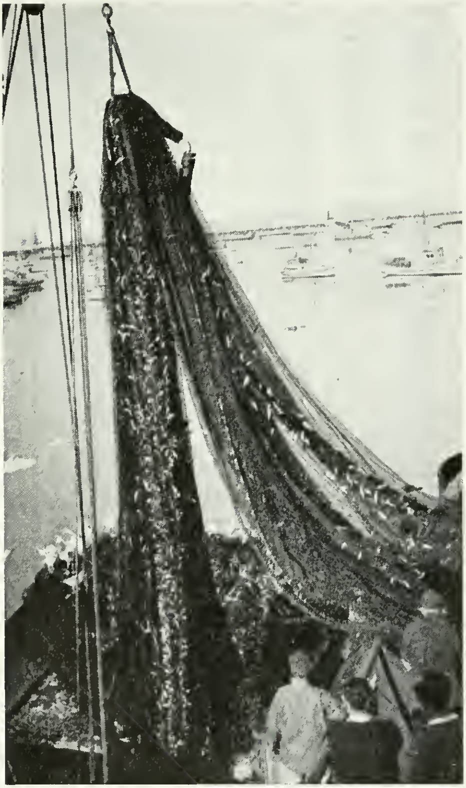

Fig. 64. Putting a sardine "Christmas tree" into a tanning vat at Monterey to boil out the gilled fish. A great many of the fish have already been removed by shaking the net. Photographed by J. B. Phillips, November 30, 1937.

These small fish gill in sardine purse seines and ring nets, occasionally to the extent that the webbing is almost obscured. When a purse seine is hoisted back aboard the boat on the boom, the suspended section assumes the general shape of a Christmas tree. Because the seething, silvery mass of struggling fish looks like ornaments sparkling under the bright flood lights, the fishermen coined the new expression, "Christmas tree," which has already become the standard term for a netful of gilled fish.

It is both a beautiful and a pitiful spectacle—pitiful when one considers that it takes hours of toil by the fishermen to "take down the ornaments," and that all the gilled fish are wasted. Canneries will not accept these fish because they are too small to can and their oil content is so low they can not be reduced profitably.

Sardines of similar sizes usually school together but in any school there may be a few individuals much larger or smaller than their

[1] Submitted for publication, January, 1938.

companions. There are, therefore, all degrees of "ornamentation." When a net is set on average commercial sizes, there are usually a few small fish present which will gill. But the real "Christmas tree" occurs when a net is set around a school of predominantly small fish. It is difficult and frequently impossible for even the most experienced fishermen to determine whether the majority of the fish in a school are large or small before setting on them.

This situation has led to condemnation of fishermen as destroyers of our fish before they have grown to marketable sizes. In reality, the fisherman does not wish to set his net on small fish and avoids them whenever possible. As soon as the fishermen see that they have set on a school of small fish they let go of one end of the net so the fish which have not gilled can escape. The gilled fish increase the net's weight and drag to such an extent that it is extremely difficult to hoist it

Fig. 65. Gilled sardines in a purse seine at Monterey. The small fish on the deck are some that have been shaken from the net. Photograph by J. B. Phillips, November 30, 1937.

back aboard the boat. Occasionally a strong wind with resulting heavy seas increases the task to the extent that large pieces of netting have to be cut away in order that at least the lead and cork lines and part of the net can be saved. Nets have been torn to shreds by the weight of gilled sardines or anchovies. In at least one instance this season an entire net was lost off San Francisco. Removing fish from a badly gilled net is an enormous task, and if they are not removed within a few hours the net rots. When one considers that a modern sardine net costs from three to five thousand dollars, it is evident that fishermen think twice before "making a set."

Removing Gilled Fish from Nets

The usual method of "taking down the ornaments" is for several men standing abreast to shake short sections of the net violently. This may be done as the seine is slowly drawn in from the water over the turntable roller or after the entire net has been brought aboard. Shaking the webbing does not remove all the fish, however. The remaining fish are then either pulled out one at a time by hand, or the net is put into a tanning vat for eight to twelve hours. Tanning both preserves the net and cooks the gilled fish to a mush. Although tanning once or twice a month is good for a net, too much seems to have a harmful effect, so many fishermen prefer to pick all the fish out by hand. The final step is always to make a "blind haul" to wash out all slime and loose fish remains. Unfortunately, tanning a net costs money and fishermen may lose a night of fishing. Frequently, the vats are in such demand that one can not be obtained without waiting a day or two, so the fish must be pulled out by hand to prevent rotting of the net.

Preventative Measures

It has frequently been suggested that the mesh size of purse seines be increased in order that small fish can escape through the webbing. This seems impractical as larger fish would then become gilled with an increased danger of damaging the net. A number of fishermen have suggested a slight reduction in mesh size. Constructing the entire net of smaller mesh would not only increase its cost but would materially increase its drag through the water, making it extremely difficult to handle, especially in rough seas. Since most of the small fish gill in the upper forty to fifty feet of webbing, a practical solution may be to make only the top strip of webbing of smaller mesh. A strip of webbing is about 45 feet wide when hung. The mesh of most sardine nets varies from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, stretched measure, when new. After tarring or tanning, the mesh shrinks to $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. It is believed that if the mesh in the top strip of webbing were not over one inch after shrinkage the numbers of gilled fish would be few even if the net were set on a school of predominantly small fish. Of course, decreasing the mesh size would naturally result in gilling of smaller fish but the sizes which one-inch mesh will gill are apparently not very abundant in deep water where purse seines are operated. A further drastic reduction of the mesh size so that even very small fish can not gill would make a net the size of a modern purse seine impossible to handle due to its tremendous drag.

Occurrence

Although "Christmas trees" seem to be caught most often within two or three miles of the coast line, they have been observed over practically the entire area covered by the Monterey and San Francisco fleets, from Point Reyes southward, around the Farallon Islands, and on down the coast into Monterey Bay. Since the opening of the sardine season in southern California on November 1, 1937, some "Christmas trees" have been caught around the Channel Islands and along the mainland south of San Pedro. Their numbers are not, however, as alarming as in central California.

Explanations for Unusual Abundance of Small Sardines

The apparent abundance of small sardines off central California may be accounted for in several ways. Most explanations seem rather absurd at first thought, but all possibilities must be considered. Probably a combination of several factors rather than any one is responsible.

In the first place, large fish, in general, have been more difficult to find than usual off central California. Consequently, fishermen are liable to take a chance and set on fish whose sizes are doubtful rather than go days without wetting their nets. In any case, normal numbers of small fish with a scarcity of larger sizes would result in more schools of small fish being set on accidentally.

Furthermore, a rapidly growing fleet of purse seiners without a proportional increase in the number of schools leads to increased competition for fish, undoubtedly resulting in more sets being made on fish of questionable sizes.

Again, changes in fishing gear may have made the small fish more evident. Previous to the 1929-30 sardine season at Monterey, practically all the nets were lamparas,[2] which were made of smaller mesh than that used in present day purse seines and ring nets. Even if small fish had been abundant in the earlier days, sizes now gilling would not have gilled in the lamparas used at that time. The fact that fish are gilling now and causing fishermen no end of trouble may make their presence more apparent than in the past. However, this is the first season that small fish have been troublesome during the eight seasons that the gear consisted chiefly of ring nets and purse seines.

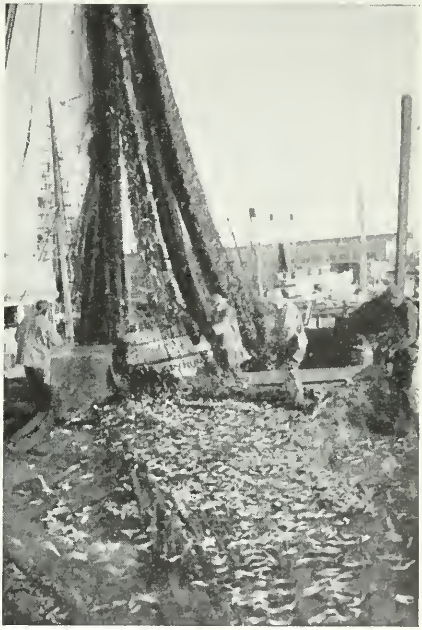

Fig. 66. Gilled sardines in a purse seine at San Francisco. Photograph by S. Ross Hatton, January 24, 1938.

In addition, the sizes of gilled sardines indicate that most of them were hatched in the spring of 1936, at which time unusually warm water was present off Monterey. Warm water conditions to the north produce heavier northern spawning. Unfortunately, we do not know enough about the movements of young sardines to justify the assumption that these fish have remained for a year and a half near the locality where they hatched.

[2] Phillips, J. B. Success of the purse seine boat in the sardine fishery at Monterey, California (1929-1930 fishing season). Calif. Div. Fish and Game, Fish Bull., no. 23, 28 pp., 1930.

On the other hand, favorable currents, temperature, or food conditions, during the summer and fall of 1937 may have resulted in an influx of small sardines from their more normal haunts, or if these fish usually pass through this area on their way to other regions, favorable conditions may have induced them to linger temporarily.

This may, then, be a localized condition not necessarily indicating a superabundance of small sardines considering the population as a whole. On the other hand, the fact remains that these fish may represent a superabundant year-class. But this is somewhat doubtful since these small sizes are apparently not outstandingly numerous in southern California waters this season. The history of the progress of this group through the fishery for the next few years may furnish the final answer.

The apparent exceptional abundance of small sardines off central California may, therefore, have been caused by any one, or a combination of factors: scarcity of large fish; a rapidly growing fishing fleet; changes in gear; or favorable oceanographic conditions which may have resulted in heavier local spawning or, at least temporarily, in an unusual concentration of these small sizes.

Sizes of Gilled Sardines [3]

It is impossible to obtain samples of sardines from any one source which will represent a true cross-section of the entire population. The nets used in the fishery are somewhat selective. Very small fish can escape through the meshes of purse seines and ring nets while slightly larger fish gill, leaving mainly adolescent and adult fish to get into the cannery catch. A few lampara nets are still being used at both Monterey and San Pedro to catch sardines and other species for the bait and fresh fish trade. These nets are usually set in fairly shallow water and catch mainly the smaller sardines. The fish school, at least to some extent, according to size. Schools of large fish may not habitually range in the same local areas as the smaller sizes so that lamparas fishing in shallow water may catch different portions of the population than larger nets set farther from shore.

In order to get a truer picture of the sardine population, samples have been measured from several sources and their size frequency distributions plotted for comparison in figure 67. The Monterey frequency polygons for samples taken at the fresh fish markets during the past fall and early winter have been combined in one curve. The San Pedro data have been treated in the same way. These market catches were made with lamparas. Measurements of gilled sardines have been made in the San Francisco, Monterey and San Pedro fisheries. Their frequencies are also shown. Two samples of sardines (not gilled) were measured at Monterey on November 2, 1937, from schools of predominantly small fish. These samples, taken with purse seines, were combined into one frequency.

Length frequency polygons of cannery sardines taken in the fall fishery at Monterey in past years [4] reveal small fish during several

[3] At San Francisco, gilled sardines were measured by G. H. Clark and S. R. Hatton. The Monterey fish were measured by J. B. Phillips. F. N. Clark and J. A. Aplin measured the sardines in the San Pedro region. The author is indebted to these persons for their kind assistance in this work.

[4] Clark, F. N. Interseasonal and intraseasonal changes in size of the California sardine. Calif. Div. Fish and Game, Fish Bull., no. 47, 28 pp., 1936.

seasons. For small sizes less than 18 centimeters body length, the length frequency polygon for this season's fall fishery at Monterey is quite comparable to those of a few past seasons when the lampara net was the only gear used. The lampara may have occasionally fished in shallow water where these small sizes have usually been found, or the

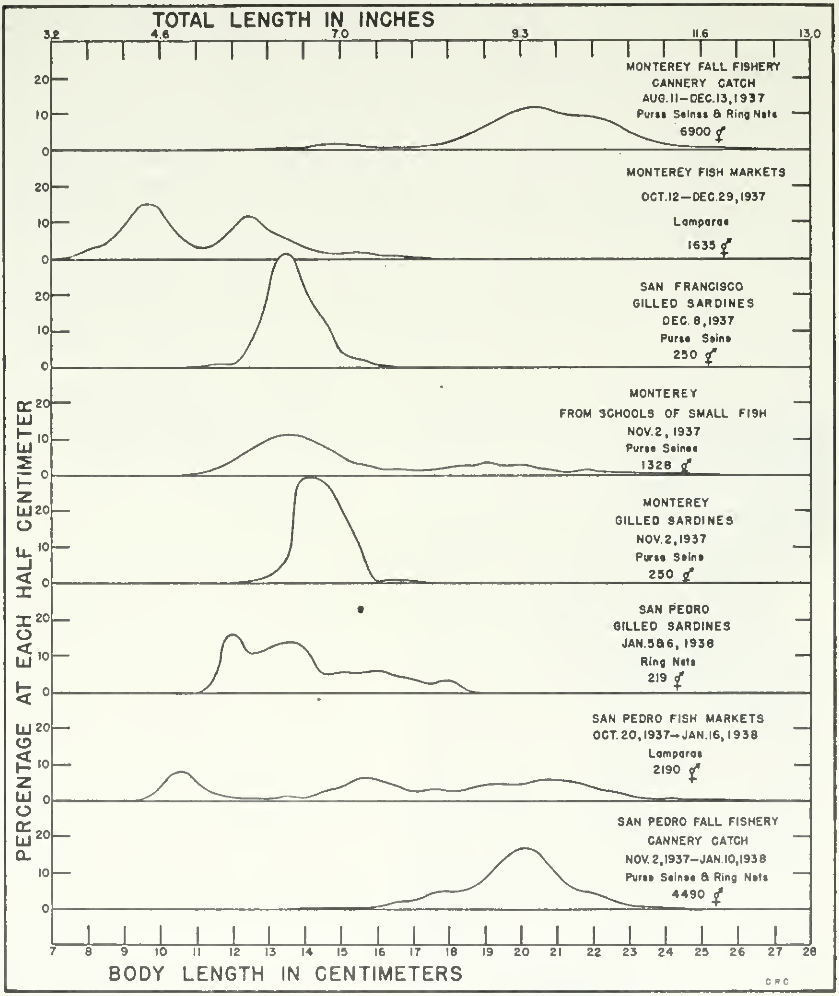

Fig. 67. Length frequency polygons showing sizes of gilled sardines compared with market and cannery catches. All measurements grouped to nearest half centimeter.

fish may also have been caught in the deeper water where the large present day seines are operated. If the latter is true, the present abundance can not be considered unusual.

The modes for the San Francisco and Monterey gilled sardines fall at points approximately midway between the upper of the two modes in the fish market frequency and the lowest mode of the cannery frequency. There may be several explanations. The most obvious ones are that possibly purse seines and ring nets gill only selected sizes of this particular group; or the smaller sizes of the group may school nearer to shore where the market boats fish, and bigger sizes farther at sea where the large nets are operated.

In contrast to Monterey, the frequency for San Pedro cannery sardines does not show a mode corresponding to sizes which gill in the nets. The frequency polygon for gilled sardines at San Pedro apparently includes fish from the two smaller size groups present in the San Pedro fish market frequency. As at Monterey, the gilled fish at San Pedro were taken from distinctly different fishing grounds than were the sardines delivered to the fish markets. This may possibly explain the difference in size distribution in the two frequencies. However, a more probable explanation is that the larger fish of the smallest group and the smaller fish of the next larger group are those which gilled in the ring nets from which the gilled samples were obtained.

On the basis of the frequencies for the sardines delivered to the fish markets at both Monterey and San Pedro, it seems evident that two distinct groups of young sardines are present in both localities. Only a small portion of the fish from the smaller groups gill in the meshes of ring nets and purse seines, the gilled fish coming chiefly from the larger of the two groups. The sizes of sardines which are gilling range from 11 to 17 centimeters, body length, or 5.1 to 7.9 inches, total length.

AN OUTLINE OF FISHING GEAR [1]

By W. L. SCOFIELD
California State Fisheries Laboratory
Division of Fish and Game

A visitor new to California is often confused by the many kinds of gear used in ocean fishing along our coast. Not only is there variety in the fishing devices themselves but there is such diversity in names that the newcomer is led to believe there is more complexity than actually exists. Later on he learns that some of the English, Sicilian, Dalmatian and Portuguese names are merely duplications of terms applied to the same type of fishing gear. The confusion is still further reduced when he realizes that many of the devices are similar in the method by which they are operated and that two or more fishing appliances may differ only slightly in construction according to the manner in which they are to be used. The different devices for catching ocean fish may be grouped into related types according to use and it is the purpose here to present such an orderly arrangement in the hope that it will aid somewhat in reducing the misleading complications in kinds and names of gear. A description of the different devices will be left to a later publication in which we plan to give the characteristics of each kind of gear and to provide a glossary of terms used in connection with ocean fishing operations.

Fig. 68. A trap for spiny lobsters, showing funnel entrance at the top of the trap. The man is holding a separate funnel from another trap. Photograph by G. R. Chute.

The outline here presented does not include a number of unusual kinds of gear used in foreign countries. For example, it makes no provision for the splash board used in connection with the Chinese trick of luring fish out of the water and into the fishing boat. It does, however, include a few illegal fishing devices occasionally attempted by an optimist before court fines dampened his enthusiasm.

[1] Submitted for publication, January, 1938.

A few of the terms used in the outline need a little explanation because sea-going fishermen as well as fresh-water anglers are blessed with a picturesqueness of language of which exactness in meaning is not an outstanding characteristic. The term "fishing gear" obviously means all the apparatus and implements used in catching fish, except that as here used gear does not include the boat employed in the fishing operations. Incidentally fishing boats are commonly called by the name of the gear fished by them, as gill netter or purse seiner for example, and likewise the men of the boat are designated by the gear they operate so that fishermen may be otter trawlers, hand liners or trammel netters.

In fishing, the two words net and seine often may be used interchangeably. Our words net and knot are related and a net is a fabric

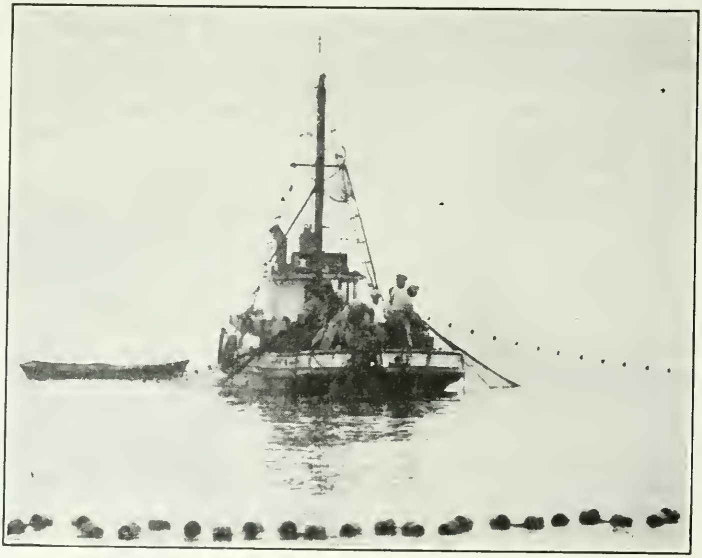

Fig. 69. Hauling a mackerel ring net. The bottom of the net has been pursed so the fish can not escape. The mesh does not show except where it is bunched. Photograph by D. H. Fry, Jr.

made by knotting cords leaving openings of uniform size. Such a fabric or net may therefore be used for confining fish, butterflies or straying locks of hair. In other words it is a very general term. A seine is a large net used to catch fish rather than butterflies, and it hangs vertically in the water with the upper edge buoyed by floats and the lower edge weighted. The word seine is therefore sufficiently general to warrant its application to many types of fishing nets.

A net when laid out, cast, circled or shot is said to be "set" or "in a set" and the captain or the boat itself is said "to set on" a school of fish, but this is not the use of the word "set" as applied in the classification of gear. A net or line is considered set when it is anchored or in some way attached to the bottom or shore so that it is not free to move with the water currents. By contrast a drift line or net has no such fixed attachment to the bottom or shore and is therefore free to drift with any currents of the water.

Two simple words of similar sound but very different meaning are constantly confused—troll and trawl. Troll literally means wander or move about, but in fishing it is the moving through the water of a line with one or more hooks. Trolling is pulling a line with hooks through the water as from the stern of a boat while under way. A trawl is a bag net intended to be dragged along, usually on the bottom of the sea, so trawling is the dragging of such a net. Fortunately in this State we are spared the confusing application of the word trawl to a long stationary set line as is so frequent among fishermen in some of our eastern states.

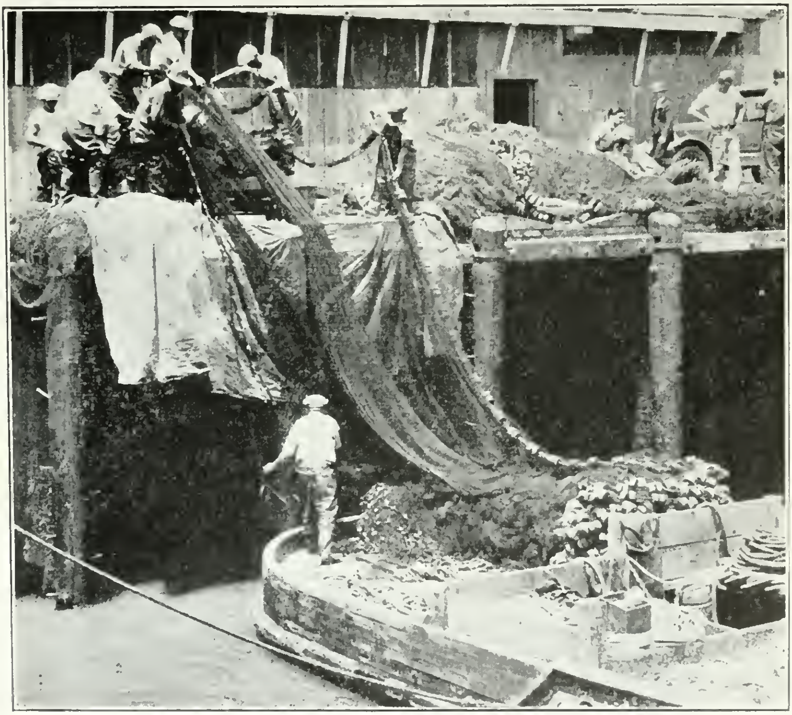

Fig. 70. Unloading a sardine ring net from a boat for tanning and mending. This net is over 1200 feet long. Photograph by D. H. Fry, Jr.

A fish trap is some sort of an impounding device, drifting or set, and the term may be applied to a great variety of such structures, most of which are not permitted under California law. Small traps for fish or lobsters may legally be used in parts of this State under certain circumstances, and such traps usually are built of wood slats or woven wire over a wood frame. A small trap constructed of cord webbing over hoops is anchored in streams but this, as well as the wicker trap fished by our Indians, is given the special name "fyke." Strictly speaking a fyke is a funnel-shaped entrance leading to a small opening difficult to find as an exit which is the principle used in a common form of fly trap. The term fyke may be applied to any such funnel entrance in fishing gear and the anchored impounding traps used in some of our California streams are locally called fyke nets.

Entangling devices capture fish by two methods called gill and trammel. In a gill net the fish pokes his head into a small mesh of the net and when he attempts to back out finds that his extended gill covers are caught, thus the name gilling, but actually the fish is frequently found tightly wedged in the opening rather than caught by the gill cover. Trammel means to tie up or restrain in a confined space and a trammel net uses two or three walls of webbing, the inner curtain of small mesh hung slack with an outer wall of large mesh. The fish pokes the slack small mesh webbing through a large mesh of the outer wall and finds himself in a pouch or pocket of the net and so entangled that he can not execute a strategic retreat. An important difference between these two types of gear is that a gill net is obviously highly selective as to size of fish caught, whereas a trammel net entangles fish of a wide range of sizes.

In the outline the frequently used terms, circle net, round haul and haul seine, have been avoided because they are inclusive and do

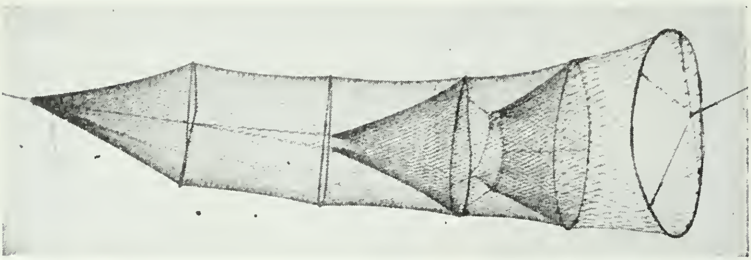

Fig. 71. A fyke net; open end at the right, bait at the left. This type of net is anchored in a stream. Once the fish have entered the net they find that the two funnels or fykes make escape difficult. Photograph by D. H. Fry, Jr.

not apply to any one kind of gear. The term circle net is occasionally useful in referring to the class of nets that are laid out in a circle until the two ends meet and are then pulled aboard a boat. Circle nets would then include the purse, lampara and ring nets but would exclude a gill net when fished in a circle, as it sometimes is. Round haul was originally applied in California to the lampara to distinguish it from the purse seine but now that the modified ring net has been evolved the term round haul has little meaning. Likewise the term haul seine is used too loosely and could apply as well to a beach seine as to any one of the three circle nets. The term half ring applied to a net is merely a survival from the time when lamparas had purse rings on one wing or half way around each wing. Since we no longer have nets ringed in this way, the term half ring should be dropped out of the picture following the gear to which the name once applied.

It should be pointed out that no arbitrary classification of gear can accurately cover each type of apparatus, because slight changes in construction or method of operating may convert one device into another or into a hybrid that in appearances resembles one parent but behaves like the other. For example, a drift gill net in a stream is supposed to drift free with the current but an ingenious fisherman discovered that smooth rock weights attached by lines to the lead line of such a net would drag on the stream bed and retard the drift, yet these drags were not strictly anchors or fixed attachments to the bottom. In another sense the net resembled a vessel dragging her anchor. The courts ruled

Fig. 72. Mackerel fishing—the man in the foreground is using a pole line and hook, the other man is operating a dip net made of chicken wire. Photograph by Richard S. Croker, June, 1934.

that the rocks prevented the net from drifting free with the current and the gill net was thereby converted from a drift to a set net.

In spite of the variations in gear and the diversity in names the essential principles involved in capturing fish are simple. Man uses (1) a spear or related tool, (2) a hook, or (3) a net to confine in a small space or to entangle the victim.

OUTLINE OF FISHING GEAR

I. MISCELLANEOUS DEVICES
   1. Spears—Gaff
   2. Shooting—Dynamite
   3. Poison
   4. Snares
   5. Diving
   6. Rakes—Forks—Oyster dredges
   7. Brush weirs
   8. Traps

II. LINES
   1. Pole (including kite line)
   2. Hand (drop line)
   3. Set (trot)
   4. Drift
   5. Troll (jig)

III. NETS
   1. Impounding nets
      a. Lifted
         (1) Dip nets
         (2) Hoop nets (including crab nets)
         (3) Blanket nets—Outriggers
         (4) Cast nets
      b. Pulled
         (1) Beach seines (chinchola)
         (2) Purse seine
         (3) Lampara
         (4) Ring net
         (5) Trawl
            (a) Beam
            (b) Drag (paranzella)
            (c) Otter
      c. Set
         (1) Trap
         (2) Fyke
         (3) Chinese shrimp net
   2. Entangling nets
      a. Gill nets
         (1) Drift
         (2) Sunken—Submerged—"Diver"
         (3) Set—Anchored—Staked
         (4) Circled
      b. Trammel nets
         (1) Drift
         (2) Set

REPORT ON THE CALIFORNIA OYSTER INDUSTRY FOR 1937[1]

By Paul Bonnot
Bureau of Marine Fisheries
California Division of Fish and Game

Humboldt Bay

The 1937 season at Humboldt Bay (May to October) represents the third year in which a program of oyster research has been carried on with the local oyster, *Ostrea lurida*, and the biological material collected is the most complete so far obtained. Some pertinent facts are beginning to emerge from the study of the data of the last three years. As expected (Bonnot, 1937a) the 1937 set was comparatively light. No artificial collectors were used in the bay, but several carloads of dried Japanese oyster shell were laid out. A set was obtained in commercial quantity on this cultch; although nothing approaching the set of the 1936 season occurred.

The growing of native oysters in Humboldt Bay may be said to have passed the experimental stage, in so far as commercial production is concerned. The heavy set of 1936 is growing well with a small normal mortality. Considerable difficulty has been experienced in separating the young oysters caught on the new type of collector used (Bonnot, 1937b), and many of the spat have died from overcrowding. Experiments are now being conducted to obtain a formula for cement which will more readily separate from the wood after the setting is completed.

The collecting of data was carried on as in previous seasons, using the same stations as before. Samples of oysters were obtained once a week from the three stations to be tested for maturity, and the record of the spawning is complete for 1937. It was not possible to obtain a complete record of this phase of the work during the previous seasons, due sometimes to weather and sometimes to lack of equipment.

The 1938 season, from present indications, may show a much more prolific set than that of 1937, in which case several detailed experiments can be conducted which should add materially to our present knowledge.

The two active companies have imported eastern oyster seed during the last two seasons and some of the resulting oysters are now being marketed. Very few natives are as yet ready for market but it is expected that by the end of another season they will be available in some quantity. The eastern oysters did not ''harden up'' or become ''fat'' until early December and even then were not quite up to the usual standard. This condition, however, need not be considered as an indication that the easterns are not suited to the conditions in this bay. The fall of 1937 was unusually warm which would tend to delay ''fattening.'' Also during some seasons many oysters do not become prime at all for reasons which are at present obscure. As the easterns

[1] Submitted for publication, January, 1938.

were all laid out on ground which was comparatively high, a bed in deeper water may react favorably for "fattening."

A third company, impressed with the possibilities of the bay, commenced operations in November and plans to have dikes and spat collecting equipment ready by the time the spawning starts in 1938.

The location of the three stations originally selected for collecting data and used continually for three seasons, was determined primarily by the proximity of natural oyster reefs. Although all three localities are subject to the general conditions prevailing in the bay, considerable differences appear when a comparison of the data is made. The only factor common to all three and different from the main bay is a slightly lower salinity due to incoming fresh water. The amount of this influx is different at each place, with a consequent difference in actual dilution.

Although all three localities are favorable to the growth of oysters, as demonstrated by the presence of natural reefs, the hydrographical conditions are sufficiently dissimilar to cause a difference in the rate of spawning and the time and intensity of setting. The salinity varies, of course, but the difference between the stations is very small. The temperatures probably do not vary to any extent, although this can not be definitely determined at present as only one recording thermometer is available.

A number of pertinent conclusions can be inferred or demonstrated from the present data. The oysters start spawning when the water temperatures reach a minimum of 13° C. This was also found to be true for the Puget Sound area. (Hopkins, 1937.) The spawning increases to a maximum in about two weeks' time and then slows up somewhat, although spawning oysters are present during the whole season. The swimming larvae start to set approximately thirty days after the spawning peak. The determining factor is apparently a series of neap tides followed by a series of spring tides. No correlation between the tide range and setting is evident. As spring tides consistently follow neap tides, a wave of setting which begins during a series of neap tides can be expected to reach a peak just previous to or during the following run of spring tides.

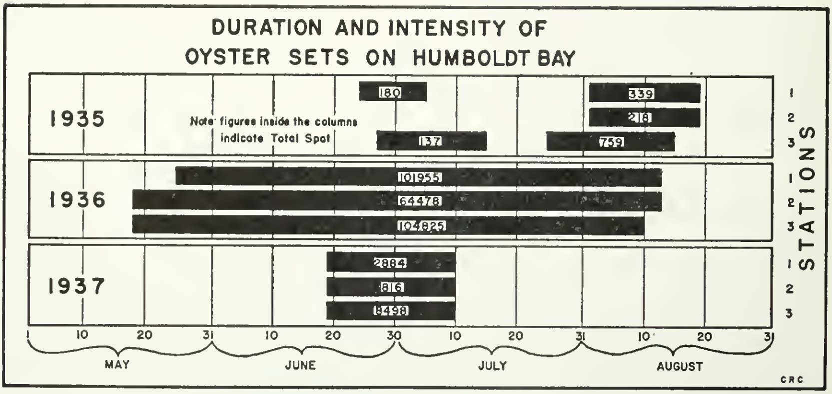

Fig. 73. The duration and intensity of the sets of native oysters, *Ostrea lurida*, at the three experimental stations maintained by the California Division of Fish and Game on Humboldt Bay, 1935, 1936 and 1937.

Data from other bays (Hopkins, 1937) demonstrate two waves of setting during a season. This has not occurred consistently at Humboldt Bay. Figure 73 illustrates the setting waves for all three stations during the three seasons. The horizontal bars indicate the approximate time extent of the setting waves and the figures give the total comparative size of set as shown by the shell bag counts. The year 1935 was at variance with the other seasons in time of set and was in accord with the data of other bays, showing two waves of set, the second greater than the first. There was considerable dissimilarity during all three seasons in the number of spat set at each station, as well as a great difference between seasons.

Station 3 (Eureka Slough) has a consistently higher spat fall than the other stations and this acts as a natural compensation to maintain the bed, as Eureka Slough with the largest influx of fresh water silts heavily during the winter with a consequent high mortality among the spat. It was estimated that during the winter of 1936, 75 per cent of the set of the previous season was killed by silting. An inspection of stations 2 and 3 during the summer of 1937 revealed little or no mortality at station 2 and a thriving cluster of young oysters on every pebble and shell fragment; whereas at station 3, clusters of old shell were covered with the dead valves of the previous season's set. The spring freshets seem to clear the silt away in Eureka Slough, leaving the bottom covered with comparatively clean shell ready for the next season's spat fall. Station 1 (Mad River Slough) falls between these extremes. The natural bed is a comparatively small local area surrounded by soft mud, but as the currents are strong the bed seems to maintain itself at a consistent numerical strength. Any silt carried over the bed is brought by the tidal currents, as the fresh water which is present in small amounts comes from seepage through several miles of swamp land, possibly from Mad River.

It was noted during the 1936 season (Bonnot, 1937a) that the swimming spat, once started on a setting cycle, do not set continually or uniformly, but attach themselves more plentifully at certain times than at others. That is, a bag of shell exposed for a period of a week will show one, two or three distinct age-classes. Some may have been attached for only a few hours while others may be four, five or six days old. There is seldom any gradation from one of these age-classes to the other. It can be concluded therefore that the larvae are attaching themselves to the cultch offered only during short periods, limited by a necessary combination of environmental factors. If it were possible to run a continuous hourly test during one of these spurts of setting much useful information might be gathered, and it was with this in mind that a test run was made at station 3 during July, 1937. As little is known concerning this phenomenon it would be a fortunate chance rather than deliberate calculation to hit one of these surges of setting. In the present instance the set had definitely stopped altogether and no second wave occurred. It is hoped that next season an opportunity may be presented to run several continuous hourly collections of data, if necessary through a period of 48 or 60 hours.

Bodega Lagoon

The growing of Japanese oysters, *Ostrea gigas*, during 1937 has progressed satisfactorily throughout the State. Plantings, totalling 3550 cases of seed, were made during the spring and everywhere the new seed is growing nicely.

In 1932 three small experimental plants of Japanese seed were made in Bodega Lagoon but the situations chosen were unfavorable and no returns were obtained. In 1936 a single test plant of 25 cases was laid out in what appeared to be a suitable location and, as the results were encouraging, a much larger planting was made in the spring of 1937. The oysters from the 1936 planting are now of marketable size and the 1937 seed is showing a very good growth. The principal need of the Bodega bed at present is a drastic culling as the oysters are still in the original clusters, resulting in crowding, which makes for many misshapen individuals and retarded growth. The seed on an individual shell of the original cultch is generally far too numerous to be allowed to grow *in situ*, as the oysters are all competing for food and space and the result is a number of long, narrow, thin-shelled oysters. If broken apart, not necessarily into singles, but into groups of four or less, the oysters have a chance to expand and grow, and a more uniform, round, deeply cupped shell is developed, with a correspondingly larger oyster.

From present indications, the Bodega bed seems to possess the necessary requirements for growing Japanese oysters successfully and in considerable quantity.

Tomales Bay

Tomales Bay has an old established oyster business based on eastern oysters, *Ostrea virginica*. Some effort was made, several years ago, to develop the indigenous natives, *O. lurida*, but the activities of the introduced eastern oyster drill, *Urosalpinx cinerea*, made the attempt abortive. Plantings of Japanese seed were started in 1933 by the company handling the easterns. Their Japanese beds are now of some extent and they have been marketing the oysters for several years. Several other plants of Japanese seed have been made by other individuals in other parts of the bay with satisfactory results. The available area in Tomales Bay suitable for growing oysters is limited, due to topographical features and although the bay is not at present producing to capacity the most favorable locations are already under cultivation.

Drakes Estero

In 1932 and 1933 several test plants of Japanese seed were made in Drakes Estero. These were so successful that a corporation was formed and larger plantings have been made during the last several years. In common with most attempts to adapt exotic species to a strange environment, mistakes were made at first in the selection of suitable areas, but after several years of trial and error the merits and demerits of various parts of the bay have been determined. At present the beds are in a flourishing condition. Oysters have been marketed in increasing numbers from these beds for several years.

The available growing area of the bay is extensive and there is still ample space for expansion.

San Francisco Bay

Only one company cultivates oyster beds in San Francisco Bay at present. They have handled eastern oysters for many years. They started with Japanese seed in 1933, and have made several large plants. The Japanese oysters grow more slowly in San Francisco Bay than in some of the other localities and acquire a greenish tinge, due perhaps to copper salts. This coloring does not affect their edibility in any way. Eastern oysters held in the bay for any length of time also become tinged with green. The native oyster, although plentiful, does not grow to a sufficient size to be marketable. As the bay is heavily infested with the eastern oyster drill, brought in with the first introductions of eastern oysters, any attempt to cultivate the natives would start under a disadvantage and the cost of production would be considerably higher in consequence.

Morro Bay

Test plants of Japanese seed were first made in Morro Bay in 1932. Despite the absence of any systematic attention these oysters grew very well until picked up and sold by poachers. In the spring of 1937 a test plant of 50 cases was made and these have been carefully tended. They have done very well, and as there is considerable available area the bay may become an important oyster growing location.

Newport Bay

In the spring of 1937 a test plant of 50 cases of Japanese seed was laid out in Newport Bay. The oysters have shown a larger growth than those in more northern bays, due perhaps to the prevailing higher water temperatures. Because of the higher water temperatures, however, they have not hardened up so well. It may be that the marketing season for these oysters will be confined to the colder months of winter, as the approach of cold weather seems to cause oysters to harden or fatten.

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NOTES

VOLUME 24 APRIL, 1938 Number 2

THE 1937 PISMO CLAM CENSUS

The annual census of Pismo clams, *Tivela stultorum*, at Pismo Beach was taken by the staff of the California State Fisheries Laboratory on November 17-19, 1937. Age determinations were made at the Laboratory, and, following the custom of the past two years, clams aged without injury were replanted on a southern California beach. Included were 1080 individuals, of which 731 were clams of the year. This is the largest of the three plants.

The total number of clams taken was the greatest in many years. A very strong incoming year class following so shortly after the large set of 1935 is responsible for this. In all, 1179 clams were counted. Of these, 63.4 per cent were clams of the year, 8.7 per cent one-year, 21.0 per cent two-year, 0.6 per cent three-year, 1.6 per cent four-year, 0.6 per cent five-year, 2.7 per cent six-year, and 1.4 per cent seven years or older. As is usual, the bulk of the year's set was found on the portion of the beach that is open to digging. There it represented 105 per cent of the 1935 set. In the area closed to digging it was but 86 per cent of 1935, the set for the entire beach equalling 97.0 per cent of that year's set. The individuals of the incoming class were noticeably smaller than is usual, the average size falling at 14.9 mm. and the range extending from 8 to 26 mm. A size more in accordance with expectancy was shown by the incoming group taken at the same time of year in 1936, the mean of that group falling at 21.6 mm., while the range was 13 to 37 mm. Whether a late set, unfavorable water conditions, lack of food or other factors are responsible for the small size noted this year is a matter of conjecture.

The large 1935 class shows a better survival rate in the open area than did the strong 1929, 1930 and 1931 classes at the same age: 33 per cent compared with 18 per cent. However, in the closed area the opposite holds true for but 29 per cent of the 1935 class survived as against 35 per cent of the 1929, 1930 and 1931 classes at the age of two years. The number of spawning clams (clams four years and older) present in the closed area is but half of what it was in 1936 and 80 per cent of 1935. Clams of legal size formed 17 per cent of the total compared with 22 per cent in 1936. In the open area, no clams of legal size were found, and those four years and older were but 37 per cent of 1935. A further decrease in the number of spawning clams in the open area may be expected in 1938, as nearly all of the survivors of the large sets of 1929, 1930 and 1931 will have entered the legal catch by that time, the 1933 class will be reaching legal size, and will be removed immediately and the incoming spawning group (1934 class) is negligible.

The most encouraging feature of this year's census was the discovery of the good set for 1937. There have been but two really poor sets since 1929—those of 1932 and 1934—whereas those of 1931 and 1935 as well as 1937 have been exceptional. On the other hand, the drop in number of spawning and legal-sized clams in the closed area is disappointing. From 1929, when the area was closed, to 1933 clams of legal size were very scarce, forming not over 2 per cent of the population. A steady increase followed, and in 1936, 22 per cent were of legal size. Although the drop noted this year is not great, it does dampen hopes that the area might be repopulated to something of its former status. With the succession of large sets of the past few years the potential future of the population is very good. However, a continued decrease may be expected in years to come if public opinion in the Pismo area continues indifferent, for more adequate protection against the poaching which is known to be taking place can be given only with the cooperation of the local residents. In their hands lies the ultimate fate of the beach.—*P. M. Roedel, California State Fisheries Laboratory, January, 1938.*

PINK SALMON IN CALIFORNIA

Pink or humpback salmon, *Oncorhynchus gorbuscha*, are only rarely found in California, being abundant only from Washington north to Alaska. Hence, it is felt that reports of considerable numbers running in northern California streams in 1937 should be made a matter of record. The last previous California specimen was reported in 1933 from the egg-taking station of the U. S. Bureau of Fisheries on Mill Creek, a tributary of the Sacramento River.

On October 8, 1937, Captain J. D. Dondero of the California Division of Fish and Game, Eureka, sent a small salmon to the San Francisco office for identification. The fish proved to be a mature female pink salmon, eighteen inches long. It had been taken on a spinner in tidewater of the Mad River, Humboldt County.

Following the receipt of the above fish some additional reports of humpback salmon were sent in by two Division of Fish and Game wardens in the North Coast area.

Warden Ovid Holmes of Fort Bragg reported as follows:

"The humpbacks were first noticed this year (1937) in the Ten Mile and Garcia rivers about October 1. In the Ten Mile River they were seen spawning about five miles upstream from the mouth. I might say also that there was quite a run of them, ranging in size from three to six pounds. Many people were interested in knowing what kind of fish they were, and whether they all took my explanation as to the species, I could not say. I might also say that seven years ago I caught a male of the same species in the Ten Mile River on November 7, and one the following year on February 6. I have not seen or heard of them since those two years in the streams along the Mendocino Coast until this fall. Also there seems to be a much larger run of them this year than in the previous years mentioned. Whether this is true or not I can not say for sure, as in the previous years the water was roily as we had had several freshets and the fish could not be seen. However, this year the water was clear and many quite large schools of them were seen, causing quite a lot of talk around here. There is no doubt the fish hit this section every so often and spawn here. Further than that I can not tell you any more about them.''

Warden Leo Mitchell of Point Arena also sent in a report. He states, ''On September 26, I was told of a large run of unknown fish in the Garcia River. I went to investigate on the 27th and found them spawning all over from the Red Bridge to the western boundary of the Indian Reservation, a distance of about two miles. The water was rather low and beds quite mossy. I found females without and males with a hump working hard on the beds. The run seemed large. I would say that on September 27 and October 1 and 2, when I was patrolling the river quite closely for trout fishermen, I saw several hundreds. Finally I found a dead male but it was too far gone to send in. It was 23 inches long, 8 inches wide at hump, gray in color and with teeth in upper and lower jaws. I could not count the scales, pyloric caeca, or soft rays in the anal fin. A particular fact is that black spots covered all fins and the tail.

''On the third of October I tried to make a count of the number of fish but it was very difficult. During one hour near Windy Hollow Ford I counted 116. I became immensely interested and inquired about other coastal streams. Warden Holmes told me of their presence in the Ten Mile River and Warden Von Arx said they were in the Russian River. I saw them myself in this river, milling around on the riffle at Lone Tree west of Monte Rio on October 6, and then just under the bridge at Monte Rio on October 22. They had disappeared from the Garcia around the fifteenth of October. As far as I can tell, six were caught by sportsmen before I came back and were found to be good eating but poor fighters. I saw two brought to the Point Arena Inn.''

The foregoing descriptions of the fish are not sufficiently detailed to make certain the identification as to species. However, both Wardens Mitchell and Holmes have had long experience and are thoroughly familiar with the fish normally present in the streams. The information is therefore thought worthy of record.—*A. C. Taft, California Division of Fish and Game, December 11, 1937.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year

Revenue for Fish and Game Preservation Fund:

Current Year:

Licenses:	Detail	Total
Angling licenses, 1938	$141 00	
Angling licenses, 1937	285,340 55	
Commercial hunting club licenses, 1937-1938	900 00	
Commercial hunting club operators' licenses, 1937-1938	280 00	
Deer tag licenses, 1937	86,808 00	
Fish breeders' licenses, 1937	40 00	
Fish importers' licenses, 1937	20 00	
Fishing party boat permits, 1937-1938	186 00	
Fish packers' and wholesale fish dealers' licenses, 1937-1938	1,010 00	
Game breeders' licenses, 1938	2 50	
Game breeders' licenses, 1937	117 50	
Hunting licenses, 1937-1938	228,139 75	
Hunting licenses, 1936-1937	19,982 50	
Kelp licenses, 1937	20 00	
Market fishermen licenses, 1937-1938	40,790 00	
Trapping licenses, 1937-1938	1,919 00	
Total licenses		$665,696 80
Other revenue:		
Court fines	$27,284 94	
Fish packers' tax	103,559 92	
Fish tags, 1937	1,767 24	
Game tag sales	161 34	
Interest on bank balances	712 73	
Kelp tax	145 25	
Lease of kelp beds	384 66	
Miscellaneous sales	2,756 87	
Publication sales	15 01	
Salmon tax	20,880 49	
Total other income		$157,668 45
Grand total current year revenue		$823,365 25

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Operating Expenditures—89th Fiscal Year:					
Administration:					
Accident and death claims			$485 01		$485 01
Cashier	$300 00				300 00
Executive	2,499 96	$57 91	1,370 67		3,928 54
Exhibits			1,200 00		1,200 00
General office	3,681 33	2,463 38	9,605 23	$66 44	15,816 38
Legal			2,394 17		2,394 17
Library	900 00	1 71	69 74	259 79	1,231 24
Property inspection		2 00	86 70		88 70
Prorata department accounting	5,000 00		6,000 00		11,000 00
Prorata General Fund expense			2,752 46		2,752 46
Publicity			2,001 82		2,001 82
Total Administration	$12,381 29	$2,525 00	$25,965 80	$326 23	$41,198 32
Patrol and Law Enforcement:					
Cannery inspection	$10,266 86	$379 04	$1,692 74		$12,338 64
Executive	7,110 00	372 66	1,385 84	$65 28	8,933 78
General office	2,805 48	240 93	1,689 93	134 91	4,871 25
Junior patrol	1,423 12	152 19	352 73		1,928 04
Land patrol	92,540 04	16,654 20	31,929 31	13,331 76	154,455 31
Marine patrol	23,400 82	9,877 74	14,304 98	2,074 07	49,657 61
Pollution patrol	3,104 19	858 43	2,040 44	124 99	6,128 05
Total Patrol and Law Enforcement	$140,650 51	$28,535 19	$53,395 97	$15,731 01	$238,312 68
Marine Fisheries:					
Executive	$3,660 00	$107 82	$230 35		$3,998 17
Fieldsupervision	1,640 00	157 14	1,458 87		3,256 01
Fish cannery auditing			660 95		660 95
General office	4,008 01	92 04	495 44		4,595 49
Research and statistics	18,602 10	1,883 62	5,098 99	$1,311 67	26,896 38
Total Marine Fisheries	$27,910 11	$2,240 62	$7,944 60	$1,311 67	$39,407 00
Fish Conservation:					
Cooperative Research-Stanford University	$979 67	$175 12	$333 88	$44 95	$1,533 62
Executive	3,180 00	121 42	309 58	915 90	4,526 90
Field supervision	5,055 06	465 06	2,162 66	605 27	8,288 05
Fish planting	2,601 22	1,046 25	1,630 31	4,334 24	9,612 02
Fish rescue	3,367 85	418 74	1,142 12	208 33	5,137 04
General office	2,397 41	24 75	36 27	173 67	2,632 10
Pollution inspection	1,560 00	179 03	443 02		2,182 05
Research	1,282 42	81 39	489 21	87 22	1,940 24
Statistical	1,140 00		477 50		1,617 50
Alpine Hatchery	897 23	636 09	159 47	550 65	2,243 44
Basin Creek	2,202 61	1,123 88	285 95	541 78	4,154 22
Beaver Creek Egg Collecting Station	250 00				250 00
Beaver Creek	148 55	46 90	8 58		204 03
Big Creek	1,561 67	922 18	167 25	543 45	3,194 55
Blackwood	272 81	218 39	1 00		492 20
Blue Lakes Egg Collecting Station	400 00		16 00		416 00
Bogus Creek Egg Collecting Station		14 00			14 00
Brookdale	1,320 32	1,109 03	201 07		2,630 42
Burney Creek Hatchery	2,613 27	882 61	311 48	552 66	4,360 02
Carmen Lake Egg Collecting Station	312 00	2 24	10 43		324 67
Central Valleys	1,513 31	1,119 85	992 23	527 39	4,152 78
Cold Creek	2,468 27	1,695 42	466 08	579 48	5,209 25
Cottonwood Lakes Egg Collecting Station	83 87	11 10	75 23		170 20
Fall Creek Egg Collecting Station		12 61	85 00		97 61
Fall Creek	2,941 13	1,638 82	181 44	6 06	4,767 45
Feather River	2,089 55	791 50	264 35	164 35	3,309 75
Tahoe	2,980 35	1,245 13	369 82	43 23	4,638 53
Fern Creek	912 71	347 00	56 27		1,315 98
Fishing Creek Experimental Station	358 06	22 25	5 31		385 62
Forest Home	5,597 51	6,893 25	997 08	34 47	13,522 31
Fort Seward	1,968 71	697 40	98 05	673 95	3,438 11
Hornbrook Egg Collecting Station		41 03			41 03
Hot Creek	1,440 81	954 46	127 36		2,522 63
Huntington Lake	246 00	253 15	156 40		655 55
Kaweah	2,375 32	563 81	736 59	52 06	3,727 78
Kings River	2,725 98	1,057 32	775 01	35 12	4,593 43
Klamathon Egg Collecting Station	1,412 91	121 48	324 58	12 21	1,871 18
Kosk Creek Egg Collecting Station		8 44			8 44

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Lake Almanor	$3,046 17	$1,200 60	$251 21	$133 58	$4,631 56
Lake Eleanor Egg Collecting Station		18 94			18 94
Little Walker Lake Egg Collecting Station	259 03				259 03
Madera	439 84	432 55	243 83		1,116 22
Marlette Lake Egg Collecting Station	713 17	4 79	26 35		744 31
Mount Shasta Exp. Hat.	361 29	426 21	25 09		812 59
Mount Shasta	14,369 73	9,310 24	1,963 84	115 00	25,758 81
Mount Tallac	692 32	715 81	30 60		1,438 73
Mount Whitney	5,248 64	3,247 83	1,822 93	730 49	11,049 89
Mud Creek Egg Collecting Station	9 21				9 21
Prairie Creek	2,475 13	754 80	386 55	587 05	4,203 53
Rush Creek Egg Collecting Station	369 33	49 81			419 14
Scott Creek Egg Collecting Station	750 00	77 04	87 03		914 07
Shackleford Creek Egg Collecting Station		31 25	50 00		81 25
Shasta River Egg Collecting Station	293 54	41 13	95 20	6 64	436 51
Shasta River Experimental Station	152 00	53 17	49 23		254 40
Snow Mountain Egg Collecting Station		31 50	1 00		32 50
Waddell Creek Station	231 94	12 36	27 09		271 39
Warner Creek Station	9 21				9 21
Yosemite	1,889 55	707 81	152 25	9 84	2,759 45
Yuba River	1,651 80	610 99	200 18	3 12	2,466 09
Total Fish Conservation	$93,618 48	$42,667 93	$19,308 96	$12,272 16	$167,867 53
Hydraulics:					
Engineering	$2,250 00	$262 51	$1,080 72	$1,502 27	$5,095 50
Executive	2,010 00	150 98	449 20		2,610 18
Fish screens		144 55		1 64	146 19
General office	960 00	45 88	38 21	147 31	1,191 40
Total Hydraulics	$5,220 00	$603 92	$1,568 13	$1,651 22	$9,043 27
Game Conservation:					
Elk refuge	$1,188 32	$119 07	$299 79	$131 81	$1,738 99
Executive	5,627 48	373 21	1,062 15	27 77	7,090 61
Field				17 06	17 06
Game bird distribution	800 00		207 04		1,007 04
General office	2,412 44	115 54	10 57	103 06	2,641 61
Grey Lodge refuge	1,920 00	343 80	119 33		2,383 13
Imperial refuge	720 00	80 95	45 54		846 49
Los Banos refuge	1,497 16	326 59	365 22	47 22	2,236 19
Los Serranos game farm	6,449 90	3,449 85	1,680 25	767 88	12,347 88
Predatory animal control	15,331 19	2,102 42	5,729 79	32 52	23,195 92
Research	272 74	39 45	553 36		865 55
Suisun refuge	940 00	353 87	259 80	114 82	1,668 49
Winter feeding and salting of game		190 30			190 30
Yountville game farm	7,564 31	6,517 23	2,139 18	210 98	16,431 70
Total Game Conservation	$44,723 54	$14,012 28	$12,472 02	$1,453 12	$72,660 96
Licenses:					
Executive	$1,650 00		$23 14		$1,673 14
General office	733 67	$79 99	1,724 60	$2,093 90	4,632 16
License distribution	5,391 02	13,139 50	32,367 78	91 67	50,989 97
Total Licenses	$7,774 69	$13,219 49	$34,115 52	$2,185 57	$57,295 27
Special Item—Construction of research boat					$3,000 00
Total 89th Fiscal Year Expenses paid from Support Appropriations					$628,785 03
Expenditures for Additions and Betterments:					
Permanent Improvements:					
Purchase of game refuges and public shooting grounds and C.I.E. Chap. 157-37	$470 00	$714 58	$1,462 31	$24 68	$2,671 57
Contributions to Employees' Retirement System					9,203 26
Total Current Biennium					$640,659 86

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Prior biennium appropriations:					
89th Fiscal Year:					
Special Item—Expenses of California Code Commission, Chap. 645-33					$0 37
88th Fiscal Year:					
Special Item—Construction of Russian River Jetties, Chap. 989-33					365 84
Support:					
88th Fiscal Year				$56,166 16	
87th Fiscal Year				16 62	
Total Support					$56,182 78
Special Item—Predatory Animal Control, 88th Fiscal Year					3,426 15
Expenditures for additions and betterments, permanent improvements, purchase of game refuges and public shooting grounds and C. I. E., 88th Fiscal Year					18,141 67
Total Prior Biennium Appropriations					$78,116 81
Grand total					$718,776 67

SEIZURES OF FISH AND GAME

October, November, December, 1937

FISH:	
Abalone	238
Bass, black	103
Bass, striped	159
Bass, striped, pounds	130
Catfish, pounds	6
Clams	919
Cockles	220
Crabs	22
Flounders	2
Halibut, pounds	106
Lobsters	819½
Lobsters, pounds	2,233
Lobster pots	71
Lobster receivers	16
Lobster traps	94
Salmon	61
Sheepshead, pounds	220
Sunfish	16
Trout	177
Trout, pounds	14
Tuna, yellowfin, pounds	6,705

GAME:	
Antelope head	1
Bear skin	1
Curlew	5
Deer	41½
Deer head	1
Deer meat, pounds	1,064
Doves	136
Ducks	72
Elk	1
Geese	2
Godwit	1
Grebe	2
Grouse	1
Meadowlark	4
Mink hides	3
Mudhens	29
Muskrat pelts	19
Pheasant	38
Quail	257
Rabbit	34
Robins	2
Sandpipers	12
Sparrow	14
Swan	3
Towhee	1
Willets	2
Yellowhammer	1

GAME CASES

October, November, December, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope; possession	1		
Bear; closed season	2	$50 00	
Deer; evidence of sex removed; failure to fill out tag; failure to retain hide and horns; dogs killing deer in refuge; closed season; mutilating tags; offering hides for sale; transporting illegally; no tags; tags not countersigned; killing, possession doe, fawn, forked horn in Dist. 1¾, spike buck	140	5,736 00	281¼
Doves; closed season; overlimit	10	347 50	
Ducks; closed season; operating commercial club without license; overlimit	25	650 00	
Firearms in refuge	53	1,046 00	2
Geese; closed season	2	10 00	
Grouse; possession	1	50 00	
Hunting; closed season; night hunting; in refuge; making false statement to procure license; no license; transferring license; failure to show license on demand; using another's license	127	1,666 50	89½
Illegal shooting	34	535 00	30
Mink; closed season	2	10 00	5
Mudhens; closed season	5	55 00	
Muskrat pelts; illegal possession	2		
Nongame birds; closed season; killing, possession	14	335 00	
Pheasants; closed season; overlimit; selling	36	1,275 00	40
Pigeons; closed season	1	100 00	
Protected birds; possession	31	660 00	25
Quail; closed season; overlimit; selling	33	1,290 00	50
Rabbits; closed season	7	132 50	
Spotlight hunting	5	325 00	90
Trapping birds	2	25 00	
Trapping; no license	3		
Trespassing	9	200 00	
Using cane gun	1	25 00	
Totals	546	$14,523 50	612¾

FISH CASES

October, November, December, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone; closed area; out of shell; overlimit; undersize	37	$490 00	32
Bass, black; overlimit; undersize	8	120 00	
Bass, striped; overlimit; undersize	38	770 00	
Catfish; selling undersize	1		
Clams; out of shells; overlimit; undersize	39	1,223 50	397
Cockles; overlimit	1	25 00	
Commercial fishing; no license	73	880 00	60
Crabs; closed season; undersize	8	120 00	
Fishing; disturbing nets; failure to record fish purchases; closed area; closed season; from dam; too near dam, ladder; no license; night fishing; using another's license; using fresh trout roe; using prohibited gear	149	2,963 50	166½
Frogs; undersize	1	25 00	
Halibut; undersize	1	10 00	
Lobsters; closed season; oversize; undersize	33	765 00	625
Pollution	15	1,125 00	
Salmon; closed season; overlimit; selling; shooting; spearing; taking on spawning area	32	775 00	285
Trout; overlimit	6	120 00	
Totals	442	$9,412 00	1,565½

FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES FOR OCTOBER, NOVEMBER AND DECEMBER, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Landed in Region 70, Los Angeles	Landed in Region 80, San Diego	Total pounds
Barracuda	328,034	222,858	550,892
Cabrilla	15,113	1,874	16,987
Corbina, Mexican	738	--------	738
Grouper	3,678	306	3,984
Halibut, California	3,566	42,399	45,965
Mackerel, Pacific	--------	1,239	1,239
Mackerel, Spanish	14,875	4,177	19,052
Perch	--------	215	215
Rock Bass	9,780	7,400	17,180
Rockfish	--------	14,108	14,108
Sardine	--------	90	90
Sea-bass, Black	99,714	44,812	144,526
Sea-bass, Totuava	588,454	--------	588,454
Sea-bass, White	10,481	133,341	143,822
Shark	1,189	995	2,184
Sheepshead	207	3,911	4,118
Smelt	--------	1,319	1,319
Swordfish, Broadbill	--------	4,645	4,645
Tuna, Albacore	234,731	--------	234,731
Tuna, Bluefin	670	2,840	3,510
Tuna, Bonito	190,381	641,835	832,216
Tuna, Oriental	104,162	--------	104,162
Tuna, Skipjack	1,738,759	9,790,088	11,528,847
Tuna, Yellowfin	3,421,675	13,649,638	17,071,313
Whitefish	711	15,796	16,507
Yellowtail	91,378	887,267	978,645
Miscellaneous fish	707	--------	707
Crustacean:			
Lobster, Spiny	--------	305,657	305,657
Shrimp	2,090	--------	2,090
Total pounds	6,861,093	25,776,810	32,637,903

* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

FRESH FISH IMPORTATIONS BY POINT OF ORIGIN* FOR OCTOBER, NOVEMBER AND DECEMBER, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Gulf of California	West coast Lower California	International waters south U. S. boundary (definite origin unknown)	Mexican mainland, Central and South America	Japan	Total pounds
Barracuda		222,858	328,034			550,892
Cabrilla	3,545	1,874	11,568			16,987
Corbina, Mexican	738					738
Grouper		306	3,678			3,984
Halibut, California		42,399	3,566			45,965
Mackerel, Pacific		1,239				1,239
Mackerel, Spanish		4,177	14,875			19,052
Perch		215				215
Rock Bass		7,400	9,780			17,180
Rockfish		14,108				14,108
Sardine		90				90
Sea-bass, Black		44,812	99,714			144,526
Sea-bass, Totuava	588,454					588,454
Sea-bass, White		133,341	10,481			143,822
Shark		995	1,189			2,184
Sheepshead		3,911	207			4,118
Smelt		1,319				1,319
Swordfish, Broadbill		4,645				4,645
Tuna, Albacore					234,731	234,731
Tuna, Bluefin		2,840	670			3,510
Tuna, Bonito	170	641,835	190,211			832,216
Tuna, Oriental					104,162	104,162
Tuna, Skipjack		7,786,659	3,700,686	7,336	34,166	11,528,847
Tuna, Yellowfin		2,667,455	6,649,293	7,667,534	87,031	17,071,313
Whitefish		15,796	711			16,507
Yellowtail		892,998	85,647			978,645
Miscellaneous fish			707			707
Crustacean:						
Lobster, Spiny		305,657				305,657
Shrimp	2,090					2,090
Total pounds	594,997	12,796,929	11,111,017	7,674,870	460,090	32,637,903

* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

CALIFORNIA FRESH FISH LANDINGS* FOR OCTOBER, NOVEMBER AND DECEMBER, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Region 10, Del Norte	Region 20, Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds
Anchovy				1,800	10,000		64,835		76,635
Barracuda						35,786	377,670	224,496	637,952
Cabezone				515	826	78			1,419
Cabrilla							15,113	1,874	16,987
Carp			12,137						12,137
Catfish			154,188						154,188
Corbina, Mexican							738		738
Cultus, Pacific	6,104	51,503		108,465	58,361	471	470		225,374
Eel							123		123
Flounder, Starry		15		36,704	2,658				39,377
Flying Fish							783		783
Grouper							3,678	306	3,984
Hake				21,020			15		21,035
Halibut, California				3,193	4,195	114,280	27,407	58,134	207,209
Halibut, Northern		5,360							5,360
Hardhead			28,935						28,935
Herring, Pacific				78,030				4,107	82,137
Kingfish				311	47,302	65	97,921	114	145,713
Mackerel, Horse					2,029		1,934,595		1,936,624
Mackerel, Pacific				7,476	331,724	17,061	18,674,731	454,644	19,485,636
Mackerel, Spanish							14,875	4,177	19,052
Mullet							257		257
Perch		15		19,427	864	739	34,198	215	55,458
Pike			85						85
Pompano, California							51		51
Rock Bass						2,877	27,277	27,769	57,923
Rockfish	4,832	23,914		244,313	730,993	62,729	120,149	34,585	1,221,515
Sablefish		78,543		2,550	16		24,583		105,692
Salmon			307						307
Sand Dab				132,641	2,185		1,678		136,504
Sardine			33,783,700	141,559,352	159,278,906		107,948,987	214,355	442,785,300
Sculpin						36	24,787	3,910	28,733
Sea-bass, Black						6,746	100,195	45,522	152,463
Sea-bass, Short-fin								10	10
Sea-bass, Totuava							588,454		588,454
Sea-bass, White				216	4,947	39,781	34,030	143,773	222,747
Shark		873	7,288	185,464	69,255	26,095	17,433	12,192	318,600

Sheepshead						2,479	24,421	5,733	32,633
Skate				144,390	2,631	10,825	1,386		159,232
Smelt		2,867		45,396	20,709	1,957	56,594	1,810	129,333
Sole				1,949,364	27,735	38,358	283		2,015,740
Split-tail			1,311						1,311
Sucker			3,808						3,808
Swordfish, Broadbill						7,042	77,085	60,585	144,712
Tuna, Albacore		258		680	120,581		904,198		1,025,717
Tuna, Bluefin						120	171,987	2,840	174,947
Tuna, Bonito					38	3,896	677,910	712,525	1,394,369
Tuna, Oriental							104,162		104,162
Tuna, Skipjack						19	1,818,461	9,871,266	11,689,746
Tuna, Yellowfin						195	3,422,601	13,649,656	17,072,452
Turbot				21,597	2,509	36			24,142
Whitefish						11,052	6,491	18,895	36,438
Yellowtail							93,903	888,110	982,013
Miscellaneous Fish		6,820		37,575	12	1,117	3,914		49,438
Crustacean:									
Crab	548	17,564		770,082	10,070				798,264
Crab, Rock							162		162
Lobster, Spiny						78,850	153,752	378,948	611,550
Prawn					1,576				1,576
Shrimp				161,864			2,090		163,954
Mollusk:									
Abalone					241,225	352,962	1,582		595,769
Clam, Cockle				96			5,969		6,065
Clam, Gaper		1,056		426					1,482
Clam, Pismo					7,428	48,285			55,713
Clam, Soft-shell				23,985					23,985
Clam, Washington		6,678		465					7,143
Octopus		106		223	377	13	91		810
Oyster, Eastern		6,657		114,465					121,122
Oyster, Japanese				279,526					279,526
Oyster, Native				1,798					1,798
Squid					279,199		3,975		283,174
Total pounds	11,484	202,229	33,991,759	145,953,409	161,258,351	863,950	137,666,050	26,820,551	506,767,783

* Importations of fresh fish from foreign countries included. See foreign importation tables.

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California Fish and Game

"CONSERVATION OF WILD LIFE THROUGH EDUCATION."

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TABLE OF CONTENTS

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58775

SARDINE OIL AND OUR TROUBLED WATERS [1]

By W. L. Scofield

California State Fisheries Laboratory
Division of Fish and Game

Our sardine fishery in California has had a short, spectacular and tragic career. In the few years since the start of the World War, it has risen from insignificance to a place among the leading fisheries of the world and it now is facing a crisis. Our management of this fishery during the next few years will determine whether this career is to be a skyrocket that will drop back into darkness after a brief burst of glory, or whether it will be made a genuine career that will bring continuous wealth and satisfaction to the people of the State for years into the future. The fishery can be abandoned as a worked-out mine or it can be treated as a farm to produce a rich annual crop continuously. The fishery in its brief existence has produced many millions of dollars, and, if abandoned, this source of wealth to the people of the State will be canceled. If managed as a farm on the basis of sustained yield, the continuous crop will be worth several millions of dollars each year indefinitely into the future. There can be no question as to which procedure will yield the greatest total return and utilize this great resource most profitably. The question is whether we can recognize the crisis and apply common sense to the problem before it is too late.

The sardine is our problem child with great possibilities for good or harm, according to the way it is handled. It has one quality that can not be ignored, and the near future will determine whether it is a curse or a blessing. The sardine is rich in oil. The oil can be extracted cheaply and sold at a good price, and this is why the sardine is such a problem. Other fishes with less oil and less potential wealth can be more easily managed, but in the case of the sardine the oil has been at the bottom of the trouble and will make or break the sardine fishery. The oil has been used in vast quantities for industrial purposes such as paint, soap and linoleum, with only a small portion of it hydrogenated for human food. In the canned sardines the oil accounts for the high food value and rich flavor of the fish, but the amounts of oil that have gone into cans are small compared to the amounts that have been extracted and shipped out in tank cars. Sardines congregate in great schools and can be caught in quantity at low cost, so that the extracted oil can be produced and marketed in successful competition with vegetable and animal fats such as cottonseed oil and lard. This explains why our supply of sardines has suffered such a heavy drain. The fish flesh, after oil and water have been pressed out, is dried and ground for marketing as fish meal (stock food and fertilizer), but fish meal production is only incidental to oil extraction in the sardine reduc-

[1] Presented for publication, April 27, 1938.

FIG. 74. Approximately half of the San Pedro sardine fleet of purse seine boats photographed March 5, 1938, by Richard S. Croker. The small market boats in the left foreground are not purse seiners and they fish sardines only as bait. This forest of fishing boat masts partially explains where our sardines have gone.

tion plants of the State. The sale price of fish meal goes a long way toward paying the costs of operation, but it is the sardine oil that brings in the real money. Even the canning of sardines has become almost a side line to the extraction of sardine oil.

Early in the management of her fisheries, California adopted the policy that her fish should be used as food for man and should not be converted into meal and oil for industrial purposes, but an exception was made in the case of sardines. The excuse given for this exception to the general policy was that it would assist in the development of the then infant industry, but the ready money in the oil began to cause trouble almost from the start. The first cannery dumped at sea the scrap (offal) left from canning, but soon small reduction plants were established to use the offal and avoid polluting the ocean with waste fish material. Then the profit in oil was discovered and the reduction plants grew in capacity at an astonishing rate. With increased capacity,

FIG. 75. Sardine boats: foreground, a Monterey lampara launch which was typical of the sardine fishing boat at that port only a few years ago; background, a purse seine boat typical of the modern sardine fleet. Photograph by J. B. Phillips, October, 1930.

more sardines were needed. Thus began a long struggle in the courts and in the Legislature to use whole sardines in the reduction plants. More plants were built and canned goods were rushed to market, sometimes at less than the cost of production in order to get more offal and more whole fish into the reduction plant for the profitable oil. Step by step the Legislature yielded to the demand for more whole fish in the reduction plants, till finally the lid was off and the reduction of whole sardines ran practically wide open.

The story of the struggle against unrestricted reduction of whole fish has been an interesting chapter in the development of this industry, but the questions involved are a little too complicated to be covered here. However, one or two of the principles can be mentioned briefly as they are still operative and will be of importance in future discussions of the sardine industry. When a sardine is to be canned, the head is cut off well back on the body of the fish so as to clean the body cavity, and about one-third of the total weight is discarded as offal. Broken, crushed and off-sized fish are not used in the can and are roughly classed as offal, so that from a ton of sardines canned there is 40 to 50 per cent of the weight that does not enter the can but goes to the reduction plant as offal for conversion into oil and meal. A ton of sardines in suitable condition and of proper sizes will produce roughly 22 cases (48 oval one-pound cans to the case), but to allow for broken or small fish 20 cases per ton was adopted as standard. This allowed roughly half of each ton to go into the reduction plant as offal, but this half was offal plus a certain amount of whole fish. Then there was pressure to lower the number of cases required per ton so that more whole fish could be reduced and the 20-case requirement was dropped to 18, 15 and now to 13½ cases per ton, thus allowing more and more whole fish to go into the offal pit for the production of oil and meal. The leeway or tolerance allowed by the lowered case requirements made possible the use of increasing amounts of whole fish not cleaned for canning and this whole fish has become known locally as "overage."

Oil profits from "offal" and "overage" induced several changes in the sardine law so that a system of "special permits" developed under which additional whole fish, with certain restrictions, could be reduced to oil and meal. Each ton of additional whole fish meant ready money in sardine oil. Thus there was fish scrap from cleaning, plus whole fish allowed under the low case requirement, plus whole fish under special permit. In that way only a very small proportion of the sardine catch entered cans but a very large part went to oil and meal in the reduction plant. Oil meant money and ever increasing amounts of sardines were needed to supply the demand for oil.

A canning operation where all sardines are used for human food results in one-third to one-half the weight converted into meal and oil. This meal production from offal alone is more than the State consumes, which is ironical because the farmers of the State have been led into favoring unrestricted sardine reduction for the sake of cheap fertilizer and poultry and stock feed. This was dust in their eyes. The supporters of unrestricted reduction desired more oil, not more meal, and the normal amount of by-product meal from offal in canning is greater than the State consumption, so meal is shipped out of the State. Shipping out additional meal would not lower the price locally. The farmers were hoodwinked into supporting one of their competitors in the production of animal fat.

This story of the growth of the oil business should not give the reader the false impression that all sardine canners favored developing an oil rather than a canning business. Many of them felt that the huge catch for oil was a mistake and actively opposed sardine reduction except as a by-product of canning. If the catch of sardines could have been limited to canning, the great increase in catch would have been avoided and the sardine problem would now be just another routine job in fishery management. But part of the men in a group of business competitors can scarcely afford to hold back on principle and refuse quick profits which others in the same business are harvesting, yet in spite of the quick profits, the leading canners of the State were actively supporting the Division of Fish and Game in its efforts to cut down on the oil production and bring the industry back to a basis of canning. They could see the handwriting on the wall and felt that the sardine supply could not stand up under such a heavy strain. Most of the canners believed that the sardine catch should be curtailed instead of allowed to increase each year, and as long as six years ago they were willing to accept the recommendations of the Division that the catch for the State should have a fixed maximum limit each year. The limit originally proposed by the Division was 250,000 tons per year, but 300,000 tons was the figure of later discussions. This limit was to be applied as a beginning and the amount was to be decreased later if it proved to be too high. This amount was to be allotted among the canners on some basis of canning capacity and past performance, and it began to look as though the problem

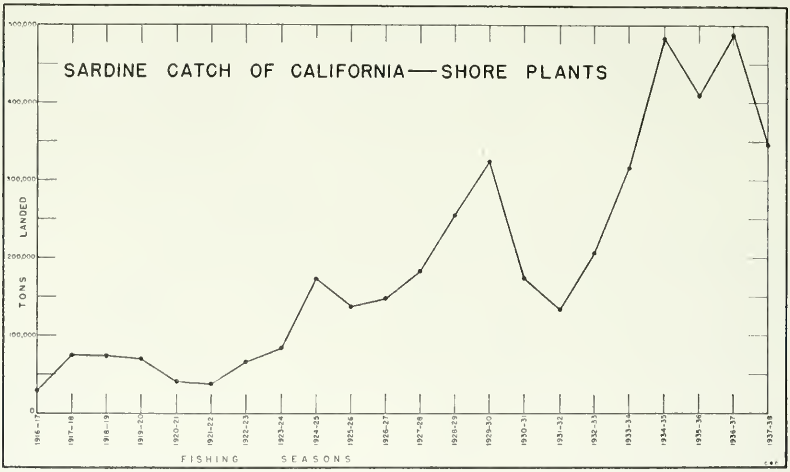

FIG. 76. The California sardine catches by fishing seasons, exclusive of deliveries made to off-shore reduction ships. Fluctuations of catch have followed roughly the changes in economic conditions throughout the country, but the general trend of the catches over this 22-year period has been upward due to increased fishing effort.

child had grown up into a sensible and useful citizen, when someone threw a monkey wrench into the proceedings.

A year or two before this, a trial had been made at reducing sardines on the high seas outside State jurisdiction and thus to gain completely unrestricted tonnage for oil with no canning whatever to hamper oil production. The trial was not promising the first two seasons, but later it succeeded in a big way and a number of ships were outfitted to reduce sardines beyond the three-mile limit. This wide-open reduction blocked the plan of restricting the sardine catch. The shore plants could not cut their operations to a canning basis while their successful competitors on the high seas were operating reduction ships unrestricted. Nor would the State Legislature curtail the established shore industry, employing nearly 10,000 cannery workmen, while unregulated competition from reduction ships threatened to run the canners out of business. Thus, at about the depth of the 1930-1934 depression when relief rolls were bulging, our Legislature and Division of Fish and Game felt that they had no alternative but to help the shore plants, and permits were granted for additional amounts of sardines to be diverted to reduction plants ashore. This caused a local island of prosperity in the sea of depression and fishermen left the relief rolls for sardine fishing.

Sardine reduction created local prosperity along the water front, but the jubilation was short lived, for soon it was discovered that the heroic depression treatment was proving to be more of a curse than a blessing. The supply of sardines could not stand up under an additional strain at a time when the strain should have been lessened. The supply of fish was already overtaxed and increasing the annual catch did not help a bit. (See Fig. 76.)

Overfishing for a period of years is now causing a collapse in the supply of sardines and after the too merry dance we now face the irksome task of paying the piper a debt long overdue. Our sardine catch will diminish automatically because the supply left in the ocean can not furnish the huge catches of the past few years. This form of automatic catch curtailment will not help the future of the industry, because as the supply of fish dwindles the fishermen will take too great a proportion of what remains in the ocean till we reach a point where sardines will be so scarce it will no longer pay to fish for them. That will mean the resource has been mined out and the sardine plants abandoned as "ghost towns."

Overfishing for all practical purposes means an annual catch greater than the replacements each year by young recruits. A catch greater than replacements cuts down the growing stock. If the overcatch can be curtailed soon enough, it may not have done great damage to the stock, but a long continued overdraft will seriously cut down the stock in the ocean. Future catches must then be drastically cut so as not to exceed replacements in the diminished ocean stock. Even when the catch is curtailed to equal replacements in the smaller stock, we have a fishery running in low gear. Of course, the annual catch should not exceed replacements but if allowed to do so and the fact is discovered in time, the catch can be cut down and the stock on hand can be built back to its former level. From then on the annual crop can be maintained at a maximum with a full growing stock to spawn a full quota of new fish each year. This is an ideal picture not often attained, but the essential fact is that when we find an ocean population has been seriously overfished, we are faced with the choice of letting it dwindle to almost zero by the process of diminishing returns, or we can regulate the annual catch so as to build back the ocean stock and thereby increase the future annual harvests. Obviously the resource should be managed to maintain a full spawning and growing stock so that the annual catch can be maintained continuously at the maximum.

A restriction of annual catch hurts but also it hurts to have a valuable resource vanish and thereby cut off future catches entirely. Our ever present sardine problem child is now faced with the inevitable prospect of receiving severe hurts. The catch will be far less than in the past. If we could bear up under a still more severe restriction of catch till the ocean stock was built back to its former level, then the damage from overfishing could be repaired and eventually we would be reaping a large annual harvest again. That annual harvest should never be as great as it was from 1934 to 1937, because such an excessive catch would again be overfishing and cutting down our ocean stock instead of maintaining it at a high level of productivity.

The simple sketch of figure 77 illustrates diagramatically what has happened in our sardine fishery and what may happen in the future. The black line of the curve represents the past trend of the sardine catch in California which rose rapidly each year with the addition of more and bigger fishing boats. Finally we reached a point where added fishing effort would not increase the annual catch. Worse still, added boats could not hold the catch at its former level because overfishing had gone on too long and the sardine supply started to collapse. That is where we stand at present (the 1937-38

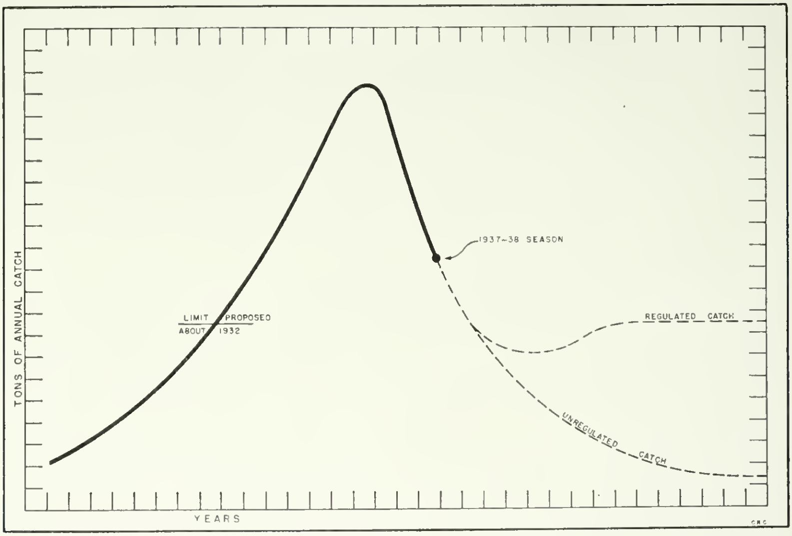

FIG. 77. Diagram to show the California sardine catch of the past as a solid line and the trend of catches in the future as dotted lines.

fishing season just closed). Very likely the collapse will continue even though we deliberately cut the annual catch to a figure far below the present level. But if the catch can be cut to a point where it is below the amount of young fish replacements, then we can build back the depleted stock over a period of years to its former productive level. From that point on, the catch could be adjusted to approximately equal the replacements and that would give us the ideal maximum annual yield. We can assume that the ideal maximum level would be somewhere in the neighborhood of the 250,000 ton limit proposed about six years ago by the California Division of Fish and Game, but this of course would have to be determined by trial. If we do not sufficiently curtail the yearly harvest, our ocean stock will be still further diminished and future catches will be correspondingly less. The logical outcome of unregulated catch is the economic balance where the fish are so scarce it is economically unprofitable to expend much effort searching for them and we can then maintain our supply at that low level. When our sardines increased in numbers they would be caught and when abundance decreased, fishing would stop except for an occasional museum specimen. This may sound silly, but it has been argued by a few people with no outward sign of jesting that we need not be concerned about our sardine supply, for it will adjust itself at an economic level if left alone. The tragic jest is that our sardine probably would do just that if left alone. The buffalo did.

Adequate management of a fishery requires considerable knowledge of changes in abundance, methods for measuring abundance, survival success of spawnings, and usually we need to know the character of the stock in the ocean and much of the life-history of the species, such as spawning habits, migrations, growth rate and size at sexual maturity. In the case of the sardine we already have much of this information, for the Division of Fish and Game arranged that the California State Fisheries Laboratory should conduct a study of the sardine fishery and work started twenty years ago, in February, 1918. More systematic and intensive work began the following year and a comprehensive plan of study was drawn up in 1919 and published.[2] As the work progressed the results were published and our bulletins and pamphlets on the sardine when all assembled make a small armful. Throughout, our chief concern has been with adequate methods for determining the supply in the ocean and changes from year to year in the supply, especially those changes caused by man's fishing.

Beginning in 1920 and at intervals thereafter it was pointed out that a too extensive enlargement of the sardine fishery was very apt to lead to depletion, and officials of the Division of Fish and Game tried in every way to prevent the establishment of independent reduction plants and endeavored to hold the industry on a strictly canning basis so as to avoid over-utilization of the supply. Eight years later the danger signs of overfishing had appeared and more specific warnings were issued to point out breakers ahead. At the State Legislature in March, 1929, the indications of overfishing were explained and a plea made to confine the use of sardines to canning. By 1930 the indications of depletion were so serious that State officials and leaders of the sardine industry were officially warned at a meeting of the Jost Assembly Interim Committee held in San Pedro on April 16, 1930. At this meeting the danger signs were explained and discussed. Similar warnings appeared in our published bulletins and in the published Biennial Reports of the Division of Fish and Game. Mimeographed predictions of a sardine shortage, dated August 29, 1933, were distributed and the following year a similar prediction was published,[3] but during these years any suggested curtailment of the sardine catch was opposed on the grounds that the evidence presented by the research staff was not positive proof of serious depletion. Obviously our research staff was unable to offer positive proof of serious depletion till it had occurred, but the indications of lessened supply were presented and it was then urged that the time was at hand to begin locking the stable doors before the horses were gone. This record of warnings and predictions is not presented in a spirit of "I told you

[2] The proposed investigation of the sardine. Calif. Fish and Game, vol. 6, pp. 10-12, 1920.

[3] The 1934-1935 sardine season. Calif. Fish and Game, vol. 20, pp. 298-300, 1934.

so'' or a futile crying over spilled milk, but it is merely in answer to the question that someone is sure to ask soon, ''why didn't you tell us?''

While answering a question before it is asked, possibly a few of the questions that already have been asked should have the answers repeated briefly. One such question is why is the use of food fish in a reduction plant allowed? The answer is that the law prohibiting the use of fish in a reduction plant was amended to provide that a revokable permit may be granted to use fish in a reduction plant if certain

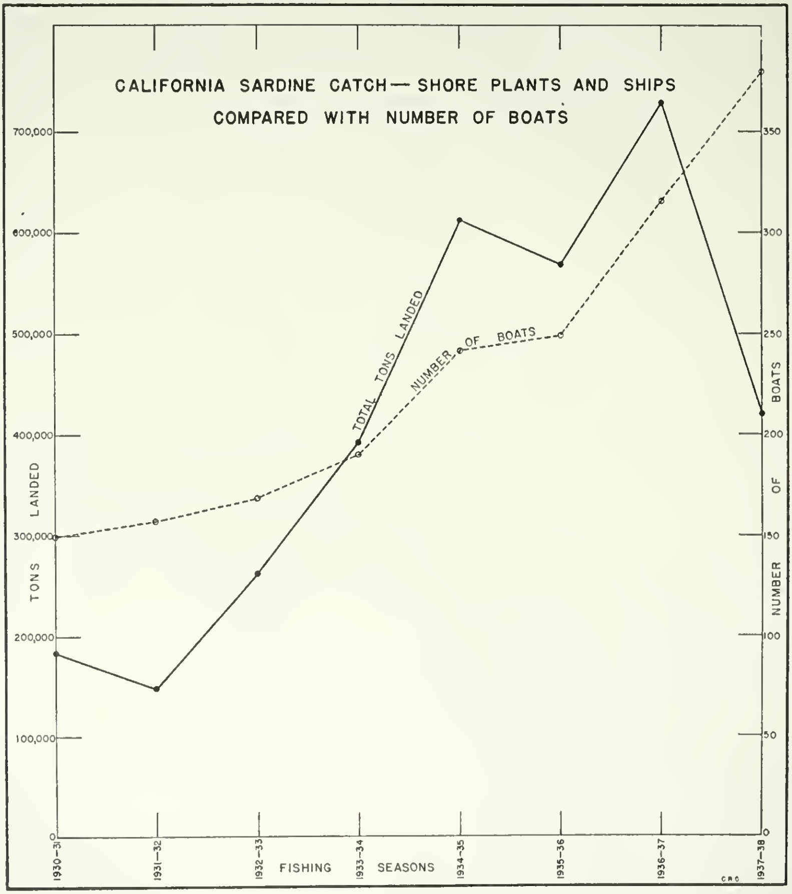

FIG. 78. The sardine catch of the last eight fishing seasons compared with the number of fishing boats employed. In the past the catch could be increased by adding more fishing boats, but we have now reached the point where additional fishing effort will not prevent a drop in the total catch.

restrictions and regulations are complied with. No such permits are granted except for sardines. Fish other than sardines cost too much and have too little oil, so the plant operator would lose money on every pound of food fish (except sardines) put into his reduction plant. He is in business to make money not to lose it, so the only fish he reduces is sardines. As the prices paid for other species are based on their value as food, and the heads and viscera resulting from cleaning operations would otherwise be wasted, the offal of all kinds of fish is converted into oil and meal at a slight profit. This margin of profit would disappear if the expensive whole fish were reduced, consequently barracuda, white sea-bass and other sport and food fishes are not used in California reduction plants.

We have been asked if the recent drop in the sardine catch is our principal evidence of depletion. The answer is that the total catch is a measure of what is taken out, not what is left in the ocean. The sardine total catch measures the abundance of sardines on the cannery floor, not the abundance in the sea. The catch is the result of fishing effort and under normal conditions we can increase the total catch by increasing the fishing effort. The **catch per unit of fishing effort** is significant and is one of the best ways of measuring abundance in the ocean. If the return in fish for a given unit of fishing effort drops down over a period of years, then this catch per unit of effort is a strong indication of a drop in abundance of fish in the ocean. In some cases fishing effort can be measured roughly by the number of boats employed in the fishery, but there is more to fishing effort than the number of boats engaged. Some boats may be larger than others, fish longer hours, have bigger or better nets or help each other locate fish and thereby increase their catches. In the sardine fishery the boats have completely changed in the last twenty years. (See Fig. 75.) Not only are there more boats but each boat is larger, fishes longer, can go farther for fish, uses different gear, larger nets, and many use radio-telephone. The average sardine boat today can catch at least five times as many sardines as the average boat twenty years ago. In 1919 the largest sardine cannery in the State could handle 100 tons per day by working overtime, and six fishing boats did occasionally deliver as much as 100 tons in a day to this cannery. Fifteen years later one of the newer boats could swamp such a cannery with two-thirds of its catch, and such a boat frequently delivered more fish than the six boats had caught in 1919.

In spite of this great increase in the catching power and efficiency of the fishing boat, we can get a rough idea of fishing effort during recent years by knowing the number of boats engaged in the fishery. (See Fig. 78.) The improvement in fishing boats has continued but changes during the last six or eight years may not have been quite as great as in former years. All this means that sardine fishing effort has increased greatly in twenty years and the number of boats employed in the fishery tells only part of the story. Increased fishing effort brought the sardine total catch up to an all-time high during the fishing season of 1936-37, and the following season more than 60 additional fishing boats joined the fleet in the hope that the 1937-38 season would be even larger, but the total catch of the augmented fleet of 380 boats made a catch only about 60 per cent as large as in the preceding season. Naturally, it would be unwise to jump at conclusions as the result of one bad year, but our conclusions are based on observations over a twenty-year period, and eight years ago there were strong indications that the average boat was having increasing difficulty in making its catch. By the time of the peak season, 1936-37, many of the fishermen recognized the truth of our contention that sardines were becoming decidedly scarce compared with earlier years. The big catch of 1936-37 resulted from adding about 65 new boats that year, but the average boat did not do well and many boat owners were discouraged. Then the following poor season added black crepe to their gloom and they reluctantly admitted that the sardine supply was in a state of collapse. Increased fishing effort will increase the total catch within reasonable limits, but if the supply of fish is too greatly diminished then the total catch can not be increased no matter how great the effort. In this extreme, greater effort can not catch fish that are not in the ocean to be caught.

Since the sardine boats fish only in a narrow strip along the shore and the Pacific Ocean is so large, how is it possible that there should be a serious depletion of sardines? It is true that sardine fishermen do not go much beyond the 500-fathom depth line and this is because they fish were the fish are. Sardines are not uniformly diffused throughout the Pacific; our species is confined to a narrow belt along the shore. As they move up and down the coast, overfishing in a small area drains the supply and long continued overfishing in the coastal strip of water can reduce the ocean stock of sardines to the vanishing point. The great sardine fishery of Japan does not take our sardine. The Japanese catch is made up of several species, no one of which is the same as our species. The catch in Japan is made over a much larger area than we have on our coast, and though the Japanese catch is great their fishery per square mile is far less intensive than in our fishery. These points have been covered in detail by our sardine publications.

The following questions concerning sardines are frequently asked so brief answers are given with a few of the references to publications which explain fully the answers.

1. Is the California sardine a true sardine?

   Answer: Yes.

   Reference:

   The California sardine. Calif. Fish and Game Comm., Fish Bull., no. 11, pp. 8-17, 1926.

2. Is the California sardine different from the Japanese sardine?

   Answer: Yes. Our sardine differs distinctly from that of Japan. The California sardine is a larger species and the two forms are entirely separated geographically.

   Reference:

   Same as above.

3. What is the northern and southern range of our sardine?

   Answer: The California sardine has been taken as far north as southern Alaska, off the outer coast of Vancouver Island, along the entire coast of Washington, Oregon, California, Lower California, and into the Gulf of California.

   References:

   The California sardine. Calif. Fish and Game Comm., Fish Bull., no. 11, pp. 8-17, 1926.

   A summary of the life-history of the California sardine. . . . Calif. Fish and Game, vol. 21, no. 1, pp. 2-3, 1935

4. Are sardines found only near shore?

Answer: Yes. We have no records of sardines having been seen or caught more than 300 miles from land.

Reference:

Early life-history of the California sardine. . . . Calif. Div. Fish and Game, Fish Bull., no. 41, p. 7, 1934.

5. Where are most sardines caught?

Answer: Sardines are taken in commercial quantities from British Columbia south to the Mexican waters. All of the fishing grounds lie close to shore over depths not greater than 500 fathoms.

References:

Fishing areas along the California coast for the sardine. Calif. Div. Fish and Game, Fish Bull., no. 25, pp. 12-14, 17-21, 28-33, 38-39, 40-44, 1930.

Fishing localities for the California sardine, 1928-1936. Calif. Div. Fish and Game, Fish Bull., no. 48, pp. 1-11, 1937.

Yield per area of the California sardine fishing grounds, 1935-1937. Calif. Fish and Game, vol. 23, no. 4, pp. 307-309, 1937.

6. Do our sardines go to Japan?

Answer: No. The sardine found in Japan is a different species than that found in our waters. Sardines have been tagged off British Columbia and the various localities off California. Recoveries of these tags show that our sardines move up and down the British Columbia, Washington, Oregon and California coast.

References:

First report of sardine tagging in California. Calif. Fish and Game, vol. 23, no. 3, pp. 190-192, 1937.

Northern recovery of California sardine tags. Calif. Fish and Game, vol. 24, no. 1, pp. 70-71, 1938.

7. Where do sardines spawn?

Answer: Sardines have been known to spawn as far north as San Francisco, as far south as Lower Californa, but the main spawning grounds are off Southern California from Pt. Conception to San Diego, within 100 miles of shore.

References:

Early life-history of the California sardine, with special reference to the distribution of the eggs and larvae. Calif. Div. Fish and Game, Fish Bull., no. 41, pp. 5-25, 1934.

The relation between surface water temperature and the distribution of spawn of the California sardine. Calif. Fish and Game, vol. 23, no. 2, pp. 132-137, 1937.

8. When do sardines spawn?

Answer: The spawning season for the California sardine is from February through July. The peak of the spawning is in April and May.

References:

Early life-history of the California sardine, with special reference to the distribution of the eggs and larvae. Calif. Div. Fish and Game, Fish Bull., no. 41, pp. 7-8, 1934.

Maturity of the California sardine. . . . Calif. Div. Fish and Game, Fish Bull., no. 42, pp. 25-34, 1934.

9. Do they spawn more than once each year?

Answer: There is only one spawning season for the sardine in the spring and early summer. During this four- to five-month time interval each individual fish may spawn as often as two to four times.

Reference:

Maturity of the California sardine. . . . Calif. Div. Fish and Game, Fish Bull., no. 42, pp. 14-19, 1934.

10. Do sardine eggs float freely in the ocean?

Answer: Yes. The eggs are found floating at and near the surface.

Reference:

Early life-history of the California sardine, with special reference to the distribution of the eggs and larvae. Calif. Div. Fish and Game, Fish Bull., no. 41, pp. 1-44, 1934.

11. How many eggs are spawned?

Answer: The number of eggs produced by a female at one spawning varies from 35,000 to 65,000. Larger fish produce more eggs than small ones.

Reference:

Maturity of the California sardine. . . . Calif. Div. Fish and Game, Fish Bull., no. 42, p. 21, 1934.

12. What do sardines eat?

Answer: Sardines feed on minute plants and animals floating freely at the surface of the ocean.

Reference:

Early life-history of the California sardine. . . . Calif. Div. Fish and Game, Fish Bull., no. 41, pp. 25-29, 1934.

13. What gear is used to catch sardines?

Answer: Sardines are taken in three kinds of round haul nets, called purse seines, ring nets and lamparas.

References:

Methods of sardine fishing in southern California. Calif. Fish and Game, vol. 7, no. 4, pp. 219-237, 1921.

The ring net, half ring net, or purse lampara in the fisheries of California. Calif. Div. Fish and Game, Fish Bull., no. 27, pp. 7-16, 1930.

Sardine fishing methods at Monterey, California. Calif. Div. Fish and Game, Fish Bull., no. 19, pp. 19-36, 1929.

Success of the purse seine boat in the sardine fishery at Monterey, California. . . . Calif. Div. Fish and Game, Fish Bull., no. 23, pp. 5-16, 1930.

14. Are the same sized sardines taken throughout each fishing season?

Answer: No. During the fall and early winter months, the fishery draws on smaller and younger adults. In the winter and early spring months, the larger older adults are taken.

References:

The California sardine. Calif. Fish and Game Comm., Fish Bull., no. 11, pp. 132, 139, 200, 1926.

. . . Changes in size of the California sardine. Calif. Div. Fish and Game, Fish Bull., no. 47, pp. 1-13, 1936.

Seasonal average length trends at Monterey of the California sardine.

Calif. Div. Fish and Game, Fish Bull., no. 13, pp. 1-12, 1928.

Seasonal changes in the daily average length of the California sardine. Calif. Div. Fish and Game, Fish Bull., no. 26, pp. 1-20, 1930.

15. Is the supply being depleted?

Answer: Yes. The first evidences of overfishing were shown by an extension of the fishing grounds to meet the greater demands of the industry. These were followed by a shortening of the life span of each year-class in the fishery. At the same time the fishermen were having to develop more efficient methods and to work harder to obtain the same sized catches. During the past sardine season the return to each individual fisherman has been very much reduced in spite of very efficient fishing methods.

References:

. . . Changes in sizes of the California sardine. Calif. Div. Fish and Game, Fish Bull., no. 47, pp. 26-27, 1936.

Changing abundance of the California sardine measured by length of scouting time. Calif. Fish and Game, vol. 19, no. 2, pp. 136-141, 1933.

Fishing areas along the California coast for the sardine. Calif. Div. Fish and Game, Fish Bull., no. 25, pp. 22-23, 33-38, 1930.

16. What is the program of study?

Answer: Determination of changes in abundance, estimates of population, spawning success and such life-history data as offer a promise of aiding in the management of the sardine fishery. California's first contribution to fisheries science was the formulation of a comprehensive program of fact-gathering for the purpose of managing our fisheries on a basis of sustained yield. This long range program has been carried on without interruption for a period of twenty years. The purpose of our studies, the methods used and results obtained have been fully published at frequent intervals. Statement and explanation of the program appeared in the following references:

The proposed investigation of the sardine. Calif. Fish and Game, vol. 6, pp. 10-12, 1920.

The scientific investigation of marine fisheries, as related to the work of the Fish and Game Commission in southern California. Calif. Fish and Game Comm., Fish Bull., no. 2, 26 pp., 1919.

Biennial Reports of California Division of Fish and Game, as follows:

No. 26, 1918-1920, p. 61
No. 27, 1920-1922, p. 75
No. 28, 1922-1924, p. 58
No. 29, 1924-1926, p. 75
No. 30, 1926-1928, p. 118
No. 31, 1928-1930, p. 130
No. 32, 1930-1932, p. 80
No. 33, 1932-1934, p. 55
No. 34, 1934-1936, p. 50

A FISHERIES LIBRARY AND ITS USES [1]

By Katherine Karmelich
California State Fisheries Laboratory
Division of Fish and Game

Visitors to the California State Fisheries Laboratory are often surprised to find that we have a library where so much literature is available on fisheries and allied subjects dealing with the science of the sea. Perhaps it is because the fishing industry is considered by the romantic public as nothing more than the picturesqueness of the fishermen going to sea. And, perhaps it is because fishing to others simply means the efforts of the fisherfolk to provide fish for the nation's table. However, it is much more than that. The fishing industry compares favorably in magnitude and financial status with major and better known enterprises. For today, fish are not only eaten but they furnish a source of material for manufacturing such products as medicine, paint, soap, linoleum, cattle feed, and various other commodities, which we more or less take for granted without realizing their origin. In order to maintain this industry for the welfare of the people and keep it on a profitable scale for future generations, we must learn something about the life in the sea. This means an understanding of the habits, food and migrations of the various inhabitants, which necessitates delving into the mysteries enveloped by the vastness of the ocean.

The need for such knowledge about the fisheries of California led to the initiation of fisheries research work in 1917 and the establishment of the California State Fisheries Laboratory by the Division of Fish and Game. This was done through the farsightedness of N. B. Scofield, chief of our Bureau of Marine Fisheries, and his associates. Immediately the importance of a library in this specialized field was felt, and about this nucleus has grown an extensive library, which now comprises a large collection of marine biological literature emanating from various countries throughout the world.

A library is essentially an indispensable tool in any type of research, whether conducted for commercial or purely scientific purposes. This is illustrated by the number of special libraries established by commercial companies, government bureaus and other agencies for their particular uses. Much time and effort can be saved through the facilities offered by a library, as needless repetition of work is eliminated through a knowledge of what has already been done, and discoveries in one particular phase of research can be applied in allied investigations. The library is the center of such information and is therefore intrinsically a part of research.

Closely interwoven with the principles of the workers of the Division of Fish and Game to serve the people by studying the natural resources and advising on the best means of conservation in order that full benefit may be received, are the aims of the library also to

[1] Submitted for publication, April, 1938.

serve by disseminating the information contained in its archives. The library was primarily established for the research staff in order that they might have access to the published results of investigations conducted in similar lines by other governmental and private agencies. But, with the expansion in the California fishing industry, the library is now not only consulted by the personnel of the Division but by various commercial concerns, the fish canning industry, fishermen, scientists engaged in research for other organizations (United States and foreign), students, motion picture companies, and others, besides the "Izaak Waltons" in the sport fishing field.

Although the library is for reference purposes only, the literature in the library is available to everyone for consultation and it is an interesting part of the day's work to answer the questions of those

FIG. 79. The library of the California State Fisheries Laboratory, Terminal Island, California.

visiting the library. The inquiries deal with varied subjects, such as chemical analysis of fishes; bacteriology of fresh and preserved products; whether a dolphin is a fish or a mammal; tanning of shark hides; identification of marine specimens; fish culture; parasites in fishes; frog farming; methods of preservation of fishery products (commercial and home canning, smoking, salting, etc.); fish oil and meal; geographic distribution, habits and anatomy of fishes; fisheries statistics in this and other countries; fishing methods and gear; foreign fisheries; sport fishing; pollution; mollusks; crustaceans; pearl essence; equipment of aquariums for commercial and private uses; and innumerable others. Requests by mail for information are also received almost daily.

In order to serve those employees of the Division of Fish and Game who are out in the field and thus lack the facilities of a library, lists of the literature received each month are compiled and distributed. In this way, they are informed monthly about the latest publications, which the library then makes available to them. This list is now not only sent to our staff members but to others not in the employ of the Division, who express a desire to know of the current literature.

Another method of disseminating information is our circulating or "grapevine" library, suggested by H. B. Nidever, field inspector for the Division of Fish and Game. This is reserved for the Division employees, principally for the wardens stationed away from headquarters where they have no means of securing books to further their knowledge about the natural resources (including marine biology and fisheries), principles of conservation, and law enforcement. The books are circulated, and after one man reads a book, he passes it on to a co-worker, mailing to the library a card (supplied for that purpose) with the name of the person to whom the book is given, in order that a record may be kept. After the book is read by all interested persons, it is then returned to the library. This "grapevine" method has met with the enthusiasm of the employees.

Another service of the library is the compilation of bibliographies of literature on specific subjects for the general public as well as for the employees of the Division. Thus, bibliographies on tuna, sardines. mackerel, refrigeration, fish eggs and larvae, barracuda, etc. have been prepared. The tuna, sardine and barracuda bibliographies have been published.[2] A subject and author index to volumes 1-20 (1914-1934), inclusive, of "California Fish and Game," was compiled and published.[3]

To make for immediate access to the literature, the California State Fisheries Laboratory library is classified and cataloged. Because of its specialized material, the standardized decimal system used generally in public libraries was not directly applicable to our library. It was therefore necessary to make modifications and additions to the decimal system in order that the literature could be classified properly. Another consideration was that the system should be flexible and expansive enough to allow for future enlargement of the library.

The card catalog of authors and subjects, filed alphabetically, is an important tool. New accessions are cataloged as received, so that the card file is kept up to date. This catalog now contains many thousands of cards. Pamphlets in the form of special reports, articles in magazines and those reprinted from journals, and government publications are treated and cataloged individually. Pamphlets and magazines are given just as much importance if not more than bound books, as the reports issued in the frequently published journals contain the most recent information available on the subject. Bound books are often compilations of what has already been made known.

It is essential to keep a constant lookout for all new reports and books in order that the library may have every important published contribution bearing on fisheries research work and allied subjects.

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[2] Corwin, Genevieve. A bibliography of the tunas. Calif. Div. Fish and Game. Fish Bull., no. 22, 103 pp., 1930.

Wheeler, Genevieve C. A bibliography of the sardines. Calif. Div. Fish and Game, Fish Bull., no. 36, 133 pp., 1931.

Walford, Lionel A. The California barracuda (*Sphyraena argentea*). I. Life history of the California barracuda. II. A bibliography of barracudas. (Sphyraenidae). Calif. Div. Fish and Game, Fish Bull., no. 37, pp. 73-120, 1932.

[3] Calif. Fish and Game, vol. 22, no. 4, app., 60 pp., 1936.

However, it is the policy not to secure a set of journals or books just for the sake of completeness, but rather to have only those parts of the set which are of particular use in the library.

The library now (April 30, 1938) contains approximately 2086 bound volumes and 31,155 pamphlets (unbound) including serial publications. A very large part of this collection is secured free of charge by exchanging the publications of the Division of Fish and Game ("Fish Bulletins," "California Fish and Game," etc.) for those of other agencies, societies, government bureaus and individual authors. We are therefore indebted to these sources for their contributions. If it had been necessary to purchase all the literature in the library, the cost would have been enormous. As it is, because so much has been and is available without charge through exchange arrangements, the financial maintenance of the library is really comparatively low. Through the facilities of a loan service with university and public libraries, we are able to borrow those books and journals which are only occasionally referred to or the cost of which is prohibitive.

In order to show the type of literature in the library, the following list of major subjects with a few references is appended. The subject classifications are of necessity very general, as space does not permit a detailed and more specific grouping of subjects with complete bibliographic references for each. The list is simply to serve as an illustration and is by no means a comprehensive representation of the library. Although some serial publications, mentioned below, are listed under such general classifications as "Biology, Ecology, and Science in General," they include specific reports on marine biological and fisheries subjects. Such papers are frequently found scattered in scientific journals dealing with various subjects.

BIOLOGY, ECOLOGY, AND SCIENCE IN GENERAL

Textbooks on these subjects.

Periodicals such as Nature (London), Natural History (New York), Science and Scientific Monthly (New York).

Publications of various organizations throughout the world, including:

Academy of natural sciences of Philadelphia.
American museum of natural history, New York City.
Bernice P. Bishop museum of Polynesian ethnology and natural history, Honolulu.
Ecology. Ecological society of America. Lancaster, Pa.
Liverpool biological society. Liverpool University Press.
South Australian museum, Adelaide.
Stanford university. Biological sciences. Stanford University, Calif.
Washington. University. Publications in biology. Seattle, Wash.
U. S. National museum. Washington, D. C.

FISHERIES BY-PRODUCTS. *See* TECHNOLOGY

FISHERIES STATISTICS

Official government publications on fisheries statistics of foreign and domestic fishing ports—amount caught, value of fresh and preserved products, etc.

FISHES AND FISHERIES

The library contains works on fishes and fisheries of the world, a few of which are:

Books:

Alward, G. L. The sea fisheries of Great Britain and Ireland. Grimsby, Albert Gait, 1932. 474 pp., app.

Barnhart, Percy S. Marine fishes of southern California. Berkeley, University of California Press, 1936. 209 pp.

Curtis, Brian. The life story of the fish. New York & London, D. Appleton-Century Co., 1938. 260 pp.

Dean, Bashford. A bibliography of fishes. New York, American Museum of Natural History, 1916, 1917, 1923. 3 vols.

Faber, G. L. The fisheries of the Adriatic and the fish thereof. London, Bernard Quaritch, 1883. 292 pp.

Fulton, T. W. The sovereignty of the sea. Edinburgh & London, Wm. Blackwood & Sons, 1911. 799 pp.

Goode, George Brown. American fishes; a popular treatise upon the game and food fishes of North America with especial reference to habits and methods of capture. Boston, L. C. Page & Co., 1903. 562 pp.

Günther, Albert. Catalogue of the fishes in the British museum. London, Taylor and Francis, 1859-1870; reproduced by photolithography, Adlard & Son, 1937. 8 vols.

Jenkins, J. T. The sea fisheries. London, Constable & Co., 1920. 299 pp.

Jordan, David Starr. Fishes; rev. ed. New York, D. Appleton & Co., 1925. 773 pp.

Jordan, David Starr, and Evermann, Barton W. The fishes of North and Middle America; a descriptive catalogue of the species of fish-like vertebrates found in the waters of North America, north of the Isthmus of Panama. Washington, Government Printing Office, 1896-1900. 4 vols.

Kyle, Harry M. The biology of fishes. New York, Macmillan Co., 1926. 396 pp.

Meek, Alexander. The migrations of fish. London, Edward Arnold, 1916. 427 pp.

Norman, J. R. A history of fishes. London, Ernest Benn Ltd., 1931. 463 pp.

Norman, J. R., and Fraser, F. C. Giant fishes, whales and dolphins. New York, W. W. Norton & Co., 1938. 361 pp.

Tressler, D. K. Marine products of commerce: their acquisition, handling, biological aspects and the science and technology of their preparation and preservation. New York, Chemical Catalog Co., 1923. 762 pp.

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In addition to the subject classifications as listed above, we have publications and books dealing with other subjects, such as fresh-water fishes and fisheries, fish culture, marine flora, navigation, wildlife and other natural resources. Fish and game laws, reports and magazines issued by the various State commissions in the United States are also on file. The library has a large collection of maps and charts, particularly of the Pacific coastal waters, including those issued by the U. S. Hydrographic Office.

DUCK HUNTING ON THE SAN DIEGO LAKES [1]

By E. H. Glidden
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When California duck hunting is mentioned most people think of Sacramento Valley rice fields or Suisun marshes. However, some of the best waterfowl shooting in the State is to be had in the extreme south, on Salton Sea and the various reservoirs in San Diego County. These bodies of water are the concentration places for many species of ducks during the winter months, unbelievable numbers of the birds pausing there on their way south to Mexico or ending their migrations at that point.

There are ten large lakes in San Diego County, all of them artificial. The City of San Diego owns six—Barrett, Hodges, Morena, Upper Otay, Lower Otay and El Capitan. Although these are city lakes they are not in the city itself, being located in the hills back of San Diego. The Escondido Municipal Water District owns Lake Wohlford. The other lakes—Henshaw, Cuyamaca and Sweetwater—are owned by private water companies. There has been hunting on all the lakes except El Capitan, which has only recently been formed. Sweetwater Lake has been closed to hunting during the past three years, however. In addition to the foregoing there are several small, unimportant lakes in the county.

Hunting at present is confined to shore hunting, shooting over decoys and just optimistically rowing around after the birds. However, the lakes have derived much of their fame from the "duck drives" which were formerly conducted on them. This was the common method of hunting until it was declared illegal about ten years ago. The practice was first started about 1908 by E. S. Babcock, who was then the owner of the Upper Otay Lake. Guests of his numbering ten to fifteen would start at one end of the lake in rowboats and proceed up the lake in a line. They naturally drove all the ducks ahead of them. The large ducks would leave the lake entirely, but the low-flying ruddies upon reaching the end of the lake would fly back over the boats in an effort to return to the part of the lake they had just been driven off. Then the shooting would begin. Most of the hunters used two guns; when one became too hot from repeated shooting it was doused in the water and tossed into the boat to cool off while the other was being used. As ducks were plentiful, limit bags were the rule. Many coots were also shot. These birds often graced the tables of fashionable hotels and were served as "king rails"—a more attractive name perhaps than mudhen.

In later years duck drives were conducted on all the lakes by private individuals or were organized on the spur of the moment by groups of hunters. It was only on Sweetwater Lake that organized,

[1] Submitted for publication, April, 1938.

FIG. 80. A duck drive at Sweetwater Lake, San Diego County, 1926. The hunters are setting out and have not yet gotten into formation.

commercially conducted drives were held. These commenced about 1916 and were instituted in an effort to reduce pollution of the lake. It was thought that the ducks caused the muddy taste of the water. However, some time later it became known that plant growth caused the taste and it would have been better to leave the birds to eat the plants than to shoot or drive them away.

The Sweetwater drives were held twice weekly, on Wednesdays and Sundays, commencing at 8 a.m. No shooting over decoys was permitted until the drive was over, which was usually about 11.30 a.m.

FIG. 81. A duck drive under way at Sweetwater Lake, 1926.

Over 50 boats, with two or three hunters to the boat, took part in the drive. The boats lined up under the guidance of a captain, who kept them in line, and proceeded slowly up the lake. As soon as the bombardment commenced, most of the large ducks took altitude and left the lake. They spent the morning on the ocean or on the coastal bays, returning in the afternoon after the excitement had died down. As a consequence, most of the ducks killed were ruddies; in fact I would be safe in saying that 75 per cent were ruddies. Coots also took considerable punishment. The average bag per hunter was about 20 ducks (the limit was 25).

When a flock of ducks passed over the line of boats it was greeted with a volley. Everyone raced for the fallen birds, shouting, "my

FIG. 82. The end of a duck drive at Sweetwater Lake. Only a part of the hunters are shown.

duck, my duck!", and it was a case of finder keeper—the first one to reach a duck claimed it. It has been said that the most successful hunters were those who didn't even shoot—they could get to the down birds quicker. In spite of all the shooting, no serious accidents ever resulted from the drives.

The hunters who wanted to shoot over decoys either had to stand by until the drive was over or take part in it. This was where the most serious abuse of the drive took place. The unscrupulous hunter, who of course was in the minority, would join the drive and kill as many ruddies as he could. These he would either give away or hide. Then he would spend the afternoon shooting over his decoys, and perhaps take a limit of sprig, canvasbacks and other large ducks in defiance of the law. The decoy hunters shot only the larger ducks, generally ignoring the ruddies. As mentioned above, the duck drives are now a thing of the past. Even if they had not been prohibited, the complete protection given to the ruddy duck by federal regulations in 1932 would have put an end to them.

The City of San Diego has kept records of the hunting on city-owned lakes for a number of years. These records, which have been

FIG. 83. A limit of ducks shot during a drive on Sweetwater Lake. Most of these ducks are ruddies.

made available to us through the kindness of Mr. R. Wueste, in charge of water impounding for the city, give a good idea of the relative amount of hunting from year to year. (See Tables 1 and 2.) Every hunter wishing to shoot on a city lake must first obtain a daily permit from the keeper of the lake. The keeper records the number of permits issued and also checks the kills of as many of the hunters as possible. Actually he can check only the boat hunters, when they return their rented boats, and the shore hunters are seldom checked (they seldom get many ducks either). Consequently the tables do not show the average kill per hunter, as only part of the total kill can be shown. However, as the checked kill is probably the same relative proportion of the total kill from year to year, the figures presented in table 1 are of value in that they show a steady decline in the number of birds shot.

This drop is due to several causes, all of which are tied in with the big decline in the number of hunting permits issued. A nationwide scarcity of ducks became so serious that the U. S. Biological Survey in 1931 commenced a series of drastic regulations curtailing the kill of waterfowl. These regulations took the form of shorter seasons, shorter shooting hours daily, lower bag limits and complete protection of certain species, among other restrictions. This, along with the increasing scarcity of the ducks, resulted in less people hunting and in less birds per hunter.

The leading species of duck in 1937 was the bluebill, followed by teal. (See Table 2.) This is unusual, as the predominating species is generally sprig, followed by bluebill (since ruddies have been on the protected list). The 1937 season opened very late (November 27), by which time the early arriving sprig had mostly gone on to the south. Ten days before the opening there were thousands of sprig, widgeon and spoonbills on the lakes, but they left for Mexico and did not return until a couple of weeks after the season closed. During the open season most of the ducks to be found on the lakes were bluebills, teal and the protected species—principally ruddies and canvasbacks. Due to the inability of most of the hunters to distinguish the protected species, many of these were accidentally shot (and promptly confiscated). Many of the hunters claimed that an earlier season would do away with the necessity of having a protected list, as most of the nonprotected ducks arrive early and nearly all of the protected birds arrive late.

In spite of the great decline in hunting on the lakes, San Diego County still ranks among the leading duck hunting counties of the State, as shown by the reports given on hunting license applications. Among the 58 counties, San Diego (including San Diego Bay and other tidewater hunting areas as well as the lakes) ranked tenth for both the 1934 and 1935 seasons.

TABLE 1

Waterfowl Kills on San Diego City Lakes[a]

Season	Hunting permits issued	Checked kill[b]			
		Ducks	Coots	Miscellaneous[c]	Total
1928-29	10,530	59,406	7,169	5	66,580
1929-30	10,915	42,091	10,260	16	52,367
1930-31	8,077	28,993	3,547	55	32,595
1931	4,780	25,253	2,525	47	27,825
1932	4,722	14,820	4,683	6	19,509
1933	4,501	14,327	6,412	4	20,743
1934	3,253	10,648	4,969	59	15,676
1935	1,587	5,285	1,746	22	7,053
1936	842	1,912	1,062	0	2,974
1937	1,237	4,303	1,883	0	6,186
Totals	59,444	207,038	44,256	214	251,508

[a] Compiled by R. Wueste, in charge of water impounding for City of San Diego.
[b] This is the kill of the hunters actually checked by the keepers, not the total kill.
[c] Includes geese, jacksnipe, etc.

TABLE 2

Waterfowl Kill On San Diego City Lakes 1937 Season[a]

Species	Morena	Barrett	Upper and Lower Otay	Hodges	Total
Mallard	25	7	1	13	46
Gadwall	41	76	1	68	186
Widgeon (Baldpate)	70	8	31	11	120
Teal	292	308	364	274	1,238
Spoonbill (Shoveller)	302	89	73	52	516
Sprig (Pintail)	453	263	41	111	868
Bluebill (Scaup)	471	518	243	97	1,329
Total ducks	1,654	1,269	754	626	4,303
Coots (Mudhens)	619	312	483	469	1,883
Total waterfowl	2,273	1,581	1,237	1,095	6,186
Total hunters	411	240	393	193	1,237
Hunters checked	382	240	195	172	989

[a] Compiled by R. Wueste, in charge of water impounding for City of San Diego.

RECENT DISASTROUS EFFECTS OF OIL POLLUTION ON BIRDS IN THE SAN FRANCISCO BAY REGION [1]

By JAMES MOFFITT AND ROBERT T. ORR
California Academy of Sciences

Considering the number of oil tankers that have been wrecked in recent years in or close to the entrance to San Francisco Bay and the marked decreases that have occurred in our waterbird populations, the effect of petroleum liberated under such circumstances becomes increasingly important. The devastating effects that crude oil may have on aquatic birds and the degree in which a pollution may destroy numbers of different species, in relation to their habitats and habits were exemplified by a recent disaster that occurred off the city of San Francisco.

On March 6, 1937, the passenger steamer *President Coolidge* struck the Associated Oil Company tanker *Frank H. Buck* in the Golden Gate. Helpless, the *Buck* drifted seaward with the outgoing tide, finally becoming stranded 100 yards offshore, about one-quarter of a mile southwest of Mile Rock Lighthouse. Here the vessel lay, her stern rising and falling in the ocean swells and her hull spewing oil at each heave until she finally broke up several months later.

Aldrich (Bird-Lore, vol. 40, pp. 110-114, 1938) has recently given an account of the effect of this oil pollution, stressing mainly the reaction of various species afflicted. In the present paper the authors have attempted to give data relative to the extent of the oil pollution and habitats involved.

The *Buck* carried a cargo of 65,000 barrels (2,730,000 gallons) of crude oil. From the time of the collision until the boat broke up, this polluting substance was discharged into the surrounding waters. Greatest quantities escaped shortly after the accident and during a heavy storm on March 22, 1937. Following this date there was an obvious lessening in the quantity of escaping oil which was correlated with a corresponding reduction in resulting bird casualties.

The collision was entirely accidental and subsequent conduct of the Associated Oil Company and authorities in charge of pollution matters left nothing to be desired in their efforts to alleviate conditions. Indeed, the episode can only be classed as a most unhappy accident, costly to those financially involved as well as to innocent victims, including boat and littoral property owners, aquatic bird populations and various forms of marine life.

The area covered by oil pollution, so far as could be ascertained, extended from Point Reyes, south to below Half Moon Bay or along about 55 miles of coast line. Oil pollution was very noticeable in the vicinity of the Lightship, 10 miles offshore from Mile Rock Lighthouse,

[1] Submitted for publication, May, 1938.

according to Captain Louis L. Lane, bar pilot. In the vicinity of the Farallon Islands, however, approximately 28 miles offshore, unusual quantities of oil were not apparent, according to Oliver R. Berg, keeper of the Farallon Light Station. It is hence probable that severe oil pollution did not extend more than from 15 to 20 miles to sea opposite the Golden Gate. Little oil entered San Francisco Bay, except for a narrow strip reaching at least as far as Alcatraz Island shortly after the collision, and minor pollution on some of the beaches. Bakers Beach, however, between the wreck and the Golden Gate, was in a constant state of pollution.

Our attention was first drawn to the effects of this disaster upon bird life on the occasion of the senior author's visit to Tomales Bay,

FIG. 84. The Associated Oil Company tanker *Frank H. Buck,* wrecked off the Golden Gate, March 6, 1937. Photograph supplied through the courtesy of the *San Francisco Chronicle.*

Marin County, on March 14. Here, not more than 10 surf scoters (*Melanitta perspicillata*), 6 western grebes (*Aechmophorus occidentalis*) and 3 common loons (*Gavia immer immer*), out of hundreds of the former and dozens of the two latter species present, were observed to be affected by oil. Since the mouth of Tomales Bay lies well northeastward of Point Reyes its waters were free from pollution; consequently the affected birds must have encountered the oil somewhere to the south and flown to Tomales Bay. Most of the victims were but lightly affected and had normal control of their faculties. A grebe and a scoter, however, were so oil-besmirched as to be virtually helpless. Reports of other observers indicated that at no time during the following three months were there many oil-soaked birds on this bay. This tends to show that either the individuals of species affected in the main area of pollution to the southwest do not visit Tomales Bay, or that birds that had encountered much oil were unable to travel this far. On a visit to this bay on June 25, 1937, no birds that were incapacitated by oil were encountered by the senior author.

After noting the oil-sick birds on Tomales Bay on March 14, 1937, the senior author visited Bolinas Bay and Lagoon where conditions were found to be very bad. On driving along the 3¾ miles of road skirting the eastern shore of the lagoon literally hundreds of dying birds were observed, but very few individuals were seen dead at this time. Eared grebes (*Colymbus nigricollis californicus*) appeared to outnumber affected individuals of all other kinds combined, although at a later date in this same locality western grebes predominated. At several places where pickle-weed (*Salicornia ambigua*) approached the water's edge, clumps of this growth appeared to be moving. Upon close inspection this apparition was seen to consist of the heads and necks of dozens of these birds ineffectually attempting to remove oil from their feathers with their bills. The lesser numbers of affected birds consisted mainly of western grebes, loons and ducks of several species. Lack of time prevented a count being made of the doomed birds, a circumstance which has since been regretted. Although several species of gulls were fairly common in this vicinity but a single western gull (*Larus occidentalis occidentalis*) was found to be affected. Subsequent observations at various localities where oil pollution was severe indicated that gulls were relatively immune from this source of danger. This was attributed largely to their habit of not resting to any great extent on salt water. Rocks, piles, islets, sandy beaches and even fresh-water lakes are used for this purpose by gulls to a much greater extent in this region. Much of their food, likewise, is gleaned from the surface of the water while on the wing.

At Stinson Beach the senior author met Paul A. Shaw, chemist in charge of the pollution detail for the California Division of Fish and Game, who stated that there was already so much oil on the waters of Bolinas Lagoon that little could be done to remedy matters at present. Had time permitted, Shaw said, it might have been possible to have protected the lagoon by placing a log boom across its narrow entrance. He also asserted that everything possible was being done to correct conditions at the wreck, the source of trouble, but that heavy seas hindered salvage and protectionary efforts. It seemed that clean-up work along the beaches and the humane dispatch of helpless birds comprised the extent of assistance that could be rendered.

Returning from Sausalito to San Francisco by ferryboat on the evening of March 14, about midway across San Francisco Bay, the senior author observed an intertidal streak of oil, about 60 feet in width, extending from the Golden Gate at least to Alcatraz Island. As food refuse was likewise concentrated in this ribbon of greatest danger many gulls were seen feeding here, mostly dipping, petrel-like, to snatch morsels of food from the filthy mass. Occasionally individuals were seen to alight and a number of the gulls observed flying overhead were partly coated with oil.

The following day the authors decided to take advantage of the opportunity afforded by this catastrophe to salvage avian skeletal material. With this purpose primarily in mind, joint visits were made to the beaches of San Francisco and San Mateo counties on March 16, to Half Moon Bay on March 22, and to Bolinas Bay and Lagoon on March 23, 1937. It has since been regretted that, on these occasions, more careful notes were not taken of the total number of affected individuals and kinds encountered in relation to the areas traversed.

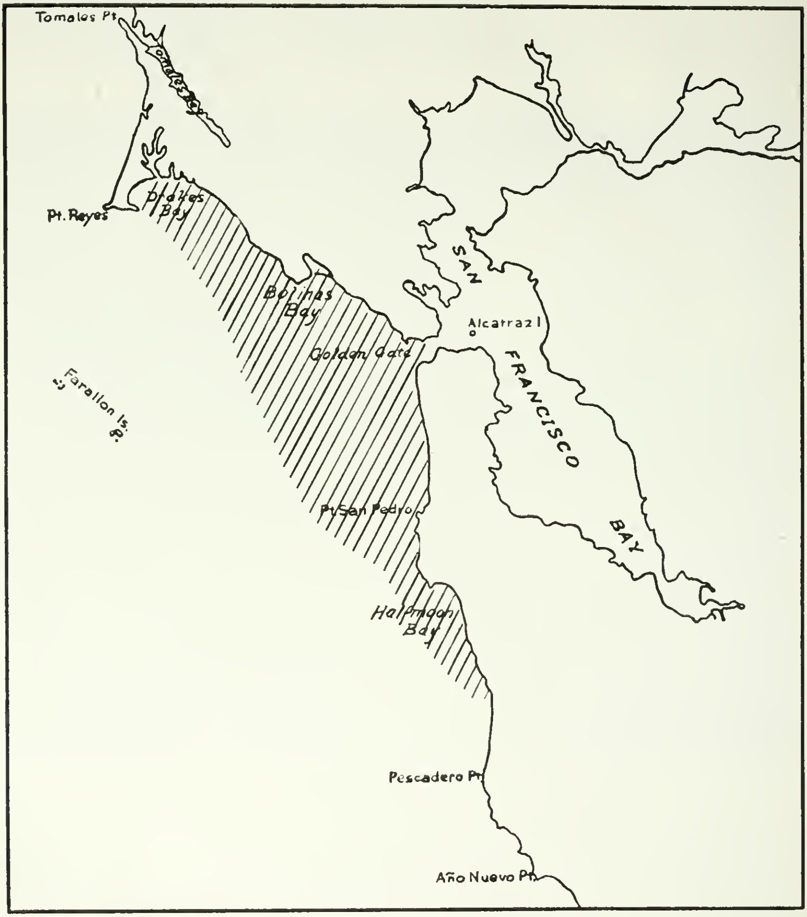

FIG. 85. Map of the San Francisco Bay region with shaded portion showing the extent of oil pollution as a result of the wrecking of the Associated Oil Company tanker *Frank H. Buck.*

In the course of our ocean beach patrols individuals of the following species were found dead, presumably as a result of contact with oil: red-throated loon (*Gavia stellata*), Holboell's grebe (*Colymbus grisegena holböllii*), western grebe, white-winged scoter (*Melanitta fusca dixoni*), California murre (*Uria aalge californica*) and marbled murrelet (*Brachyramphus marmoratus marmoratus*). Only four marbled murrelets were noted in all. The rarity of members of the family Alcidae among the oil victims, except for California murres, and absence of any representatives of the order Procellariformes was a matter of surprise, as at this season we had reason to believe that several species of auklets and murrelets as well as petrels and shearwaters were common offshore. The almost total absence of these forms, save for the murres, seemingly indicated that the other species range farther from shore than the oil extended.

The murres predominated greatly among the ocean beach victims as was evidenced by a census made by Orr just north of Half Moon Bay beach. Here 30 carcasses were counted along a littoral sand beach over a distance estimated to be one-quarter of a mile in length. Assuming that this section was average for the polluted coast line of about 55 miles, no less than 6600 murres fell victim to the catastrophe. That this estimate is conservative, in face of the fact that currents may conceivably have (unknown to us) concentrated the bodies at this point or the birds been especially abundant off this locality, are the considerations that we found similar aggregations of corpses of this species on other beaches, that Orr's census represents but one day out of many of peril which existed for the birds, and the count was made before the end of the danger. Furthermore, the bodies had been washed upon the beaches for some time prior to our visit and many carcasses may have either been buried out of sight in the sand or removed by several causes. It would seem that the loss of this number of murres should seriously affect the status of the already sadly depleted colonies of the species inhabiting this portion of the California coast. Mass numbers on the breeding cliffs comprise the murres' best method of protection against their arch enemy, the western gull. Information supplied by Berg, however, indicates that no diminution is apparent in the numbers of murres at that insular colony, although Captain Lane assures us that murres are now relatively scarce between the Golden Gate and the Lightship, some ten miles offshore, where, prior to the time of the wreck, they were very numerous.

The absence of most species of ducks, with the exception of scoters, and the scarcity of most of the grebes and loons among the avian oil victims noted along the ocean beaches are explicable by reason of their more estuarine habits. Sanderlings (*Crocethia alba*) are common along the beaches, especially at Half Moon Bay and their custom of feeding in the shallow waters of receding waves would seem to subject them to great danger from the oil. Many individuals of this species were observed to be stained with oil, but as none were found dead it appeared that the species was able to withstand this hazard. Snowy plovers (*Charadrius alexandrinus nivosus*) were common along the dry, sandy portions of Half Moon Bay beach, but apparently were unaffected by the oil which in places covered the sands in large, asphalt-like masses.

Quite a different bird fauna was represented by the oil victims found at Bolinas Lagoon on March 23, 1937. This shallow, sand- and mud-bottomed lagoon is attractive to species preferring relatively quiet, shallow waters as is shown by the following list of species and approximate number of dead individuals found by us along the 3¾ miles of eastern shore line: common loon, 2; red-throated loon, 12; eared grebe, 12; western grebe, 200; Farallon cormorant (*Phalacrocorax auritus* *albociliatus*), 1; scaup duck (both lesser and greater), 10; American golden-eye (*Bucephala clangula americana*), 3; white-winged scoter, 60; surf scoter, 10; ruddy duck (*Oxyura jamaicensis rubida*), 25; red-breasted merganser (*Mergus serrator*), 3; glaucous-winged gull (*Larus glaucescens*), 1.

Maritime species such as murres were naturally not expected to be found here. The absence of the Pacific loon (*Gavia arctica pacifica*) and scarcity of the common loon are explicable by the preference of these species for deeper waters. The same reason accounts for the absence of Holboell's grebe. Ducks and grebes, relative to numbers present, appeared highly susceptible to the oil hazard. Curiously, black brant (*Branta bernicla nigricans*) seemed largely immune to the lethal effects of crude oil. Several hundred of these birds were observed standing on a sandbar near the mouth of the lagoon. Close scrutiny with field glasses failed to reveal the presence of oil on the feathers of these birds, although a few brant had previously been seen to be slightly oil-stained on Tomales Bay. The escape of this species from the oil peril is difficult for us to reconcile in view of its largely aquatic habits.

SUMMARY

Oil pollution of coastal waters contiguous to San Francisco Bay, the result of a shipwrecked oil tanker, presented unusual hazards to the avifauna of the areas affected during March and April, 1937. Pollution extended along 55 miles of coast line, centering at the Golden Gate and reaching from 15 to 20 miles out to sea. Its effects were felt not only by species of birds occurring along the open coast but also by those forms inhabiting shallow bays.

Among the offshore species of birds, California murres suffered most and the incident may have inflicted disastrous losses among proximal nesting colonies. Scoters and western grebes were species next in order affected. Offshore ranging forms such as murrelets, auklets, shearwaters and petrels were apparently spared because the oil did not extend sufficiently far from shore to embrace their habitats. In the quiet bays, western grebes, white-winged scoters, ruddy ducks, eared grebes and red-throated loons suffered most in the order named.

Although several kinds of gulls were commonly observed in both habitats, so few were found incapacitated by oil that it was concluded that these birds escaped largely by reason of their feeding and resting habits.

TUNA TAGGING[1]

By H. C. Godsil
California State Fisheries Laboratory
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In the tuna fishery, as in all our marine fisheries, the problem of scientific management consists essentially of determining the maximum annual yield which may be taken indefinitely. This maximum annual yield is limited by the size of the stock and the annual increase due to successful spawning. In order to maintain a fishery at its most prolific level, it is therefore necessary to establish a balance between the amounts added to the stock and the tonnage taken from the stock, and this obviously necessitates some absolute or relative measure of the three essential quantities involved, the annual increment, the stock and the catch. Concerning the latter, we have complete and detailed statistics dating back to the origin of the fishery; but about the size of the stock of tuna and its annual increase we know very little. To supplement this deficiency the present investigative program was initiated, covering in so far as this article is concerned, only the combined fishery for yellowfin tuna and skipjack.

The main objective of this investigation is to determine the nature of the stock upon which the industry depends. In the earlier years the bulk of the tuna catch was taken in the second half of the year, with the heaviest fishing in August, September and October. Through the remainder of the year catches were light, because fish were not available. Subsequently, larger boats discovered that during these lean months tuna abounded farther south, in waters hitherto unfished; whereupon the catch has since doubled, and deliveries have become fairly uniform throughout the year. Do these facts mean that the fleet is following migratory schools throughout the year, thus increasing the intensity of fishing many fold; or do they indicate that the vessels have discovered virgin grounds with distinct and separate populations, yielding a greater total catch with no increased intensity of fishing? Is this increased catch, in other words, being taken from the original stock of migratory fish, or is it coming from a separate and different stock confined throughout the year to the newer fishing grounds? This question must be answered if there is to be intelligent administration of the tuna fishery; and the answer is being sought in a careful comparison of fish from the different areas and in a tagging project.

In animal communities we find frequently that slight differences in physical characters exist within a single species, dependent either upon inheritance or upon varying environmental factors operative during critical stages of individual development. Where there is unrestricted interbreeding, and where spawning is at one time and in only one area, and where the young are raised in one area and at one time, there should not be any discernible differences within the stock. If,

[1] Submitted for publication, March, 1938.

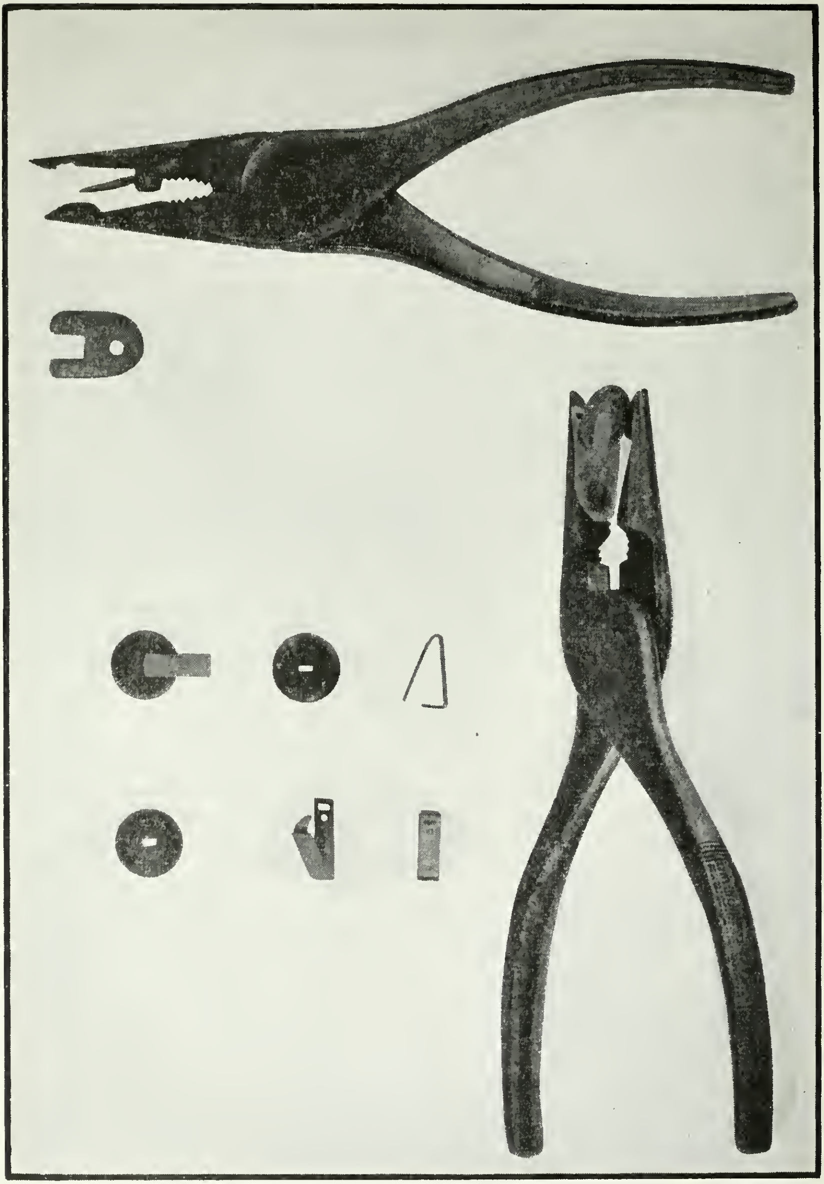

FIG. 86. The tuna tag and the modified pliers used in attaching the tag to the fish.

however, distinct populations exist, spawning at varying times and in different areas, one may justifiably expect to find physical differences in the different populations. Such differences are slight, often being less than the range of variation among the individuals of a single sample, so that it is necessary to examine large numbers of fish from the different grounds and subject the resulting values to a biometrical analysis. The results that emerge often give a clue that goes beyond the immediate problem, a clue that not infrequently throws light upon the complex life-history of the species.

The second approach to the study of the stock of tuna consists of liberating marked fish in different areas and awaiting the recovery of these marked fish to interpret their movements. Tuna tagging, ostensibly the subject of this article, was started at the inception of the tuna investigation, but because of the innumerable difficulties involved, progress has been slow. The tag finally adopted, after much forethought and some experiments, consists of two parts—a sterling silver strap and a colored celluloid disc. The strap serves merely to retain the disc on the fish, whereas the celluloid disc (colored red) is used to make the tag more conspicuous in order to facilitate recovery. The disc bears a serial number and a request to the finder to notify this Laboratory of his catch. The tag is applied to the fish in a single operation by means of a modified pair of "long nose" pliers adapted to hold the tag and lock or crimp it in place upon the fish. The tag and pliers are illustrated in figure 86. All tuna are tagged upon the preoperculum, which is the forward part of the gill cover.

In operation, two or more pairs of pliers are kept loaded and ready at hand. When a fish is caught, the arm of the pliers bearing the tag is slipped beneath the preoperculum, carrying the straight arm of the strap with it. The entering point of the arm is ground to a tapered edge so that it is possible to insert the arm directly under the preoperculum without otherwise lifting the latter. The pliers are thrust forward until the angle of the tag approaches within three or four millimeters of the opercular margin, where the strap (bearing the disc) is locked in place by pressure upon the handles of the pliers. This locking is accomplished by forcing the prong of the strap through the opercular bone and then through an aperture in the opposing arm. As the prong traverses this aperture, it strikes a shallow groove in the arm of the pliers, which deflects the point backwards and upwards, effectively locking the strap to and through the preopercular bone. The number of the tag is recorded with the size of the fish, which is then lifted from the deck and dropped overboard.

All fish are measured in order to secure their rate of growth. By measuring the fish when it is tagged and again upon its final recapture, the growth in this interim may be determined, and when sufficient records accumulate, the growth curve for the species can be established. In the case of the tuna this is the only completely satisfactory means at present available for determining growth rate. Bone and scale markings fail, due most probably to the uniform conditions under which the tuna live, and the consequent lack of the seasonal rhythm so characteristic of the temperate zones.

The entire operation takes only 15 to 20 seconds. It is necessarily fast because the tuna is a powerful antagonist that will fatally injure itself in the struggle if left too long on deck. Fortunately, when a tuna is first landed (by commercial hook and line methods) it gives a momentary flurry and then for 30 to 60 seconds remains flexed, tense and motionless. It is in this interval that the tagging must be done, for when the ensuing struggle begins it is impossible to hold even a 10-pound fish still enough to apply the tag. Moreover, in the struggle the fish begins to bleed about the gills and this weakens it to such an extent that its survival is extremely doubtful. A stunned or weakened fish on the tropical grounds is devoured by sharks almost instantly. Only vigorous uninjured fish are tagged.

Of the 4000 yellowfin tuna and skipjack that have been tagged, the large majority have been caught and tagged from commercial boats. Up to the present time this has been the only available means of securing fish from the distant grounds. Generally two investigators from the State Fisheries Laboratory accompany a commercial boat, and buy the fish from the fishermen at a previously accepted price. A tagging station is selected on the boat with some care. This must be located adjacent to the gratings where the fish are caught, yet beyond the range of flying hooks and falling fish, because the tagging is done as the commercial catch is made. On the one commercial boat on which all the tagging has thus far been done, this tagging station was located on the stern on the starboard side. On this vessel the crew habitually fish on the port side with two men in a stern grating on that side also. Whereas the remainder of the crew land their fish on the deck in the alleyway between bait tanks and rail, the two men in the after grating land their fish on the stern. This was an ideal location, because the starboard side of the stern, while not in use, nevertheless received a supply of freshly caught fish. In practice the fishermen on the stern would land their fish gently on deck when the tagger was ready, instead of in the customary commercial manner. The barbless hooks universally used are readily disengaged with little or no injury to the fish. Holding the fish with one hand, the operator then applies the tag to the right side of the fish, the number of the tag and the size of the fish being recorded by the assistant. All tuna are tagged upon the right side because in the majority of canneries the fish are cleaned with the right side up. If, therefore, a tagged fish escapes notice on the boats, it has a greater chance of recovery in the cannery if the tag is upon the upper side.

Tagging on the commercial boats is, to say the least, an interesting experience. It is a thrill to handle these grand and powerful fish. When the fish are biting fast, the decks of a tuna boat are a veritable bedlam, and the job of the taggers is a wet and gory one. Working amidst a seething mass of struggling fish, one is literally drenched in a flying spray of water, blood and slime. Blinded by this, it is at times impossible to see the fish that one is trying to tag. The absence of freeboard adds further to the confusion; for frequently with a load of fish on deck, the weather rail will roll beneath a wave, and on the return roll to leeward everything ends up in the scuppers, with the fish actually swimming along the deck—sometimes with the tagger hanging on.

The number of fish thus tagged upon a single trip has varied from 500 to 1400. Success is purely a matter of chance, depending primarily upon the size of fish taken and the rate at which the catch is made. For various reasons, the tagging thus far has been limited, to a large extent, to fish less than 20 pounds in weight. If therefore the commercial load consists entirely of large fish, very little tagging can be done. When the boat is loaded rapidly with large daily catches, fewer fish are tagged than when the catch is slow and steady. Whereas this is the only means now available of tagging on the distant grounds, it is slow and time consuming for each trip thus far has averaged 60 days. An additional disadvantage of the commercial boats is the fact that one never knows the destination. The boats go wherever fish are most available and not where the tagger wants to work. Thus, plans provide for tagging at the Galapagos Islands but so far our investigation has failed to reach this destination.

Whenever possible, *i.e.*, when tuna are in local or adjacent waters, the patrol vessels of the Division of Fish and Game are used in the tagging work. Here, the advantage of complete control over the movements of the vessel is offset by lack of proper facilities for catching fish. Lacking bait capacity and the specialized features of a tuna boat, it is necessary to catch the tuna on lures trolled astern. This method of fishing is infinitely slower and more uncertain and in consequence the number of tuna tagged from our own boats is not appreciable. The tagging procedure is essentially similar.

The lack of a suitable research vessel has greatly impeded the tuna investigation. The need has long been realized and plans for such a boat have been prepared. It is to be hoped that she will be acquired in the near future. Pending the construction of the vessel, the tagging work has been more or less held in abeyance.

At the outset of the tuna investigation, it was planned to tag a total of 10,000 fish in three fishing areas. Approximately one-third were to be tagged off the coast of Lower California, one-third off the coast of Central America, and the remaining third at the Galapagos Islands. The lesser distinct fishing areas, such as the Revilla Gigedo Islands, Clipperton Island and Cocos Island, were to be covered later. Of this plan the tagging off the mainland of Central America has been completed, though unfortunately there has been too much concentration in Costa Rican waters to the neglect of other grounds. The work off the coast of Lower California is well under way though by no means complete, whereas the tagging at Galapagos has not been started. In addition, about 140 fish were tagged at Cocos Island. From results to date it is now clearly apparent that far greater numbers must be tagged than originally planned, but the extension of this work must await the acquisition of a suitable boat.

Although 4000 fish have already been tagged, no recoveries have as yet been made. Whereas this has given rise to apprehensions concerning the fate of tags and tagged fish, it has in no way discouraged the tagging program. Every effort has been made to eliminate possible sources of loss; and there is reason to believe that the tag in use and the tagging procedure are in general satisfactory. The lack of recoveries is no doubt due to two major factors. Of these, the tremendous extent of the fishery and the small number of tags out is probably the most important. Thus, if the 4000 tags were scattered uniformly along the straight course covered by the tagging work, there would be roughly only one tagged fish per linear mile!

The second difficulty pertains to recovery. Returns depend entirely upon the tag being seen; and where large quantities of fish must be handled rapidly on the boats, no effort can be made to examine individual fish. Although this handicap is inherent, every effort has been made to circumvent it. The tagging program has been widely publicized in the industry and the cooperation of the fishermen solicited. A reward of $1 a tag is offered to the fishermen, and $0.50 per tag to the workers in the cannery. Unfortunately, magnetic tags, such as are used for mackerel and sardines can not be used profitably with tuna. To be of any value, it is necessary to know where the tag was taken; and in the majority of cases this could not be ascertained with the use of a magnetic tag because the tuna boats fish over extensive and widely scattered areas almost every trip, and the limited knowledge that a tag was recovered by a specific boat would yield no information of intrinsic value. Tuna tagging must therefore employ a ''visual'' tag.

The ultimate success of the program need not be doubted; for it will be realized when a sufficient number of fish have been tagged. In consequence the tagging program will be pursued relentlessly until we have determined the movements of the tuna, providing that the value of the work justifies the time and effort expended. For it must be borne constantly in mind that tuna tagging, spectacular though it may be, is merely a means to an end. The ultimate goal of the investigation is a sufficient understanding of the fishery in all its ramifications to enable scientific management, and the necessity or justification of the tagging program— and indeed all biological work—must be evaluated in terms of this final goal.

TUNA CANNING METHODS IN CALIFORNIA[1]

By PHIL M. ROEDEL
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INTRODUCTION

The tuna canning industry in California dates to 1907, when, following a shortage of sardines, A. P. Halfhill experimented with a tuna pack in order not to suffer closing of his plant. It was he who developed the present method of packing, and through 1911 he was the only producer. In 1912, other concerns entered the field and since that time demand and pack have increased enormously.

Canning methods, discussed in detail in the following pages, may be briefly outlined thus: The fish, upon arrival at the canneries, are eviscerated immediately unless frozen, in which case they must be allowed to thaw. Butchered, the fish are stacked in trays contained in a mobile rack, several of which are wheeled into a large iron steam cooker. Here the fish are cooked at a minimum temperature of 214 degrees F. for two to eight hours, time dependent primarily upon size. After cooking, women workers remove head, skin, bones and dark meat, leaving only four long strips of white meat. These strips are sliced into appropriate lengths, and then packed into cans by hand. Salt and oil are added, and the tins sealed. Vacuum closing machines are in common use, though some plants prefer to pass the tins through a short exhaust box (wherein they are exposed to live steam at no pressure), after which they are sealed. Two plants make no particular attempt at obtaining a vacuum, simply sealing the filled cans. Retorting under conditions of time and temperature prescribed by law completes the canning process.

THE INDUSTRY

Practically the entire California tuna pack is processed by some dozen plants situated in San Diego and the Los Angeles Harbor area (Long Beach, Terminal Island and Wilmington). The Los Angeles Harbor area is commonly referred to as the San Pedro area although no plants are located in San Pedro proper. Most of these concerns handle sardines and mackerel as well as tuna. In San Diego sardines and mackerel are of minor importance but in the Los Angeles plants they comprise the bulk of the pack. San Diego, with its large landings of yellowfin tuna and skipjack, is the leading tuna port, even though nearly twice as many plants pack tuna in the Los Angeles district.

[1] Submitted for publication, May, 1938. Although space forbids naming all of those representatives of the industry whose cooperation and assistance made possible this report, the writer wishes at this time to express to them his thanks. He is especially grateful to Mr. Alfred Luthi of the American Can Company, Los Angeles, and to Mr. Clifford S. Yeoman of the Coast Fishing Company, Wilmington, who not only extended every courtesy but who was kind enough as well to read and criticize the manuscript. The writer alone, however, is responsible for all statements contained in the report. All photographs by Donald H. Fry, Jr.

Albacore, bluefin and bonito are canned primarily at Los Angeles as is all imported tuna. Most of the yellowtail packed is handled in San Diego. In 1937, some 101,000,000 pounds of tuna and 5,000,000 pounds of yellowtail were landed in San Diego, while 71,500,000 pounds of tuna (including 10,500,000 pounds of Japanese fish) and 500,000 pounds of yellowtail were landed in the Los Angeles area. A summary of tuna and yellowtail landings for 1936 and 1937 is given in table 1.

Present importance of the tuna industry may be seen from the fact that landings of the several species are first in value and second in tonnage in the State's fisheries.

TABLE 1

Tuna and Yellowtail Landings in San Diego and Los Angeles Regions, 1936-1937

Table includes deliveries to fresh fish markets but these are small except in case of yellowtail. Importations from Japan, Northern California, Oregon and Washington, include only fish used for canning.

Species	1936			1937		
	San Diego	Los Angeles	Total	San Diego	Los Angeles	Total
Albacore	2,403	898,871	901,274	326,370	1,107,693	1,434,063
Albacore (Northern California, Oregon and Washington)		41,152	41,152		1,721,759	1,721,759
Albacore (Japanese)		1,499,233	1,499,233		1,546,939	1,546,939
Bluefin	1,284,743	17,644,884	18,929,627	1,399.151	11,287,047	12,686,198
Bonito	2,330,295	4,881,003	7,211,298	2,636,672	5,151,066	7,787,738
Mebachi (Japanese)		20,370	20,370			
Oriental (Japanese)		745,052	745,052		523,632	523,632
Skipjack	17,558,476	9,447,622	27,006,098	31,520,010	15,584,061	47,104,071
Skipjack (Japanese)		2,264,925	2,264,925		7,594,903	7,594,903
Yellowfin	58,051,689	20,300,890	78,352.579	65,405,461	26,116,802	91,522,263
Yellowfin (Japanese)		8,628	8,628		884,148	884,148
Total tuna	79,227,606	57,752,630	136,980,236	101,287,664	71,518,050	172,805,714
Yellowtail	7,932,805	2,147,706	10,080,511	4,826,612	544,369	5,370,981

THE FISHERY

The tuna canning industry is dependent in the main upon catches made by the San Diego-San Pedro tuna fleet and delivered by these vessels to the canneries. Four species form the basis of the true tuna pack: yellowfin tuna (*Neothunnus macropterus*), bluefin tuna (*Thunnus thynnus*), skipjack or striped tuna (*Katsuwonus pelamis*), and albacore (*Germo alalunga*). A fifth tuna, the bonito (*Sarda* sp.) and yellowtail (*Seriola dorsalis*) are packed tuna style but can not be marketed as "tuna." In addition, a small amount of mackerel (*Pneumatophorus diego*) is canned tuna style at San Diego.

Yellowfin and skipjack constitute a single fishery and are taken throughout a vast area extending from southern California to the equator. Of the two, the yellowfin is the finer fish and constitutes the backbone of the industry. Both species are taken throughout the year. A detailed account of this fishery is given by Godsil.[2] Bluefin are taken primarily from June to September between Guadalupe Island off the Lower California coast and Point Conception. Albacore, once of great importance, now makes a minor contribution to the total catch. It is taken mostly off southern California, though some is generally landed

[2] Godsil, H. C. The high seas tuna fishery of California. Calif. Div. Fish and Game, Fish Bull., no. 51, 41 pp., 1938.

during the fall at Monterey, while a large run occurred off the Oregon coast in the fall of 1937. Some canning of albacore has been done at Monterey but the great bulk of the catch is shipped to Los Angeles for processing. The 1937 Oregon catch was likewise shipped to southern California, but it is understood that some northern canneries have installed equipment for albacore canning in anticipation of continued northern runs. Bonito is of minor importance. It is taken off the Lower California coast throughout the year and off southern California during the late summer and fall. State law prohibits the canning of yellowtail taken in California waters. Therefore, the entire cannery catch is taken below the international line.

Certain of the San Pedro canneries depend upon imported frozen tuna from Japan for a part of their pack. Albacore and skipjack, comprising the bulk of the imports, are augmented with lesser amounts of oriental tuna (*Thunnus orientalis*), yellowfin, and occasional other species. Importations started in 1927. Until 1933, albacore was delivered in the greatest quantity, reaching a peak of some 7,000,000 pounds in 1930. Skipjack importations began in 1933 and now account for the greatest poundage, some 7,500,000 pounds being landed in 1937 as against 1,500,000 pounds of albacore. (See table 1.)

Total importations, averaging some 4,000,000 pounds a year through 1936, leaped to 10,500,000 pounds in 1937, which still is but a small proportion of the 173,000,000-pound grand total landing for the year at the two ports. Prior to 1935, small amounts of albacore and skipjack were imported from Hawaii as well. Some operators do not like the imported fish; others feel that the Japanese skipjack arrive at the cannery in better shape than those taken by the California fleet. Importations were first occasioned by expansion of the market, at which time small operators found this procedure more economical than financing tuna vessels.[3]

UNLOADING OF TUNA AT THE CANNERIES

Methods of unloading vary with the physical situations of the plants. At Terminal Island and in Wilmington, public roadways pass between the plants and their docks. The Terminal Island plants utilize large iron push carts; these are lowered into the holds of the boats where they are filled and then raised back to the street, using the boats' boom and winch. A few plants unload small albacore boats onto wooden conveyors which run from water level to the cannery, passing underneath the roadway. Scales at the Island plants are located just inside the cannery entrance. The Wilmington plant uses a wooden conveyor which brings the fish up to the street level, dropping them into carts similar to those used at Terminal Island. The scales again are located in the cannery. In all of these plants, the fish are dumped onto the cannery floor where they are sorted as to size and condition.

Long Beach and San Diego plants have their own docks. In San Diego, the weighhouse is situated in a tower beside the dock. A container is lowered into the hold, a winch and boom on the dock being utilized. When filled, the container is lifted to the weighhouse, the

[3] Godsil, H. C. The five tunas. Calif. Div. Fish and Game, Fish Bull., no. 49, pp. 24-33, 1937.

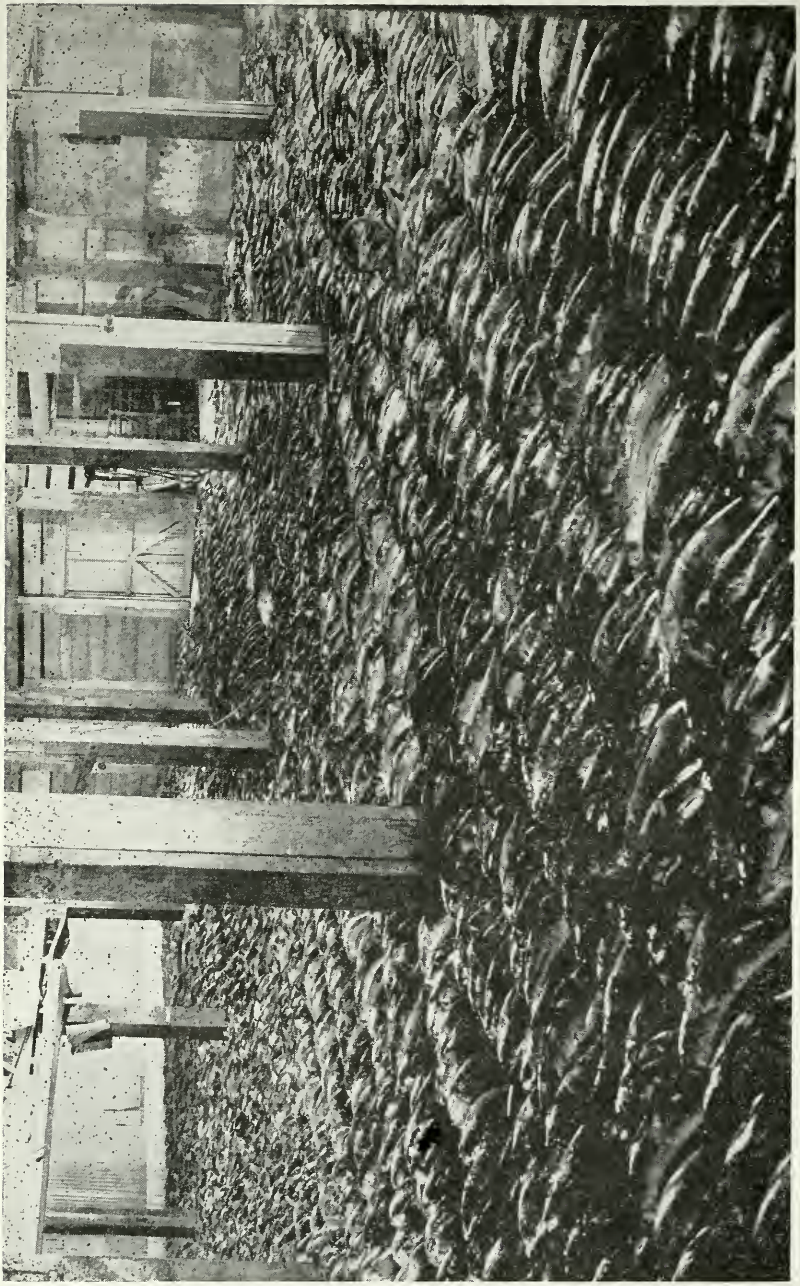

FIG. 87. Thawing tuna on the cannery floor.

weight noted and the fish dumped either into a flume or onto a wooden conveyor, which carries them directly to the butchering tables in the plants. Frozen fish are removed at the end of the conveyor; they may be diverted to other conveyors which carry them to thawing tanks, or simply lifted from the head of the butchering table. Badly mutilated fish are removed at the same time. A Long Beach company uses a wooden belt conveyor running from beneath the dock at the level of the vessel's deck to the entrance of the plant. Here the fish fall into iron carts similar to those used at Terminal Island. Whatever the method of unloading, a representative of the crew will always be found at the scales checking the weight.

The fish are washed as soon as unloaded. When a flume system is used, washing occurs during transit to the plant. Some plants using wooden conveyors have a shower system over a portion while others simply wash the fish with hoses when they are dumped on the cannery floor.

THAWING

Fish arriving in a frozen state must be permitted to thaw until they are soft enough to butcher and cook. Cooking of a "hard" fish will result in the explosion of ice crystals in the cells with resultant injury to the tissues. Opinion differs as to the proper method of thawing. In the San Pedro district, it is customary to leave the fish on the cannery floor, washing them continually, occasionally or not at all. Assortment as to size is generally made at this time. (See Fig. 87.) Some plants place a part of the fish in tanks filled with sea water and permit them to thaw there. Where space is limited, frozen fish may be heaped on the floor rather than placed in a single layer. In San Diego, thawing tanks are now in general use. The tanks, built of wood or concrete, hold from one to five or more tons of fish. The most elaborate system is found in a plant which has a conveyor running from the end of the unloading flume to the numerous thawing tanks. The fish can be diverted to the various thawing tanks as desired. When thawed, a trap at the bottom of the tank is opened and the fish are returned by flume and conveyor to the head of the butchering table. Other concerns divert the fish by flume or carry them by hand to the tanks. One plant in the San Pedro region places its fish in racks (later used in the steam cook) in which they are allowed to thaw. The fish are not washed while thawing, as the operators of this cannery feel that any speeding of the natural rate of thaw is harmful. They are, however, washed before they are racked. This plant and one other in the same area have experimented with thawing tanks but feel them unsatisfactory.

The San Diego plants using tanks feel that they get a thorough and even thaw and in much less time than is possible by any other method. However, operators in San Pedro who have tried tanks and discontinued their use claim that the thaw is not even; that where the outer layers of flesh are soft, the deeper muscles may still be frozen and that there is a tendency for the outer layers to become somewhat mushy —a condition which has caused rejection of some fish by State officials on the grounds of spoilage. Plants continuing to use tanks claim no such difficulties. It is maintained that the dissatisfied operators who used makeshift tanks with no provision for circulating water should not compare their results with the more refined systems in use at San

Diego. There are objections to thawing on the cannery floor, in either one layer or in heaps, for the following reasons: It is claimed that the top of the fish thaws more rapidly than the side against the concrete cannery floor, that streams of water are too often irregularly applied, causing a more rapid thawing of some fish, and that when the fish are piled, those on the outside thaw much more rapidly than those at the center. Further, in hot weather there is danger of the outside of a fish spoiling while the inside is still hard. As even a thaw as can be obtained is essential; the fish must not stand too long after thawing, and frozen or partially frozen fish will be spoiled in the steam cook. The most even thaw obtainable is claimed by the plant which places its fish in racks; this concern butchers and washes the fish as soon as

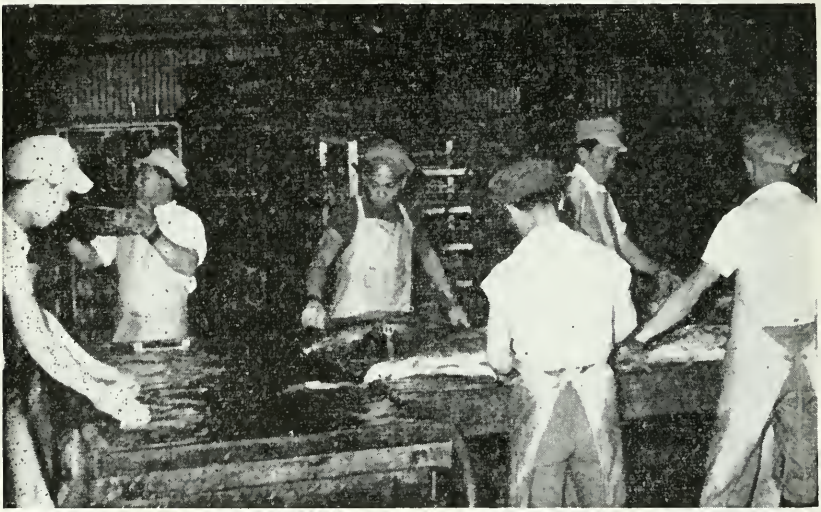

FIG. 88. Butchering yellowfin. The butchers slide the eviscerated fish into the tub where they are washed by the man at the left. The man in the left background racks the fish preparatory to the steam cook. Note the filled carriers in the background.

they are softened, but then takes the added precaution of delaying the steam cook until the fish reach a body temperature of 40 degrees F. This may take eight to twelve hours after butchering. They feel that the longer time required by this method is repaid with a finer grade of meat after the cook.

Time of thawing is highly variable and depends upon the method used, the size and condition of the fish, weather conditions, and the attitude of the plant in question as to what constitutes a proper thaw. In a thawing tank, a small fish may thaw sufficiently in two hours, whereas a fish of medium size requires three hours and a large fish, four to seven. Estimates of time required in the air vary greatly. In moderately warm weather, a small skipjack may thaw on the floor in four hours. It may stand overnight or up to 15 or 18 hours. A moderate sized fish may be left 12 to 36 hours, whereas a large one may require up to 48 hours. The process is accelerated if the fish are washed while thawing.

BUTCHERING

Unfrozen fish are butchered upon their arrival at the cannery; those frozen must perforce await thawing. The butchering crews are made up primarily of Filipinos in the San Pedro area and of Mexicans in San Diego. A simple longitudinal cut is made upon the right side of the body. The viscera are cut free at both ends of the body cavity, sometimes by the man making the initial incision, sometimes by a worker next to him. Head and gills are not removed. The fish are washed and placed in wire trays which fit in turn into mobile racks which are wheeled into the cooker. Six small fish will fit into one tray of standard size, 30 by 15 inches. Trays 36 and 42 inches in length are sometimes used to accommodate longer fish. When fish are too long for the trays, a section is cut from the tail either with a saw or with the regular butchering knife and placed beside the fish in the tray or in another basket. (See Fig. 89.) This piece may be removed either before or after butchering. The fish are placed in the trays with the incision down to facilitate drainage during the cook.

FIG 89. Cutting the fish to fit the racks. These fish are of great size; often the butchers can remove a piece of sufficient length with their knives.

Of the viscera, the liver is usually saved and sold to various pharmaceutical houses for manufacturing into medicinal oil. The balance of the viscera receives a short steam cook and is then sent to the reduction plant.

Although the actual process of butchering is nearly the same throughout the industry, the butchering tables are of two types. The older form is a mobile table with a tank, located either in the middle or at one end, in which the fish are washed. (See Fig. 88.) This type of table is in use in all of the plants in which situation or choice makes it necessary to dump the fish from carts. San Diego operators utilize a wooden belt conveyor at the end of the flume or conveyor from the weighhouse. A man at the head of the conveyor places the fish on the belt right side up, head toward the center, at an angle of somewhat less than 45 degrees. The butchers stand along the belt, the speed of which is regulated according to the number of fish the cannery feels they should be able to prepare carefully. Beyond the butchers a man washes the eviscerated fish, using a short hose for this purpose. He also removes any adhering bits of viscera. At the end of the belt, the fish are removed and racked. Recently, one plant has added a worker to each line whose duty it is to wash out the gills and mouth of each fish before it is cleaned. He is equipped with a short hose with a nozzle cut down to give considerable force to the flow of water. The tip of the nozzle is slipped under the gill cover and the water turned on for a second or so as the fish passes by on the conveyor.

Whatever the method of unloading, thawing and butchering, the finest pack will in general result from the fish which have been handled the least and with the maximum of care. Rough handling of a fish, frozen or not, will invariably cause injury to the meat.

STEAM COOKING

Following butchering and washing, the fish are, as has been indicated, placed in wire trays which fit into mobile racks. A rack of standard size holds two tiers of trays, seven trays to the tier. The standard cooking chambers hold as a rule 5 or 8 racks and are either about 13 or about 20 feet in length. They are constructed of heavy sheet iron and, as no pressure is required, are not airtight. (See Fig. 90.)

FIG. 90. Running a rack into the steam cooker.

Temperature of the precook varies with the cannery from 214 to 220 degrees F. The cooked fish may be soggy if cooked at 212 degrees or less; a temperature of over 220 degrees can be obtained but is not workable. Experiments have been made using a temperature of as much as 240 degrees F., but while time was saved the condition of the meat was not satisfactory as hurrying the cook resulted in discolored meat from insufficient drainage. Particularly stearin between the layers did not have time to soften and drain and, as one operator remarked, "showed up like cheese after the cook." As well, the high temperature cooked out the desirable natural juices. Time of the cook varies primarily with the size of the fish. It is affected as well by the ideas of the individual cannerymen and the species and condition of the fish. The object is to give a thorough cook, continuing until the flesh is easily separated from the bone and the skin comes off with ease. Such oil as is present and a good deal of the moisture are cooked out at this time.

Cooking temperature must be attained gradually or injury to the tissues will result. In general, fish brought in fresh require less time to reach cooking temperature, whereas small fish are brought up more rapidly than are the large. Estimates of time required vary from as little as 15 minutes for small skipjack to an hour for large yellowfin. One plant will take 30 minutes to reach cooking temperature with a small fish; another will reach that level in 40 minutes with a large "hard" fish; another may not differentiate as to size and allow 45 minutes for any fish. This variation between the plants may be explained, in part at least, by the differences in thawing times and methods; *e.g.*, one concern will start the cook when the fish are much colder than will another.

Time of the actual cook varies from two to eight hours. Small skipjack can be cooked in 2 to 2¼ hours. They may however be held as long as 3. Up to 25 pounds, the cook may run 3 to 4 hours. Medium sized fish cook 4 to 6 hours; an 80-pounder will require 6, whereas fish of 100 pounds and up require a full 8 hours. Fresh-caught fish may require a slightly longer cook than do those brought in frozen.

At the conclusion of the cook, the racks are wheeled from the cooker and allowed to cool. Usually, cooling goes unassisted regardless of weather although occasionally, a system of blowers is used to circulate air in hot weather. Air temperature is of course the regulating factor in cooling. Fish may stand as long as three days during the winter in the San Pedro area without spoiling. During the summer, the limit is about 24 hours. In general 8 to 24 hours is sufficient for cooling. Twenty-four hours is about the maximum standing time allowed in San Diego, with 12 to 18 hours the more customary period. Some plants give the fish a short steam cook of ten minutes or so before cleaning if the fish have stood long enough to dry excessively.

In general, the length and temperature of the steam cook are not checked by automatic recording thermometers as must be done in retorting. The usual method is to chalk the starting time together with the anticipated stopping time on the door of the cooker while temperature during the cook is read off an ordinary thermometer. One concern does, however, utilize the more refined method of recording thermometers and timing devices.

CLEANING

The cooked and cooled fish are prepared for packing by women workers. All nationalities are represented at the cleaning tables of the various plants; in general, the older women are found there while the younger ones do the packing.

The cooking racks are wheeled to the cleaning tables where men remove the trays, dumping the fish for the cleaners as required. The tables may be located in a separate room or they may be found immediately adjacent to the packing lines.

Cleaning methods are similar in all the plants. The heads are broken free, the skin is scraped off and the body broken in half longitudinally. This exposes the backbone which is lifted out. The halves are split longitudinally and the dark meat (located in a layer

FIG. 91. Cleaning the fish. The prepared strips are placed on the boards seen at the right, flakes go into the pan, waste material into the barrel.

around and below the spinal column) is carefully scraped away. Dark meat, bones, skin, fins and head are all dumped into containers for removal to the reduction plants. The long, slender strips of white meat, which correspond to the dorsal and ventral musculature, are placed on wooden trays which when filled are removed by the men workers. (See Fig. 91.) These trays are racked in wheeled carriers for transport to the slicing machines. Smaller bits of white meat are kept separate for use in the "salad" or "flake" pack or for filler in the "standard" pack. Inspection of cleaned fish varies in intensity from little if any to a careful examination of each tray before it reaches the slicer. In some plants, each cleaner is given a number and she must place a tag bearing that number on each tray of meat which she has cleaned. Each tray is then examined as suggested above with the additional check on each worker.

Slicing machines resemble miniature guillotines. The trays bearing the strips of meat are placed on a conveyor which moves under a knife blade so regulated as to cut the strips at the desired width for packing. The cut is always across the muscle fibers, *i.e.*, across the long strips of meat. (See Fig. 92.)

PACKING

In general, three grades of pack are put up, commonly termed "solid," "standard," and "salad" or "flake." The solid pack consists only of large chunks of the finest meat. No small bits of meat are used in this pack. The standard pack is made up primarily of large pieces but a certain proportion of flakes is used; the amount allowed varies with the plant and may be as little as 10 or as much as 33 per cent; it is usually held to about 15 per cent. The standard pack is calculated to absorb all of the flake material of a given run. In the salad pack, all small bits of meat are used; the bulk of this pack results when no standard pack is being put up. If the meat is tender and brittle, more flakes will result than will from dry. Usually, the type of pack to be used for a given lot is determined before the packers start work. Occasionally, a lot of mixed quality is packed more or less standard; a forelady then sorts the tins as they are en route to the capper, removing any which seem worthy of labeling under the finest brand. One plant uses this method quite regularly when the pack is nominally standard, the workers using a solid pack whenever it is possible. The bulk of the tuna pack—about 80 per cent—is placed in the familiar round half-pound tins. Quarter-pound and full-pound cans make up most of the remaining 20 per cent, though a few plants are equipped to handle four-pound tins. These last are, as may be expected, designed for hotel, restaurant and institutional trade. The half-pound tin is used almost exclusively for the flake pack; the quarter-pound almost never. A detailed analysis of the pack is found in Table 2.

Unlacquered tins are the rule. Recently, however, some plants have taken to placing part or all of their output in cans which are lacquered on the inside. By this, discoloration of the tin caused by extended contact with the meat is eliminated, the result being a pack

FIG. 92. Slicing the meat. The racks in the background hold meat already sliced, the method employed in this plant being to run the racks between the packing lines where they are unloaded as needed by the workers. Note the State inspector at the right.

of finer appearance. It is felt that use of the lacquered cans will become the rule rather than the exception. One San Diego concern uses specially made aluminum cans for its fancy pack. Some difficulty was experienced at first with these containers, but it is claimed that most of the troubles have been eliminated and that the pack is considered very fine.

TABLE 2

Tuna and Yellowtail Pack, 1936-1937[1]

Size of cans[2]	Number of cases					
	1936			1937		
	San Pedro	San Diego	Total	San Pedro	San Diego	Total
Albacore—						
4-lb., 12's	838		838			
1-lb.	8,585		8,585	11,642	102	11,744
½-lb.	43,525	35	43,560	71,268	7,934	79,202
¼-lb.	901		901	147		147
¼-lb., 100's				66		66
Bonito—						
1-lb.	7,749	6,580	14,329	16,856	6,757	23,613
½-lb.	55,747	29,657	85,404	64,979	35,551	100,530
¼-lb.	1,464	506	1,970		1,430	1,430
¼-lb., 100's	3,375		3,375	3,683	316	3,999
Bluefin—						
1-lb.	13,843	1,506	15,349	16,542	1,611	18,153
½-lb.	247,752	18,235	265,987	140,492	20,853	161,345
¼-lb.	24,546	2,649	27,195	19,926	3,091	23,017
¼-lb., 100's	24,638		24,638	10,843	1,548	12,391
12 oz.	1,208		1,208	629		629
Yellowfin—						
4-lb., 12's	811	841	1,652	962	450	1,412
1-lb.	33,243	68,294	101,537	42,787	89,866	132,653
½-lb.	279,409	864,796	1,144,205	333,422	916,287	1,249,709
¼-lb.	24,626	123,192	147,818	29,995	157,169	187,164
¼-lb., 100's	4,284	17,688	21,972	8,155	2,094	10,249
12 oz.	861		861	1,290		1,290
Striped (Skipjack)—						
1-lb.	7,016	12,802	19,818	13,748	17,414	31,162
½-lb.	138,739	235,577	374,316	198,964	408,960	607,924
¼-lb.	9,044	24,125	33,169	14,316	24,636	38,952
¼-lb., 100's	29,557	22,826	52,383	49,137	36,741	85,878
12 oz.	574		574			
Flakes—						
1-lb.	814	2,300	3,114	8,716	2,563	11,279
½-lb.	9,092	12,431	21,523	25,818	12,947	38,765
¼-lb.		236	236		394	394
Tonno—						
½-lb.	6,450		6,450	11,404		11,401
¼-lb., 100's	51,347	740	52,087	125,208	1,125	126,333
Yellowtail—						
1-lb.	6,157	12,471	18,628	1,545	14,968	16,513
½-lb.	10,912	82,208	93,120	1,807	29,131	30,938
¼-lb.		380	380		29	29

[1] Forty-eight cans to the case unless otherwise specified.
[2] From "Statistical Reports on Fresh and Canned Fishery Products, Years 1936-1937," by S. H. Dado. California Division Fish and Game, Circular, Nos. 11, 12.

Albacore is considered the finest meat and commands a premium price. It alone can be marketed as "white meat tuna." Color is the prime consideration of the American buyer; whether or not this distinction is reflected in the taste of the fish is a matter of question. Of the species more commonly taken, yellowfin provides the fanciest pack. Varying with time of year, locality taken, food, and other similar factors, the meat is of light color and good appearance. It is the finest of the yellowfin pack (fish of 30 to 60 pounds are preferred) that is marketed under the best known trade names. The designation "light meat tuna" is permissible on yellowfin, bluefin and skipjack. As a rule, bluefin and skipjack are packed standard.

Details of packing vary considerably from plant to plant. In all, conveyors (either belt or chain), which carry empty tins to the packers and the filled tins back to the capping machines, run the length of the long table at its center. Workers, all women, line the tables on both sides. In some plants, a series of rollers runs along the top center of the table down which the trays of sliced meat are shoved. Men lift the trays down beside the packers as they are required. Other plants rerack the trays after the meat is sliced; the racks are then wheeled between the packing tables and the trays removed as needed. (See Fig. 93.)

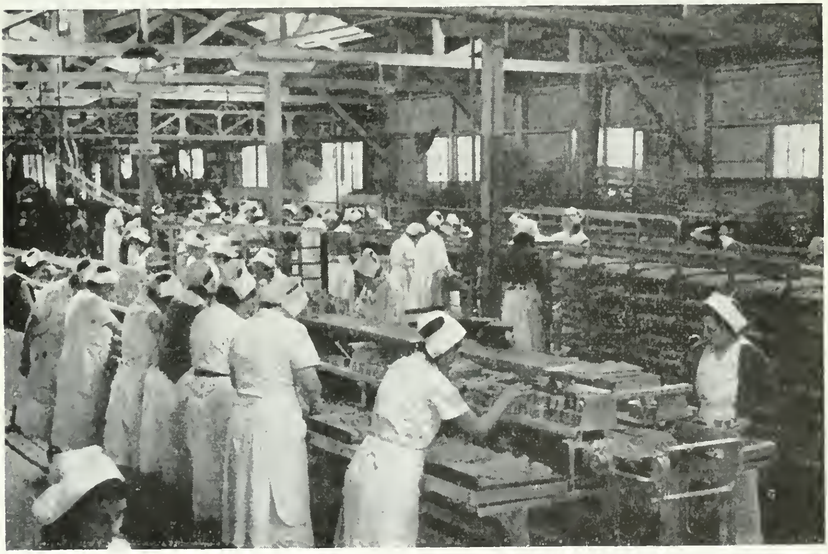

FIG. 93. General view of the packing lines. The slicing machine seen in figure 92 is to the right of the table in the foreground. Closing machines are in the left background.

All the tins are packed by hand, and the speed and accuracy with which they are filled is amazing. The slices of meat, as has been indicated, are cut to the proper height for the size tin in use. This results in the half-pound can being filled to within about a quarter of an inch of the top. Actually, a 3/16-inch headspace is calculated upon. Of this, the affixed lid will fill 5/32-inch. The chunks of meat are carefully fitted into the tin so that no space is left in the solid pack and just enough in the standard to hold the desired amount of flakes. A quick tamping of the filled tin with the heel of the hand and it is stacked before the worker. (See Fig. 94.) Balance scales are found beside each worker but are little used. An experienced packer feels confident of her ability to place the proper weight of meat in each can. A forelady periodically examines the filled tins of each worker, checking her

FIG. 94. Packing the tins. When filled, they are placed on the shelf seen in the upper right corner where they remain until checked by the forelady.

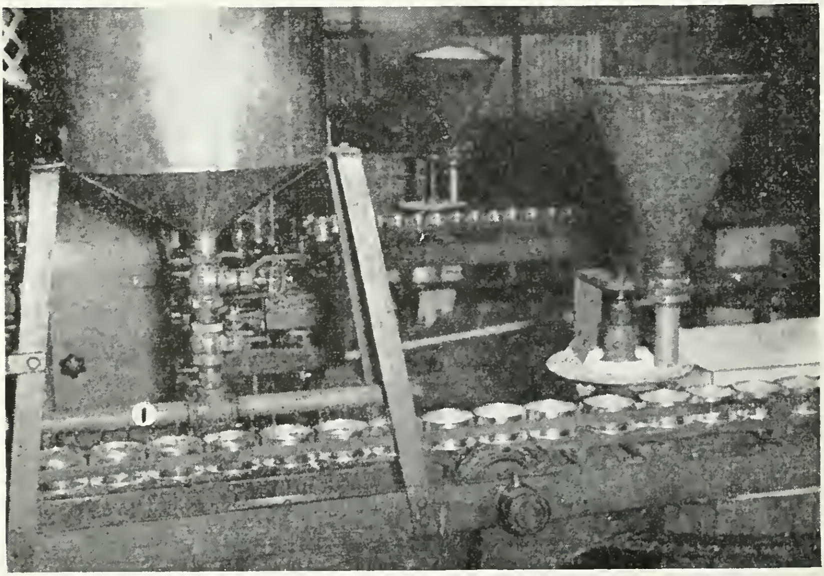

FIG. 95. Salt and oil dispensers. The tins pass from right to left. In this plant, a steady stream of oil falls from numerous holes in the pipe marked "1."

card with the number filled. The tins are then placed on the conveyor which carries them to the capping machines. The four-pound cans are packed in a slightly different fashion. Two layers, each cut to the width used in the one-pound tins, are used. This is a solid pack entirely. Minimum allowed weights of meat for the various sized containers are given in table 3.

TABLE 3

Minimum Retorting Times and Net Weights of Meat for the Various Tins[a]

Tin	Retorting time at		Minimum net weight of meat (ounces)
	240° F.	250° F.	
¼-lb.	65 min.	40 min.	3.50
½-lb.	75 min.	55 min.	5.75
1-lb.	95 min.	80 min.	11.50
4-lb.	230 min.	190 min.	46.00[b]

[a] Figures given by the California State Department of Public Health.
[b] Approximate.

Salt and oil are added to each tin by special dispensers. (See Fig. 95.) Most commonly, both are added (the salt first) just before capping. Occasionally, either or both are placed in the tins before packing. Oil is rarely added first, because of the resulting messiness along the packing line, though some operators feel a more satisfactory permeation of oil, together with a lessening of the danger of scorching one surface during retorting, would result if some of the oil were added before and some after packing. This method is employed in the four-pound pack, where one plant at least places some oil in the empty tin, some between the layers, and the balance on the top. Another method applied to the four-pound pack is to pass the filled tins under two sets of spigots four or five feet apart. The cans are filled to overflowing under the first set; by the time the second set is reached the oil has been fairly well absorbed and the tin is again filled. Some plants which use exhaust boxes add about one-third of the oil before exhausting and the balance after. If the exhaust method is employed it is customary to heat the oil. The temperature level maintained varies with the plants; in some the oil is merely warmed, in others it is kept as hot as 180 degrees F., at which level it is held constantly by one concern. Most of the companies do not attempt to regulate the temperature that closely. Another concern adds part of the oil cold before exhausting and the balance warmed after exhausting. Heating the oil results in a somewhat higher vacuum than would otherwise be obtained in the exhaust. A more satisfactory permeation through the meat is claimed as well. However, one concern which uses neither exhaust nor vacuum claims that the use of warm oil in the larger tins is not satisfactory, as it tends to disrupt too much fine material which in turn leads to a product of inferior appearance. This company does warm the oil for the quarter-pound pack for reasons discussed later. Hot oil can not be used successfully in a vacuum pack.

Estimates as to the exact amount of salt and oil to the tin were difficult to obtain. One company, however, has measured carefully the amount of each with these results:

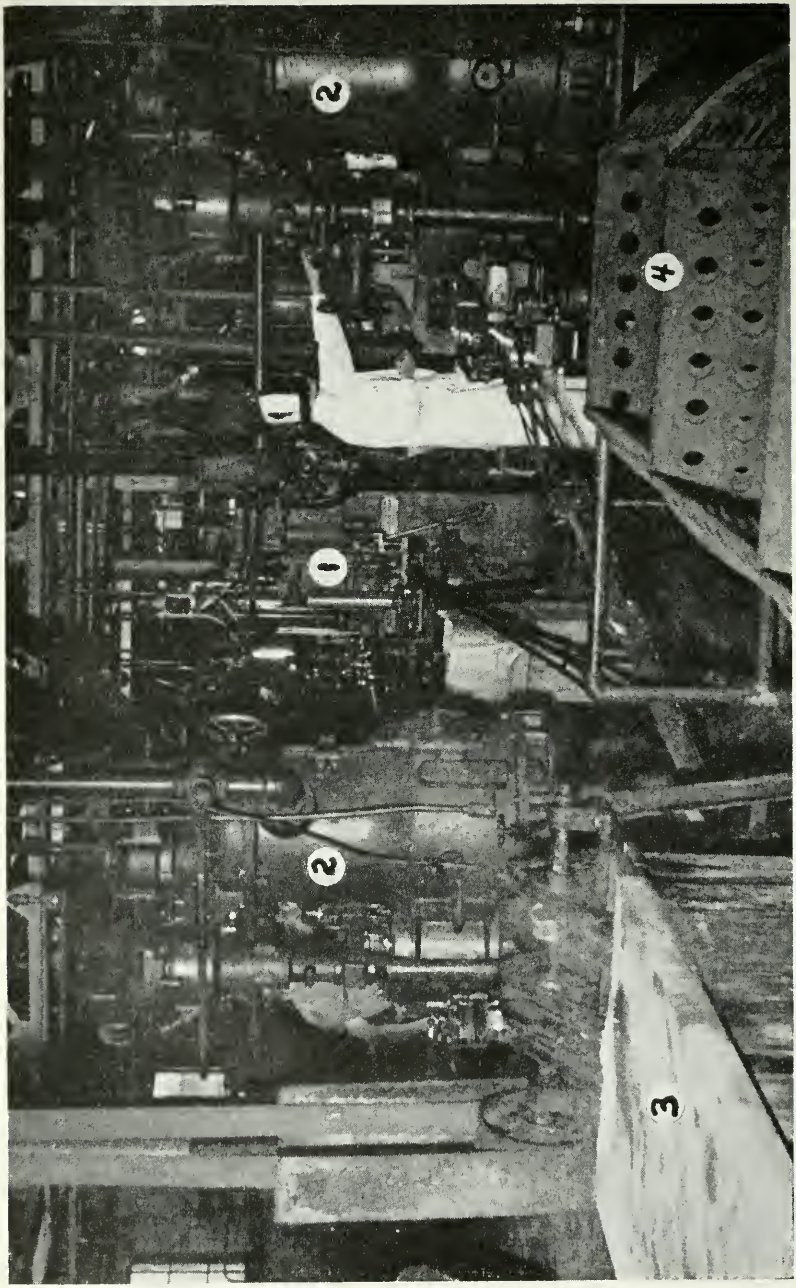

FIG. 96. General view of vacuum closing machinery. The girl operator is placing lids in the capping machine. A stack of lids may be seen directly to the left of figure "1" which indicates a capping machine. The vacuum machines are marked "2." Tins may be seen emerging from the machine on the right. They are washed in the vat marked "3." Retort baskets marked "4" are seen in the lower right corner.

one-quarter-pound:	2.83 grams salt,	½ ounce oil
one-half-pound:	3.54 grams salt,	1½ ounces oil
one-pound:	4.25 grams salt,	2 ounces oil

Other plants generally estimate the salt added as about half a teaspoon to the half-pound tin, with correspondingly less for the quarter-pound and more for the one-pound. About 24 grams is placed in the four-pound can. In general, the salt dispensers do not work too efficiently, and often one tin may receive less than its share whereas the next receives more. Estimates of the amount of oil added showed a good deal of difference between plants. One company calculates four pints to the 48-tin case, half-pound size; and six or seven pints to the one-pound case. Another adds six pints to the half-pound case and a full gallon to the one-pound case. The four-pound tins require some nine ounces. In any event, enough must be added to meet the minimum weight requirements for the various tins. A bland vegetable oil is used exclusively.

A constant flow of oil is maintained through a number of small spigots. (See Fig. 95.) There are enough of these so that each tin is completely filled by the time it has passed under all (unless but a portion of the oil is first added, in which case the number of spigots is correspondingly low). The conveyor tips slightly after oil is added to remove the excess. In some cases this is done immediately after the oil is added; in others it is somewhat delayed to permit a little permeation. A collecting basin is located below the oil dispensers. There the oil which did not fall into the cans (the oil flow is constant while the tins do not come by in a steady stream) is collected and piped off to be filtered and used again.

Vacuum closing machines are now used commonly. The tins follow the conveyor which has carried them from the packing table and pass under the salt and oil dispensers (unless, as noted above, the salt or oil is added prior to packing). Usually they first pass under a machine which tamps down the surface of the contents of each tin. The vacuum method of sealing labored under difficulties before this device was introduced. The reason for this was the tendency of the packers, who were paid by the number of tins they filled, to leave a vacant space in the bottom of the can. The air trapped therein could not be completely pulled by the vacuum. Generally, a watch is kept and tins notably over- or under-filled removed. From the tamper the conveyor leads directly to a machine which crimps on but does not seal the lid. From it the tins pass directly to the vacuum machine, a device which sucks out the air by means of a pump, the while sealing the lid. A vacuum of 10 to 12 inches is obtained in the tin; vacuum in the chamber may equal 20 inches, though it is more often about 15 inches. The large modern machine will handle 130 cans per minute. Often one or two auxiliary machines with capacities of up to 60 tins per minute are placed in the line, thus greatly increasing the amount which can be handled. From the closing machine, the tins pass through a bath of strong soap in boiling water, after which they are rinsed in boiling water. (See Fig. 96.) The conveyor terminates shortly thereafter, the tins falling into the large iron baskets in which they will be retorted. The purpose of the bath is to remove any adhering oil or other foreign material. While as strong a soap as possible must be used, care must be taken that it is not so strong as to injure the seams of the cans.

The exhaust box is still used in several plants. It consists of a long, enclosed steam chamber open at both ends, and heated with live steam at no pressure to a temperature of about 210 degrees F. Through it the conveyor passes. (See Fig. 97.) Each tin is exhausted for 1½ to 7 or 8 minutes. Salt and oil may be added before or immediately following the exhaust. Frequently part of the oil is added before and part after. Generally, the oil is heated, resulting in a higher vacuum. The tins usually pass directly to the capper, though they may go through a short "hot box" en route. The cans are washed as described above.

In the exhaust, air is driven out of the spaces in the tin and these spaces are in turn filled with live steam. The tin does not cool suf-

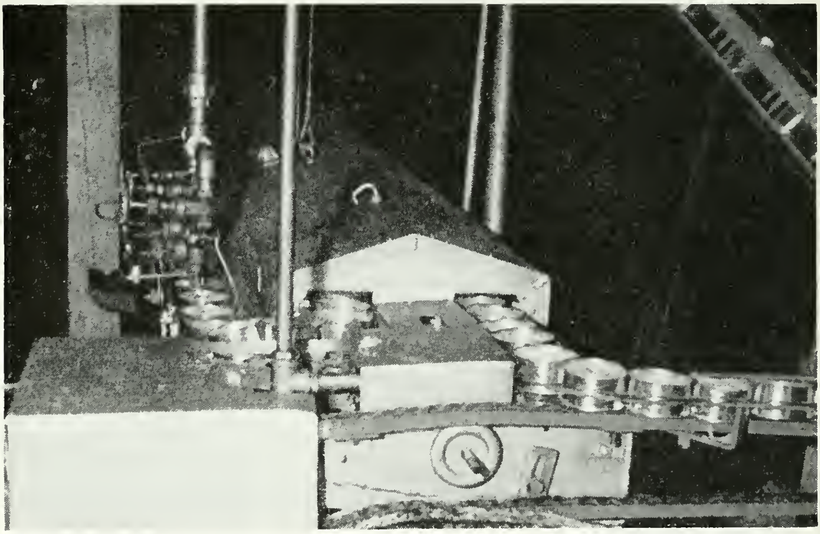

Fig. 97. An exhaust box. The tins enter at the right and emerge at the left, passing there under the oil dispenser seen at the side of the box. Salt has been added previously. The line of tins seen in the upper right corner are empties en route from warehouse to packing line.

ficiently to allow condensation until after the lid is sealed, the net result being the formation of a vacuum. A four-inch vacuum is unusual; more often it is two- or three-inch. As with the vacuum pack, from 130 tins up per minute pass through the cappers. It should be noted that these speeds do not apply to the four-pound pack as the lines handle but 20 or so of this size per minute.

Proponents of the vacuum pack argue that the higher vacuum obtained is desirable and that the additional cook given by the exhaust box is unwarranted in the case of tuna; hence there is no reason for incurring the expense of running one. Furthermore they claim that even with the best of care the box can not be kept in a completely sanitary condition. Operators using the exhaust method claim that the relatively low vacuum is ample, that they do not feel it more expensive, and that sanitary conditions may be maintained. Their chief claim is that a more uniform pack results; that the oil is sweated completely through the pack, thus eliminating any danger of scorching at one end while the tins are being retorted.

As has been mentioned previously, two plants use neither exhaust box nor vacuum machine on the bulk of their pack. They claim no difficulty with this "cold pack" at the relatively low altitudes at which their product is distributed and consequently see no reason for installing the expensive machinery which would be required to obtain a vacuum. The exception lies in the quarter-pound pack; tins of this size seem to require at least a minimum vacuum. One of the plants uses the standard vacuum machine on this pack, whereas the other simply adds warm oil, thereby obtaining something of a vacuum when the tins cool.

RETORTING

After washing, the sealed tins are dropped from the conveyor into the large iron baskets which, when filled, are wheeled into the retorts. Cooking time and temperature are governed by State law; automatic recording thermometers must be attached to each retort and the resulting charts showing temperature in the retort and time elapsed must be turned over to State officials. Most packers retort at a minimum of 240 degrees F., though to be on the safe side the temperature is often held at about 242 degrees F., while not infrequently the process is continued a few minutes more than is required by law. Pressure under these conditions is about 11 pounds per square inch. A few operators prefer a shorter retorting at 250 degrees F. Minimum requirements at these temperatures are given in table 3. A longer retorting at 230 degrees F. is permitted but no packers operate at this temperature. At the conclusion of the cook, steam is shut down and a stream of water turned into the retort while air pressure is increased to about 15 pounds. Pressure is gradually released as temperature decreases and at the end of 10 to 20 minutes the retorts can be opened. Temperature is not over 170 degrees at this time, and it may be reduced to 100 degrees before opening. Increasing the air pressure is essential; if this were not done, the drop in pressure occasioned by the condensation of the steam would cause the retort to collapse. The tins themselves might buckle if subjected to a sudden decrease in external pressure. Cooling can be accomplished by lowering the temperature slowly, but as the process is time-consuming it is used only in emergency.

Further cooling takes place in the open air, after which the tins are labelled and cased. The bulk of the pack goes 48 cans to the case; quarters are most frequently packed 100 to the case, whereas the 4-pound tins are packed 12 to the case. (See Table 2.)

Upon request of a packer and with the approval of the State Department of Public Health, the following legend may be printed on the label: "Packed and sterilized under the supervision of and according to the regulations of the State of California, Department of Public Health."

INSPECTION

The fish are subjected to rigid inspection by officials of the State Department of Public Health from the time of arrival at the cannery. Any fish in which the gills show signs of spoilage or in which the flesh is bruised or torn are immediately rejected and their weight deducted from the total landing of the boat. If a lot is of doubtful quality, the fish are packed but held apart from the balance of the output. Ultimate rejection or acceptance of the lot in question is determined by tests made upon a sample withdrawn from the lot. A further check is maintained at the cleaning tables and at the slicing machines. (See Fig. 92.) Any meat rejected after cleaning is weighed, the amount multiplied by a factor accepted by both canner and fisherman (usually 3:1 in the case of fully cleaned meat and 2:1 if head, skin and bones are included), and the poundage deducted from the earning of the boat. Rejection is based primarily on smell; the inspectors become so experienced that this method is quite effective. Texture is a factor as is appearance; "honeycombed" meat is rejected.

As mentioned previously, retorting is controlled by State law and it is here that the most stringent control is exercised. Minimum time and temperature are set by law, these minimums being set so high that infection from the canned product is impossible even though spoiled meat may have by some chance reached a tin and passed inspection. (See Table 3.) The automatically recorded charts showing duration and temperature of each retorting together with the production reports of the plants are turned over to the department and checked. In addition extensive samples are drawn from each lot of canned fish and these are carefully examined in the laboratories maintained by the department. Not until approval is given by the State officials can a given lot be released for distribution. The effectiveness of this stringent checking is evidenced by the fact that not a single case of botulism resulting from a person's eating a product commercially canned in California has been reported since 1925.

REDUCTION

Viscera, heads, bones, dark meat and any damaged or spoiled fish go to the reduction plant to be dried and ground for use as fish meal feed or fertilizer. The previously uncooked viscera are given a steam cook before reduction to avoid clogging the machinery. Generally, the reduction plant is part of the cannery but a few of the San Diego plants send part or all of this material to a company specializing in the reduction of various substances. Tuna meal is considered to be of fine texture and high quality.

Oil content is very low in the tuna. Reports vary from none recoverable to 7½ gallons or even a little more per ton.

"TONNO" AND OTHER SPECIAL PACKS

Solid pack tuna, in which olive oil is substituted for cottonseed, is marketed extensively in regions with a large Italian population under the name "tonno". The bulk of the pack is in quarter-pound tins; a small amount is packed in half-pound tins, and at least one plant is now using some four-pound containers. Almost the entire pack is put up by a few of the plants in the San Pedro area.

Packing methods are similar to those used for solid pack tuna. A double portion of salt is added and a slightly greater amount of oil may be used; one plant uses seven-eighths of a gallon of olive oil per case (100 quarter-pound tins or 48 half-pound tins) of tonno as against three-quarters of a gallon of cottonseed per case of tuna. This is accomplished by leaving a slightly greater headspace in the tin than is allowed for the tuna-style pack. The cover of the tonno can is lacquered and the word "tonno" labelled thereon. A special wide-lipped lid removable by hand is used.

In general, darker and stronger meat may be used in tonno than in fancy tuna, as the Italian buyer is not as critical in this matter as is the average American. Yellowfin, bluefin and skipjack are canned as "tonno," with skipjack the preferred species.

One concern markets a special tonno pack in half-pound tins, in which a layer of string beans is placed below and above the meat. This same company also packs a specialty known as "Ventresca." The bellies of large (40 to 50 pounds and up) fat bluefin are cut into pieces to fit half-pound cans. The skin is not removed. The pieces are boiled in a saline solution and packed, one piece to the tin, with a great deal of olive oil. It is reported that the boiling has lately been eliminated, the fish now being packed raw. This product commands a high price in Italian communities.

Another interesting pack is marketed by one concern—canned creamed tuna. For this pack, meat of the finest quality and appearance—primarily yellowfin—is used. The cooked meat is diced and packed with a liberal portion of sauce containing just the ingredients which would be used at home. It is placed in a tall 12-ounce tin and retorted for 75 minutes.

YELLOWTAIL

Relatively small amounts of yellowtail are canned. No yellowtail taken in American waters can be packed, so that which is processed comes perforce from below the international boundary. San Diego plants handle most of the catch.

Packing methods are similar to those used for the standard tuna pack, with the steam cook lasting from $1\frac{1}{2}$ to 3 hours. Half-pound tins are used primarily, though a one-pound pack is prepared as well. The product is marketed as "white meat fish" and with the word "yellowtail" frequently added as well.

BONITO

Bonito, though a tuna, can not be marketed as such as the meat is not up to the quality of the other species. It is packed just as are the others. It is labeled as "white meat fish," as is yellowtail. The word "bonito" is usually added as well.

MACKEREL

Although the bulk of the mackerel canned in California is packed salmon style, some is packed tuna style at San Diego in half-pound and one-pound tins. One plant is now attempting to build a general market for this pack; this plant uses only large fish and pays a premium price to the operators of several small set line boats. Another concern packs small deliveries in this fashion in preference to using its regular mackerel line for a short run. This company makes no attempt to advertise and sells the pack locally. Mackerel packed in this way is admittedly very good; it is the difficulty in preparing such small fish that keeps some of the other operators from attempting this pack. Packing methods are similar to those used for tuna. The steam cook lasts for about 20 minutes; the fish are in the cooker for perhaps an hour.

NOTES ON GROWTH OF GOLDEN TROUT (*SALMO AQUA-BONITA*) IN TWO HIGH SIERRA LAKES [1]

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Many fish culturists and anglers have noticed that planting fishless lakes with trout often results in very rapid growth during the first few years. That this is due to abundant food supplies for the first planting of fish, is generally recognized. Succeeding generations of naturally propagated or planted fish do not find food in such unused abundance; as a result, competition for food becomes keener and lowers growth rates. Rates of survival in the young are probably likewise reduced by the larger fish turning to cannibalism as food supplies become reduced. Certainly fewer young fish will be eaten by older ones where a homogeneous population of fish of the same age is present. Observations by many workers have shown that lakes containing fish are much poorer in available foods than unstocked lakes.

Few records are available, giving actual measurements of growth of trout in High Sierra Lakes, to show exactly what growth was achieved in any given interval of time, or in any given type of lake. Such observations have usually been based on random observations or hearsay. It is the purpose of these notes to present more concrete data on the growth rates of golden trout following planting in two barren lakes, Bright Dot and Bighorn, lying high on the east slope of the Sierra Nevada Mountains, about thirty-eight miles north of Bishop, California.

Bright Dot Lake is a beautiful High Sierra lake of nearly 100 acres, located on the south shoulder of Mt. Morrison, in the Inyo National Forest, at an elevation of approximately 11,000 feet. It lies in a rocky basin with small meadows at its upper and lower ends. No inlet is present. An outlet flows over coarse, flat rocks some hundred yards into a small, shallow pond about three feet deep. Just below this the water plunges precipitously into Convict Creek Canyon and courses about three miles into Convict Lake. Previously, Bright Dot Lake was barren of fish and, due to its inaccessibility, had been seen by few people. Inspection prior to planting showed an abundant food supply. Scuds or "shrimp" (*Gammarus limnaeus*), water boatmen, midges, diving beetles, and other aquatic foods were numerous.

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[1] Published by permission of the U. S. Bureau of Fisheries and the California Division of Fish and Game. Submitted for publication, February, 1938.

Fig. 98. Bright Dot Lake, Mono County, California. This attractive, glacial lake lies at an elevation of approximately 11,000 feet, in a rocky basin with small meadows at its upper and lower ends. September 10, 1937.

No suitable spawning areas were found. The outlet was dry when the lake was visited in 1937, two years after it was planted, and a few fish were seen stranded in the pond below the lake. Evidently, during periods of high water, a few fish had descended the outlet before it dried up.

On September 28, 1935, 9797 golden trout, averaging approximately 1.2 inches in length, were packed on horseback from the end of the road at the Convict Lake Resort and planted in Bright Dot Lake. The eggs from which these fish were reared had been taken at the Cottonwood Lakes and transported to the Hot Creek Hatchery where the young from them were grown to planting size. The data submitted for these trout indicates the growth rate from the time of planting to approximately two years later, when two separate samples were obtained on different dates, as noted below.

Bighorn Lake lies at an elevation of about 10,700 feet, at the head of Convict Creek Drainage, just below the main north-south Sierra escarpment. It drains into Lake Dorothy, which is the largest High Sierra lake in the Convict Creek drainage. Its basin is rockier than that of Bright Dot and it lacks any meadow-like areas along its margin. Examination of Bighorn Lake prior to planting also showed an abundance of available food, but apparently the lake was not as rich as Bright Dot. While no scuds were collected prior to planting, stomach examinations subsequently revealed this food. Scuds have likewise been found in the stomachs of trout caught in Lake Dorothy. The latter lake lies at an elevation of 10,340 feet.

Bighorn Lake was planted September 11, 1936. Approximately 8000 trout averaging 1.2 inches in length were packed on horseback to the lake.

The data submitted below are based upon a total of 47 specimens, of which 28 were preserved, 16 from Bright Dot Lake and 12 from Bighorn. All samples were taken with rod and line.

Acknowledgment is here made to Mr. R. C. Lewis and Mr. Leo Erkilla, who assisted in rearing and planting the fish; and to Mr. William Garner, Mr. H. John Rayner, Mr. Roy Boothe, and Mr. Fred Johnson, all of whom assisted in collecting the fish.

RATE OF GROWTH

While growth of trout in High Sierra lakes is said to be generally slow by reason of short growing seasons, poor food, and cold water, the data submitted in table 1, for golden trout planted in Bright Dot and Bighorn lakes, shows in these fish surprising growth. For instance, the fish planted in Bright Dot Lake increased about 7 times in length in about 23.4 months after planting. In slightly more than a year, fish planted in Bighorn Lake increased over 4 times in length. In Bright Dot Lake the fish ranged from approximately $5\frac{1}{3}$ inches to over $10\frac{1}{2}$ inches. Fish up to a half pound were taken in Bright Dot though the average weight attained was about one-quarter pound. The Bighorn fish averaged about 5 inches long and weighed about one ounce.

As shown in table 1, fish caught in Bright Dot Lake on September 10, 1937, averaged 8.3 inches in length. This growth was achieved after two and a fraction growing seasons in the lake. Fish caught in

FIG. 99. Bighorn Lake, Mono County, California. This lake lies at the head of the Convict Creek drainage, at an elevation of 10,700 feet. The summit of the main north-south Sierra escarpment is seen in the upper background. September 29, 1937.

Bighorn Lake on September 29, 1937, averaged 5.01 inches after one and a fraction growing seasons in the lake. The rapid rate of growth and generally excellent condition of these fish are doubtless due to great abundance of food in such unstocked lakes.

TABLE 1

Growth of Golden Trout in Bright Dot and Bighorn Lakes, Mono County, California

	Bright Dot Lake		Bighorn Lake
	Planted Sept. 28, 1935		Planted Sept. 11, 1936
Average size at planting, in inches	1.2		1.2
When taken	Aug. 17, 1937	Sept. 10, 1937	Sept. 29, 1937
Number caught	4	31	12
Average length when caught, in inches[a]	8.28	8.30	5.01
Range in length, in inches[a]	6.9-9.8	5.3-10.6	4.3-5.4
Average weight, in ounces	4.03	4.03[b]	.903
Range in weight, in ounces	2.5-6.1	1.04-8.2[b]	.58-1.14
Time in lake, in months	22.7	23.4	12.6
Total growth since planting, in inches	7.08	7.1	3.81
Average condition factor based on standard length	1.500	1.514[b]	1.055

[a] Total lengths given: from tip of snout to center of fork in tail.
[b] Average weights and condition factors determined from 12 preserved specimens out of the 31 caught on date listed in this column.

If the average increment in length of fish in each lake be divided by the time interval after planting, it will be seen that the average growth rate for all trout was about three-tenths of an inch per month. This figure is based on a growing season of 12 months. However, if the months of January to April, inclusive, are grouped as a period of relatively little growth, the rate of growth over the other eight months will be seen to average slightly less than half an inch per month. Lack of data from these and other High Sierra lakes does not permit exact calculations of growth rates in relation to seasons of growth; hence, these figures are only approximate.

With golden trout of two known ages at hand, it was thought desirable to examine scales for winter checks at each age level. In scales of the year-old trout from Bighorn Lake no winter check could be found, despite the fact that these fish were taken in the second growing season after one winter in the lake. In scales from fish slightly less than two years old from Bright Dot Lake, only a single winter check was found, although these fish were taken during their third growing season after two winters in the lake. These facts lead one to believe that, in all probability, scales were not formed until the fish were in their second summer, a possibility pointed out by Curtis (1934), with reference especially to scale formation in hatchery-reared fry after planting.

The evidence shows that under the favorable conditions offered by the two unstocked lakes the golden trout, following planting, developed at a very satisfactory rate. In specimens from both lakes the flesh was firm and pink, especially in the largest individuals. An abundance of rich, pink fat was found along the stomach and intestines. William Garner, of Convict Lake Resort, remarked that, figuratively, one could "cut steaks from their bellies."

The color of the larger, freshly captured fish from Bright Dot Lake was very brilliant and typical of golden trout. Spotting, in most specimens, was slight and was restricted for the most part to the caudal peduncle. A few specimens showed a few scattered spots along the upper side of the body, both in front of, and behind the dorsal fin.

LENGTH-WEIGHT RELATIONSHIP

In the present study total and standard lengths were taken from the 28 preserved trout from both lakes. Weights (in grams) were taken of the same series of trout following removal of excess moisture from the surface with absorbent paper for about 1½ minutes. From the measurements obtained, condition factors[2] were calculated in grams-centimeters for each individual. Averages and extremes in condition factors for 16 golden trout from Bright Dot Lake were, 1.500 (.990-1.991); and those for 12 specimens from Bighorn Lake were, 1.055 (.839-1.650). The average factor for all 28 trout was 1.315.

Curtis (1934), in his study on trout of the same stock from Cottonwood Lakes, which were first planted in 1891, calculated from total lengths an average condition factor of 1.07. The average condition factor based on total lengths of trout included in the present notes was 1.196.

STOMACH CONTENTS

Some information on foods in the lakes was gained by a study of stomach contents. In the accompanying table 2, foods are divided into two classes: general and plankton-crustacea. The former includes insects and scuds, while the latter covers only the minute, free-swimming or drifting forms common in open waters of lakes, such as water fleas, copepods and others.

Among general foods eaten by the fish from Bright Dot Lake, caddis-fly larvae (Trichoptera) formed 43.91 per cent, and midges (Chironomidae), 42.48 per cent; these two groups totaling over 85 per cent, by number, of all general foods eaten. In fish from Bighorn Lake, caddis-fly larvae formed 64.85 per cent, while midges made up 31.18 per cent. The two groups totaled over 96 per cent of all general foods eaten. The importance of caddis-fly larvae and midges as food of trout in California has been stated in recent studies by Needham (1934) and Rayner (1937). Certainly, in the two High Sierra lakes concerned in this study, both organisms were about of equal importance.

Of the plankton-crustacea eaten, water fleas and copepods comprised over 99 per cent of this class of food in the fish from Bright Dot Lake, and copepods predominated in the Bighorn specimens.

On September 10, 1937, golden trout were observed "nosing" into the marginal bottom of Bright Dot Lake. The trout were evidently feeding directly on the bottom. This was indicated by the numerous caddis-fly and midge larvae found in the stomachs. This activity could only be seen when the wind was not rippling the surface of the water.

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[2] Condition factor is a measure of the plumpness of fish in relation to length. The formula used is:

$$\text{a (condition factor)} = \frac{100 \times \text{weight in grams}}{(\text{Standard length in centimeters})^3}$$

TABLE 2

Foods Eaten by 16 Golden Trout from Bright Dot Lake, and 12 from Bighorn Lake, Mono County, California[a]

Foods eaten—general	Bright Dot Lake		Bighorn Lake	
	Number of items	Per cent	Number of items	Per cent
Beetles	34	4.40	----------	----------
True bugs	19	2.46	1	0.49
Caddis-fly larvae	339	43.91	131	64.85
Midges	328	42.48	63	31.18
Bees, ants, wasps	34	4.40	----------	----------
Leaf-hoppers	13	1.68	----------	----------
Scuds (Gammarus limnaeus)	----------	----------	6	2.97
Miscellaneous	5	0.64	1	0.49
Totals	772	----------	202	----------
Plankton-Crustacea				
Water fleas (Cladocera)	250	19.2	----------	----------
Copepods (Diaptomus)	1,050+	80.7	4,303+	99.86
Miscellaneous	4	----------	1	----------
Totals	1,304	----------	4,297	----------

[a] Average and extreme measurements of trout in inches were: Bright Dot Lake, 8.29 (5.3-10.6); Bighorn Lake, 5.00 (4.3-5.4).

Scuds or "shrimp" were found in only two fish from Bighorn Lake. These organisms were collected from Bright Dot Lake prior to stocking in 1935, but were not found in the trout. Observations showed that the planted fish had greatly reduced the quantity of this food.

Nearly 7 per cent of the general foods found in Bright Dot fish consisted of beetles and true bugs. Among the beetles a number of larvae of the dytiscid (*Hydroporus* sp.) were found. Nearly half of the true bugs consumed were water boatmen. About 6 per cent consisted of ants, bees, wasps and leaf-hoppers.

The stomach of one trout, 9.8 inches long, from Bright Dot Lake contained an adult Sierra Nevada yellow-legged frog (*Rana boylii sierrae*). On September 10, 1937, an occasional trout was seen pursued by others, swimming toward deeper water with one of these frogs held crosswise in its mouth, attempting to swallow it.

SUMMARY

In summary, golden trout planted in two High Sierra lakes, previously barren of fish, showed comparatively rapid rates of growth. Fish stocked in both lakes averaged 1.2 inches in length. Fish from Bright Dot Lake averaged 8.3 inches in length, about two years after planting, while fish in Bighorn Lake averaged 5.01 inches in slightly more than a year. The average condition factor for fish from Bright Dot Lake was 1.500; and that for fish from Bighorn Lake, 1.055. Only one winter check was found on the scales from trout that had lived two winters in Bright Dot Lake, and no winter check was found on scales of fish which had lived one winter in Bighorn Lake. Ninety-six per cent of all general foods found in the stomachs consisted of larvae and pupae of caddis-flies and midges. Water fleas and copepods formed over 99 per cent of plankton-crustacea eaten.

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LET'S GO FISHING[1]

By RICHARD S. CROKER
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California has been termed an anglers' paradise. Although sometimes we may think differently after an unsuccessful day with rod and line, there really is good fishing to be had in our State. With more and more people coming to California as tourists and more of our residents turning to the out-of-doors for recreation, a growing interest in sport fishing is noted as evidenced by increases in angling license sales and in inquiries as to where to go fishing. In answer to these many requests for information, the following outline of fishing spots has been compiled. There are so many places to fish in this State that it would not be practicable to list them all; the outline includes only the better known ones, the places most likely to provide sport to the casual or visiting angler. The dyed in the wool fisherman already has his own favorite spots—the outline will do him no good although he can have the satisfaction of criticizing it because it omits his pet creek where he can always catch the limit.

The outline is divided into four parts, corresponding to the four principal kinds of fishing: ocean, bay, stream and lake. The section on ocean angling is further divided into two parts: boat fishing and shore fishing. Conditions are always changing—the outline applies to the 1938 season. The column headed "best months" represents average conditions; sometimes the best fishing will be as much as two months earlier or later than usual.

The person who wishes to go deep sea fishing and has no friend with a yacht can avail himself of any one of three kinds of craft that make a business of taking people fishing. These are charter boats that can be hired for a day (or a season), party fishing boats that leave daily on schedule for the fishing grounds, and anchored barges that are reached by tender boats. The various kinds of boats are to be found at nearly all southern and central California seaside towns, as shown in the outline. Bait, and in some cases tackle, are provided on the boats (tackle can always be rented). Prices per day are as follows:

Charter boats—$20 to $100, depending on size of party and size of boat; bait included.
Party boats—$1.50 to $5.00 per person, bait included.
Barges—$0.75 to $2.00 per person, bait included.

In general, the higher the price, the better the equipment and service. The standard prices in southern California are $2 for party boats and $1 for barges. Tickets at San Diego are $3.50, of which $0.50

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is the license fee for fishing in Mexican waters, where the boats generally run.

Shore fishermen will find bait and tackle stands at all seashore towns. Nearly every pier has its stand, which usually has live bait for sale and tackle for rent.

Most of the enclosed bays along the California coast furnish good fishing. The most popular fishing area of the entire State is San Francisco Bay, where thousands of striped bass anglers try their luck every week of the year.

All the bays listed below afford shore fishing, and skiffs can be rented at one or more points on every bay at a cost of $0.75 to $1.50 a day. Charter boats are available at nearly every town on San Francisco Bay and tributaries at $12 and up per day for parties of several people. The charter boats, and even some of the fleets of skiffs, follow the runs of fish so that local inquiries are advisable. For instance, most of the charter boats can be found at San Francisco, Berkeley, Richmond and Marin County points during the spring and early summer, but they all move up the bay to Martinez and Port Chicago for the fall fishing. Bait and tackle can be purchased at all towns and resorts located on the bays listed below.

Open bays, such as Santa Monica Bay and Monterey Bay, are discussed in the section on ocean fishing.

Most popular of all kinds of angling in California is stream fishing for trout. There are so many miles of fishable rivers and creeks in our State that mention of the total mileage would be taken as an exaggeration. Only the most important river systems are listed in the outline below; space forbids including them all.

The outline is divided into sections corresponding to the major drainage basins. The section headed "Southern California Streams" includes the rivers and creeks south of the Tehachapis, most of which are too small to warrant discussion. There are several streams flowing eastward from the Sierra Nevada. These are also discussed separately. Most of the fishing on the East Side, however, is lake fishing. The streams of the Sacramento-San Joaquin Valley drainage system (the Central Valley) are of the greatest importance. Flowing down from the Sierras and other mountain ranges, these rivers are excellent trout streams. In their lower reaches, in the foothills and on the floor of the valley, they are notable striped bass, black bass and salmon waters. Most of the better known of these rivers are listed in the outline, but there are others equally as good. The last section lists the most important of the rivers draining into the ocean along the northern coast of the State. Included among these is the Klamath River, most famous of all our rivers from the angler's standpoint. Fishermen come from all over the world to catch the steelhead and salmon of the Klamath.

California trout streams are generally fished from the banks or by wading—they are too swift and turbulent for boat fishing. Along the lowland streams, bank fishing and boat fishing are both popular. Skiffs can be rented at many places for about $1 a day.

The Sacramento-San Joaquin Valley with its slow moving rivers and the delta country (the region downstream and west of Sacramento and Stockton) with its network of sloughs and rivers comprise one of the finest fishing areas of the State, with a great variety of fish to be caught. Of all the game fish of this region, the striped bass is best known. During the summer months, angling for the so-called spiny-rayed fishes (large- and small-mouthed black bass, crappie, calico bass and bluegill sunfish) yields good results, and this type of fishing is becoming more popular every year. Catfish are sought by great numbers of "cane-pole fishermen," and the annual salmon runs provide splendid sport. Incidentally, the striped bass, black bass, crappie, calico bass, sunfish and catfish are all non-native species, having been introduced from the eastern United States. The only native spiny-rayed fresh-water fish of the State is the Sacramento perch, which is a highly prized game fish but rather scarce.

There are two general kinds of fishing on the North Coast rivers—in fact on all the coastal streams from the Sur River north (including those not specifically mentioned). These are: salmon and steelhead fishing in the estuaries or near the river mouths during the fall and winter, and fishing for the young steelhead trout farther upstream during the summer. Steelhead and salmon are also caught upstream in the Klamath, Eel and Russian rivers during the fall and winter. Skiffs can be rented on most of the coastal rivers for $0.75 to $1.50 a day. Guides and boatmen can also be engaged on the Klamath and some of the other rivers.

There are many thousands of lakes in California containing fish. In many parts of the State, in fact, fishing means lake fishing and nothing else. Obviously, all these lakes can not be mentioned by name. However, not all the lakes of the State provide fishing; anyone planning a trip just by looking at a map and noting the large lakes would be disappointed in some of them. There is no angling in Salton Sea, Owens Lake or Mono Lake, for instance. Due to reclamation and a succession of dry winters, there has been little or no water for years in Buena Vista and Tulare lakes, but the heavy rains of the last two years have filled the lakes and there may again be fishing in them. There are several large lakes in the northeastern corner of the State which would not yield any returns to the angler: Honey Lake, Goose Lake, Tule Lake, Lower Klamath Lake, and others. On the whole, though, nearly every natural lake and reservoir will repay a visit with a catch of fish.

It is possible to rent skiffs at $1 to $2 a day on practically every lake that is reached by automobile road (and some others reached only by trail). On some municipal and private reservoirs, a $0.50 permit fee is charged.

In the following outline, the many hundreds of High Sierra lakes are not segregated—there are too many of them, nearly all with good fishing: Convict Lake, Mammoth Lakes, Virginia Lakes and all the others from Mt. Whitney north to Lake Tahoe. The lakes, at elevations of 5000 to 12,000 feet, can be reached from either the east or west sides of the mountains. Similarly there are many small lakes north of Lake Tahoe and in the Siskiyou Mountains of northwestern California.

OCEAN FISHING

Place (south to north)	Kinds of fish	Best months	Fishing methods and facilities
BOAT FISHING—			
San Diego (fishing principally at Coronado Islands, Mexico)	Yellowtail, bluefin tuna, yellowfin tuna, marlin, broadbill swordfish, white sea-bass, bonito, barracuda, rock bass, halibut, black sea-bass	April-September	Trolling for marlin and swordfish, live bait for others. Party boats, charter boats, barge
Oceanside	Yellowtail, barracuda, rock bass, white sea-bass, halibut, bonito, mackerel	May-September	Live bait fishing. Party boats and barge
San Clemente	Yellowtail, barracuda, rock bass, white sea-bass, halibut, bonito, mackerel	April-September	Live bait fishing. Party boats and barge
Newport-Balboa (some boats run to Catalina)	Barracuda, yellowtail, tuna, albacore, marlin, white sea-bass, black sea-bass, bonito, rock bass, halibut, mackerel	April-October	Live bait fishing and trolling. Party boats, charter boats, barge
Huntington Beach	Barracuda, white sea-bass, black sea-bass, halibut, bonito, mackerel	May-September	Live bait fishing. Party boats
Catalina Island (Avalon)	Yellowtail, barracuda, albacore, bluefin tuna, yellowfin tuna, marlin, broadbill swordfish	Barracuda and yellowtail: May-September Other species: August-September	Live bait fishing and trolling. Charter boats, barge
Long Beach and San Pedro (some boats run to Catalina)	Barracuda, yellowtail, tuna, albacore, marlin, white sea-bass, black sea-bass, bonito, rock bass, halibut, mackerel	April-October	Live bait fishing, trolling. Party boats, charter boats, barges
Santa Monica Bay towns: Redondo Beach, Hermosa Beach, Ocean Park, Santa Monica, Malibu	Barracuda, white sea-bass, black sea-bass, bonito, rock bass, halibut, mackerel	April-October	Live bait fishing. Party boats, charter boats, barges
Pt. Mugu	Halibut, white sea-bass	May-September	Live bait fishing. Party boat, charter boats, barge
Avila	Rockfish, cultus	June-September	Artificial lures. Party boats, charter boats
Cayucos	Rockfish, cultus	June-September	Artificial lures. Party boats, charter boats
San Simeon	Rockfish, cultus	June-September	Artificial lures. Party boats
Monterey	Rockfish, salmon, cultus, mackerel	April-September	Trolling for salmon, cut bait for others. Party boats, charter boats
Santa Cruz and Capitola	Rockfish, salmon, cultus, mackerel	April-September	Trolling for salmon, cut bait for others. Party boats, charter boats
Pedro Pt. (Rockaway Beach)	Rockfish, salmon, cultus	March-October	Trolling and cut bait. Party boat and skiffs
San Francisco	Salmon, rockfish, cultus	March-August	Trolling. Charter boats
Sausalito	Salmon, rockfish, cultus	March-August	Trolling. Charter boats
Bodega Bay	Salmon, rockfish, cultus	Summer	Trolling. Charter boats
North to Oregon	Very little fishing, sometimes commercial salmon fishermen will allow anglers on their boats	June-August	Trolling
SHORE FISHING (including surf, piers and rocks)—			
From Mexican border to Santa Barbara	Corbina, spotfin croaker, yellowfin croaker, surf perch, sharks and rays. Also barracuda, bonito, halibut, mackerel, white sea-bass from piers	April-October; some fishing all year	Casting with bait: mussels, sand crabs, pile worms. Also live bait from piers. Piers are located at: Mission Beach, La Jolla, Del Mar, Oceanside, San Clemente, Balboa Beach, Newport Beach, Huntington Beach, Seal Beach, Long Beach, Terminal Island, San Pedro (breakwater), Redondo Beach, Hermosa Beach, Manhattan Beach, Hyperion, Venice, Ocean Park, Santa Monica, Malibu Beach, Pt. Mugu Hueneme, Santa Barbara
Pismo Beach to Santa Cruz	Rockfish, surf perch, halibut, sea-trout	All year	Bait: mussels, clams, sardines. Piers are located at: Pismo Beach, Avila, Cayucos, San Simeon, Monterey, Moss Landing, Capitola, Santa Cruz
Princeton to Bolinas	Striped bass, rockfish, surf perch, sea-trout	All year	Bait: mussels, clams, sardines. Piers are located at: Princeton, Bolinas
Pt. Reyes to Oregon	Rockfish, surf perch, sea-trout	All year	Bait: mussels, clams, sardines. Piers are located at: Pt. Reyes, Crescent City

BAY FISHING

Place (south to north)	Kinds of fish	Best months	Fishing methods and facilities
Mission Bay	Spotfin croaker, yellowfin croaker, sharks, rays	April-October	Cut bait from shore, bridges or skiffs: clams, mussels, sardines, anchovies. Skiffs available
Balboa Bay (Newport Harbor)	Spotfin croaker, yellowfin croaker, halibut, sharks, rays	April-November	Cut bait from shore or skiffs: clams, mussels, sardines, anchovies. Skiffs available
Anaheim Landing	Spotfin croaker, yellowfin croaker, sharks, rays	April-November	Cut bait from shore or skiffs: clams, mussels, sardines, anchovies. Skiffs available
Other bays from San Diego to Ventura	Same general conditions		
San Francisco Bay, San Pablo Bay and tributaries (Petaluma Creek, Richardson's Bay, etc.)	Striped bass, salmon, perch, flounders, rockfish, sharks, rays	February-August	Trolling, cut bait (sardines) from boats, wharves and shore. Skiffs and charter boats available at all towns on north San Francisco Bay, San Pablo Bay and tributaries
Suisun Bay, Carquinez Straits and tributaries (Napa River, Montezuma Slough, etc.). For Sacramento-San Joaquin rivers, see River Fishing	Striped bass, salmon	All year, varying in the different local fishing areas	Trolling, cut bait (sardines) from boats, wharves and shore. Skiffs and charter boats available at many points
Bolinas Bay	Striped bass, smelt	Summer	Cut bait (sardines, pile worms). Skiffs available
Tomales Bay	Salmon, striped bass, sharks, rays	Salmon: November-December. Bass: summer	Salmon: trolling. Bass: cut bait (sardines). Skiffs available

RIVER FISHING (Name of River includes Tributaries and Forks)

Place (south to north)	Kinds of fish	Best months	Fishing methods and facilities
SOUTHERN CALIFORNIA STREAMS—			
San Jacinto River	Rainbow trout, Loch Leven trout	May-July	Bait, fly, spinner
Santa Ana River	Rainbow trout, Loch Leven trout	May-July	Bait, fly, spinner
San Gabriel River	Rainbow trout, Loch Leven trout	May-July	Bait, fly, spinner
EAST SLOPE OF SIERRAS—			
Owens River	Loch Leven trout, rainbow trout, golden trout	July-August	Fly, spinner, bait
Walker River	Cut-throat trout, rainbow trout, golden trout	July-August	Fly, spinner, bait
Carson River	Cut-throat trout, rainbow trout, golden trout	July-August	Fly, spinner, bait
Truckee River	Rainbow trout, Loch Leven trout	June-September	Fly, spinner, bait
CENTRAL VALLEY RIVERS—			
Kern River	Trout, principally rainbow	June-September	Fly, spinner, bait
Kaweah River	Trout, principally rainbow	June-September	Fly, spinner, bait
Kings River	Trout, principally rainbow	June-September	Fly, spinner, bait
Upper San Joaquin River	Trout, principally rainbow	June-September	Fly, spinner, bait
Merced River	Trout, principally rainbow	June-September	Fly, spinner, bait
Tuolumne River	Trout, principally rainbow	June-September	Fly, spinner, bait

Stanislaus River	Trout, principally rainbow	June-September	Fly, spinner, bait
American River	Trout, principally rainbow	June-September	Fly, spinner, bait
Yuba River	Trout, principally rainbow	June-September	Fly, spinner, bait
Upper Feather River	Trout, principally rainbow	June-September	Fly, spinner, bait
Pit River	Trout, principally rainbow	June-September	Fly, spinner, bait
Upper Sacramento River	Trout, principally rainbow	June-September	Fly, spinner, bait
LOWLAND STREAMS OF CENTRAL VALLEY—			
San Joaquin River and connecting rivers and sloughs (Old River, Middle River, Mokelumne River, etc.)	Striped bass, black bass, crappie, calico bass, sunfish, salmon, catfish	Striped bass: May-October Black bass, crappie, calico bass, sunfish: June-October Salmon: September-October	Striped bass: trolling, bait (sardines) Black bass: plugs, flies, spinners, live bait Crappie, calico bass, sunfish: flies, spinners, live bait, worms Salmon: trolling, spinner, casting Catfish: cut bait (sardines), worms Skiffs available at numerous points
Sacramento River and connecting rivers and sloughs (Steamboat Slough, Three-mile Slough, etc.)	Striped bass, black bass, crappie, calico bass, sunfish, salmon, catfish	Striped bass: May-October Black bass, crappie, calico bass, sunfish: June-October Salmon: September-October	Striped bass: trolling, bait (sardines) Black bass: plugs, flies, spinners, live bait Crappie, calico bass, sunfish: flies, spinners, live bait, worms Salmon: trolling, spinner casting Catfish: cut bait (sardines), worms Skiffs available at numerous points
Feather River	Striped bass, black bass, salmon, catfish	Striped bass: May Salmon: September-October Black bass: summer	Striped bass: trolling, bait (sardines) Black bass: plugs, flies, spinners, live bait Salmon: trolling, spinner casting Catfish: cut bait (sardines), worms Skiffs available at numerous points
NORTH COAST STREAMS—			
Russian River	Salmon, steelhead, black bass, striped bass	Salmon and steelhead: October-January Black bass: summer	Salmon: spinner casting and trolling Steelhead: spinner casting, flies, salmon eggs Black bass: plug and spinner casting Striped bass: trolling and sardine bait Skiffs available at several points
Gualala River	Silver salmon, steelhead trout	November-January	Salmon: spinner casting and trolling Steelhead: spinner casting, trolling, flies, salmon eggs Skiffs available
Garcia River	Silver salmon, steelhead trout	November-January	Salmon: spinner casting Steelhead: spinner casting, salmon eggs, flies
Navarro River	Silver salmon, steelhead trout	November-January	Salmon: spinner casting and trolling Steelhead: spinner casting, trolling, salmon eggs, flies Skiffs available
Noyo River	Silver salmon, steelhead trout	October-December	Salmon: spinner casting and trolling Steelhead: spinner casting, trolling, salmon eggs, flies Skiffs available

RIVER FISHING (Name of River includes Tributaries and Forks)—Continued

Place (south to north)	Kinds of fish	Best months	Fishing methods and facilities
Ten Mile River	Silver salmon, steelhead trout	October-December	Salmon: spinner casting and trolling Steelhead: spinner casting, trolling, salmon eggs, flies Skiffs available
Mattole River	Silver salmon, steelhead trout	October-December	Salmon: spinner casting Steelhead: spinner casting, salmon eggs, flies
Eel River	Silver salmon, steelhead trout	October-December	Salmon: spinner casting and trolling Steelhead: spinner casting, trolling, salmon eggs, flies Skiffs available
Redwood Creek	King salmon, silver salmon, steelhead trout	September-October	Salmon: spinner casting and trolling Steelhead: spinner casting, trolling, salmon eggs, flies Skiffs available
Klamath River	King salmon, silver salmon, steelhead trout	August-October	Salmon: spinner casting and trolling Steelhead: spinner casting, flies, trolling, salmon eggs Skiffs and guides available
Smith River	King salmon, silver salmon	September-November	Trolling and spinner casting. Skiffs available

LAKE FISHING

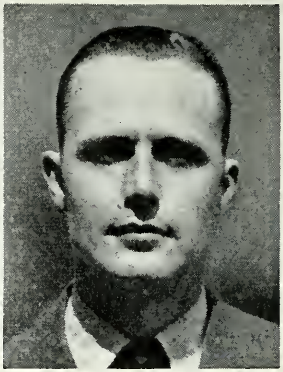
Place (south to north, in general)	Kinds of fish	Best months	Fishing methods and facilities
Ten lakes in San Diego county	Large-mouthed black bass, crappie and bluegill (largest crappie and bluegill in United States)	All year (closed seasons on various lakes are staggered)	Plug casting, flies, live bait, worms, etc. Skiffs available
Big Bear Lake	Trout, large-mouthed black bass	May-October	Casting, trolling, bait. Skiffs available
Arrowhead Lake	Rainbow trout	May-October	Trolling, bait. Skiffs available
High Sierra lakes	Rainbow, Loch Leven, cut-throat and eastern brook trout; golden trout in lakes above 10,000 feet	July-August	Spinner, fly, bait, trolling. Skiffs available on nearly all lakes reached by road and at some reached only by trail
June Lake	Trout	June-August	Spinner, bait, trolling. Skiffs available
Huntington Lake	Trout	June-September	Spinner, bait, trolling. Skiffs available
Bass Lake	Trout, black bass	June-October	Spinner, bait, trolling. Skiffs available
Lake Tahoe	Tahoe trout, mackinaw trout, rainbow trout	June-September	Trolling. Skiffs and charter boats available
Clear Lake (Lake County)	Black bass, crappie, bluegill, catfish	All year	Plug casting, trolling, bait. Skiffs available
Lake Almanor	Trout	June-September	Spinner, bait, trolling. Skiffs available.
Lakes of extreme northern California	Trout in small lakes; no fishing in large lakes of northeastern California	June-September	Spinner, fly, bait, trolling. Skiffs available on nearly all lakes reached by road

EDITORIALS AND NOTES

VOL. 24 JULY, 1938 No. 3


E. L. McKenzie


Raymond Grey


Newton G. Booth, Jr.

CHANGES IN PERSONNEL OF THE FISH AND GAME COMMISSION

There have been several recent changes in the personnel of the California Fish and Game Commission. In March, 1938, Mr. A. T. Jergins of Los Angeles resigned his post as commissioner. In April, Governor Merriam appointed three new commissioners, one to take Mr. Jergins' place, and two to fill additional posts created by the 1937 legislature. The new members of the commission are: Mr. E. L. McKenzie of Red Bluff, Tehama County; Mr. Raymond Grey of Taft, Kern County; and Mr. Newton G. Booth, Jr., of Harbin Springs, Lake County. Dr. E. C. Moore of Los Angeles and Mr. I. Zellerbach of San Francisco are the remaining members of the commission, the former retaining the presidency. With the appointment of the new members, the commission is now at its full strength of five members for the first time.

Mr. Jergins was at all times a keen advisor, sincerely interested in the work. He will be missed by all on the Division staff. One of his deep interests was the establishment and organization of the Junior Game Patrol, for which he was responsible.

The new commissioners are all business men, well acquainted with the out-of-doors and interested in conservation work.—*Herbert C. Davis, Executive Officer, California Division of Fish and Game.*

NEW PATROL BOAT PLACED IN SERVICE

An addition was made to the marine patrol fleet of the California Division of Fish and Game on April 16, 1938, with the launching of the *Tuna* at San Francisco. This new cruiser is similar in general design to the *Bonito* and *Marlin*, commissioned last year, but has a raised pilot house which gives the crew better visibility. The boat is 45 feet long, with 10-foot beam and is powered by twin gasoline engines. Sleeping accommodations are provided for two men, and large fuel tanks will enable the boat to make extended trips from its home station at Avalon, Santa Catalina Island.—*E. L. Macaulay, Chief, Bureau of Patrol, Division of Fish and Game, May, 1938.*

FIG. 100. The launching of the new patrol cruiser *Tuna*. Left to right: Warden Carmi Savage, captain of the boat; Miss Katherine Karmelich, sponsor; Mr. H. C. Davis, executive officer of the Division of Fish and Game; Assistant Warden Karl Lund, assigned to the *Tuna*. Photograph by E. L. Macaulay.

VOLUNTARY CLOSED SEASON FOR MACKEREL CANNING

Studies conducted at the California State Fisheries Laboratory indicate decided depletion of the supply of mackerel, and the seriousness of the situation has been discussed with fishermen and canners by staff members of the Laboratory. Any legal restriction of mackerel fishing passed at the next session of the Legislature would not be operative until the late summer of 1939, so if anything was done before that time it would have to be accomplished by the men of the mackerel canning industry. The proposal was made that the mackerel canners and fishermen voluntarily impose upon themselves a closed season and this met with unanimous agreement on the part of all canners and the fishermen's organizations that were consulted. The final agreement was that no mackerel should be delivered or accepted for canning anywhere in the State during the two calendar months of April and May. This voluntary restriction upon canning was lived up to strictly during April and May of 1938.

This curtailment of the mackerel catch is not sufficient to play a very important part in building back the ocean stock to its former level of productivity nor will it necessarily prevent further depletion during future months open to mackerel fishing, but the closed season is a step in the right direction and the voluntary agreement demonstrates a spirit of cooperation on the part of the industry and a genuine interest in safeguarding the future of the mackerel supply. There have been other examples in this State of voluntarily imposed restrictions in our fisheries industries, but we believe this is the first state-wide self-imposed closed season involving such a financial sacrifice on the part of packers and fishermen.—*W. L. Scofield, California State Fisheries Laboratory, May 20, 1938.*

MUST THE SCIENTIST ALWAYS BE ON THE DEFENSIVE?

EDITOR'S NOTE.—The following editorial was submitted by one of the research workers of the California Division of Fish and Game, who prefers to remain anonymous. Although it is not our policy to publish unsigned articles, we feel that this editorial should be presented for the consideration of our readers.

The accepted criterion which distinguishes man from the so-called lower animals is the superior development of his brain. During the vast stretch of time when man was slowly differentiating from the other animals, the brain was apparently merely a depository for accumulating impressions of the natural environment in which he found himself—and queer reactions some of those impressions must have produced. As time went on, there appeared men whose brain cells were superior or at least more active than those of their fellows. These accomplished individuals were not satisfied merely to absorb impressions; they analyzed them and at once found themselves in hot water. Their reasoning and conclusions tended to show and sometimes to prove that many beliefs and prejudices, backed by tradition, were either false or ridiculous or both. From that early beginning up to and including the present time, workers in the field of the natural sciences have been on the defensive. Man is a conservative and resents any departure from accepted tradition. He also resents being made ridiculous. People will go to absurd lengths to defend a premise which they have endorsed after accepted facts and even their own common sense have proved that it is false.

An understanding of these inherent traits, products of ancient impressions, makes it at once apparent that Galileo was simply asking for trouble when he discoursed on the solar system, that Vesalius unleashed a tremendous blast of vituperation by proving that men and women have the same number of ribs, and that Spallanzani, a pugnacious individual by contrast, was forced to defend belligerently his demonstration that spontaneous generation was a myth. These illustrations and many others are cited in our day with tolerant amusement as indicative of man's ignorance in his infancy, the supposition being that he has now reached maturity. Observation, however, does not substantiate this optimistic assumption. At any rate the biologist is still on the defensive.

The present human environment is largely artificial but to maintain himself, man is compelled to recognize the existence of a vast number of other organisms that live in an environment which is still natural, except where man has meddled with it. We call the study of these organisms biology, and the attempted manipulation of the natural environment conservation. In its broadest sense conservation means the management of natural resources to the end that they will continue to yield food and material for human needs without jeopardizing the basic supply. The biologist is conceded a definite position in this attempt to adjust organisms and ecological conditions to human necessities. He is encouraged to investigate the workings of natural laws and their application to human welfare, but almost without exception a natural law which does not conform to tradition is roundly denounced along with the man who discovers it. Even when no tradition or prejudice is controverted, biological work is regarded with suspicion as it is something beyond the ken of the ordinary man, who generally has only a very vague idea of the structure and functions of his own body.

Although the average citizen is largely dependent on the natural environment and its inhabitants he knows little or nothing about it. He delegates to governmental bodies the task of conserving his natural resources. The various governmental subdivisions employ trained men to acquire the necessary information by which their policies are determined. Because of their familiarity with special fields, these departments are able to present information to legislative committees and law courts for the guidance of these bodies, but at that point we run into our old friend tradition again. Having presented the results of his labors the biologist can not defend them. He must remain in the background as a spectator while lawyers, business men and others question his disinterest, deliberately misinterpret plain statements and befog simple issues with soaring flights of oratory, which admittedly are sometimes much more effective in gaining the end sought than detailed facts and cold logic. It is only fair to admit however that most biologists would not defend themselves or their work under such circumstances if it were traditionally permissible. There are not many Spallanzanis and Huxleys. With few exceptions, scientific workers can not be reached by politics or money as they set no value on power or wealth but value highly their scientific reputation. What does it matter if their work is minimized or altogether suppressed by political log rolling? They go back to their work, content that they have done their job, done it well and added to their own stock of knowledge—and that is about the only reward they generally receive or want.

To demonstrate that this is not idle speculation, suppose we examine an actual case, which is one of many. During a recent fisheries investigation a great deal of testimony was written into a report of a congressional committee and a fifteen-page pamphlet (in fine print) was appended. The pamphlet was in the interests of operators who were seeking to escape governmental supervision and to secure a more extensive exploitation of sardines, in opposition to the biologists' claims that more extensive fishing might deplete the supply. This pamphlet is of interest. In the first place it was written by an attorney who used it as the basis for his testimony before the committee. Although many of the statements are half truths, there is an impressive show of data to support a conclusion diametrically opposed to that of the biologists, but on analysis most of the figures not obviously gleaned from official reports have all the earmarks of good guessing. There are many quotations which appear very convincing, but a perusal of the scientific reports from which they were taken shows that most of them are half quotations or they have been cleverly placed in different settings, which altogether change their meaning. The writer refers to "pseudo-scientists" and sarcastically to "experts" in speaking of men who have devoted their lives to the study of a subject, about which he admittedly knows nothing. He announces that it is his opinion that this or that biological conclusion is erroneous and that his clients are being persecuted by a lot of "hired propagandists" and "political scientists." This should prove to any intelligent person that the sardines can not be depleted. After all, our attorney has nothing to lose. It is all a part of the game from his viewpoint and by speaking (and writing) with a voice of authority, he may and probably will convince many people that the interests he serves are persecuted benefactors of the race. He is considered clever if he wins his case and no stigma attaches to him if he loses. He says that a "thing is so" when the biologist says "it appears to be so," as our scientific man must always protect himself by demonstrable facts. Even if he were not influenced by the ethics of his calling, his fellows are a critical and heavy handed lot. A few bad mistakes, a hint of charlatanism and his reputation is ruined.

It is of interest to note that the issue involved in the above mentioned investigation was so befogged by oratory and appeals to the emotions that no definite action was taken and now, after a lapse of two years, the depletion of the fishery predicted by the biologists has reached serious proportions.

Suppose we have a look at "predatory animal control," another highly controversial subject, about which the biologist voices a conviction at his peril. To champion **any** species of mammal, bird or fish that tradition places on the "black list" is on a par with proclaiming yourself an Orangeman in a meeting of the Hibernian society. The sportsman, the farmer and the general public maintain fixed convictions in respect to the relationship between so-called predators and "game." A few casual observations are all that is necessary for confirmation. Yet the biologist who has the temerity to defend any predator must produce exhaustive and incontestable data to clear himself of the taint of heresy, and even then any future work he may do is viewed, at least by laymen, with suspicion because he has dared to contradict an established prejudice. This attitude is so pronounced that much worthwhile work is buried in obscure scientific journals where it will be reasonably safe from lay observation, or remains unpublished. In the meantime the sportsman and the farmer proceed to eliminate "predators" at every opportunity, failing to make a distinction between the harmful and the really beneficial species. The results are sometimes deplorable. The "game" animals and birds, in many cases, are not in the least benefited and sometimes are actually harmed, while the people are forced to spend enormous sums of money in an endeavor to check real pests such as ground squirrels, rats and insects—a task which constituted the life work of most of the late and unlamented "predators."

This discussion, with concrete cases, could be prolonged but enough has been said to indicate our meaning. So the next time you cut yourself badly and the doctor uses some new-fangled disinfectant, don't start an argument with him over the relative merits of the boiled cow dung and spider webs your great grandmother used in contrast to his germ killer. Also, the next time you encounter a sportsman with his gun and his limit of quail, don't shoot him. He is a predator, of course, but for all you know he may be a good husband, a kind father and a worthy citizen.

RADIO TELEPHONES ON FISHING BOATS

During the 1936-37 sardine season a few purse seine boats were equipped with radio telephones. Their value as an aid to the fishermen was soon recognized. Several more local purse seiners seeking tuna in Mexican waters the following summer added radio telephones to their equipment. At the present time roughly one-third or about seventy-five of the purse seine boats on the Pacific Coast are equipped with sets. Practically all of the remaining boats have radio receivers so they can pick up information sent to other boats, but can not themselves broadcast. Many more sardine boats will install radio telephones before the next sardine season (1938-39).

Prior to the introduction of radio telephones on fishing boats, fishermen hesitated to reveal the location of their catches. The first boats to obtain transmitters even went as far as to agree on prearranged codes for the names of localities. In this way they could tell their friends where they were finding fish and at the same time mislead others. This system was soon found quite unsatisfactory, so that now all boats are glad to give information to anyone in exchange for similar information.

Since sardine, tuna or mackerel schools travel from place to place the boats finding fish tell the other boats so that they may move into areas where fish are known to be present. Previously a boat would often scout for days without finding fish or knowing where fish were being caught. Frequently, such boats would return to port to question other fishermen unloading their vessels. This was not only time consuming but information thus obtained was often unreliable due to the traditional reluctance of the fisherman to have others fish where he does. Radio telephone is especially helpful to purse seiners going down into Mexican and Central American waters for tuna, as they scout over several hundred square miles while fish frequently "show" only in very localized areas.

Besides broadcasting fishing conditions, the sets are valuable in disseminating weather information. Business is often transacted over the air and not infrequently fishermen notify worrying families that they are in a snug anchorage during a blow. Fish dealers, canneries and reduction plants can be notified as to when to expect fish. They then know when and how large a crew to call, so that no time is wasted in unloading and processing the catch. In case of engine breakdowns or other trouble, aid may be summoned by calling a Coast Guard station or the nearest telephone company station. In case of injury to a crew member, medical advice can be asked and not infrequently Coast Guard planes have responded to reports of serious accidents by taking doctors to the scene.

Drag boats fishing for bottom fish off central and northern California find the radio telephone useful for the same reasons as do the purse seiners. Furthermore, the companies operating these boats can direct their boats to deliver their fish at different ports; or tender boats can be notified as to their location and pick up catches of several boats, thus saving the individual vessels a trip to port and back to the fishing grounds.

In southern California, boats taking out sport fishing parties have found radio telephones a decided asset to their business. Frequently one company operates several boats. Each boat will go to a different place but keep in contact with the others by air. If one boat gets into considerably better fishing than any of the others, those which are having poor luck go to the more fruitful areas.

Radio telephone has therefore raised the efficiency of our fishing fleet and thereby increased the fishing intensity.

Nothing has brought the fishermen together into a close fraternal group more than the radio telephone. They have dropped their old secretive traits to a large extent and are more anxious than ever to help the other fellow as they know they will get the same in return. At times it is illuminating to ''tune in on the boats,'' as interesting or humorous conversations frequently go over the air. Any home radio within range and equipped to receive short waves can hear the fishing fleet on 2738 kilocycles (other frequencies are used for ship-to-shore communication).

The cost of complete radio telephone equipment installed in a boat ranges from $300 to $1,000. The power outputs of most fishing boat sets range from 15 to 50 watts, the average transmitter being 25 watts. The range of an instrument varies considerably, depending upon the boat's location and meteorological conditions. The usual daytime range of the average transmitter is from 150 to 200 miles. Under unusually favorable conditions, the night range is practically unlimited whereas under exceptionally adverse conditions little more than ten miles can be reached. However, this low limit is rather infrequent.

Telephone companies operate three shore stations on the Pacific Coast through which land connections to any telephone may be made: KOW at Seattle, KLH at San Francisco, and KOU at San Pedro. Rates are reasonable. If the boat is within a radius of 150 miles of the shore station the charge is $1.50 for three minutes and $0.50 for each additional minute. For any distance over 150 miles from the shore station the toll is $3 for three minutes and $1 for each additional minute. If it is necessary to make a long distance connection between the telephone company's station and the party ashore, the land toll is added to the cost. One-third of the radio linkage charge (not including land toll) is paid to the owner of the boat. If the boat phones someone ashore, the rate is therefore one-third less; if someone ashore phones the boat, the boat makes one-third of the land-to-boat toll. This is merely an inducement on the part of the telephone companies to encourage the ship-to-shore convenience they offer. Two boats can, of course, talk to one another without cost. It is only when messages are sent through commercial shore stations and telephone wires that tolls are charged. The Federal Communications Commission does however require that one man on each boat carrying radio telephone be licensed. The examination for a license is such that anyone familiar with the standard routine of simple radio telephone operations can easily pass it after a little coaching by someone already licensed to operate a set.—*John F. Janssen, Jr., California State Fisheries Laboratory, May, 1938.*

AIR BUBBLES AS A FISH SCARE

When a purse seine is set around a school of sardines or tuna the fish frequently sound in an effort to evade their captors. If the net is pursed before the school sounds, the force of tons of fish making a desperate effort to go through the bottom of the net frequently splits the webbing and the fish escape. Often, part of the school sounds, carrying the cork line beneath the water while the rest of the school swims over and away.

A simple and ingenious method was used by a few fishermen during the 1936-37 sardine season to discourage the fish from sounding. It is quite successful and its use has spread during the 1937-38 season. The device consists merely of a long rubber hose through which a small stream of air is forced. The hose measured on one boat was $\frac{5}{8}$-inch in diameter with a 3/16-inch hole. A few lead weights are fastened near the end of the hose to sink it. When fish threaten to sound, the fishermen turn on the air and drop the hose over the side so the end reaches the bottom of the net. The stream of bubbles rising in the water is an effective scare and the fish come back to the surface.

Before a sardine or tuna net is pursed, the fish frequently escape through the opening beneath the boat. To keep the fish well back into the net, the air hose is hung over the side and air blown into the water till the net is completely pursed. This method is especially useful in tuna fishing.

When large catches of sardines or tuna are made, the fish are bunched into two or more sections of the net and brailed out of each section separately. In such a case the school can be ''split'' by trailing the end of the hose through the fish. The school separates where the bubbles are rising and part of the net is drawn up confining the fish in two sections. With tuna this may be repeated until the fish are in several bunches alongside the boat.

In Mexican and Central American waters sharks are a serious menace to tuna purse seines. When a set is completed, large sharks tear the webbing in an effort to get the impounded tuna. Fishermen frequently lower below the bag of their net a weighted can perforated with very small holes and filled with diesel oil. The small streams of oil slowly rising toward the surface tend to intimidate the sharks to some extent, but the method is not always entirely successful. It has recently been found that air serves the purpose a little better than oil and has the advantage of being very much easier to handle. A weight is attached to the air hose about one fathom from its end. The hose is then lowered alongside the impounded tuna, outside the net, till it is a short distance below the bottom of the net. The air rushing from the hose whips the free end beyond the weight, spreading the stream of bubbles over a considerable area and scaring the sharks away.

An ample supply of air under pressure is always available on purse seine boats, as compressed air is used to start their diesel engines. The air is usually piped to a jet on the port side of the deckhouse to which the hose is attached.

Frequently a short section of pipe closed at the end and perforated with many small holes is fastened to the end of the air hose to produce many small bubbles. This innovation does not seem necessary as satisfactory results are obtained when the air is released from the free end of the hose.—*John F. Janssen, Jr., California State Fisheries Laboratory, March, 1938.*

RUBBER FLOATS FOR NETS

Since time immemorial fishermen have used wooden or cork floats to lend buoyancy to their nets. In 1936 a few sardine fishermen in southern California tried hollow rubber floats in place of some of the regular corks on their purse seines. These floats were shaped like the corks already in use but were slightly larger. They have been very satisfactory but their high price makes their use throughout a large net practically prohibitive. A number of purse seines, however, have them along the landing bag where corks split and break from chafing against boat and skiff. These rubber floats are not to be confused with the large balloon-like rubber or canvas floats (Scotch buoys, 12 to 24 inches in diameter) frequently fastened to the cork lines of purse seines.

Recently the rubber floats have been improved by manufacturing them with round instead of square edges and inflating them slightly. After injecting neverleak, air is applied through a self-sealing soft rubber valve.

The rubber floats have several advantages over corks. For one thing they do not become water-logged and a rubber float is more buoyant than a water-soaked cork. Rubber floats will not split and break and can stand no end of abuse. They have not been in use long enough to test their longevity but it is safe to say that they will last considerably longer than cork. If they prove to last long enough, their high original cost may consequently be offset. When setting a net, due to their smooth surface, rubber floats pay out without catching on webbing, gunwale or roller.

Rubber floats are made in two sizes: one, four inches long by seven inches in diameter for purse seines; and the other, oval in shape and looking much like wooden floats, is six inches long and four inches in diameter. The latter are used primarily on gill nets. Holes through the center are made in three sizes: $\frac{3}{4}$ inch, 1 inch or $1\frac{1}{4}$ inch in diameter. Special sizes of floats may be made to order.

The only company known to make rubber net floats at the present time is located in San Pedro. The manufacturer has applied for a patent.—*John F. Janssen, Jr., California State Fisheries Laboratory, April, 1938.*

REVIEWS

The Life Story of the Fish

By Brian Curtis; introduction by William Beebe. New York, D. Appleton-Century Co., 1938. 260 pp., 36 figs., index. $3.

Reviewing this book places me in a somewhat difficult position. Because it is written by a friend and a fellow staff member of the California Division of Fish and Game, any glowing words of praise may be construed by the skeptic as so much ''blarney.'' Be that as it may, it is only in superlatives that the book can be described. The reader is referred to countless reviews in scientific and semi-scientific publications—all of them more than favorable. Furthermore, ''The Life Story of the Fish'' was selected as the April, 1938, book-of-the-month by the Scientific Book Club—and April was a month of heavy competition.

The book was written primarily for anglers and aquarists, to give them easy access to the vast store of information on fish known only to scientists and stored in scientific laboratories and libraries. Usually attempts at sugar coating such difficult subjects as the life of the fish result in dismal failures—sentimental tommy-rot unacceptable to the public and biologists alike. In this case, however, the author has treated his subject with rare understanding, humor neither crude nor forced, facts neither dull nor insipid. Whoever reads the first chapter will not be satisfied to set the book down until he turns the last page, and that holds equally well for the laboratory technician, the field naturalist, the student of human life, the angler and aquarist for whom the book was intended, and the person who scarcely knows a fin from a scale but who appreciates beautiful writing.

The title well describes the contents; it is the life of the fish, from the egg to adult maturity. The text is divided into several convenient sections, each dealing with a phase of the life and structure of fish—all fish, from the most primitive to the most advanced (and incidentally the author explains what the ichthyologist means by ''primitive'' and ''advanced''). At only one place does the author seem to go into too much detail; his account of the eyesight of fish is rather involved, though better than any other I have seen. The vision of a fish is a complicated and controversial subject and perhaps needs such full treatment.

The fishermen or fish fancier who reads this book can dumfound his less fortunate friends with his seemingly inexhaustible fund of sound information; he can answer questions that have stumped them all ever since the first angler cast a line and since primitive man discovered that he could keep fish in captivity.

This is one book that a reviewer can honestly say should be in the hands of every biologist, sportsman, nature lover and aquarist.—*Richard S. Croker, Editor, California Fish and Game.*

Giant Fishes, Whales and Dolphins

By J. R. Norman and F. C. Fraser. New York, W. W. Norton & Co., 1938. 361 pp., 8 col. pls., 97 figs. and many drawings, index. $4.

This book is a scholarly yet readable account of an intensely interesting subject. It was prepared to answer the many questions asked of museums and laboratories by the public to whom large fish and whales are always intriguing.

The authors, outstanding authorities in their fields, are both of the Department of Zoology, British Museum. The book is divided into two parts: "Fishes" by Norman, and "Cetaceans" (whales and dolphins, or as we call them, porpoises) by Fraser. Both authors present their subjects in a highly commendable way, covering the vast field adequately but without unnecessary detail, relieving the formidable succession of facts with anecdotes and humor.

The section on giant fishes confines itself to the larger kinds of fishes of all parts of the world—the kinds that fishermen and others continually inquire about. The material and arrangement are excellent. Sizes of record fish are given wherever possible.

The section on whales and porpoises is especially useful, as little readable literature on this subject is available to the general public. Here also, interesting facts on life-history, distribution and size are well presented.

W. P. C. Tenison is responsible for the illustrations which are both accurate and entertaining. The reviewer particularly enjoyed the sketches at the beginning and end of each chapter.

This book should be in every general and specialized library and should prove a useful reference to every student of fish and whales. In the short time it has been in our library, we have had occasion to answer several inquiries through reference to it.— *Richard S. Croker, Editor, California Fish and Game.*

The Small-mouthed Bass

By Carl L. Hubbs and Reeve M. Bailey. Cranbrook institute of science, Bloomfield Hills, Mich. Bulletin, no. 10, 92 pp., 10 pls., 5 figs., January, 1938. $0.75.

This little book is the answer—for one species—to a long felt want for concise general descriptions of American game fishes, suitable for angler, scientist and conservationist alike. It contains sections on the classification and identification of the small-mouthed bass (with a key to the black basses); brief descriptions of the closely related large-mouthed bass and spotted bass; distribution and habitat of the smallmouth; its hibernation; reproduction, development, age and rate of growth, food and parasites; and the senses of taste, smell, sight, hearing, touch and mass movement. Sections on angling and conservation round out the text, and there is a good bibliography.

Although pertaining entirely to conditions in the Middlewest and East, the book will be of considerable interest to California readers. Our State has many waters suitable for, and in fact containing, small-mouthed black bass, and the reader can make comparisons between local conditions and those described. As a matter of fact, a good deal of the value of the book lies in the store of information on all fresh-water fish; especially interesting to the angler are the sections on the senses of fish.

In making a general presentation of the subject, the authors have done a good job. However, the style is just a little too formal and there are too many technical words for the sportsman-reader. On the other hand, the fish culturist who is accustomed to these terms will be on the lookout for specific facts to help him in his work—and will be disappointed. Nevertheless, this paper makes a fine attempt to bridge the gulf between the popular and the scientific sides of the story, and when all is said and done the result is certainly worth while.

It has long been the reviewer's contention that there is a real need for short popular accounts of the habits and life histories of our game fishes, and that these be made available to the sportsmen who are really interested in more than just catching fish. The book under review is perhaps the best step in this direction since the Province of Ontario issued a few short articles several years ago.—*Richard S. Croker, Editor, California Fish and Game.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1937, to March 31, 1938, of the Eighty-ninth Fiscal Year

Revenue for Fish and Game Preservation Fund:	Detail	Total
License revenue:		
Angling, 1938	$28,180 50	
Angling, 1937	387,779 35	
Commercial Hunting Club, 1937-38	900 00	
Commercial Hunting Club, operators, 1937-38	280 00	
Deer tags, 1937	120,880 00	
Fish breeders, 1937	365 00	
Fish importers license, 1937	100 00	
Fish packers and wholesale shellfish dealers	1,035 00	
Fishing party boat permits, 1937	308 00	
Game breeders, 1938	795 00	
Game breeders, 1937	117 50	
Hunting, 1937-38	393,528 27	
Hunting, 1936-37	20,000 50	
Kelp, 1937	30 00	
Market fishermen, 1937-38	44,810 00	
Trapping licenses 1937-38	2,563 00	
Total license revenue		$1,001,672 12
Other revenue:		
Court fines	$34,849 88	
Fish packers tax	199,156 81	
Fish tags	2,712 64	
Game tags	200 34	
Interest on bank balances	712 73	
Kelp tax	187 33	
Lease of kelp beds	384 66	
Miscellaneous sales	4,705 37	
Publication sales	15 01	
Salmon tax	22,506 43	
Total other revenue		$265,431 20
Total revenue for Fish and Game Preservation Fund		$1,267,103 32

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to March 31, 1938, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Operating Expenditures—89th Fiscal Year					
Administration:					
Accident and death claims			$592 17		$592 17
Cashier	$750 00				750 00
Executive	3,749 94	$186 44	1,922 97	$919 13	6,778 48
Exhibits			1,200 00		1,200 00
General office	5,926 33	4,617 93	14,200 11	511 56	25,255 93
Legal			3,894 17		3,894 17
Library	1,350 00	28 14	109 55	326 73	1,814 42
Property inspection		21 44	95 85	12 05	129 34
Prorata Department Administration	7,519 99		6,000 00		13,519 99
Prorata General Fund expense			4,563 04		4,563 04
Publicity			2,022 82		2,022 82
Total Administration	$19,296 26	$4,853 95	$34,600 68	$1,769 47	$60,520 36
Patrol and Law Enforcement:					
Cannery Inspection	$17,359 41	$874 33	$2,299 74	$266 48	$20,799 96
Executive	10,665 00	627 02	1,928 06	65 28	13,285 36
General office	4,495 80	502 35	1,772 07	914 56	7,684 78
Junior patrol	1,946 02	259 58	493 15		2,698 75
Land patrol	140,242 82	27,635 95	47,447 56	21,723 25	237,049 58
Marine patrol	35,660 55	14,317 49	24,947 26	5,272 75	80,198 05
Pollution patrol	4,754 19	1,346 27	2,888 05	124 99	9,113 50
Total patrol and Law Enforcement	$215,123 79	$45,562 99	$81,775 89	$28,367 31	$370,829 98
Marine Fisheries:					
Executive	$5,490 00	$156 42	$343 60		$5,990 02
Field supervision	2,420 00	225 01	1,643 02		4,288 03
Fish cannery auditing			1,411 75		1,411 75
General office	6,420 59	102 12	592 21		7,114 92
Research and statistics	28,327 36	2,635 13	7,960 65	$1,448 82	40,371 96
Total Marine Fisheries	$42,657 95	$3,118 68	$11,951 23	$1,448 82	$59,176 68
Fish Conservation:					
Cooperative research—Stanford University	$2,344 67	$242 68	$484 60	$67 82	$3,139 77
Executive	4,770 00	169 99	434 30	1,012 70	6,386 99
Field supervision	7,532 48	826 08	2,763 92	1,388 86	12,511 34
Fish planting	2,601 22	1,121 02	1,714 86	4,334 24	9,771 34
Fish rescue	4,387 85	521 94	1,293 15	208 33	6,411 27
General office	3,516 40	92 29	52 33	324 71	3,985 73
Pollution inspection	2,340 00	237 40	543 34	1 17	3,121 91
Research	1,618 10	102 39	631 36	87 22	2,439 07
Statistical	1,710 00		764 00		2,474 00
Alpine	897 23	647 88	168 44	550 65	2,264 20
Basin Creek	3,231 76	1,899 41	411 46	541 78	6,084 41
Bear Lake Egg Collecting Station	100 00	72 81			172 81
Beaver Creek Egg Collecting Station	250 00		75 00		325 00
Beaver Creek	148 55	46 90	8 58		204 03
Big Creek	2,446 67	1,324 62	222 73	548 75	4,542 77
Blackwood	287 81	218 39	1 00		507 20
Blue Lakes Egg Collecting Station	400 00		16 00		416 00
Bogus Creek Egg Collecting Station	241 61	77 21	131 80		450 62
Brookdale	2,205 32	1,177 64	280 71	12 91	3,676 58
Burney Creek Hatchery	3,963 27	2,425 09	608 33	552 66	7,549 35
Carmen Lake Egg Collecting Station	312 00	2 24	10 43		324 67
Central Valleys	2,391 81	1,146 94	1,359 83	905 02	5,803 60
Cold Creek	2,492 27	1,783 31	617 71	579 48	5,472 77
Cottonwood Lakes Egg Collecting Station	83 87	11 10	75 23		170 20
Fall Creek Egg Collecting Station		29 21	85 00		114 21
Fall Creek	4,434 84	2,607 40	210 25	6 06	7,258 55
Feather River	2,929 55	1,772 17	319 80	193 23	5,214 75
Fern Creek	992 23	347 24	60 17		1,399 64
Fishing Creek Experimental Station	358 06	22 25	5 31		385 62
Forest Home	8,455 01	8,196 20	1,467 62	34 47	18,153 30
Fort Seward	2,938 71	835 96	102 65	682 38	4,559 70

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to March 31, 1938, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Hat Creek Egg Collecting Station		$113 98			$113 98
Hornbrook Egg Collecting Station	$190 00	58 63	$97 89		346 52
Hot Creek	2,183 56	1,956 63	162 05	$5 06	4,307 30
Huntington Lake	246 00	253 15	156 40		655 55
Kaweah	3,422 90	1,309 59	985 70	141 90	5,860 09
Kings River	3,597 11	1,189 71	859 28	35 12	5,681 22
Klamathon Egg Collecting Station	1,412 91	121 48	324 58	12 21	1,871 18
Kosk Creek Egg Collecting Station		8 44			8 44
Lake Almanor	4,383 75	1,377 02	387 13	167 22	6,315 12
Lake Eleanor Egg Collecting Station		18 94			18 94
Little Walker Lake Egg Collecting Station	259 03				259 03
Madera	749 51	484 55	269 48		1,503 54
Marlette Lake Egg Collecting Station	713 17	4 79	56 90		774 86
Mt. Shasta Experimental Hatchery	781 29	493 82	28 09		1,303 20
Mt. Shasta	21,060 44	12,166 16	2,292 37	178 97	35,697 94
Mount Tallac	1,052 32	1,341 25	30 60		2,424 17
Mount Whitney	8,155 36	3,521 53	2,048 79	730 49	14,456 17
Mud Creek Egg Collecting Station	114 69	10 30		4 50	129 49
Pasadena Reservoir Egg Collecting Station	215 00	4 81			219 81
Prairie Creek	4,148 13	1,091 90	416 90	609 55	6,266 48
Rush Creek Egg Collecting Station	369 33	49 81			419 14
San Lorenzo Egg Collecting Station	8 00	128 72	1 00		137 72
Scott Creek Egg Collecting Station	1,125 00	81 77	114 89		1,321 66
Shackleford Creek Egg Collecting Station	226 00	35 16	70 00		331 16
Shasta River Egg Collecting Station	663 34	114 91	95 20	6 64	880 29
Shasta River Experimental Station	152 00	60 75	49 23		261 98
Snow Mountain Egg Collecting Station	1,200 00	112 26	105 17	19 68	1,437 11
Tahoe	4,285 35	1,367 44	498 22	57 37	6,208 38
Upper Truckee Egg Collecting Station	54 84				54 84
Waddell Creek Station	531 94	22 22	33 27		587 43
Warner Creek Egg Collecting Station	116 86	43 06			159 92
Yosemite	2,798 26	808 80	208 16	45 36	3,860 58
Yuba River	2,411 64	971 56	294 50	3 12	3,680 82
Total Fish Conservation	$137,009 22	$57,280 90	$24,505 71	$14,049 63	$232,845 46
Hydraulics:					
Engineering	$3,576 43	$452 17	$1,296 91	$1,571 77	$6,897 28
Executive	2,985 00	257 82	574 31		3,817 13
Fish screens	347 76	549 77	36 61	2,552 12	3,486 26
General office	1,440 00	78 40	88 60	201 16	1,808 16
Total Hydraulics	$8,349 19	$1,338 16	$1,996 43	$4,325 05	$16,008 83
Game Conservation:					
Elk refuge	$1,548 32	$194 76	$436 22	$131 81	$2,311 11
Executive	8,652 47	676 56	1,548 13	27 77	10,904 93
Field				17 06	17 06
Game bird distribution	800 00	478 42	339 76	16 06	1,634 24
General office	3,308 89	139 34	14 51	103 06	3,565 80
Grey Lodge Refuge	2,880 00	618 47	215 85	489 25	4,203 57
Imperial Refuge	1,350 00	105 34	66 69		1,522 03
Los Banos Refuge	2,307 87	467 30	485 33	47 22	3,307 72
Los Serranos Game Farm	9,732 90	4,332 54	1,923 49	2,327 37	18,316 30
Predatory animal control	23,546 35	3,628 98	9,663 03	1,183 24	38,021 60
Research	196 43	21 19	68 80	78 74	365 16
Statistics	842 74	57 97	828 87		1,729 58
Suisun Refuge	1,310 48	481 63	416 08	114 82	2,323 01
Winter feeding and salting of game		384 64			384 64
Yountville Game Farm	11,102 12	8,801 82	2,991 05	900 96	23,795 95
Total Game Conservation	$67,578 57	$20,388 96	$18,997 81	$5,437 36	$112,402 70
Licenses:					
Executive	$2,475 00	$9 67	$34 58	$1,071 20	$3,590 45
General office	1,063 67	132 22	1,706 48	2,093 90	4,997 27
License distribution	8,065 54	15,282 86	48,858 79	91 67	72,298 86
Total Licenses	$11,604 21	$15,425 75	$50,599 85	$3,256 77	$80,886 58

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to March 31, 1938, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Special Item:					
Construction of research boat					$3,000 00
Total Eighty-ninth fiscal year expenses, paid from supplementary appropriations					$935,670 59
Expenditures for Additions and Betterments:					
Permanent Improvements:					
Purchase of game refuges and public shooting grounds and C.I.E., Chap. 157-37	$3,041 34	$5,462 91	$1,944 60	$690 85	$11,139 70
Contributions to Employees' Retirement System					9,203 26
Total current biennium					$956,013 55
Prior Biennium Appropriations:					
Eighty-ninth fiscal year:					
Special Item: Expenses of California Code Commission, Chap. 645-33					37
Eighty-eighth Fiscal Year:					
Special Item: Construction of Russian River Jetties, Chap. 989-33					365 84
Support:					
Eighty-eighth fiscal year					$57,055 45
Eighty-seventh fiscal year					19 49
Total Support					$57,074 94
Special Item: Predatory Animal Control:					
Eighty-eighth fiscal year					$3,426 15
Expenditures for Additions and Betterments, Permanent Improvements, Purchase of Game Refuges, and Public Shooting Grounds and C.I.E.:					
Eighty-eighth fiscal year					$18,141 67
Total Prior Biennium Appropriations					$79,008 97
Grand total					$1,035,022 52

SEIZURES OF FISH AND GAME

January, February, March, 1938

Game:	
Brant, black sea	5
Canary, wild	3
Coot	1
Deer	8
Deer hide	1
Deer meat, pounds	1,868
Dove	16
Ducks	111
Elk	1
Goose	5
Grebe	1
Hawks	2
Killdeer	3
Lesser scaup	1
Mallard Hen	1
Marbled Godwit	1
Meadow larks	2
Mockingbird	1
Mudhens	14
Pheasant	12
Quail	23
Rabbits	13
Robins	6
Seagulls	1
Sea scoter	1
Sparrow, white-throated	2
Squirrels	2
Squirrel skins	4
Surf scoters	2
Swan	1
Venison ham	1

Fish:	
Abalones	273
Abalones, pounds	20
Barracuda, pounds	2,140
Bluegills	3
Catfish, pounds	41
Clams	1,883
Clam forks	3
Clams, quarts	1
Cockles, pounds	350
Crabs	3,336
Crab traps, boxes	46
Eastern brook trout	41
Lobsters	117
Lobster traps	54
Mackinaw trout	1
Pyramid Lake trout	12
Rainbow trout	116
Salmon, pounds	25
Set lines, feet	300
Steelhead	107
Steelhead, pounds	280
Trout	23
Yellowfin tuna, pounds	10,586

GAME CASES

January, February, March, 1938

Offense	Number arrests	Fines imposed	Jail sentences (days)
Beaver; no license	2	$50 00	30
Birds; possession in violation of Fish and Game Code	1		
Brant; take	2		
Deer; possession spike buck, closed season, possession venison, possession parts of female, possession does and fawns, transporting into closed district, tags not validated, failure to produce hide and horns, illegal possession deer meat, killing spike buck, killing doe, possession deer, evidence of sex removed	88	2,513 00	1,983
Doves; closed season	7	140 00	
Discharging firearms in a fowl refuge	2		
Ducks, possession closed season, overlimit, early shooting, kill and possess wild ducks, possess surf scoter closed season	16	195 00	237
Firearms; possession in refuge	5	25 00	
Fur bearing mammals; take for profit, no license	1		
Game; possession of ten days after close of season	1	25 00	
Game birds; closed season, shooting from auto, sell, trade, barter wild game birds, no license	8	70 00	10
Geese; shooting after 4 p.m., kill closed season	3	60 00	
Hunting; no license	21	260 00	180
Mudhens; possession, kill closed season, take after 4 p.m.	5	25 00	
Mink; trapping out of season	1	10 00	
Night hunting	5	45 00	10
Non-game birds; hunting, shoot; take grebe, robins, meadowlark	21	295 00	100
Pheasants; closed season, no license, kill hen, possession male	19	835 00	215
Protected birds, no license, marbled godwit	2	35 00	
Quail; possession overlimit, closed season, possession valley quail	7	135 00	
Rabbits, no license, closed season, cottontail and brush, closed season	20	227 00	10
Seagull; killing, possession	1	25 00	
Shorebirds; possession killdeer	8	100 00	
Squirrels; grey squirrel skins, possession tree squirrel, grey squirrel	3	20 00	37½
Shooting after 4 p.m.; migratory waterfowl	5	115 00	
Swan, possession wild	1	25 00	
Trapping, no license	2		
Waterfowl, take between 4 p.m. and 7 a.m.	2	40 00	
Wood ducks, possession of	1	12 50	
	260	$5,282 50	2,812½

FISH CASES

January, February, March, 1938

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones; using diving apparatus to take, possession undersized, bring ashore out of shells, undersized red, overlimit, undersized green, closed season, undersized black, no license, sliced abalones, take in marine refuge, no permit, possession black abalones less than five inches	41	$480 00	20
Angling; no license, closed stream, closed tributaries to Russian River, closed territory	20	195 00	65
Barracuda; possession and sell undersized	1		
Bass; fishing for striped—no license, take striped by other than hook and line, overlimit	6	10 00	
Bluegills; closed season	1	25 00	
Catfish; retaining less than nine inches in length, sale of, undersized	2	40 00	
Clams; undersized pismo, possession in clam refuge, overlimit pismo, no license, take pismo clams in clam preserve	57	780 50	400½
Cockles; more than six dozen in possession, possession undersized	6	85 00	10
Commercial fishing; no license	39	530 00	12½
Crabs; taking undersized, possession undersized; take from Dist. 1½ to 2, take female crabs	34	345 00	641
Dynamite; placing in State waters to take fish	1	100 00	
Failure to show license on demand	8		
Fish spear; possession within 300 feet of stream	4		
Frogs; possession undersized	1	25 00	
Gaff; possession within 300 feet of stream	1		
Game fish; no license	2	10 00	
Gill net in Dist. 2, in Old River, meshes less than 5½-inch in length	2	25 00	
Lobsters; possession undersized; possession spiny lobsters less than 10½ inches	3	25 00	12½
Net; operating in Dist. 1	1	25 00	
Operating set lines in White Slough, in Taylor Slough, Middle River, Honker Bay, District 1	11	430 00	
Perch; possession closed season	2	30 00	
Pollution	23	2,055 00	
Roundhaul net in District 19-A	6	100 00	
Seining in District 20	4	1,200 00	
Spear in possession in creek	3	75 00	
Steelhead; illegally taken, overlimit, spearing in Santa Ynez River, gaffing, closed season, no license, selling	8	125 00	1
Taking with set lines; crappie, perch, sunfish at night	1	25 00	
Trout; taking during closed season, no license, unlawful possession closed season, more than daily bag limit, overlimit	11	167 00	30
Yellowfin tuna, sale undersized	1	500 00	
Totals	300	$7,407 50	1,192½

CHANGE IN PRESENTATION OF FISHERIES STATISTICS

To meet changing conditions, the former quarterly tables of landings of commercial fish in California which have appeared in *California Fish and Game* for a number of years, have been supplanted by monthly tables. Although this new monthly record covers the same material, the figures will not be entirely comparable with the former quarterly tables. The change has been made with the idea of simplifying and improving the usefulness of the records presented. The major differences are therefore outlined and the reasons for each change are given.

1. Quarterly tables were formerly published chiefly because the magazine was issued quarterly. It is the consensus of opinion that monthly records will be far more useful.

2. With the cessation of commercial salmon fishing in the rivers of the northern part of the State, there was eliminated the need for keeping the Del Norte and Eureka records separated. In the new tables these two regions have been combined.

3. The new heading of the table, "Fresh Fish Landings of California Boats", means exactly that. The table now represents the catch of the California fishing fleet without the confusing inclusion of importations from other states and foreign countries. The record of species landed in Los Angeles and San Diego regions from south of the international boundary represents the catch of California boats, manned by California fishermen. In some cases these boats go as far south as the equator and either return to their home port with the catch or transfer it to a tender to be delivered to the canneries and fresh fish markets in California. There is one possible exception in the record of spiny lobsters. On the west coast of Lower California the lobster camps are financed and outfitted in California, their supplies and even the drinking water are carried from California. Natives in skiffs attend the lobster traps, but the catch is delivered to a tender which takes the supplies to the camp and returns to California ports with the catch. For the purpose of this record this lobster catch was included with the take of California fishermen.

4. In the former quarterly tables, the poundage was credited to the place where the business was transacted. This was misleading in the case of the trawler catch, a large portion of which is landed half the length of the State away from its final destination, the business headquarters. In the new monthly tables we are endeavoring to rectify this and credit the trawler fish to the region in which it is first landed.

5. The importation tables have been divided into two types: one, a record of the fish delivered from other states and foreign countries to the California canneries for packing; and the second, the voluntary record of importations to the fresh fish markets for sale in competition with the catch of California fishermen.

Formerly these importations were included in the total landing tables for California, and a separate table was given, which showed these importations combined with the catch of California fishermen beyond the State boundaries.

The table of importations for canning is complete and records such items as fish taken by fishermen in the states to the north and shipped to our canneries, as well as fish caught in Japan, frozen and delivered by ocean liner for packing in California.

The importations for the fresh fish markets are far from complete and for this reason should be treated separately. Formerly the figures were included in the landing table. These have been eliminated because they were misleading.—*Geraldine Conner, Fisheries Statistician, California State Fisheries Laboratory, June 15, 1938.*

FRESH FISH IMPORTATIONS FROM OTHER STATES AND FOREIGN COUNTRIES
JANUARY, 1938

	Oregon	Gulf of California	Japan
For canneries:			
Tuna, Albacore	7,207	----------	----------
For fresh fish markets:*			
Corbina, Mexican	----------	8,587	----------
Sea-bass, Totuava	----------	392,306	----------
Crustacean:			
Shrimp	----------	1,425	----------
Total pounds	7,207	402,318	

FEBRUARY, 1938

	Oregon	Gulf of California	Japan
For canneries:			
Tuna, Albacore	26,624	----------	----------
Tuna, Skipjack	----------	----------	106,362
For fresh fish markets:*			
Corbina, Mexican	----------	11,921	----------
Sea-bass, Totuava	----------	659,265	----------
Crustacean:			
Shrimp	----------	225	----------
Total pounds	26,624	671,411	106,362

MARCH, 1938

	Oregon	Gulf of California	Japan
For canneries:			
Tuna, Skipjack	----------	----------	66,939
For fresh fish markets:*			
Barracuda		316	----------
Cabrilla	----------	2,673	----------
Corbina, Mexican	----------	22,604	----------
Sea-bass, Black	----------	177	----------
Sea-bass, Totuava	----------	538,349	----------
Total pounds	----------	564,119	66,939

* This record includes only that fish which is voluntarily reported to the Division of Fish and Game and does not represent all importations.

FRESH FISH LANDINGS OF CALIFORNIA BOATS, JANUARY, 1938

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south International boundary		Total landings of California boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total	Region 70, Los Angeles	Region 80, San Diego	
Anchovy						50,769		50,769			50,769
Barracuda							60	60	185,295	33,979	219,334
Cabezone	160			51	36			247			247
Cabrilla									18,695	23,314	42,009
Carp		862						862			862
Catfish		15,484						15,484			15,484
Cultus, Pacific	14,622		18,700	13,296	45	121		46,784			46,784
Flounder, Starry	277		12,491	499				13,267			13,267
Grouper									2,168	1,591	3,759
Hake			1,440					1,440			1,440
Halibut, California			385	2,231	30,138	24,566	27,476	84,796	7,795	29,382	121,973
Hardhead		1,055						1,055			1,055
Herring, Pacific	5,100		245,522					250,622			250,622
Kingfish				11,747		30,027		41,774			41,774
Mackerel, Horse				167		2,225,952		2,226,119			2,226,119
Mackerel, Pacific			1,013	115,498	7,358	9,404,563	245,586	9,774,018			9,774,018
Mackerel, Spanish									810	2,199	3,009
Perch	209		7,267	361		13,855		21,692			21,692
Pike		27						27			27
Rock Bass					1,128	1,577	842	3,547	1,492	2,748	7,787
Rockfish	9,677		79,583	249,239	22,866	29,872	4,701	395,938		4,353	400,291
Sablefish	492					14,197		14,689			14,689
Salmon		2,229						2,229			2,229
Sand Dab	1,040		42,020	291		717		44,068			44,068
Sardine		10,579,300	29,990,508	16,923,741	16	45,379,882		102,873,447			102,873,447
Sculpin					124	8,159	228	8,511			8,511
Sea-bass, Black					845	62	42	949	15,390	6,832	23,171
Sea-bass, White				2,734	5,815	1,770	2,441	12,760	722	2,495	15,977
Sea-trout, California	236							236			236
Shark	2,427	4,241	555,734	60,436	23,222	3,248	3,921	653,229		753	653,982
Sheepshead					169	1,575	446	2,190		2,264	4,454
Skate			55,501	5,274	2,613	982	152	64,522			64,522
Smelt	189		11,980	3,480	818	13,883	494	30,844		525	31,369
Sole	3,900		586,238	12,011	8,106	92		610,347			610,347
Split-tail		717						717			717
Sucker		62						62			62

Tuna, Bluefin						141		141			141
Tuna, Bonito					3,526	457,256	240,398	701,180	51	39,008	740,239
Tuna, Skipjack									152,125	34,248	186,373
Tuna, Yellowfin									772,465	2,914,379	3,686,844
Turbot			6,321	491		7		6,819			6,819
Whitebait	4,177		316					4,493			4,493
Whitefish					3,742	2,808	135	6,685		13,609	20,294
Yellowtail						15	15	30	1,375	103,180	104,585
Miscellaneous fish	260		12,393		399	643		13,695			13,695
Crustacean:											
Crab	28,444		303,504	1,872				333,820			333,820
Crab, Rock						862		862			862
Lobster, Spiny					23,134	23,479	7,704	54,317		176,505	230,822
Prawn				80				80			80
Shrimp			61,066					61,066			61,066
Mollusk:											
Abalone				46,350	48,237	50		94,637			94,637
Clam, Cockle			44	7		1,560		1,611			1,611
Clam, Gaper			211					211			211
Clam, Pismo				3,458	13,982			17,440			17,440
Clam, Razor	4							4			4
Clam, Soft-shell	15		6,859					6,874			6,874
Clam, Washington	2,369		232					2,601			2,601
Octopus	28		138	262		3		431			431
Oyster, Eastern			24,798					21,798			24,798
Oyster, Japanese			91,769					91,769			91,769
Oyster, Native			2,944					2,944			2,944
Squid				43,530		345	293	44,168			44,168
Total pounds	73,626	10,603,977	32,118,977	17,497,106	196,319	57,693,038	534,934	118,717,977	1,158,383	3,391,364	123,267,724

* The eight geographical regions of the State are as follows:

Regions 10 and 20. Del Norte and Eureka. Del Norte, Humboldt and Mendocino Counties.
Region 30. Sacramento. The Sacramento and San Joaquin river systems with the delta areas, including Suisun Bay and Lake County.
Region 40. San Francisco. Sonoma, Marin, San Francisco and San Mateo Counties, including San Francisco Bay points.
Region 50. Monterey. Santa Cruz and Monterey Counties.
Region 60. San Luis Obispo, Ventura and Santa Barbara Counties.
Region 70. Los Angeles. Los Angeles and Orange Counties.
Region 80. San Diego. San Diego and Imperial Counties.

These tables subject to slight revision due to belated supplemental items.

FRESH FISH LANDINGS OF CALIFORNIA BOATS, FEBRUARY, 1938

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south International boundary		Total landings of California boats
	Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total	Region 70, Los Angeles	Region 80, San Diego	
Anchovy						2,902		2,902			2,902
Barracuda						3,270	148	3,418	122,023	37,596	163,037
Cabezone	51			85				136			136
Cabrilla									7,251	7,548	14,799
Carp		1,441						1,441			1,441
Catfish		8,835						8,835			8,835
Cultus, Pacific	21,069		11,413	3,136				35,618			35,618
Flounder, Starry	1,013		26,419	388				27,820			27,820
Grouper									1,019	1,149	2,168
Hake			2,900					2,900			2,900
Halibut, California			1,257	4,058	22,018	39,282	45,645	112,260	33	222	112,515
Hardhead		625						625			625
Herring, Pacific	25		149,961	397				150,383			150,383
Kingfish				4,605	59	32,444		37,108			37,108
Mackerel, Horse				2,965		677,765		680,730			680,730
Mackerel, Pacific				99,376	126	2,287,758	20	2,387,280			2,387,280
Mackerel, Spanish									1,792		1,792
Perch	602		9,894	1,333	10	7,966		19,805			19,805
Pike		114						114			114
Pompano, California						163		163			163
Rock Bass					9,875	2,525	400	12,800	989	2,182	15,971
Rockfish	13,396		51,679	186,842	32,351	26,322	845	311,435		11,391	322,826
Sablefish	1,086			90	10	23,547		24,733			24,733
Salmon		1,017	878					1,895			1,895
Sand Dab			62,392	91		561		63,044			63,044
Sardine			55,671	2,097,643		52,440,068	214,915	54,808,297			54,808,297
Sculpin					291	5,719	350	6,360			6,360
Sea-bass, Black					1,833	56	216	2,105	12,956	22,298	37,359
Sea-bass, White				129	1,560	2,419	2,103	6,211	1,526	14,596	22,333
Sea-trout, California	330							330			330
Shark	248	188,604	132,659	37,597	31,058	7,831	4,282	402,279			402,279
Sheepshead					1,448	2,051	133	3,632		1,934	5,566
Skate			61,168	12,224	3,456	1,093		77,941			77,941
Smelt	105		25,003	781	1,236	15,401		42,526		12	42,538
Sole	884		451,103	18,837	10,877	446		482,147			482,147
Split-tail		1,974						1,974			1,974

Sucker		76						76			76
Tuna, Bonito					3,888	268,421	298,821	571,130	1,635	25,078	597,843
Tuna, Skipjack									8,215	38,495	46,710
Tuna, Yellowfin									681,882	2,175,859	2,857,741
Turbot			1,005	1,096				2,101			2,101
Whitebait	10,623		1,402					12,025			12,025
Whitefish					918	2,010	30	2,958	156	6,281	9,395
Yellowtail							578	578	1,766	56,686	59,030
Miscellaneous Fish			12,493	145	791	282		13,711			13,711
Crustacean:											
Crab	19,686		317,312	3,532				340,530			340,530
Crab, Rock						533		533			533
Lobster, Spiny					14,792	12,331	504	27,627		231,016	258,643
Shrimp			15,852					15,852			15,852
Mollusk:											
Clam, Cockle			38			1,695		1,733			1,733
Clam, Gaper			204					204			204
Clam, Pismo				2,039	13,182			15,221			15,221
Clam, Soft-shell	15		7,971					7,986			7,986
Clam, Washington	2,582		195					2,777			2,777
Octopus	207		103	50		12		372			372
Oyster, Eastern			31,595					31,595			31,595
Oyster, Japanese			101,048					101,048			101,048
Oyster, Native			1,418					1,418			1,418
Squid						53,865		53,865			53,865
Total pounds	71,922	202,686	1,533,033	2,477,439	149,779	55,918,738	568,990	60,922,587	841,243	2,632,343	64,396,173

FRESH FISH LANDINGS OF CALIFORNIA BOATS, MARCH, 1938

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south International boundary		Total landings of California boats
	Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total	Region 70, Los Angeles	Region 80, San Diego	
Anchovy				2,650		1,757		4,407			4,407
Barracuda						4,813	74	4,887	67,031	88,282	160,200
Cabezone			215	100	20			335			335
Cabrilla									4,860		4,860
Carp		5,714		1,335				7,049			7,049
Catfish		24,076						24,076			24,076
Cultus, Pacific	36,653		15,325	4,023		19		56,020			56,020
Flounder, Starry	927		32,772	2,798				36,497			36,497
Grouper									233	1,222	1,455
Hake			150					150			150
Halibut, California			398	4,193	30,976	33,939	31,746	101,252		5,098	106,350
Hardhead		24						24			24
Herring, Pacific			5,466					5,466			5,466
Kingfish			195	5,440	50	9,072	42	14,799			14,799
Mackerel, Horse						41,500		41,500			41,500
Mackerel, Pacific				17,203	140	1,908,627		1,925,970			1,925,970
Mullet						190		190			190
Perch	1		10,000	969		9,030		20,000			20,000
Pike		362						362			362
Pompano, California						7		7			7
Rock Bass					719	1,311	3,046	5,076	1,250	2,570	8,896
Rockfish	10,962		109,052	174,039	6,883	42,364	3,243	346,543		15,405	361,948
Sablefish	5,696		2,223	121		29,663		37,703			37,703
Salmon		5,324	5,745	89				11,158			11,158
Sand Dab	946		57,658	5,655		807		65,066			65,066
Sardine				27,450		13,855,613	150,245	14,033,308			14,033,308
Sculpin						4,312	5,330	9,642			9,642
Sea-bass, Black					1,825	408		2,233	8,528	9,067	19,828
Sea-bass, White					3,405	363	1,606	5,374		12,244	17,618
Shad		13,179						13,179			13,179
Shark		189,591	44,092	25,172	31,810	10,133	6,253	307,051		225	307,276
Sheepshead					1,361	306	195	1,862		688	2,550
Skate			77,863	21,411	3,567	1,525	275	104,641		50	104,691
Smelt			55,175	345	2,742	6,863		65,125			65,125
Sole	32,114		351,371	62,818	19,445	415		466,163			466,163
Split-tail		1,748						1,748			1,748

Sucker		189						189			189
Tuna, Bonito					37	57,223	27,989	85,249	100	17,462	102,811
Tuna, Skipjack									202,831	544,688	747,519
Tuna, Yellowfin									1,377,849	4,603,613	5,981,462
Turbot			3,381	2,000				5,381			5,381
Whitebait	10,554		1,864	93				12,511			12,511
Whitefish					419	3,968	90	4,477		2,678	7,155
Yellowtail						1,126	491	1,617	1,782	218,225	221,624
Miscellaneous fish	1,085		10,346	4,825	348	133		16,737			16,737
Crustacean:											
Crab	18,356		197,068	3,536				218,960			218,960
Crab, Rock					10	47		57			57
Lobster, Spiny					5,037	5,537	252	10,826		162,372	173,198
Shrimp			43,137					43,137			43,137
Mollusk:											
Abalone					3,867	236		4,103			4,103
Clam, Cockle			20			2,125		2,145			2,145
Clam, Gaper			151	20				171			171
Clam, Pismo				1,800	13,966			15,766			15,766
Clam, Soft-shell	15		6,946					6,961			6,961
Clam, Washington	2,126		223					2,349			2,349
Octopus	157		246	194		2		599			599
Oyster, Eastern			28,575					28,575			28,575
Oyster, Japanese			116,279					116,279			116,279
Oyster, Native			2,180	8,000				10,180			10,180
Squid						63,170		63,170			63,170
Total pounds	119,592	240,207	1,178,116	376,279	126,627	16,096,604	230,877	18,368,302	1,664,464	5,683,889	25,716,655

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CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION."

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TABLE OF CONTENTS

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62500

STUDIES ON THE NESTING CYCLE OF THE CALIFORNIA VALLEY QUAIL IN 1937 [1]

By Ben Glading

San Joaquin Experimental Range

Introduction

The foothills of the western slope of the Sierra Nevada of California have long been a favorite hunting ground for sportsmen, particularly those residing in the San Joaquin and Sacramento valleys. This area abounds in California valley quail (*Lophortyx californica vallicola*), western mourning doves and cotton-tail rabbits.

There are many ecological problems concerning the lives of these game species which are in need of study in order to answer certain game management questions. Sumner (1935) has provided details on the California quail in the Santa Cruz Mountains of the humid coast region, but knowledge of valley quail for other, quite different environments such as the foothill region of the Upper Sonoran Zone is, for the most part, lacking. A complete study is needed for each major ecological division of the California quail's range. In order to provide for this in the Sierra foothills, the Cooperative Quail Management Study Committee was organized.[2]

The area chosen for the study is the San Joaquin Experimental Range, situated in the foothills of Madera County, 25 miles east of Madera, California. The Range includes 4500 acres of rolling hills and swales with occasional small canyons; the altitude is 700 to 1500 feet. The soil is for the most part granite sand with small areas of adobe in the swales. Granite and quartz outcrops form a prominent feature of the landscape.

The San Joaquin Experimental Range has been selected by the United States Forest Service as an example of typical foothill grazing country in the interior of California. Experiments are in progress here on range and livestock management in cooperation with the University of California and other agencies. It is therefore well adapted for a study of game management in this foothill region.

There is more man-caused interference to wildlife on this Range than is the case on most foothill ranches. Crews engaged in construc-

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[2] The Committee is composed of Tracy I. Storer, chairman, and J. T. Emlen, Jr., of the University of California College of Agriculture; E. E. Horn of the U. S. Biological Survey; E. I. Kotok, M. W. Talbot, H. H. Biswell, and J. W. Nelson of the California Forest and Range Experiment Station, U. S. Forest Service; and F. P. Cronemiller and F. W. Johnson of Region 5, U. S. Forest Service. Messrs. Storer and Horn form a special technical advisory committee. Funds for the project are supplied by Region 5, U. S. Forest Service. The writer has been engaged by the Committee as a resident investigator at the San Joaquin Experimental Range. Additional help in various projects was obtained through the use of U. S. Forest Service Junior Assistants to Technicians and Civilian Conservation Corps enrollees for manual labor. Studies began in December, 1936, and are still in progress (July, 1938).

tion of fences, roads, etc., and technical men in various lines of research create more disturbance here than on private lands. Cattle are of course present in most of the pastures on the Experimental Range.

The common trees of the area are blue oak (*Quercus douglasii*), interior live oak (*Q. wislizenii*), digger pine (*Pinus sabiniana*), and California buckeye (*Aesculus californica*). These are scattered, giving the landscape a rather open appearance. Of shrubs, buckbrush (*Ceanothus cuneatus*), "white thorn" (*C. divaricatus*), manzanita (*Arctostaphylos mariposa*), and bush lupine (*Lupinus albifrons*) are the most common. On some parts of the Range the shrubs occur in small dense patches, otherwise they are scattered. The small vegetation is composed chiefly of annual weeds and grasses, largely introduced species; broadleaf filaree (*Erodium botrys*), soft-chess brome grass (*Bromus mollis*), and fescue grass (*Festuca megalura*) are the most abundant. This annual type vegetation, characteristic of the foothill belt, supplies an abundance of seed.

Weather conditions at the Range are representative of the foothill belt. The average annual rainfall is about 17 inches, received mostly in the months from October to April; little or no rain falls from May to September. During the dry summer season the daily maximum temperature commonly goes over 100° F., and has reached 115° F. Winter minima are slightly below freezing; snow falls only rarely. During the summer the relative humidity is low (average daily minima from 15 to 20 per cent). No fog or dew is present in the summer.

Excellent studies on the nesting habits of several American quail are available, such as that on the eastern bobwhite by Stoddard (1931), on the Gambel quail by Gorsuch (1934), and on the California quail by Grinnell, Bryant and Storer (1918), but up to the present, this important phase of valley quail life has remained untouched from the game management point of view. Sumner (1935) felt it inadvisable to conduct such a study for fear of setting up unnatural conditions, and leading curious predators to the nests.

The Committee felt that major emphasis should be placed on the nesting cycle. Preliminary study suggested that loss of adult birds due to predation was not a major factor at the current population level. Roosting and escape cover seemed adequate over a large part of the Range for a much larger number of quail than were present. The local population of quail approaches, and in some small areas exceeds the hypothetical maximum concentration of one bird per acre put forward by Errington and Hamerstrom (1936) and others for the eastern bobwhite. Yet local reports of much heavier valley quail concentrations in the past imply that the maximum carrying capacity of this foothill country may be several fold greater. Some observations by Horn (1938, pp. 58-60) suggest that regulation of predators during the nesting season might build up the quail population. In view of these and other considerations a complete, quantitative study of nesting was deemed desirable.

General Habits of the Quail Prior to Nesting

Studies of the behavior of flocks and of individuals carried on throughout 1937 showed that until early in March the coveys comprised about 30 birds each. Then groups of from 2 to 10 were to be

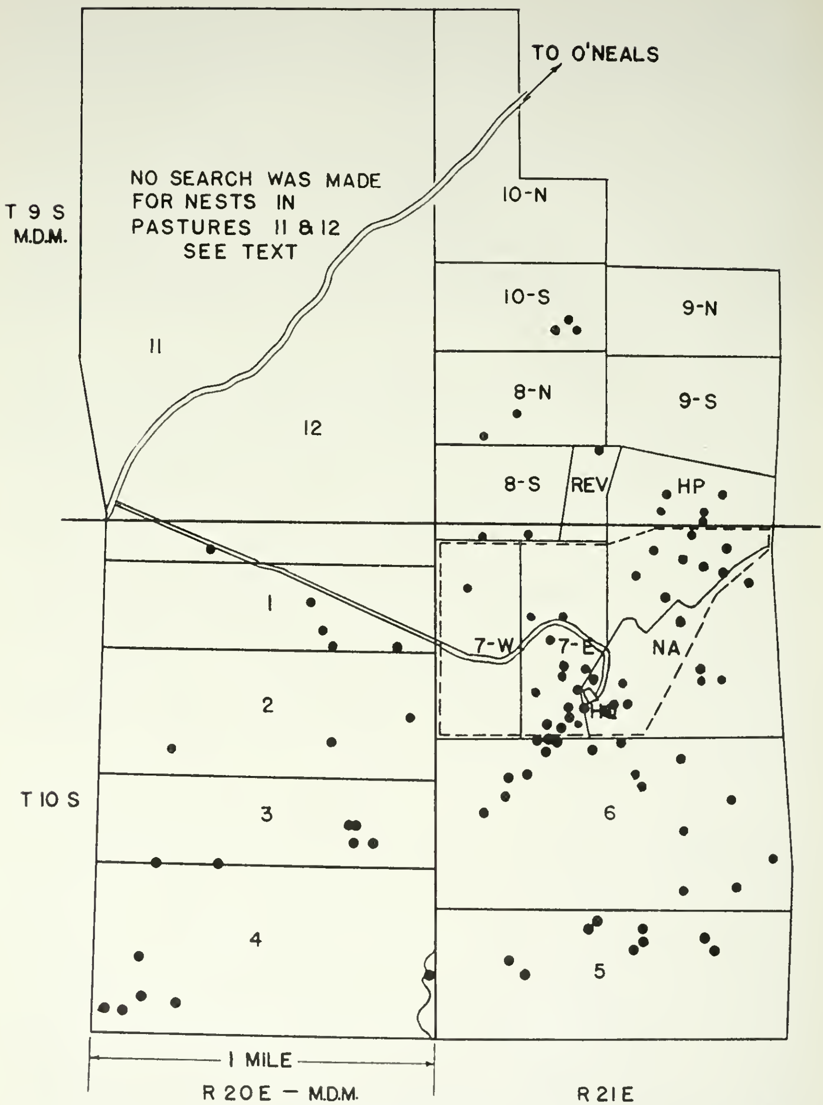

FIG. 101. Map of the San Joaquin Experimental Range, near O'Neals, Madera County, California, showing various pastures and other divisions, together with location of 93 nests of valley quail studied in 1937. Numbers refer to various pastures. HQ: headquarters building, NA: natural area, HP: horse pasture, Rev: revegetation area. The dotted lines bound the area on which ground squirrels were poisoned in 1936 and 1937.

seen during the loafing hours. These smaller groups usually recombined for the evening feeding period and for roosting. At this season the birds became very secretive, and it was increasingly difficult to make observations on the natural behavior of courtship and mating. The picture has been fitted together with occasional observations. By the last of April, coveys were largely broken into pairs; it was then a common thing to see a group of quail assembled for the evening feeding, cross a road, one pair at a time, the whole party taking as long as 10 minutes to cross. The first pair might be some 50 yards distant when the last cock and hen passed.

During April and May, frequent ''cows!'' (Sumner's call of an unmated cock) were heard. The low assembly call from a hen would bring several crowing cocks to her side. On one occasion, after one of these meetings, a pair was seen to go into a dense patch of *Ceanothus* and a loud series of ''whip-whips'' and clucking notes could be heard accompanied by scuffling in the leaves. This was interpreted as being an act of copulation.

Methods of Locating Nests

During this period of pairing, two men were constantly in the field, observing paired birds and looking for possible nests. The first definite attempt at nesting was noted on April 22. In the prenesting period, about 50 markers were placed at spots from which paired birds were flushed, in order to determine if these trysting places would be chosen as nesting sites. No nest was subsequently found in the immediate vicinity of any such marker.

In May, a crew of from four to six men was in the field daily, searching for nests. The method employed was to examine (theoretically at least) every foot of the ground in certain areas. Pastures 1, 3, 4, 6, the Natural Area and the Horse Pasture (see Fig. 101) were covered at least once by this crew, and 17 of the 50 nests found during May were so discovered. The remaining 33 were spotted either by investigators on observational hikes or by field workers engaged in other lines of endeavor.

Most of the nests were happened upon accidentally. Some were found by watching the actions of mated birds. A quail cock resting in an oak tree during the middle of the day was considered to be in the vicinity of a sitting hen, and several nests were found by searching the area about such a male. Search by individual observers was more profitable than mass effort. All nests located after June 1 were discovered by individuals, mostly by the writer and his assistant.

Long ropes were dragged between two men in the hopes of flushing incubating birds from their nests. This method was given a fair trial but proved almost useless due to the rocky and brushy nature of the country.

Period of Nesting

Ninety-six nests, including two just outside the Range fence, were found from April 22 to July 26, 1937, both dates inclusive.

The first (No. 1) was constructed by a cock thought to be the mate of a hen used as bait in a ''cock and hen'' trap. He abandoned this attempt after being watched for two days, when his mate escaped from the trap.

Nest No. 2 was found on April 23, while under construction; it was subsequently successful. The earliest nests can safely be said to have been started during the last half of April. This checks well with what could be predicted by figuring back from the appearance of the first broods. In 1937 the first brood seen in the field was noted on May 26.

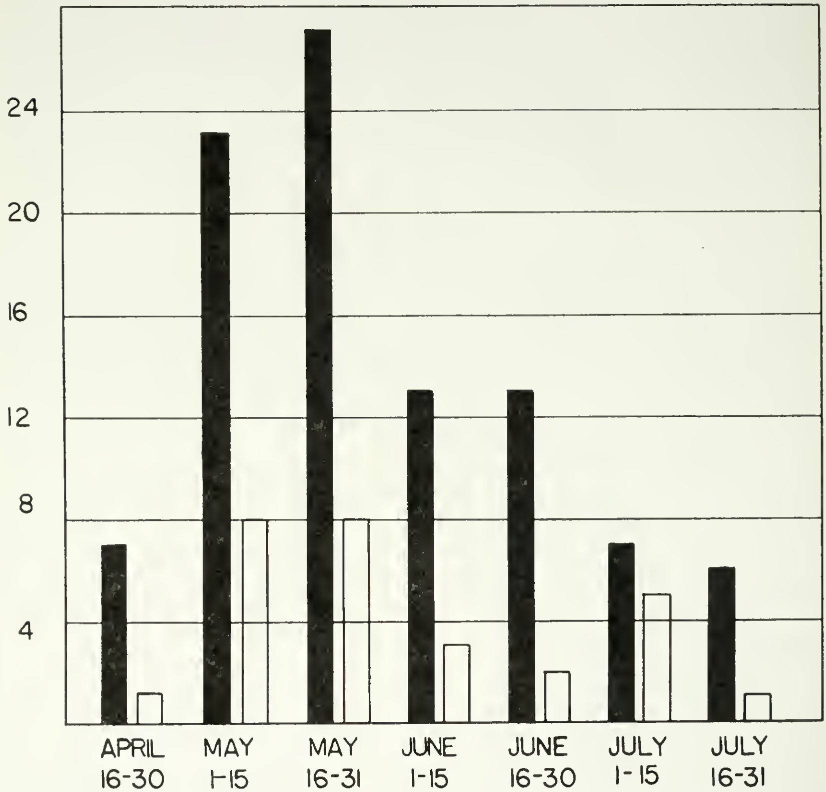

FIG. 102. Valley quail nests found (solid bars) on San Joaquin Experimental Range in 1937, by semi-monthly periods, together with numbers considered to have been robbed by ground squirrels (open bars).

Nesting reached a peak during May, according to the number of nests found during the several months: April, 7; May, 50; June, 26; July, 13.

In figure 102, the nests are grouped by semimonthly periods according to the dates when first seen. This grouping includes everything from those in early stages of construction to those from which broods had already hatched; the figure is an index of the nesting season as this term is commonly used.

There is a little evidence that some of the nests started during the latter part of the season were second attempts by birds that had had a previous nest either disturbed or destroyed. Nest No. 81 was accidentally destroyed by workmen who covered it with dirt on June 29. A pair of quail was observed about this spot several times during the next few days, and it was thought that they were making another attempt. A nest, No. 83, found on July 6, was about 15 yards from the site of No. 81, and then contained three eggs. Two other instances of parallel character were observed.

The last nest that came under observation, No. 93, was found on July 26, soon after having been destroyed by some unknown predator. Despite fairly active search during the ensuing fortnight and casual watch thereafter, no nests were found after this date.

Methods of Observation During Nesting Season

In view of Sumner's (1935) and other objections to detailed nesting studies of game birds, great care was exercised in this part of the study.

To get a rough check on the gross effect of nesting studies on the quail population, Pastures 11 and 12 (see Fig. 101) were left unstudied. This area had 629 quail (one bird per 1.74 acres) in February, 1937, compared with 1494 quail (one bird per 1.59 acres) on the remainder of the Range which was under observation for nests. In March, 1938, 500 quail (one per 2.19 acres) were counted on the unstudied area, and 1045 quail (one per 2.27 acres) were counted on the studied area. Other factors, such as moderate grazing over most of the studied area during the nesting season, as against light or no grazing on the control area may have affected the quail population on these areas to some degree; but the figures for 1938 do not demonstrate any disproportionate loss that could indisputably be said to have been caused by nesting studies.

Because of the possibility of upsetting natural conditions, great care was exercised in making observations. Most of the notes were made from daily visits on foot; the observer never approached closer than was necessary (30 inches or more) to see either the eggs or the sitting hen. If it was not possible to count the eggs without disturbing the cover, they were left until opportunity presented itself to make a proper check.

Nests located close to roads were ordinarily observed from an automobile. At several field nests a blind was used to obtain data on feeding and incubation periods of adults, time and other details about hatching, etc. The blind was always 30 feet or more from the nest.

No nest on the Range was touched by an investigator until permanently quitted by the attending quail; two on land adjacent to the Range were robbed for experiment.

Evidence that nesting studies present a fairly true picture of conditions as they existed naturally was obtained by comparing mortality figures of nests that were watched with those not watched (already destroyed or hatched when found). Table 1 summarizes information on these two groups of nests.

TABLE 1

Comparison of the Fates of Studied and Unstudied Nests

Fate	Nests observed while being attended by quail	Nests destroyed, abandoned or hatched when first seen	Total
Successful	14	3	17
Abandoned before laying	9	4	13
Abandoned after laying	3	2	5
Loss ascribed to ground squirrels	24	6	30
Loss ascribed to other predators	7	18	25
Destroyed by accident	4	2	6
Totals	61	35	96

With 61 observed nests versus 35 unobserved nests, there is a rough ratio of 2 to 1 for the two groups. The ratio of 14 to 3 for the successful nests would indicate that observation is not in itself prejudicial to success by the birds. It must be admitted, however, that nests from which young have already hatched are more difficult to find; hence the recorded ratio is probably inaccurate in this respect.

For abandoned nests, the ratio of 2 to 1 is fairly upheld although as noted below, field conditions have a very great influence on the figure.

Nests destroyed by predators show a 5 to 4 ratio. Depredations by ground squirrels (being difficult to find) are low with the "unobserved" nests, whereas work of the larger predators is high in the "unobserved" category, since their depredations are relatively easy to discover.

Details about all the 96 nests found in the summer of 1937 are given in table 2.

Nesting Materials and Construction

Dry grass (of the previous year in the case of early nests, of the current year in the case of later ones) comprised the lining of most nests. Dry willow leaves and various species of dried weeds were used in a few. In general nests were roofed, at least during the early part of incubation, by various types of vegetation, sometimes by overhanging rocks.

In the choice of nesting sites, it seems to be the custom for the female to take the lead, although the male undoubtedly assists, both in this activity and in the actual construction of the nest (*cf.* nest No. 1, discussed above). Hen No. 36702, evidently in search of a nesting site, was accidentally trapped on April 14. She was used for "bait" in a cock and hen trap and later escaped from this trap through a tunnel made by a ground squirrel in search of the grain inside of the hen's chamber. About a week later, she was found dead in the outer chamber of the same trap (unbaited) so it would seem that this particular hen had an unfortunate predilection for nesting at this site.

Paired birds disturbed while they are in the process of constructing a nest, even to the minor extent of being flushed because of an observer's presence 25 or 30 yards distant, in many cases will not return to that site. This happened with nests Nos. 4, 12, 13, 15, 37, 38 and 54. Whether the birds can not find their way back to the site or have a psychological aversion to the spot is a matter of conjecture.

TABLE 2

Valley Quail Nests on San Joaquin Experimental Range, 1937

Nest No.	Pasture No.	Date first seen	Located in cover type	Total eggs	Date of hatch	Number of young	Terminal date and cause of failure
1	7E	4/22	A				4/23—A.B.L.[1]
2	6	4/23	A	(7)	5/28	4	
3	7E	4/26	A				4/27—A.B.L.[2]
4	5	4/28	A				4/28—A.B.L.[2]
5	4	4/28	B	7			4/29?–Ground squirrel
6	8S	4/29	B	4			5/4?—Ground squirrel
7	6	4/30	B	?			? —Unknown
8	4	5/3	A	8			5/3?—A.A.L.[4]
9	4	5/4	B	?			? —Ground squirrel
10	7E	5/4	B	?			? —Ground squirrel
11	5	5/5	F	14			5/9?—Ground squirrel
12	8S	5/6	D				5/6?—A.B.L.[3]
13	6	5/7	B				5/7?—A.B.L.[3]
14	H.P.	5/7	D	14?			? —Skunk
15	7E	5/10	B				5/10—A.B.L.[2]
16	N.A.	5/11	A	1			? —A.A.L.[3]
16a	N.A.	5/13	A	(17)			5/17—House cat
17	N.A.	5/11	A	(13)			6/5?—Unknown
18	N.A.	5/11	A				5/11—A.B.L.[2]
19	H.P.	5/10	B	8			5/11—Ground squirrel
20	N.A.	5/11	A	10			5/12—Ground squirrel
21	7E	5/11	B	8?			? —House cat
22	N.A.	5/14	D	2			5/15?–Ground squirrel
23	6	5/13	B	12			5/15?–Ground squirrel
24	5	5/14	F	(16)			5/17 and 21—Ground squirrel
25	6	5/14	F	6			5/15?–Ground squirrel
26	6	5/14	A	(15)			5/22?–Coyote
27	5	5/13	C	(18)			5/18—Ground squirrel
28	5	5/13	A	(15)	6/18	13	
29	Near 11	5/12	A	(15)			5/20—Trampled by horse
29a	Near 11	5/25	C	(13)			5/25—Robbed for experiment
30	1	5/17	G	8			5/18?–Ground squirrel
31	1	5/17	D	10			5/25—Trampled by cow
32	6	5/19	F	(8)			5/20—Coyote
33	7E	5/20	B	?			? —Coyote
34	6	5/20	F	8			5/22?–Ground squirrel
35	6	5/20	D	5+			5/25—Ground squirrel
36	4	5/20	C	4			5/24—Ground squirrel
37	3	5/21	B				5/21—A.B.L.[3]
38	3	5/21	C				5/21?–A.B.L.[2]
39	3	5/21	A	3+			? —California jay
39a	3	5/21	A	?			? —California jay
40	4	5/21	C	15			5/22—Bobcat
41	H.P.	5/21	C	1			? —A.A.L.[3]
42	1	5/22	A	(11)	5/30?	11	
43	H.P.	5/22	C	1			? —A.A.L.[3]
44	4	5/22	A	?			? —Coyote
45	3	5/24	C	?			? —A.B.L.[5]
46	7E	5/24	B	(12)	6/16	12	
47	H.P.	5/24	B	5+			? —Bobcat
48	7E	5/25	A	(2+)			? —Coyote
49	3	5/25	F	(10)	?	10	
50	2	5/26	A	(9)	6/18	9	
51	6	5/26	A	(9)	6/13	8	
52	4	5/26	A				? —A.B.L.[2]
53	7W	5/26	A	?			? —Ground squirrel
54	6	5/28	C				? —A.B.L.[2]
55	H.P.	6/1	C	5+			? —House cat
56	H.P.	6/1	C				? —A.B.L.[6]
57	N.A.	6/1	A	(15)			6/4 —Ground squirrel
58	5	6/3	I	(12)			6/8 —Ground squirrel
59	6	6/4	A	?			? —Ground squirrel
60	5	6/4	D	(21)	6/10	18	
61	N.A.	6/7	D	?			? —Unknown
62	7E	6/8	B	(7)	6/13	7	
63	N.A.	6/9	A	(10)			6/23—Ground squirrel
64	H.P.	6/9	E	(12)			6/20—Unknown
65	H.P.	6/7	E	10+			? —House cat
66	7E	6/12	H	(9)	7/8	9	
67	2	6/14	G	(14)	6/22	14	
68	N.A.	6/16	A	?			? —House cat
69	5	6/16	B	?	?	?	
70	2	6/17	I	(9)	7/8	9	
71	5	6/17	D	(9)			6/23—Trampled by cow
72	7E	6/19	H	(13)	7/4	12	

TABLE 2—Continued

Valley Quail Nests on San Joaquin Experimental Range, 1937

Nest No.	Pasture No.	Date first seen	Located in cover type	Total eggs	Date of hatch	Number of young	Terminal date and cause of failure
73	1	6/25	J	(7)			7/6 —Ground squirrel
74	6	6/28	A	(10)			7/26—Ground squirrel
75	6	6/28	E	?			6/28—Ground squirrel
76	8N	6/28	C	(19)	7/4	11	
77	N.A.	6/29	A	(10)	7/2	10	
78	7E	6/29	C	(1)			7/12—Ground squirrel
79	7E	6/29	E	(9)			7/17—Ground squirrel
80	8N	7/1	B	(8)			7/10—Fox
81	10S	6/24	E	9+			6/29—Construction
82	10S	7/6	E	(13)			7/10—Ground squirrel
83	10S	7/6	E	3+			7/6 —Ground squirrel
84	N.A.	7/6	B	(3)			7/12—Ground squirrel
85	H.P.	7/9	E	6+			? —Skunk
86	H.P.	7/9	G	9			7/29—Skunk
87	12	7/12	K	7			7/14—A.A.L.[7]
88	7E	7/16	D	14			? —Skunk
89	7E	7/16	D	1+			? —Trampled by cow
90	8S	7/16	B	(6)	7/12	6	
91	N.A.	7/21	A	?			? —Ground squirrel
92	H.P.	7/26	A	8+			? —Unknown
93	H.P.	7/26	A	3+			? —Unknown

Figures in the fifth column "total eggs", surrounded by parentheses, indicate that the set reached some stage of incubation.

Letters used in the "cover type" column refer to types explained in the text below.

A.B.L.—Abandoned before laying.

A.A.L.—Abandoned after laying.

[1] Made by cock while hen was in nearby trap; abandoned when hen escaped.

[2] Cause of abandonment unknown.

[3] Abandoned because of disturbance by man.

[4] Hen killed by Cooper's hawk.

[5] Hen killed while constructing nest, by a house cat.

[6] Abandoned because of rodent disturbance.

[7] Abandoned because of automobile traffic.

Nesting Cover

Eleven different cover types were used. Following is a summary of these types and the numbers of nests found in each. (See Fig. 107.)

A. Dry grass or weeds; no other protection: 31 nests. The sites varied as to the amount of adjacent cover from those built in isolated clumps of grass or weeds surrounded by extensive areas of scant vegetation to others in large areas of rather tall, dense, dry grass. (See Fig. 103.)

B. Dry grass or weeds growing through fallen, dead brush: 19 nests. On some parts of the Range, there are many relics of *Ceanothus cuneatus* bushes destroyed by fire in 1929. These have for the most part fallen. This brush is very resistant to weathering and has remained in place to form the framework of small, though dense coverts used by birds and rodents. (See Fig. 105.)

C. Granite or quartz outcrops in dry situations: 13 nests. In addition to the main protection of rocks, some nests here had screens of scant vegetation.

D. Green vegetation in the bottoms of wet swales or close to streams: 10 nests. Spanish clover (*Lotus americanus*) and true clovers (*Trifolium* sp.) form the bulk of this vegetation.

E. Tarweed (*Hemizonia virgata*) and turkey mullein (*Eremocarpus setigerus*): 8 nests. These two weeds make most of their growth after other vegetation is dry, and remain green throughout the

Fig. 103. Typical nest of valley quail in dry grass (No. 63, cover type "A"); later robbed by ground squirrel. (Compare Fig. 104.)

Fig. 104. Same nest as in figure 103 after being robbed by Beechey ground squirrel. Note lack of disturbance of either roof or lining.

rest of the summer. They grow in greatest abundance in swales wet during the early growing season.

F. Deerweed (*Lotus scoparius*): 6 nests. This is a low, dense shrub about one to two feet high, occurring in clumps on the more rugged parts of the Range.

G. Under live shrubs other than deerweed: 3 nests. These were respectively under a young *Ceanothus cuneatus,* a *Rhamnus californica,* and a small *Salix* sp. In view of the abundanee of *Ceanothus* over the Range, it was surprising that other nests were not found associated with this shrub. The grass about the bases of this shrub on the Range is, however, fairly well eaten down by rabbits, and does not afford adequate nesting cover for quail.

H. Piles of scrap lumber: 2 nests.

I. Rocks close to running streams: 2 nests. This cover is really a combination of types C and D. (See Fig. 106.)

J. Niche or pocket in the bank of an eroded gully: 1 nest.

K. Straw pile: 1 nest. This nest was in rye straw scattered in a re-seeding attempt on the bank of a road cut.

Figure 107 shows also the numbers of nests, both successful and unsuccessful in each cover type. For some, the number of cases is too small to warrant any conclusions.

Nesting Habits

Eggs are deposited at the rate of approximately three every four days, varying with individual hens. The period between layings seems to be from 25 to 30 hours, judging from observations in about a dozen instances. As the hen is about to lay, both cock and hen go to the vicinity of the nest; the cock usually takes post in a nearby tree or tall shrub while the hen goes on the nest. A number of dropped eggs were found in the field.

During the period of incubation, approximately 22 days, the hen spends the hours from about 8 a.m. to 3:30 p.m on the nest. She feeds with her mate from about sunrise to 8 o'clock and again, in the afternoon, she joins him from the hour indicated until about dusk, when she once more returns to the nest. Presumably she spends the night on the nest with the cock roosting nearby. The time spent on the nest by the hen is, however, not narrowly fixed but seems to vary according to the temperature of the day. On very hot days, the hen is prone to return to the nest earlier in the morning and to leave later in the afternoon.

While the hen is on the eggs, the cock takes post in some inconspicuous place in a tree or tall shrub, at an average of 25 or 30 yards from the nest, depending on the proximity of such cover. At intervals during the day, he gives low assembly calls and conversational notes. In late afternoon, these calls become more frequent, ceasing as the hen leaves the nest and flies to the tree in which her mate is perched. The pair then usually indulges in several minutes of ''talking,'' after which they fly off to their feeding ground.

Sumner (1935, p. 202) has stated that cocks giving the explosive ''cow'' call are unmated. Experience on the Range, however, suggests that this note may be given by mated males. To quote from field notes of May 20, 1937, on nest No. 42:

FIG. 105. Typical open nest (No. 23, cover type "B") of valley quail in dry grass and weeds growing through dead and fallen brush. Such brush affords some mechanical protection to nests from grazing animals.

FIG. 106. Valley quail nest (No. 70, cover type "I") under a rock close to a stream. Once during incubation the stream was only three inches from the edge of the nest.

"3:25 p.m. Pair of birds seen to leave this spot (region of nest). Flew to north outside of rodent *ex*closure. Fed under blue oak. Cock flew up into blue oak and gave typical 'cow'—no other males about. Hen responded with assembly call and cock joined her."

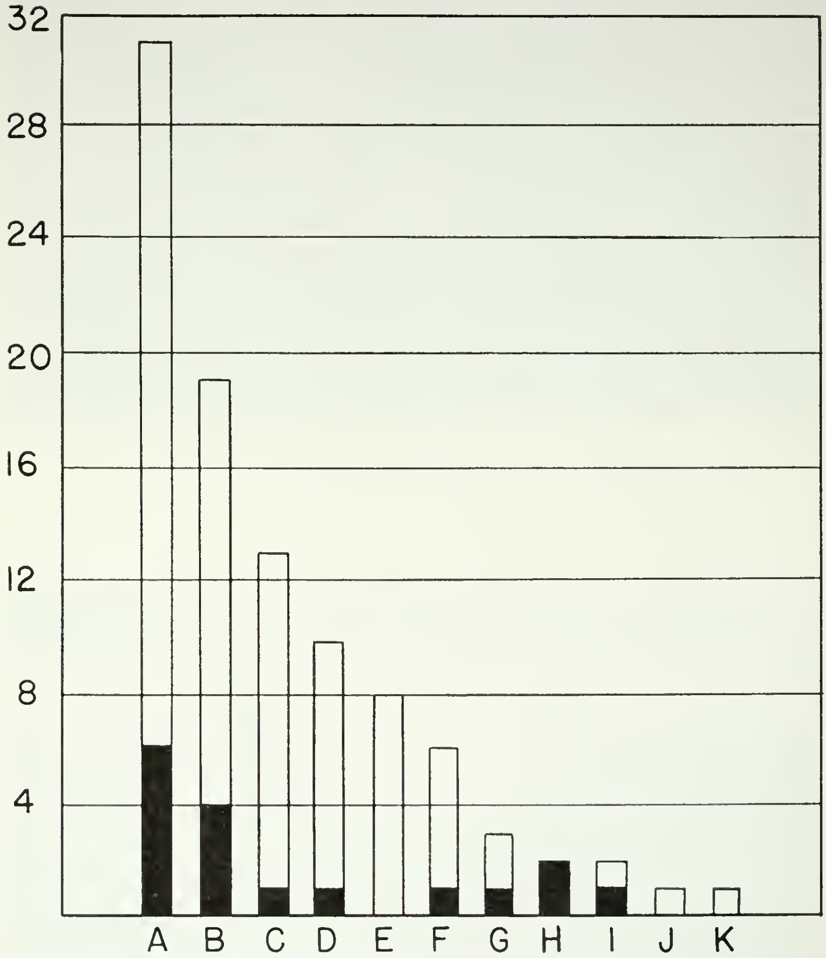

FIG. 107. Relative use of different cover types by valley quail in placing nests. Letters at bottom refer to cover types discussed in text (pp. 326-328). Black bars indicate successful nests; open bars, unsuccessful nests.

The eggs of this pair had been incubated since about May 7. Several other observations of crowing by obviously mated males led the writer to believe that the "cow" call is made by cocks desiring female companionship and not solely by unmated cocks.

As already indicated, the male is ordinarily in the vicinity of the nest during the period of incubation but there is no record in this study of a nest being incubated by a cock.

In 40 nests on the Range that had reached the stage of incubation an average of 10.97 eggs per clutch (limits of 1 and 21) was found. Grinnell, Bryant and Storer (1918, pp. 522-524) give the average clutch for California valley quail as 14.6 in an aggregation of records from the whole range of this subspecies within the State.

A decline in clutch size is evident at the Range toward the end of the nesting season. Thus, in 26 nests, May 1 to June 15, the average clutch was 12.2 eggs; in 15 nests, June 16 to July 15, the average was 8.5. (See Fig. 108.)

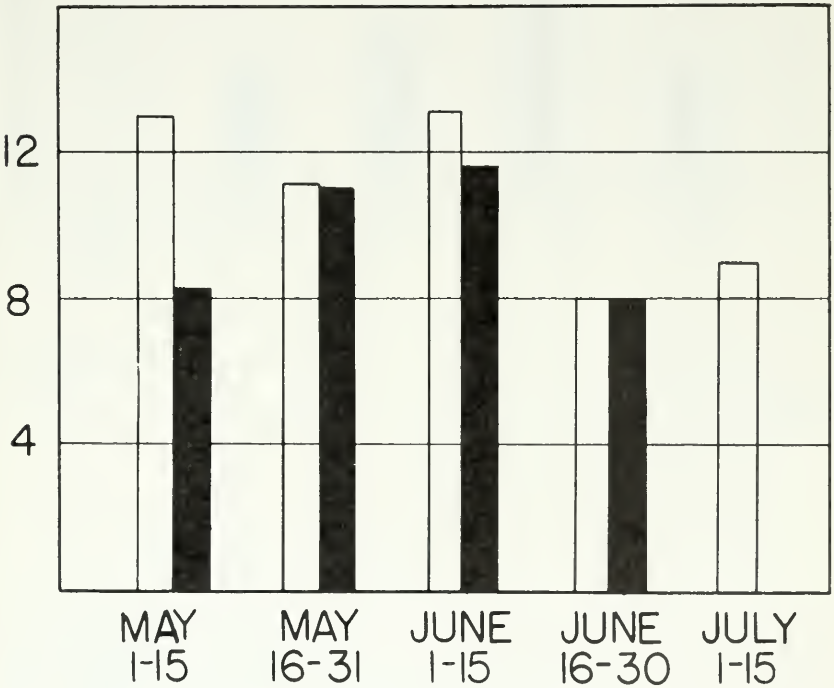

FIG. 108. Clutch size of all incubated nests and broods from successful nests of valley quail by semi-monthly periods in 1937. Open bar, average number of eggs; black bar, average number of young.

The number of nests in which incubation started in the several semimonthly periods, was as follows: May 1-15, 9 nests (3, or 33.3 per cent, successful); May 16-31, 10 nests (7, or 70 per cent, successful); June 1-15, 7 nests (4, or 57 per cent, successful); June 15-30, 8 nests (3, or 37 per cent, successful); and July 1-15, 7 nests (none successful). (See Fig. 109.)

The seasonal decline in percentage of successful nests and in clutch size, coupled with the premise that quail having a first attempt destroyed will renest, suggests that control of nesting predators, if undertaken, will give better results if done early in the season.

Hatching occurs about 22 days after the start of incubation as indicated by data from five successful nests where the date of start of incubation was known.

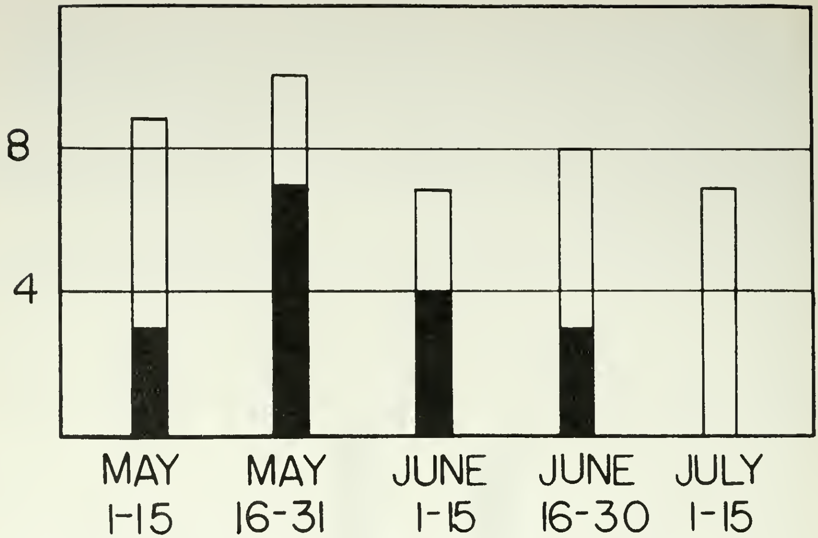

FIG. 109. Incubated and successful nests of valley quail in 1937. Black bar, successful nests; open bar, nests incubated, but not successful.

The behavior of the adults at hatching time may be illustrated by quoting from field notes on nest No. 2 of May 28, when the observer remained in a nearby blind throughout the day:

"8:45 a.m. Hen went on nest

"1:30 p.m. Hen still on nest

"2:00 p.m. Hen cast shell from nest

"2:20 p.m. More bits of shell cast out of nest by hen

"2:45 p.m. More bits of shell cast out of nest by hen

"3:45 p.m. Hen flew about 30 feet from the nest and walked back, calling as she came, uttering low, clucking notes. She was joined by four chicks. Group started feeding near nest. Male sat in blue oak over blind until hen and chicks got to taller grass about 150 feet away and then joined them.

"4:30 p.m. Observer left blind. Three eggs were left in the nest, making the total of seven recorded for the clutch. These three were later opened and found to be rotten."

The average number of young hatched in 16 nests throughout the season was 10.18 per nest (limits of 4 and 18). Evidence for these figures was derived by counting the number of pipped shells or by subtracting the number of unhatched eggs left from the known total clutch. For those in which incubation started during the first half of May, the brood averaged 8.3 birds per successful nest. Those in which brooding commenced in the latter half of May had a mean brood of 11.1. For the first half of June, the corresponding figure was 11.7 young, and for the latter half of June, 8.3 young per brood.

None of the nests in which incubation started in the month of July was successful.

Fate of Nests

In the total of 96 nests entered in table 2, every one happened upon is included, from those in the earliest recognizable stages of construction to those first seen when no longer attended by birds, by reason of abandonment, destruction or hatching. Due to the obvious impossibility of being present at all of the nests all of the time, it was necessary to establish criteria for determining the fate of those destroyed or hatched during the absence of an observer. (See Fig. 110.)

Successful

Successful nests were identified by finding egg shells showing the typical pipping ring. Young quail, like most birds, cut a neat ring about the larger end of the shell, leaving a cap that is either thrown off entirely or left hinged to the remainder of the shell by a bit of the shell membrane. A majority of the shells remaining in a successful nest will show a definite pip ring; some, however, are broken into small bits, evidently by the hen pecking at them after the young have emerged.

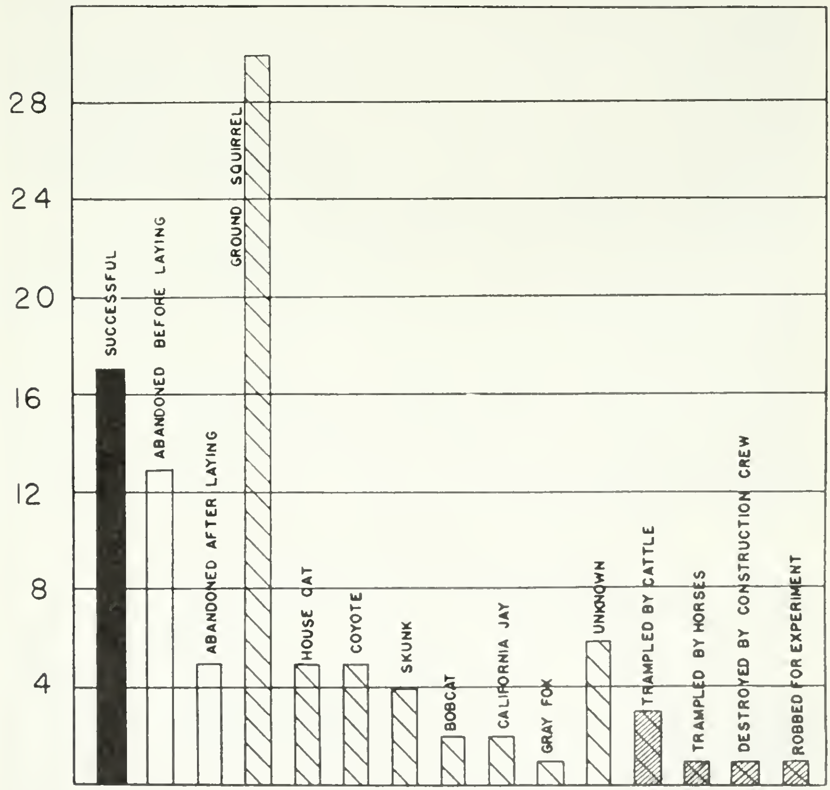

FIG. 110. Fate of 96 valley quail nests at San Joaquin Experimental Range in 1937.

Seventeen of the total nests found in the course of the 1937 study were successful. This figure can not be considered as a reliable index of the percentage of successful nests in the foothill region as a whole. It is recognized that nesting studies even at best are liable to introduce additional factors not present in the strictly unmolested natural condition. In addition, the possibility that pairs unsuccessful at first will make additional attempts at nesting, as suggested above, some of which might be successful, would make the percentage of pairs eventually producing broods greater than the figure cited above. This point has been considered in detail in respect to the ring-necked pheasant in the Midwest by Errington and Hamerstrom (1937).

Abandoned

Nests listed as abandoned before laying were those where birds had been observed in the process of nest building, but not attended by quail on later visits by the observer. Only two nests, Nos. 2 and 83, observed during the process of construction were later found to have eggs deposited in them. Quail seem to exhibit practically no sense of nest ownership until eggs have been laid. During construction, a pair will abandon the nest at the slightest disturbance, but show increasing reluctance to do so as the number of eggs in the clutch mounts, as indicated beyond.

Thirteen nests were abandoned before eggs had been deposited in them. This figure in itself is probably not significant for two reasons: first, the short period in which it is possible to observe such nests indicates that in all probability there are relatively more abandoned nests than were actually found; and second, the observer's presence is undoubtedly a factor in causing abandonment, which fact alone would make the observed percentage too high.

Abandonment of a nesting site before eggs are laid is not considered to be serious, since another site will probably be chosen in which to deposit the eggs. This type of nesting failure is here included merely for completeness of record and to show the presence of this trait among quail.

Five nests were abandoned after eggs had been deposited. Three of these (Nos. 16, 41 and 43) contained only one egg each. Nest No. 8, which had contained eight eggs, was left unattended after the hen had been killed by a Cooper's hawk. The fifth nest, No. 87, with seven eggs was presumably abandoned because it was located too close to a well traveled motor road.

TABLE 3

Summary of the Causes of Nest Abandonment

Abandoned before laying		Abandoned after laying		
Cause assigned	No. of cases	Cause assigned	No. of cases	No. of eggs
Disturbance by man	7	Hen killed by Cooper's hawk	1	8
House cat	1	Automobile traffic	1	7
Disturbance by rodent	1	Unknown	3	1 each
Cock's nest (mate died)	1			
Unknown	3			
Total	13	Total	5	---------

Destroyed by predators

In attempting to determine what species of animal is responsible for destruction of a nest, where this occurs in the absence of an observer, reliance must be placed on "sign" in the form of droppings, hair, tracks or characteristic manner of nest destruction and egg eating.

Beechey ground squirrel—Perhaps the most difficult predator on which to obtain evidence is the Beechey ground squirrel (*Citellus beecheyi beecheyi*), most serious of all nest destroyers in the foothill regions. The evidence against the ground squirrel may be listed under several categories.

Early in the season a number of nests were found to have been neatly robbed by some small predator that left no definite "sign." Because of the abundance of ground squirrels (estimated population of 10 per acre) on the Range and the verbal suggestion by E. E. Horn that these animals elsewhere had been considered to play an important role with quail, it was deemed desirable to set up some experiment to determine the part the ground squirrel might play in respect to quail nests. (Gorsuch, 1934, pp. 68-69.)

Accordingly, on May 3, 1937, seven valley quail eggs taken from a nest, the hen of which had been killed by a Cooper's hawk, were placed in a man-made nest in a half-acre permanently fenced ground squirrel *en*closure. Boiled canvas gloves were used to handle the eggs and to make the nest in an effort to avoid contamination with human scent; the observer's feet came no closer than 30 inches to the "nest". The "nest" was located in a natural setting, about 10 yards from the main burrow of the ground squirrels resident in the enclosure. It was roofed with a standing clump of red brome (*Bromus rubens*) and lined with red brome and soft-chess brome. At 1 p.m. the eggs were placed in the nest. The whole enclosure had been recently gone over by men taking plant samples, so that any chance that the rodents would track the observer to the immediate spot was slight. The nest was then observed from a blind until 2:30 p.m., during which time only two squirrels were noted to come out of the burrows. At this time, they did not forage about. At 4:30 p.m. the observer returned and found that the nest had been neatly robbed. The improvised roof and lining were entirely undisturbed.

The next day, a quail egg was found cast up on the earth about the opening of one of the squirrel burrows. Examination on succeeding days revealed many small pieces of shells cast up about the mouths of the burrows, sufficient to represent four eggs.

The experiment was repeated some weeks later, and a squirrel was seen to enter the artificial nest cautiously, grasp an egg with its incisor teeth, and run to its burrow. This was late in the day. Next morning the remaining eggs were gone. In this case also the nest was undisturbed save for the removal of the eggs.

The counterpart of this performance under natural conditions was observed on nest No. 24 by John T. Emlen (Emlen and Glading, 1938). This nest was farther from the squirrel's burrow than the experimental one, which may account for the difference in behavior in that the squirrel retired only a short distance from the nest to eat the egg, instead of taking it to the burrow. This nest was attended by an incubating hen, but such was not the case in the experimental nest.

The evidence obtained from the experimental nests and from Emlen's observation led to ascribing robberies without significant signs of disturbance to *Citellus b. beecheyi.* The conclusion is tentative since it is possible that snakes or other animals may have been responsible for some of these robberies. Snakes known to steal eggs are relatively scarce on the Range, and certain nests were robbed in short order, so it is felt that snakes can be only a minor factor locally in this type of predation. The only snakes present which are potential nest robbers are the gopher snake (*Pituophis catenifer heermanni*), the king snake (*Lampropeltis getulus boylii*) and the striped racer (*Coluber lateralis*), all of which are relatively uncommon locally. That the Pacific rattlesnake (*Crotalus viridis oreganus*) does not regularly include quail eggs in its diet is illustrated by an instance connected with nest No. 80. A rattlesnake was found resting in the nest on the full clutch of eggs. When first seen, the snake was relaxed as if sleeping. It was killed, in the supposition that it had had a full meal of eggs, but the stomach was entirely empty. Bent (1932) reports a parallel case with the scaled quail that is commented on by Gorsuch (1934). In view of all these considerations, nests that were neatly plundered, with the lining and roof left intact, were ascribed to the ground squirrel. In a few cases, this diagnosis was at least partially substantiated by the finding of quail egg shells at nearby ground squirrel workings or on lookout rocks used by the squirrels.

Further evidence against the ground squirrel as an important nest destroyer was the finding of quail egg shells about the mouths of squirrel burrows in the field in five different places apart from any quail nests here recorded. In yet another place an egg shell of the western mourning dove was discovered on a squirrel's "door-step."

Thirty (31.25 per cent) of the 96 nests seen in 1937 were considered to have been raided by this predator.

Evidence of a different sort, to support the contention that this ground squirrel is a major predator of quail nests, was obtained in rodent *ex*closures at the Range. These *ex*closures are each 50 feet by 50 feet and are surrounded with a 3-foot hardware cloth fence, topped by a galvanized sheet metal overhang; they are used to help determine the effect of rodents on the foothill ranges and are practically squirrel-proof. The plant cover within these *ex*closures is heavier, due to absence of cattle and rodents. This probably accounts for the apparent preference of quail for these sites. Eight of the 96 nests were found inside of such rodent *ex*closures, and of these, five nests were successful. Of the remaining three, one was abandoned before eggs were laid in it, and the other two were destroyed by California jays. The 62 per cent (5 out of 8) success within these plots compared with the 13 per cent (12 out of 89) success on the balance of the Range supports the contention that rodents affect the nesting success in quail.

Additional evidence on the relation of ground squirrels to quail was obtained from the results of a small rodent control campaign carried on in the headquarters area (HQ)—about 300 acres—to reduce the squirrels as a public health measure. This area was treated with strychnine-coated barley during May, 1936, and again in May, 1937.

Censuses of quail here were taken both before and after control was applied. In February, 1936, 90 quail were counted in 3 coveys. In February, 1937, 9 months after the first application of poison, 229 quail were recorded. In August, 1937, after the second poisoning, 420 birds were seen.

In a second area of approximately 350 acres (adjacent to the poisoned area but not so treated) the February, 1936 census was 90 birds; that of February, 1937 was 135 birds; and that of August, 1937, 299 birds. By way of comparison, the original 3600 acres of the Range had 1662 quail in February, 1936, and 2123 in February, 1937, an increase of 29 per cent. The 350 acres not poisoned showed a 50 per cent increase for the same period, whereas the poisoned area had an increase of 154 per cent! Increased population in the non-poisoned "control" area may have been due to overflow from the poisoned area adjacent.

A census in March, 1938, gave 1545 quail on the 3600 acres of the original Range, 90 on the control area, and 220 for the poisoned area. (See Table 4.)

TABLE 4

Comparisons of Quail Populations on Poisoned and Non-Poisoned Lands

	February, 1936		February, 1937		August, 1937		March, 1938	
	Poisoned area	Control area	Poisoned area	Control area	Poisoned area	Control area	Poisoned area	Control area
Quail	90	90	229	135	420	299	220	90

Future plans call for a more extensive study of the importance of ground squirrels as nest predators and on the use of ground squirrel poisoning as a game management tool.

House cat—House cats have been responsible for a number of nest failures. They have a fairly characteristic way of cracking the eggs and removing the contents. (Compare Stoddard, 1931, p. 190, pl. 36.) The egg shells are crushed into two or three pieces and the contents are licked out. Shells are found mostly within two or three feet of the nest. The nest is usually torn up to some extent and often the remains of the incubating hen are to be found nearby, with feathers scattered in a characteristic fashion. Instances of house cat destruction can usually be substantiated by finding tracks of these animals about the nests.

Feral house cats accounted for five of the nest failures. Observations made during the investigation indicate that the wild house cat is an abundant and bothersome pest locally, even in areas distant from human habitation. An instance illustrating the abundance of wild house cats on the Range was obtained in an effort to get rid of cats around headquarters. A group of seven house cats was harbored by a cat enthusiast in the Civilian Conservation Corps camp. It was decided to trap and kill these "subrosa." An intensive campaign was carried on, and in about a week seven cats were killed. An investigator surreptitiously looked into the original source and to his consternation found seven cats alive and healthy!

Coyote—Nests that had been roughly destroyed, with small bits of well-chewed eggs scattered about, were attributed to the coyote. This type of damage is very similar to that described by Stoddard for dogs. Roaming dogs are not common on the Range, and some of the coyote diagnoses were verified by tracks, so that all nests found so destroyed were attributed to the coyote.

Five losses were ascribed to coyotes.

Skunk—The egg-eating habits of skunks are very well outlined by Stoddard. Several nests at the Range were found that exhibited every detail of destruction as outlined by Stoddard (1931, p. 186, pl. 35, fig. 2). The shells are for the most part merely smashed in on one side and have the contents neatly licked out; the relics are left in or near the nest. The hen may or may not be killed. (See Fig. 111.)

FIG. 111. Nest (No. 14) of valley quail robbed by skunk. Each egg is crushed in on one side and the contents sucked out; the shell is usually in one piece. Feathers of the killed hen are in the background.

Skunks were responsible for four (4.16 per cent) nest robberies and the death of one hen.

Bobcat—The bobcat destroys a nest in much the same manner as the house cat, only it scatters nesting materials about more widely. Two nests were lost to bobcats, tracks being found in the vicinity of both.

Gray fox—The gray fox has been a suspect in the matter of nest robbing. Thought to be typical of fox work was nest No. 80, which was destroyed on July 10. To quote from field notes of that day:

"7-10-37. 10:00 a.m. Nest visited—found robbed, not badly disturbed, but lining partly scattered and some small shell fragments scattered about * * *. A few small, dog-like tracks [these were later checked and found to be fox] were found in the dust around the nest * * *. The fact that no quail feathers were found indicated that the hen probably flushed, and did not put up a struggle, nor was she killed.''

Nest No. 80 was the only one definitely attributed to the gray fox, but it is felt that some of the earlier nests listed as ''destroyed—predator unknown'' could possibly have been lost to the gray fox. Foxes are fairly abundant on the Range and in the vicinity. Field workers report them frequently from various parts of the Range, and it is not uncommon to see them at night while driving along little used motor roads.

California jay—Destruction by the California jay was diagnosed by finding bill marks on the egg shells. These shells still contained some of the yolk and white, in contrast to those destroyed by mammals, which were licked clean. Two robberies blamed on the jay were of nests located within a rodent *ex*closure.

Two nests (Nos. 39 and 39a) about five yards apart, presumed to be successive nests of the same pair, were robbed by the California jay. Since the jay has such a characteristic manner of destroying nests, it is certain that additional predation by this bird was not overlooked in the study.

Unknown predators—Six nests were destroyed by unknown predators, all presumably mammals, judging from ''sign'' found at the nests. These nests probably could all be ascribed to cats, dogs, coyotes, foxes, bobcats, or raccoons, but the evidence was inadequate for positive identification.

Miscellaneous Losses

Six nests were listed as destroyed accidentally or otherwise. Instances of destruction by cattle and horses were identified by tracks of the animals up to and on the nest. Nests in this category contained merely an ''omelet'' of smashed quail eggs. Three were trampled by cattle. It is significant that all of these were in patches of green vegetation in swales or by streams (cover type ''D''), places frequented by cattle in search of succulent vegetation on an otherwise arid range. No correlation was found between intensity of grazing and destruction of nests by cattle. It is believed that nests located in this succulent forage are always in danger of being trampled due to the thoroughness with which these places are grazed, regardless of the intensity of grazing over a pasture as a whole.

One nest, No. 29, was trampled by a horse, and while only a few eggs were smashed, the hen abandoned the nest.

A construction crew inadvertently threw dirt on nest No. 81.

Nest No. 29a from without the Range was robbed to supply eggs for the second experimental nest used in the rodent enclosure. It was not located on the Range proper, and is here included only for completeness of record in compiling cover, size of clutch and other data.

Summary and Conclusions

1. The nesting cycle of the valley quail in the foothills of the Sierra Nevada is considered to be an important phase of the game management problem of this species in California.

2. In a study on the San Joaquin Experimental Range of the U. S. Forest Service in Madera County, California, during 1937, a total of 96 nests of valley quail was found.

3. Courtship and nesting behavior are outlined.

4. The maximum number of nests was found in the month of May.

5. The average clutch size in 40 incubated nests was 10.97 eggs. The average brood size in 16 hatched nests was 10.18 young.

6. A wide range was exhibited as to choice of nesting cover, with dry grass being used most commonly, both as cover and as lining for the nests.

7. Methods of identifying the work of nest predators are given.

8. Seventeen of the 96 nests were successful.

9. Ground squirrels are inferred to have robbed 30 of the 96 nests.

10. An increase of quail has followed reduction of ground squirrels by poison on a 300-acre area for two years.

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EIGHTH ANNUAL BLACK BRANT CENSUS IN CALIFORNIA[1]

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Due to the writer's absence in the East, the 1938 black brant (*Branta bernicla nigricans*) census was supervised by Dr. R. T. Orr, Assistant Curator of Birds and Mammals, California Academy of Sciences. Dr. Orr counted the birds on Tomales Bay and the usual cooperators, mentioned beyond, at other points. Violent storms at census taking time in some cases considerably complicated securing accurate counts. Nevertheless, all save the Tomales Bay one are judged to be complete and as satisfactory as conditions permitted. Special thanks are due the cooperators this year for venturing forth in such disagreeable weather.

Humboldt Bay

Captain J. D. Dondero of the California Division of Fish and Game counted the brant on Humboldt Bay from car, foot and row boat, February 10, 1938. He secured a fair census totaling 45,000 birds. Some local residents then claimed more brant and ducks present than for many years. The brant were still arriving at Humboldt Bay at census taking time. Captain Dondero advised that at 6 p.m., February 13, when at the lighthouse, he saw two flocks of about 500 birds come from the south and alight on South Humboldt Bay.

Later, under date of March 13, 1938, Captain Dondero made the following report:

"More than 100,000 black sea brant on Humboldt Bay. Feed must be getting short as these birds are going out in the open fields feeding on green grasses, something that the old timers say they have never seen the brant do before."

Bodega Bay

Due to the absence of Dr. J. M. Linsdale, usual cooperator for this area, Game Warden Bert Laws counted the brant on Bodega Bay (Lagoon) from 10:30 a.m. to noon, February 12, 1938. The tide was falling (high, 8:43 a.m., 6.2 ft.; low, 3:41 p.m., — 0.7 ft.) and the Bay was choppy from a fresh southwest wind. Brant were found scattered over the open water except in the southeast corner of the Bay where 425 were on shore. Counting from land with binoculars, Laws totaled 1475 brant.

Tomales Bay

Dr. Orr's report of the census made by him at this Bay, February 12, 1938, is quoted below. Tides on Tomales Bay were essentially the same as noted above for Bodega Bay.

[1] Submitted for publication, August, 1938.

"Arrived at Pt. Reyes Station about 8:55 a.m. The day was exceedingly stormy with heavy rain falling in the lowlands and snow on Mt. Tamalpais. High tide around 9:00 a.m. No brant were seen until I was midway between Marshall's and Hamlet, then a few were noted along shore. Close to Hamlet 20 were seen. Inspection of the Bay with a 20x telescope between successive downfalls of rain showed most of the brant to be one-half to one mile north of Hog Island. Large numbers were seen moving about, mixed in with thousands of cormorants, ducks and gulls. Weather conditions and the tendency of the birds to move about made any count impossible so I waited until afternoon and low tide. By 1:00 p.m. the brant began concentrating just north of Hog Island and by 1:30 p.m. it was possible to take a count because the majority of the brant were in a long line stretching from just north of Hog Island to a point about one and one-half miles north. Several counts showed approximately 2600 brant in the one raft. They were fairly easy to count, even though far away, because there were practically no cormorants or scoters mixed with them. This group gradually moved south on the west side of the island, came around the south side of the latter and then worked north on the east side. There were probably several hundred more that were overlooked. At this same time a group of 273 was seen feeding on the mud flats between Hamlet and Preston Point. About one dozen individuals were also seen close to shore just south of Hamlet. It was impossible to determine what brant, if any, were present between Tom's Point and the ocean, as 17 days of rain had made it impossible to use any of the dirt roads leading west from the highway to the Bay. In all about 3085 black brant were estimated to be in the Bay south of Tom's Point."

Drake's Bay

Game Warden R. J. Yates took the brant census on this Bay, also known as Limantour Bay and Drake's Estero, February 12, 1938. Tidal and weather conditions were similar to those reported for Bodega and Tomales bays. He concluded 3500 brant were present and commented as follows:

"The storm had driven the birds all to the upper end, there being less than one hundred birds at the mouth of the Bay, so I feel that this estimate is very close as it is seldom that we can find the birds in one area."

Morro Bay

Game Warden F. W. Hecker and Dr. A. P. Marshall undertook the annual brant census at Morro Bay on February 12, 1938. The tides were: high, 8:35 a.m., 6.4 ft.; low, 3:38 p.m.,—0.5 ft. Mr. Hecker's report is quoted as follows:

"This year's brant census was made by Dr. A. P. Marshall and myself, and due to the position of the birds at the time it was necessary to make the count from shore. The greater part of the birds were feeding in the salt-grass flats within the boundaries of the State Park refuge. This is the first time that either of us ever saw any number of brant in that area or saw any of them feeding in the salt grass. This may be due to the fact that the flats were recently flooded by heavy storms. We were unable to determine what they were feeding upon.

"The total count was 5738 brant. Two weeks ago there were conservatively 10,000 brant on the Bay, but about half of them left during the heavy storms earlier in the week.

"During the time we were counting the brant we saw a duck hawk strike and bring down a brant in flight, either breaking or cutting its right wing so badly that it was unable to fly. This is the largest bird we have ever seen a duck hawk bring down."

Mission and San Diego Bays

Game Warden E. H. Glidden's report is quoted for this area. Mr. L. M. Huey, who for the sixth time cooperated this year, also provided a detailed report of the count, for which and his continued interest in the censuses, special thanks are due. Mr. Glidden's account follows:

"February 12, 1938, assisted by Mr. L. M. Huey, San Diego Natural History Museum, and Mr. Earl Warren, President of local chapter of the Izaac Walton League, the brant census was taken on San Diego and Mission bays from 9:00 a.m. to 5:00 p.m. The tides on that date were: high at 7:12 a.m., 7.0 ft.; low, 2:07 p.m.,—1.6 ft. The count as follows by actual count:

San Diego Bay (Cottonseed Point)	397
Mission Bay east of Causeway	104
Mission Bay west of Causeway	221
Total	722

"Birds feeding on mud flats. Many birds in immature plumage.

"Believe increase of birds during past few years may be attributed to an earlier closed season and better food conditions as floods during 1927 deposited an untold amount of silt in bays, which covered many acres of their principal food (eel grass) which is now coming up in sections formerly silted over.

"A preliminary census was taken on February 11, 1938, which disclosed 142 birds on San Diego Bay and 253 on Mission Bay. At that time visibility was exceptionally poor due to rain and winds.

"February 12 saw clear skies with exceptionally good visibility."

TABLE 1

Recapitulation of the California Black Brant Census, 1931-1938

Locality	1931	1932	1933	1934	1935	1936	1937	1938
Humboldt Bay	Unsatisfactory	29,415	5,000	16,860	115,000	50,000	22,500	45,000
Bodega Bay	None made	3,200	977	1,298	3,700	350	1,500	1,475
Tomales Bay	9,445	6,285	7,409	5,565	6,850	9,175	1,556	3,085
Drakes Bay	None made	2,108	318	2,189	1,995	1,500	1,500	3,500
Morro Bay	4,493	2,938	None made	3,895	7,544	5,000	5,331	5,738
Mission Bay	71	No birds	115	154	9	30	450	325
San Diego Bay	No birds	No birds	No birds	7	55	No birds	350	397
Totals	Incomplete	43,946	13,819	29,968	135,153	66,055	33,187	59,520

Remarks on the 1937-38 Brant Flight

As usual, maximum seasonal brant concentration was not reached on Humboldt Bay until about a month after census taking. This year seems to have been a "good" one for the birds there, the census figure being exceeded only by counts of 1936, 1935 and the large, but unsatisfactory one of 1931. These occasional large assemblages of the birds on Humboldt Bay are difficult to reconcile with other factors. This season, counts elsewhere save Tomales Bay, where possibly all the birds present were not tallied, are about normal as has been the case in other years of heavy concentration on Humboldt Bay. It has been shown (California Fish and Game, vol. 21, 1935, p. 344) that large numbers of brant do not only occur in heavy winters, for that of 1930-31 was a light one. Furthermore, all data point to the fact that the brant that arrive at Humboldt Bay in numbers from January onward, come from the south (California Fish and Game, vol. 18, 1932, pp. 304, 306; vol. 21, 1935, p. 344), just as Captain Dondero reports them to have arrived on February 13 of this year. If bad weather were a factor accounting for large local concentrations, we would not expect them to be forced north by it in mid-February, yet this appears to be exactly what happens. The explanation appears to be that the birds first visit Lower California bays in autumn and leave them in mid-winter, probably as feed becomes depleted, then take advantage of southerly winds for their northward flights.

First arrivals of black brant at Tomales Bay in autumn have been recorded in previous census reports in *California Fish and Game* as follows:

1927, November 17, "several hundred"	(vol. 17, 1931, p. 397)
1931, November 8, 100 birds	(vol. 18, 1932, p. 305)
1932, November 16, 175 birds	(vol. 19, 1933, p. 259)
1933, October 19, "a few birds"	(vol. 20, 1934, p. 357)
1933, October 25, "several hundred"	(vol. 20, 1934, p. 357)
1936, November 15. "large numbers"	(vol. 23, 1937, p. 293)

Mr. Leonard Penhale, Department of Exhibits, California Academy of Sciences, happened to be at Tomales Bay on November 10, 1937, where he witnessed arrival of the first seasonal visitors. According to him, the birds came from the north in groups of about 50 each, commencing about noon and continuing through the afternoon until about 10 flocks or a total of 500 brant were present by evening. Local residents informed him that they were the first brant noted that autumn. The date appears to be about average for the locality, disregarding the exceptionally early flight of 1933. It should be noted that these birds came from the north, as it is believed do other autumn-arriving brant along the California coast. It is not until January that wintering flocks are augmented by returning migrants from the south.

Bodega, Tomales and Drake's bay populations should be considered collectively because of apparent interchange of brant. The 1938 total for the three bays, 8155, is nearly double the extremely low one of 4556 for 1937, yet behind the 1932-36 five-year average of 10,584. The aggregate population of these bays, also of other California ones save Humboldt, appears to run rather uniform from year to year. It suggests that the same birds, probably about all the food supplies can accommodate, return to the bays season after season. Occasional large concentrations on Humboldt Bay may be explained by the fact that it supports by far more brant food (eel grass) than do other California bays, that its usual quota of brant is below its carrying capacity, hence when feed becomes scarce elsewhere (Lower California, most likely) it is there that the birds come.

Brant seemed to linger in California later than usual in the spring of this year. Commander H. E. Parmenter (Gull, vol. 20, 1938, p. 27) recorded 175 birds present at Tomales Bay, May 18, and 500 on the 26th. He thought that the bulk of them left between then and June 1, when only 11 individuals were found. Eighteen were seen there on June 6. Several other reports reached me of observations of small flocks along our coast in mid-May. Two brant able to fly, thought to be laggard immatures, were found on Tomales Bay, July 21, 1938. The fact that these birds could fly indicates that the seasonal moult is late in this, as in other far northern breeding species of geese.

Attention is directed to Captain Dondero's remarks that in March brant were feeding on upland grasses about Humboldt Bay. His supposition that shortage of aquatic feed was the cause is probably correct. Mr. Hecker's report of the Morro Bay birds feeding in salt grass showed that the departure from normal habits was not confined to Humboldt Bay. J. E. Cushing, Jr., advised me that during the winter at Tomales Bay, brant were observed feeding on algae on mud flats at the head of the bay where they were theretofore unrecorded; also, that Mr. Nick Kojick of Blakes Landing, a reliable observer, had seen them feeding in grass fields in that vicinity. All these reports coming for the first time in one winter caused concern over the status of the brant's principal winter food, eel grass, and fear that the parasite that has wreaked such havoc among Atlantic Ocean *Zostera* and incidentally brant, may have reached the Pacific Coast. We were fortunate to have Dr. Clarence Cottam, in charge, Food Habits, Division of Wildlife Research, Bureau of Biological Survey, with us in July. He has been studying the disease of Atlantic Coast eel grass for several years. Dr. Cottam was so kind as to visit Tomales Bay with me on July 21, 1938, when we found the eel grass to be in excellent condition. Dr. Cottam considered it healthy indeed and could find no reason for concern.

Mr. Glidden's suggestion that reestablishment of eel grass in silted beds of San Diego Bay may in part account for the repopulation of the bay by brant is a likely one. The censuses show a gratifying increase in number of birds visiting the locality, though not quite so many this season as last. Both Mr. Glidden and Mr. Huey, in their separate reports, commented upon the large proportion of brant in immature plumage, seemingly indicative of a successful breeding season last summer.

A report of brant observed in Lower California, Mexico, waters in March, 1938, by D. H. Fry, Jr., is presented in the next article.

Summary

In point of total numbers, the 1938 census of black brant in California is about average for the eight seasons in which counts have been made. Humboldt, our most important brant bay, had more than usual numbers present at census-taking time and a tremendous concentration a month later. Here, the 1938 figures exactly doubled the previous year's, one of light visitation. The aggregate total for Bodega, Tomales and Drake's bays was somewhat under the 1932-36 average for the region, but an incomplete census was probably obtained at Tomales Bay this year and the deficiency might make up the differ-

ence. The Morro Bay 1938 result is close to counts obtained the previous two seasons, but twice as many birds were reported present two weeks before census taking. While somewhat lower than in 1937, the Mission-San Diego Bay aggregate of 722 brant indicates that numbers of the birds have become reestablished there after years of absence.

BRANT CENSUS OF SAN QUENTIN BAY, LOWER CALIFORNIA [1]

By DONALD H. FRY, JR.
California State Fisheries Laboratory
Division of Fish and Game

Early in the spring of 1938 the California Division of Fish and Game boat *Bluefin* made one of its many fisheries research trips into Lower California waters.

On March 20, bad weather forced us to run for cover and we anchored under Cape San Quentín. The following morning, it was still

FIG. 112. Brant over the west arm of San Quentín Bay, Lower California. This scene is a typical one: rocky shoals, sand dunes near the shore, and a low flat, brushy coastal plain extending for miles. Photo by D. H. Fry, Jr., March 21, 1938.

quite rough outside, but San Quentín Lagoon was calm. This lagoon is a famous spot for brant and we decided that with the ocean as rough as it was the best use we could make of our time was to count the brant in the lagoon as a supplement to the census made annually in California by James Moffitt. (See pages 341-346.)

To carry out the plan, four of us crossed the bar in the outboard powered dinghy and went on up the channel into the lagoon. Few

[1] Submitted for publication, June, 1938.

brant were encountered until we neared the dividing of the channel. At this point there were many harbor seals, including some tiny pups. After some searching we found the channel going into the west arm

FIG. 113. More brant—try to get this close when you have a gun! West arm of San Quentin Bay. These low black cliffs are a somewhat less typical shore line (compare figure 112). The hay-stack-like hill in the background is one of several which serve as unmistakable landmarks for mariners. Photo by D. H. Fry, Jr., March 21, 1938.

of the lagoon and from then on birds were numerous. Making a reasonably accurate count was easier than we had hoped. The channel runs near the eastern edge of this arm and most of the brant were on that side. As we approached, they would get up, fly a short distance, settle near the western shore and stay there. They did not do the thing we feared most, *i.e.*, move around so much that it would have been difficult to keep track of the flocks.

Taking a proper census of the eastern arm was not so easy. The wind had risen and was kicking up a nasty chop that tossed the boat around and made it hard to count the brant in a large flock. In addition most of the birds we stirred up would either fly ahead of us and settle among other flocks or circle past us and settle behind us on the far side of the arm. None of them flew very far but there was nothing orderly about the procedure, and an accurate count seemed impossible. So, we followed one shore line, chased all the birds over to the other and then returned, staying far enough from the flocks so we could count them without making them fly. This worked perfectly until we came to a wide spot where shoal water kept us from getting close enough to make more than a rough estimate of the number of birds in that area.

The census:

Ocean to dividing point of arms of lagoon (counted)	180
Western arm (counted)	850
Eastern arm above salt works (counted)	35
Eastern arm below salt works (counted 200, plus estimated 300)	500
Total	1565

As to the accuracy of the census, taking everything into account, it seems to us that the error might have been as great as 250 birds plus or minus but was probably much less. This is allowing for birds which might have been overlooked near the shore line and birds which might have been counted twice in crossing from one arm of the lagoon to the other.

3--62500

HUNTING SEASONS IN GERMANY [1]

By Tracy I. Storer
College of Agriculture
University of California

With an Introductory Note by Donald H. Fry, Jr.

During the early 1880s, my grandfather spent several years in Germany. As he had always hunted in the United States, it was only natural that he should do the same over there. Recently, one of his hunting licenses came to light. As a license it was hardly more than a curio, but the abstract of hunting seasons on its back should be of interest to any hunter. These seasons are shown in exactly the same way in which seasons are shown on our California game cards. It seemed quite desirable to publish a translation in *California Fish and Game,* but some of the terms used by German hunters are quite specialized and my German dictionary and I were unable to arrive at any very definite conclusions about the exact meaning of some of them. Finally, to get a trustworthy translation, the card was sent to Tracy I. Storer of the University of California, College of Agriculture, who has spent several years studying game conditions in Europe.

The following notes and translations are Dr. Storer's:

The accompanying translation of a hunting license for the Grand Duchy of Saxony-Weimar-Eisenach for 1881-82 makes available information as to the open seasons for hunting in that portion of Germany 57 years ago. It will be noted that the seasons on both resident and migratory species were long, in some degree comparing with seasons for hunting in those years in California (1880: ducks, September 15 to March 15; quail, September 15 to March 15; doves, June 1 to January 31). A translation of the Prussian Hunting Law of January 18, 1934, now the "national game code" for Germany, shows that for many species of game in that country long seasons still prevail. By comparison, in California the seasons are now much shortened (1934: ducks, October 1 to January 15 [federal regulations cut this to Saturdays and Sundays only from November 15 to December 31]; quail, November 1 to December 31; doves, September 1 to December 15 [or October 31].) Game in Germany has been carefully managed for many decades and shooting rights have been leased (as indicated in the footnote on the license.) Lessees have been required to conserve a breeding stock and "game hogs" were and are quickly dispossessed of hunting privileges.

The following table compares the shooting seasons for some common game animals of central Germany in 1881-82 and in 1934.

[1] Submitted for publication, July, 1938.

Some Hunting Seasons in Germany

	According to Hunting License of Grand Duchy of Saxony-Weimar-Eisenach 1881	According to Prussian Hunting Law of January 18, 1934
Red deer, males	July 1-Jan. 31	Aug. 16-Dec. 31
Females and calves	Sept. 1-Jan. 31	Oct. 16-Jan. 31
Fallow deer, males	July 1-Jan. 31	Sept. 1-Dec. 31
Females and calves	Sept. 1-Jan. 31	Oct. 16-Jan. 31
Roe deer, males	June 1-Jan. 31	June 1-Oct. 15
Females	Oct. 16-Dec. 14	Oct. 16-Dec. 31
Calves (female)	none	Oct. 16-Dec. 31
Badger	Oct. 1-Nov. 30	Sept. 1-Dec. 31
Hares	Sept. 1-Jan. 31	Oct. 1-Jan. 15
Capercailzie and black game, males	Sept. 1-May 31	April 1-May 15
Females	Sept. 1-Jan. 31	none
Hazel grouse	Sept. 1-Jan. 31	Sept. 1-Nov. 30
Bustards, males	July 1-Apr. 30	Apr. 1-May 15
Pheasants, males	Sept. 1-May 31	Oct. 1-Jan. 15 (exceptionally to Apr. 15)
Females	Sept. 1-Jan. 31	Oct. 1-Jan. 15
Partridges	Sept. 1-Nov. 30	Sept. 1-Nov. 30
Wild ducks	July 1-Mar. 31	July 16-Dec. 31 (exceptionally to Jan. 31)

Grossherzogthum Sachsen-Weimar-Eisenach.

No. 358.

Jagd-Schein

für den Verlagsbuchhändler Hl. Alb. Bancroft

wohnhaft zu Weimar

gültig vom

24.ten Septbr 1881 bis 24.ten Septbr 1882

Weimar, den 24.ten September 1881.

Gültig auf Ein Jahr.

Bezahlt mit 8 Mark.

Der Grossh. S. Direktor des I Verwaltungsbezirks.

W. Henn

Diesen Jagdschein hat der Inhaber bei Ausübung der Jagd stets bei sich zu führen und ihn auf Verlangen des Jagdberechtigten, des Jagdpächters, des bestellten Schützen, des Gemeindevorstandes, der zur Feld- oder Jagdpolizei beauftragten Gemeindediener, ingleichen der Grossh. Gendarmerie oder sonstigen Polizeibeamten vorzuzeigen, bei Geldstrafe bis zu 15 M.
Wer es versucht, sich durch einen, nicht auf seinen Namen ausgestellten fremden Jagdschein zu legitimiren, wird mit einer Strafe von 15–150 M belegt.

Grossherzogthum Sachsen-Weimar-Eisenach.

GRAND DUCHY OF SAXONY-WEIMAR-EISENACH

No. 358 HUNTING-LICENSE

Valid for one year.

Paid with 8 Marks [? $2.00].

for the bookseller Mr. Alb. Bancroft

residence at Weimar

valid from

24th Septbr 1881 until 24th Septbr 1882

Weimar the 24th Septbr 1881

The Grand [Duchy] S. [i.e. of Saxony] Director of the I Administrative District.

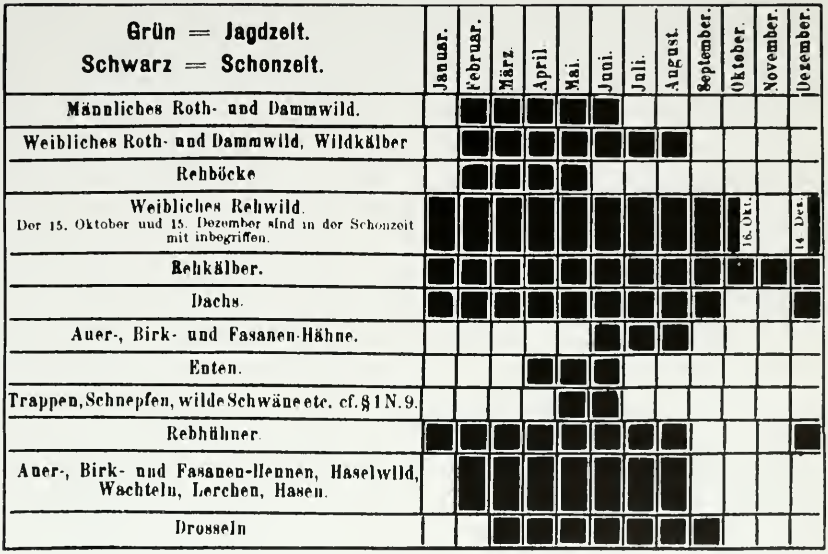
[Signature] [?] W. Henn

The licensee has always to carry this license upon his person while hunting and he has to show it upon demand of the holder of the hunting right, the holder of the [local] hunting lease, the hired guards, the communal president, the communal employees of the field and hunting police, as well as to the grand ducal gendarmerie or other police officials, on penalty of up to 15 M [arks fine].

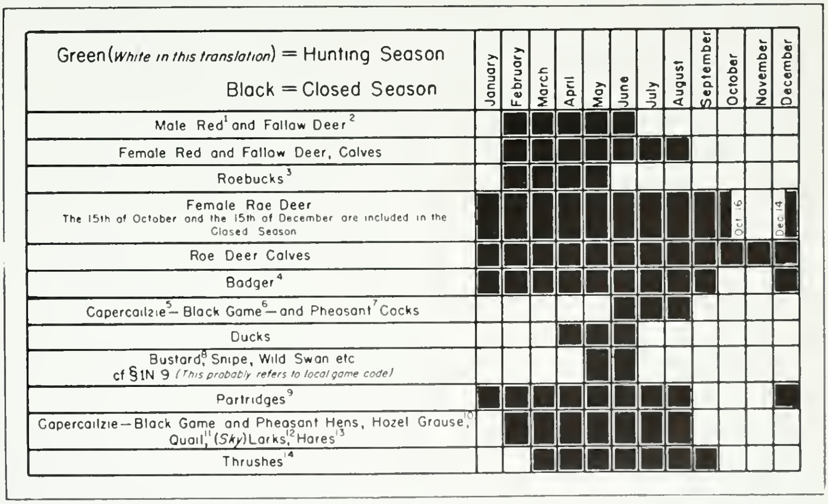
Anyone who tries to use a license which is not issued in his name is fined from 15-150 M [arks].

Grand Duchy of Saxony-Weimar-Eisenach

FIG. 114. Upper: reproduction of the face of a German hunting license issued in 1881. The original license is 5¼ x 3½ inches. Lower: the translation.



Grün = Jagdzeit. Schwarz = Schonzeit.	Januar.	Februar.	März.	April.	Mai.	Juni.	Juli.	August.	September.	Oktober.	November.	Dezember.
Männliches Roth- und Dammwild.		■	■	■	■	■						
Weibliches Roth- und Dammwild, Wildkälber		■	■	■	■	■	■	■				
Rehböcke		■	■	■	■							
Weibliches Rehwild. Der 15. Oktober und 15. Dezember sind in der Schonzeit mit inbegriffen.	■	■	■	■	■	■	■	■	■	■ 16. Okt.		14. Dez. ■
Rehkälber.	■	■	■	■	■	■	■	■	■	■	■	■
Dachs.	■	■	■	■	■	■	■	■	■			■
Auer-, Birk- und Fasanen-Hähne.						■	■	■				
Enten.				■	■	■						
Trappen, Schnepfen, wilde Schwäne etc. cf. § 1 N. 9.					■	■						
Rebhühner.	■	■	■	■	■	■	■	■				■
Auer-, Birk- und Fasanen-Hennen, Haselwild, Wachteln, Lerchen, Hasen.		■	■	■	■	■	■	■				
Drosseln			■	■	■	■	■	■	■			



Green (*White in this translation*) = Hunting Season Black = Closed Season	January	February	March	April	May	June	July	August	September	October	November	December
Male Red[1] and Fallow Deer[2]		■	■	■	■	■						
Female Red and Fallow Deer, Calves		■	■	■	■	■	■	■				
Roebucks[3]		■	■	■	■							
Female Roe Deer The 15th of October and the 15th of December are included in the Closed Season	■	■	■	■	■	■	■	■	■	■ Oct 16		Dec 14 ■
Roe Deer Calves	■	■	■	■	■	■	■	■	■	■	■	■
Badger[4]	■	■	■	■	■	■	■	■	■			■
Capercailzie[5]—Black Game[6]—and Pheasant[7] Cocks						■	■	■				
Ducks				■	■	■						
Bustard,[8] Snipe, Wild Swan etc cf § 1N 9 (*This probably refers to local game code*)					■	■						
Partridges[9]	■	■	■	■	■	■	■	■				■
Capercailzie—Black Game and Pheasant Hens, Hazel Grouse,[10] Quail,[11] (*Sky*) Larks,[12] Hares[13]		■	■	■	■	■	■	■				
Thrushes[14]			■	■	■	■	■	■	■			

FIG. 115. Upper: reproduction of the reverse of a German hunting license issued in 1881, showing open and closed seasons. Lower: translation. Footnote numbers refer to scientific names, as follows: [1] *Cervus elaphus* (equivalent to elk in U. S.); [2] *Cervus dama;* [3] *Capreolus capraea;* [4] *Meles meles;* [5] *Tetrao urogallus;* [6] *Lyurus tetrix;* [7] *Phasianus* sp.; [8] *Otis tarda;* [9] *Perdix* sp.; [10] *Tetrastes bonasia* (equivalent to ruffed grouse in U. S.); [11] *Coturnix coturnix;* [12] *Alauda arvensis;* [13] *Lepus* sp.; [14] Family Turdidae.

A STUDY OF THE TROUT (*Salmo irideus* Gibbons) FROM WADDELL CREEK, CALIFORNIA [1]

By Cedric O. Snyder

Introduction

This paper presents the results of an examination of an angler's catch of rainbow trout taken at intervals throughout the year in one of the smaller coastal streams of California.

The data used in this inquiry were obtained from upwards of one thousand trout caught by Mr. Theodore J. Hoover, Dean Emeritus of the School of Engineering, Stanford University. These fish were taken between May 1, 1927, and May 1, 1928, in Waddell Creek which flows through Mr. Hoover's Rancho del Oso. They were captured by fishing several times each month with the usual angling equipment consisting of rods, lines and lures. The data secured consisted of measurements of body length, weight in grams, a determination of sex, and scale samples from each fish. The scales were prepared and mounted by the usual methods employed for microscopic examination of fish scales. All were mounted in a Karo medium.[2]

Mr. Hoover's main purpose in collecting these fish and the attendant data was to determine if possible the age groups and their relative proportions in the catch—information not then available and yet very desirable in formulating plans for the conservation of the species.

That portion of Waddell Creek that flows through the Rancho del Oso has with the kindly interest of Mr. Hoover been the center of trout investigation for some years. A biological study of the stream valley was made by Merrill W. Brown (unpublished manuscript). A trout study was made by David Shepherd in 1929. He found that seven families of insects contribute largely to the trout food of this stream. These are: Rhyacophilidae, 2 species; Hydroptilidae, 1 species; Philopotamidae, 1 species; Odotontoceridae, 1 species; Hydropsychidae, 1 species; Sericostomatidae, 4 species; Limnophilidae, 5 species. The stomachs of 55 fish were carefully examined. They contained 3703 organisms. Of these, 2135, or about 57 per cent, were insects in various stages of development. Larval stages were represented by 53 per cent of the entire stomach contents. Other animals than insects were arachnids, isopods, amphipods and nemathelminthes—all of these constituting about 42 per cent of the food. A further contribution to the food

[1] Submitted for publication, February, 1938. This article was abstracted from a paper presented as a thesis in partial fulfillment of the degree of Master of Arts at Stanford University.

Editor's note: Lest the reader be confused by the use of two different specific names for the rainbow trout, *S. irideus* and *S. gairdnerii,* in recent articles appearing in *California Fish and Game,* we should like to call attention to the fact that there are two schools of thought on the subject, each favoring a different name. For the time being, individual authors may use whichever name they prefer.

[2] *Karo Korn Syrup* was adopted as a scale mounting medium by Dr. Willis H. Rich and his assistants in salmon studies because of its rather high refractive index and because it forms a lasting mount of the scale.

situation in Waddell Creek was made more recently (Needham, 1934). Fragments of small plants as pollen grains, etc. often form some of the stomach contents, but it is quite likely that these are ingested along with surface insects.

In general, it may be said that the trout food of a stream depends very largely upon the neighboring terrain and that when natural forest or grass land conditions are preserved, the stream will be found to contain a sufficient amount of food. When the forests and meadows have been destroyed by fire or by overgrazing, the food supply will be disturbed in a large measure.

In 1933 the California Trout Investigations, sponsored by the California Division of Fish and Game, the United States Bureau of Fisheries and Stanford University, with the cooperation of Mr. Hoover, established a weir in the stream for the purpose of observing migrations and other habits of fish.

The present study was made and the report prepared under the direction and with the aid of Professor Willis H. Rich of Stanford University.

The Rainbow Trout

From the point of view of most anglers, two species of trout occur in our coastal streams, namely, the "steelheads" and the "rainbows." The larger, more plainly colored migrant from the ocean is placed in the first category, whereas the smaller and more brilliantly colored stream trout is referred to by the latter name. Many ichthyologists were formerly of a like opinion, and the scientific literature of fishes then recognized the two forms as distinct species (Jordan and Evermann, 1896). At the same time, they did not recognize any marked anatomical differences between the two and they were unable to find the young of two distinct species in the same stream.

It is now established beyond doubt that both the so-called steelhead and rainbow are members of the same species, the steelhead being the adult individual which has lived for a time in the ocean, whereas the rainbow is the stream fish which has not yet migrated to the sea.

Recognition of the steelhead and rainbow as distinct species contributed in a measure to their depletion, as laws intended to protect and conserve them permitted an undue amount of fishing for both adults and young of the same species. Even now, some sportsmen are slow to recognize that killing a little stream trout means the death of a potential steelhead of several pounds.

As a matter of fact two distinct species of trout do occur in the more northern coastal streams of California, each with its stream and ocean form of population. One of these is the cut-throat trout, *Salmo clarkii*, akin to the species *S. henshawi* found in the waters of the eastern Sierran slopes and in Nevada. While plentiful in Oregon, Washington and to the northward, *S. clarkii* lives in only a few of the very northernmost streams of California, including Mad River in Humboldt County. In Redwood Creek, for example, one may find small cut-throat and rainbow trout, while large cut-throat steelheads and rainbow steelheads migrate in from the ocean. The State fish hatchery in that locality takes spawn from both, the hatcherymen having no difficulty in distinguishing them.

The rainbow trout, *Salmo irideus* Gibbons, the species here dealt with, inhabits the streams of the Pacific Coast wherever conditions permit. It enters the streams as a steelhead and migrates even to the uppermost tributaries to spawn, after which it usually returns to the ocean. The young of the steelhead remains in the stream an indefinite time, progressing with growth to deeper water, eventually to enter the sea and finally to become a steelhead like its parent.

The rainbow trout is a beautifully colored fish, although not to be compared with some of its more brilliant relatives as the golden trout of the High Sierras. Generally speaking, it exhibits three phases or variations of color while living in fresh water. The first of these may be called seasonal variation. It comes upon the fish as they approach maturity. The bright colors, particularly on the sides, become greatly intensified, whereas the background becomes darkened. The second is referred to as local variation. Fish found in deep pools or in dark or densely shaded water are invariably more somber in appearance than those found elsewhere. In boggy streams they often become a very dark brown-black, the color even extending to the ventral surfaces. In streams where the water is bright and sunny and where the fish are exposed to much light, they generally are much lighter in color. Here the upper surfaces have a great deal of yellow and the belly is light and silvery. The third is called geographic variation. Many observers, particularly sportsmen, speak of very noticeable varietal characteristics that are nearly always based upon color but which sometimes take into account body form. Some of these have been recognized by ichthyologists and given names. California fish hatcherymen frequently speak of such forms as the "Kosk Creek trout," the "Rising River trout," the "pogey" of Lake Tahoe, and others. This condition appears to be no different from that found in other species of fish, as well as in birds, and in mammals of wide distribution, particularly in the West.

Rainbow trout are semiboreal in their distribution, being found in streams where the water is clear, cool, and through its rapid flow, well aerated. Although such conditions are usually associated with the higher mountain systems such as the Sierra Nevada and the Siskiyou, the Coast Range offers comparable situations. The tributaries of the streams that rise in them have a slight snowfall during a portion of the winter months, are bordered by coniferous forests, and are cooled by frequent fogs throughout the warmer part of the year. Taken together, these factors aid in effecting a suitable temperature for the needs of growing trout.

Description of Waddell Creek

As previously noted, the fish with which the present study is concerned were taken in Waddell Creek. This creek is, like many others in the region, an almost perfect likeness of larger coastal streams; its mouth, its lagoon, its lower reaches, and finally its upper tributaries—all present in miniature the general characteristics of such rivers as the Eel and the Klamath.

Waddell Creek flows into the ocean a few miles south of Año Nuevo Point on the northwestern coast of Santa Cruz County. (See Fig. 116.) Rising in the Santa Cruz Mountains at an altitude of 1500 feet, it drops rapidly to sea level through the rather short distance of twelve miles. This drop results in numerous rapids and waterfalls which cause the current to be rather swift. Two main branches are formed by the juncture of a half dozen or so tributary creeks whose source is in the California Redwood Park (Big Basin). The branches,

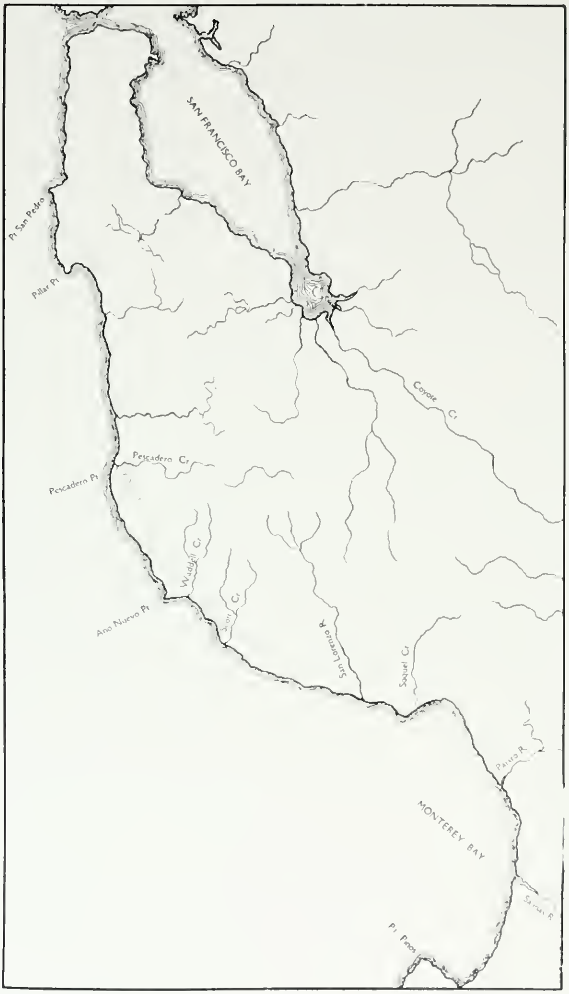


FIG. 116. Map showing relationship of Waddell Creek to the other streams between San Francisco and Monterey Bay.

called East and West, respectively, join to form the main stream. The lower portion of the stream presents a drowned mouth or lagoon which is intermittently closed by a shifting bar. During the high water of winter it is almost constantly open. Beginning with deep-cut gorges, characteristic of the tributaries and to a lesser extent of the branches whose banks start to recede, the valley of the main stream broadens out, forming numerous patches of cultivated grass lands, and finally the crop fields of Rancho del Oso. Transition coniferous forests composed of redwoods, firs and bays, are frequent along the bands of the upper reaches but recede toward the summits of the main stream valley. Upper Sonoran groves of buckeye, manzanita, madrone and chaparral comprise an intermediary growth of woody plants with islands of redwood and bay, extending nearly to the creek. Dense fogs spread over the creek during a portion of the year and to a certain extent affect the temperature of the water by cooling it. The flow is that of a perennial stream, although some of the tributaries which pass through the drier hillsides disappear during the summer and early fall, excepting for a few pools.

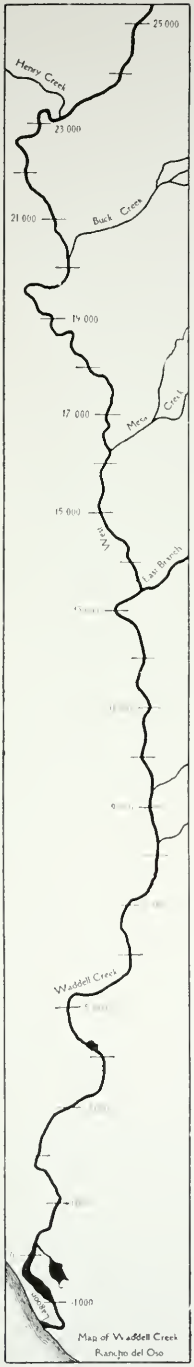


Fig. 117. Map of Waddell Creek. The figures represent distances in feet.

Fish Fauna of Waddell Creek

No strictly fluvial fish is to be found in Waddell Creek. In this respect, it conforms with other coastal streams from the Golden Gate to Monterey Bay. (See Fig. 116.) The species constituting the fish fauna of the stream are very limited in number. Bullheads (Cottidae) occur in varying abundance: *Cottus asper* and *C. aleuticus* are abundant and *C. gulosus* has been reported. The stickleback (*Gasterosteus cataphractus*) is more abundant in the lagoon and for a short distance up stream. In the lagoon itself are found certain salt-water forms as the striped bass (*Roccus lineatus*), the goby (*Gillichthys mirabilis*) and some flat fishes. The writer is not sure whether lampreys enter this creek as they do in many others.

The most important fishes found are the Salmonidae: the silver salmon (*Oncorhynchus kisutch*) and the rainbow trout (*Salmo irideus*). Silver salmon make regular migrations into the stream to spawn. The young of this fish grow very rapidly and are sometimes caught by anglers who mistake them for young rainbow trout. The exact ecological relations existing between any of these species or between any of them and the trout are scarcely known. It is reported that the cottoid fish feed upon the eggs and young of the trout when opportunity occurs.

The San Lorenzo, Pajaro and Salinas rivers, which enter Monterey Bay, have a fluvial fauna much like that of the Sacramento River (Snyder, 1913). In former years trout seemed to be just as abundant in these streams as in those where the fluvial fish were absent.

Depletion of Trout

Within the past forty years, the native trout have become greatly depleted, especially in the coastal streams. These are easily accessible because of lack of deep snow in the winter and spring, and they are also near the centers of population from which most of them may be reached in a few hours' time over fine highways. One may readily appreciate the increasing scarcity of the fish in both size and number during this period by referring to early accounts of fishing conditions. One writer (Welch, 1929) says:

"Prior to 1905 and the enactment of a law fixing the daily creel limit at 50 trout, a catch of from 100 to 300 trout taken from the coastal streams by one fisherman during the day was not unusual. A catch of a dozen adult steelhead trout, or from 20 to 30 so-called 'grilse' (one- and two-pound steelhead trout) was not exceptional * * *. Between 1895 and 1905 fishermen who sold their fish frequently made catches of from 200 to 350 trout per day in the streams of Santa Cruz County * * *. In April, 1900, I saw 600 (four to ten inches) steelhead trout that had been taken on hook and line from Soquel Creek in Santa Cruz County, by one fisherman during one day * * *. I recall a catch of 618 trout and 21 adult steelhead trout taken on hook and line by four fishermen during one day in the lagoon at the mouth of San Gregorio Creek, in April, 1887. During the sixties, seventies and eighties, thousands of so-called 'grilse' or 'salmon trout' were caught by hook and line by fishermen fishing off 'Meiggs Wharf,' from the wharves all along the San Francisco water front and off the Oakland Mole."

While there can be no question of the serious depletion of rainbow trout, the exact causes of it are not so apparent. In the minds of many anglers, at least as they express it, depletion is not the result of their own sporting activities. They usually ascribe the principal ravages of the fish to three groups of animal predators: such mammals as the racoon, the mink and the marten; such birds as the merganser, the kingfisher and the water ouzel; and such other fish as the Sacramento pike, the hardhead and the black bass. Of the mechanical agencies, they list the following as the more important: irrigation ditches, power dams, stream pollution, and the "inefficiency" of artificial propagation.

A careful observer will be forced to conclude from reviewing the available evidence on causes of depletion of the trout that, while all of the above noted agencies do to a greater or lesser extent affect the number of trout, the angler tends to overlook one important cause, namely, himself. For there is no doubt that depletion upon a large scale began with the advent of the angler.

Age and Growth of Rainbow Trout

As is the case with many other fish, the anatomical structure of the scales of trout furnishes the best means of determining the age of the individuals, and, at the same time, it offers clues to the solution of questions relating to other factors in their life-history.

The scale of the rainbow trout is an epidermal structure which is deeply pocketed anteriorly in a fold of the skin. It first appears on the surface of the body of the very young fish as a somewhat circular plate with thickened edges, which, interrupting the light, makes it look through the microscope like a more or less complete ring. As the fish increases in length, succeeding plates, which appear

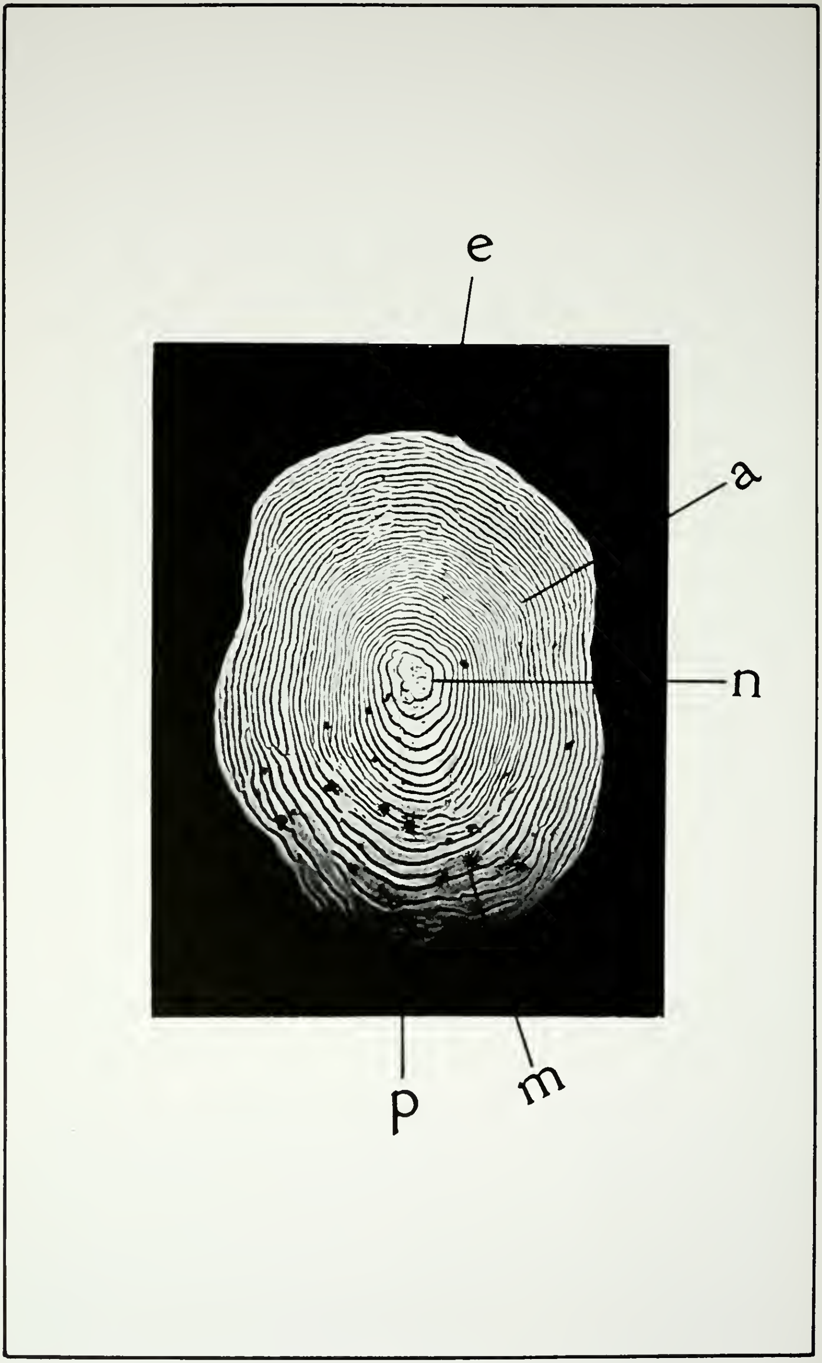


FIG. 118. Trout scale, from fish in its second year, 185 mm., July 7; *e* is anterior end; *p*, posterior end; *n*, nucleus; *a*, annulus; and *m*, melanophore.

as additional rings, usually termed circuli, are added with the growth of the scale. Barring accidents, the scales are never shed, and the growth of the scale bears a rather definite relation to the growth of the body, as is true in other fishes.

A photomicrograph of a scale magnified 34 diameters is presented in figure 118. It is seen to be irregularly oval in shape, with a differentiated anterior part *e*, and a posterior part *p*. The anterior part is the portion which was embedded in the skin, while the posterior end is the exposed part. The central portion *n*, sometimes termed the nucleus, represents the primitive plate, while the surrounding dark rings represent the edges of plates formed through added growth. It will be noted that the rings or circuli are more numerous and regular on the anterior part of the scale. They succeed each other in fairly regular fashion until a region, *a*, is reached where they become somewhat broken and very closely apposed. This narrow region is termed the annulus, and it is known to mark a period of slow or interrupted growth. Beyond the annulus the circuli are farther apart and somewhat more definitely outlined. The fish was taken July 7, when it measured 185 mm. in length.[3] The egg from which it was hatched was deposited in late winter or early spring, and as will be seen the primitive plate appeared in the early summer, when the fish measured about 35 mm., while the annulus was formed at some time during the following winter. It may be concluded then that the fish was killed early in the second year of its life.

A scale of a larger fish, 212 mm. in length, is shown in figure 119 *m*, which is also enlarged 34 diameters, as are all other scale magnifications in this paper. It was taken March 11. Three successive annuli are developed: a', a'' and a''', indicating that the fish was just entering its fourth year of growth. This trout was a little steelhead and the region of the scale exterior to the center annulus a''', is known to represent ocean growth—the broad or widely spaced circuli being characteristic.

In passing it may be noted that the dark spots (see Fig. 118, point *m*) on the posterior part of the scale are melanophores, which, when very abundant, form the black spots of the skin.

The two specimens here figured have unusually regular and well defined circuli and annuli as will be seen when they have been compared with others.

Figure 119*n* is of a scale from a fish measuring 188 mm. in length and killed August 2. It was in its third year—two annuli appearing, a' and a''. The widely spaced rings immediately bordering the first annulus, a', indicate a period of very rapid growth.

In order to determine if possible at about what time and at what length of fish the scales first appear, Mr. Hoover made a collection of small fish during the summer of 1927 on ten dates from May 21 to July 21, inclusive, at stations from 3000 to 4300. (See Fig. 117.)

An examination of these fish shows that scales first appear on the sides of the body in the region of the lateral line. For example, a specimen measuring 45 mm. in length and caught on June 4, had scales with two circuli only. These were found in four or five rows above

[3] All lengths are standard total length as measured from the tip of the snout to the tip of the middle caudal rays.

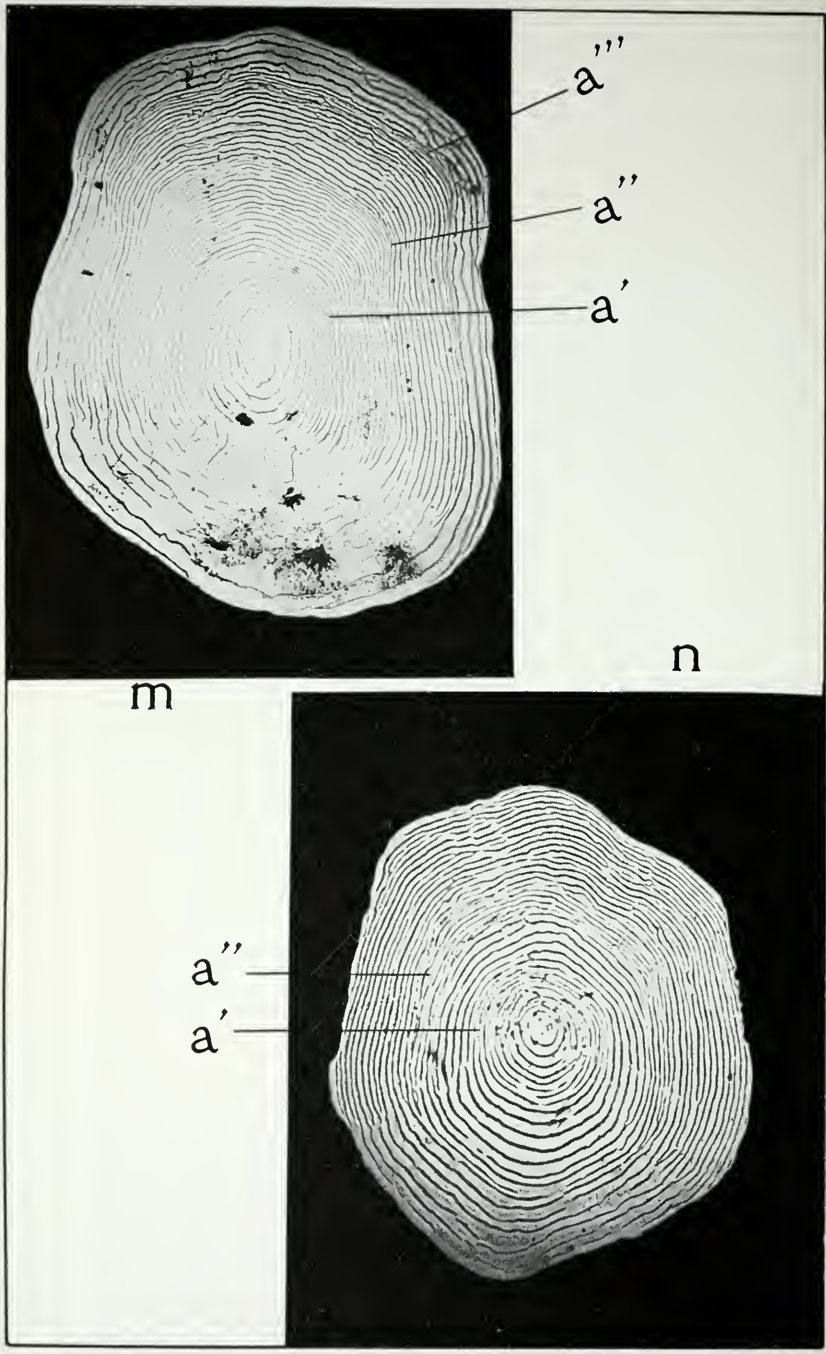


FIG. 119. Trout scales; *m*: 212 mm., March 11; *n*: 188 mm., August 2.

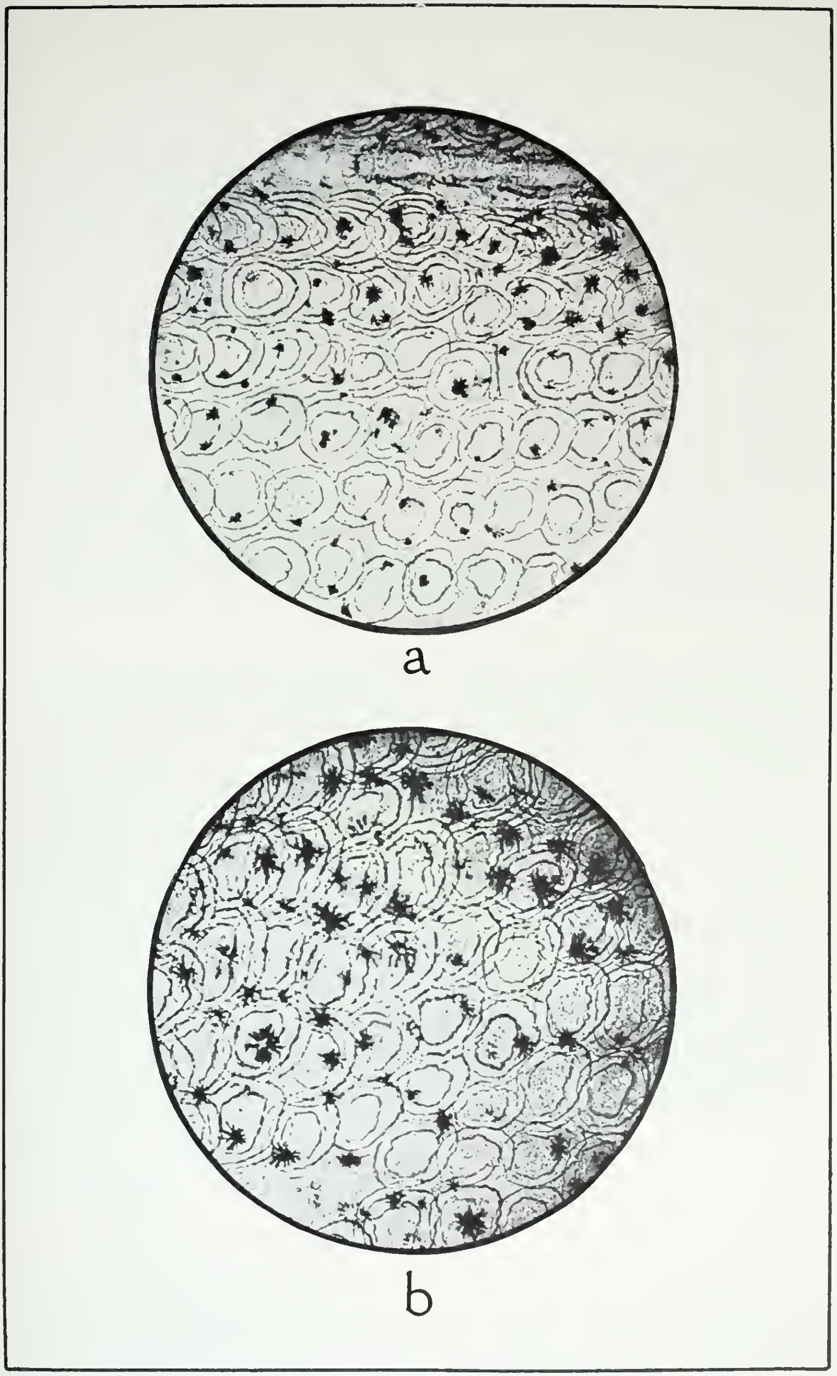


FIG. 120. Sections of skin with scales adhering, from young trout; *a*: 52 mm., May 28; *b*: 48 mm., June 26.

and below the lateral line along the middle of the body. In the region immediately behind the shoulder an occasional single plate appeared, while on the posterior part of the body in the region of the unpaired

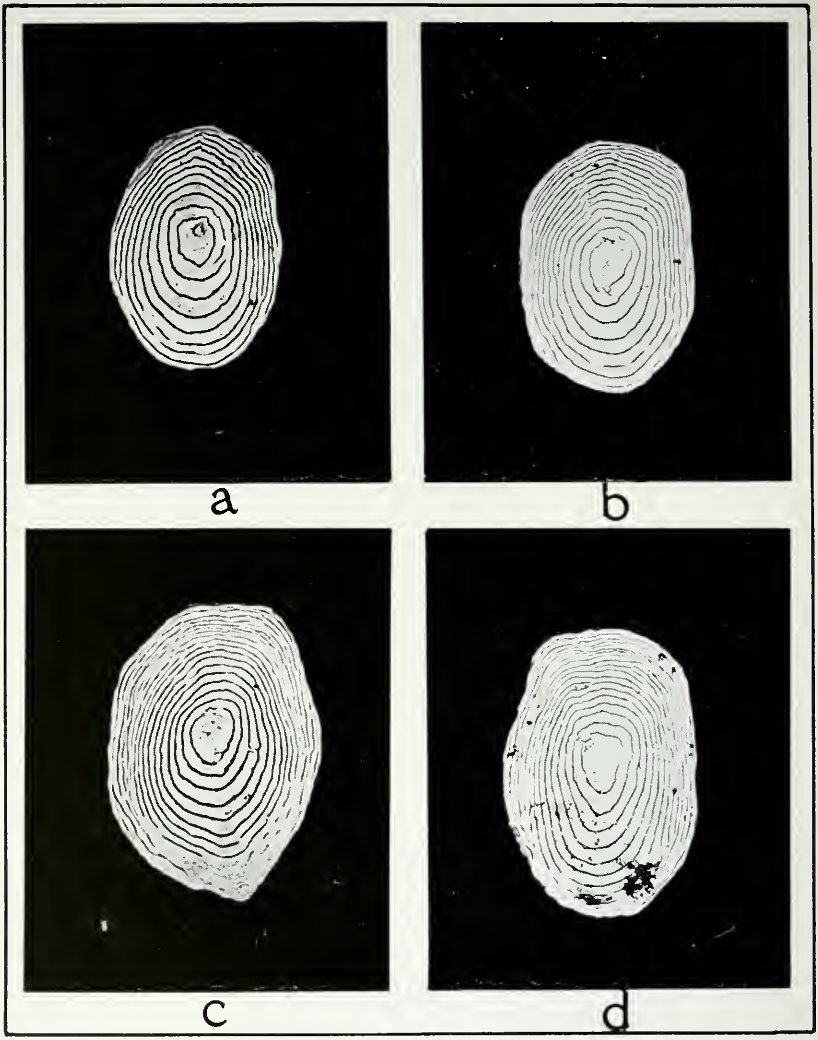


Fig. 121. Scales from young rainbow trout:
a: 87 mm., July 7
b: 97 mm., August 15
c: 107 mm., January 21
d: 115 mm., February 5

fins, the rows were reduced to two series on the lower side of the lateral line, finally disappearing near the base of the caudal fin. A specimen measuring 52 mm. in length was taken on May 28, and had scales rather well developed over most of the body. Along the lateral line, both above and below it, and extending from head to tail, were rows of overlapping scales. The largest of these, which in all cases were along the lateral line, had four circuli, and farther down the sides of the body there were not more than two, and occasionally somewhat nearer the ventral surface one circulus, or the outline of the primitive plate only, appeared. This specimen is illustrated in figure 120*a*, where the lateral line with its bordering rows of overlapping scales is definitely shown at the upper side of the figure. The perfect alignment of the scales has been disturbed in freeing the patch of skin from alcohol-hardened mucus.

The next illustration, figure 120*b*, is that of the scales of a fish measuring 48 mm. in length and taken June 26. The body was fairly well covered with scales, some of which had as many as five circuli. Both of these examples (magnified also 34 diameters) seem to have slightly larger primitive plates than is ordinarily the case.

From the examination of this series of young trout, it was found that the scales first appear in the region of the lateral line late in May when the fish is from 35 to 40 mm. in length. Individual variation in the size of the fish of the year is at this time quite pronounced.

Data relating to these fish are assembled in table 1.

TABLE 1

Date (1927)	Length in mm.	Length (mm.) having scales	Number of circuli	Locality station
May 21	25–40			3,500
May 28	22–52	43–52	2–4	3,000
June 4	26–45	41–45	2–3	10,500
June 11	29–42	36–42	1–2	4,200
June 19	26–45	37–45	1–4	4,300
June 26	25–46	36–46	1–5	4,000
	30–62	44–62	4–9	3,000
June 29	28–72	35–72	2–13	
July 14	30–39	39–	–3	11,000
	33–76	33–76	3–13	9,000
July 18	42–64	42–64	5–12	14,500
July 21	30–78	32–78	2–12	2,500

As one might expect, trout grow more rapidly during the summer, when conditions such as temperature and food supply are most favorable. Scales of these rapidly growing fish are illustrated in figures 121*a* and 121*b*. In an occasional individual, there appears to be a slowing down of growth early in the fall (*e.g.*, September 9) while others taken in the same vicinity are still growing rapidly. Fish with retarded growth at this time are so much in the minority as not to deserve consideration. Generally speaking, growth continues until early winter, January being the month in which it slows down to a marked degree.

Scales taken from fish, in which very little growth was apparent at the time of capture, are illustrated in figures 122*a* and 122*b*. The first was taken January 14 and measured 139 mm. in length. It is of a fish in the second year of growth and it may be noted that the circuli near the margin of the scales are very closely apposed. Figure 122*b* is of a fish taken February 5, which measured 114 mm. in length. It is in its first year of growth; here again the outer circuli are closely

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apposed, forming an annulus. In figures 122*c* and 122*d*, from fish taken February 11 and March 10, respectively, new growth appears beyond the annulus in each case. Figure 122*c* represents a fish which is

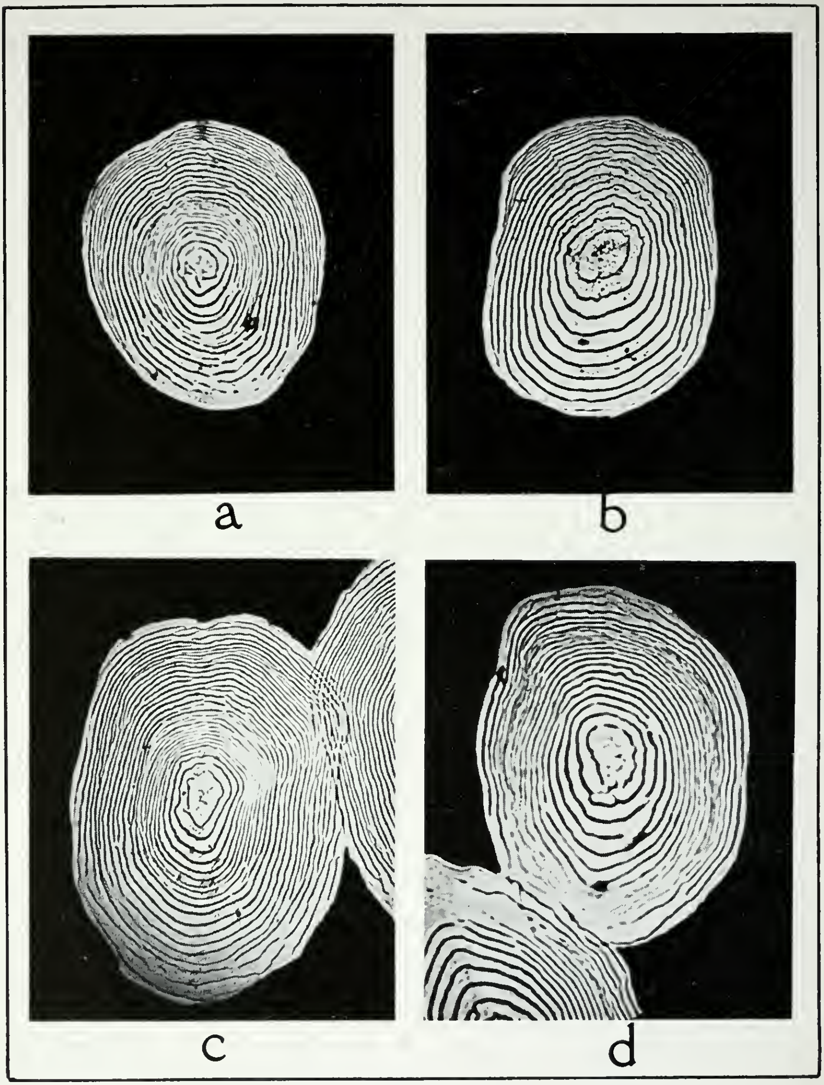

FIG. 122. Trout scales:
a: 139 mm., January 14
b: 114 mm., February 5
c: 139 mm., February 11
d: 138 mm., March 10

entering its third year of growth, while figure 122*d* is one entering its second year. Returning to figure 121, *c* and *d* represent scales of fish in which new growth has also started. The first of these was from a fish taken January 21; the second, February 5. Sometimes new growth may have started in December. A scale from a fish taken December 27 showing new growth is illustrated in figure 123*a*. Figures 123*b* and *c* represent fish where new growth has just started or has slightly progressed.

From these and other examples it may be seen that the seasonal retardation of growth does not occur in all fish in the stream at the same time. It seems that most individuals change from slow to rapid growth late in January and in February. Usually, rapid growth has been resumed in March and April and is in full progress in April and early May.

It will be seen that in age determination, account is taken of the presence or absence of the annulus. In figure 121*a* no annulus has formed as yet. The fish from which this scale was taken measured 87 mm. in length and the date of its capture was July 7. From what has been shown relating to the early appearance and growth of the scale, it is safe to conclude that this is a fish of the year in a stage of rapid growth. In figure 122*b*, a fish taken February 5, and measuring 114 mm. in length is represented. Here it will be noted that the circuli are very similar in character as viewed from the primitive plate outward until just before the margin of the scale is reached where a well-formed and very distinct annulus, which represents a check in growth, has appeared. A little later and after growth has been resumed, this fish would be said to have entered its second year growth. It may, even now, and without this new growth, be considered for statistical purposes in its second year. Returning to figure 118 for comparison, it will be seen that the scale illustrated in figure 122*b* corresponds to that portion of the scale from the nuclear plate *n* up to and including the annulus *a*. The region beyond the annulus is usually spoken of as the area of second year growth, although the fish was not actually one year old at the time the annulus was formed.

Since in a population of fish the appearance of the annulus is spread over a considerable period of time, it is evident that for practical purposes and to avoid confusion it is convenient to record age as of the calendar year of life.

It may here be remarked that the illustrations are of particularly well-formed and clear-cut scales. Many examples have irregularities of various kinds which at times render age determination difficult or doubtful. When material is collected for study, the samples should contain large numbers of scales so that provision may be made for faulty ones.

Following the above brief description of the method of age determination, a tabulated analysis of the ages of some 795 fish at the time of capture is here given. (See Table 2.) The table does not include fish of the fourth year-class, eight in number, collected in January, February and March. Including these, the totals and percentages would be as follows:

First year: males 16, females 13, 3.65 per cent
Second year: males 312, females 275, 73.84 per cent
Third year: males 92, females 79, 21.51 per cent
Fourth year: 8 fish, 1.00 per cent

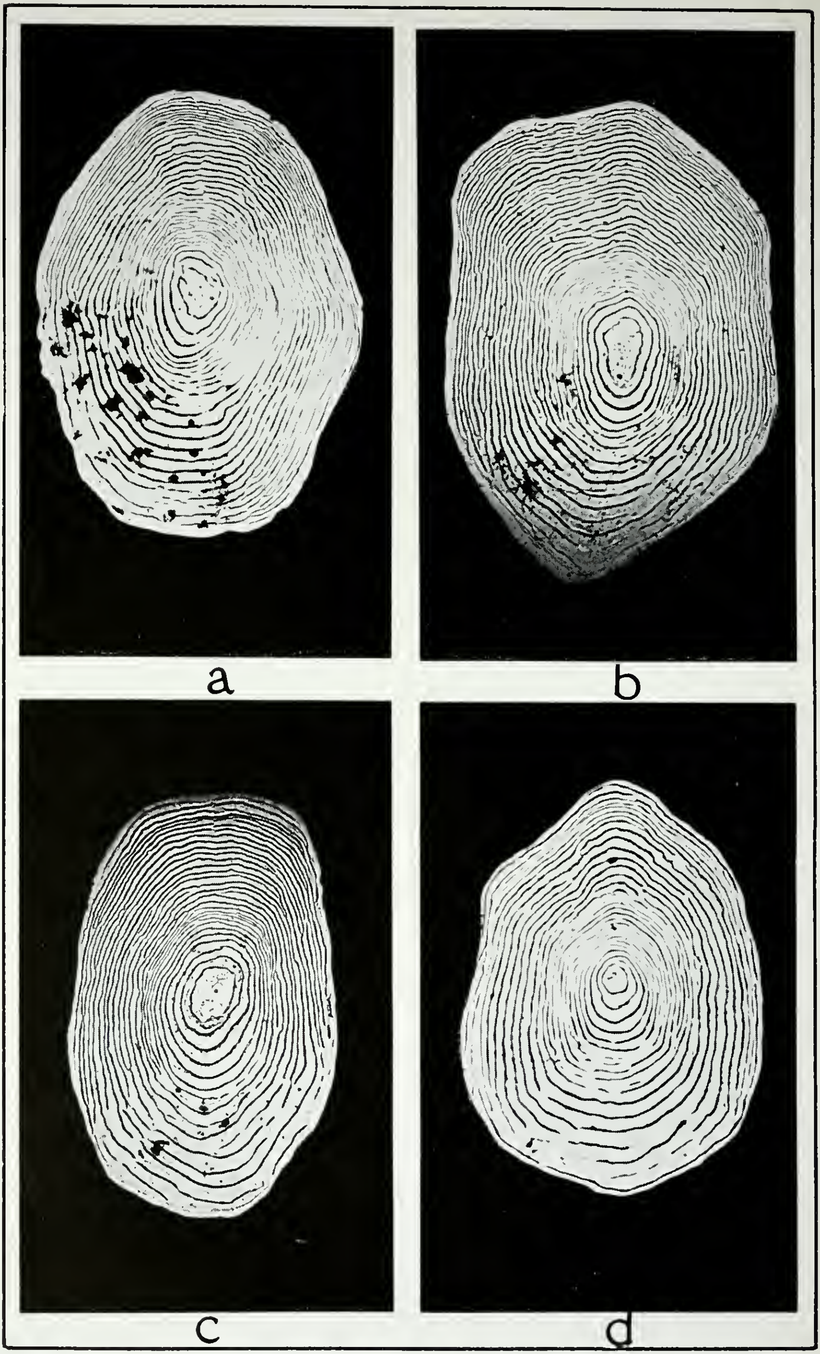

FIG. 123. Trout scales:
a: December 27
b: February 11
c: February 26
d: March 4

It appears that second year fish furnish the mass of the catch. They number some 73.8 per cent, while third year fish are represented by about 21.5 per cent. Average lengths of these year-classes as they appear in the catches by the month are given in tables 2 and 3.

TABLE 2

Age Groups in the Angler's Catch

Date 1927-1928	Maximum and minimum lengths in mm.	First year		Second year		Third year	
		Males	Females	Males	Females	Males	Females
May 1	97–170			6	8	2	4
May 8	114–167			9	8		
May 15	95–152			11	8	2	
May 21	124–173			11	12	1	
May 28	106–160			19	7		1
Totals				56	43	5	5
Per cent				90.82		9.18	
June 4	80–166	1		7	9	1	
June 5	94–225			12	9	4	2
June 11	88–190	1		9	13	1	1
June 18	117–193			16	9	1	
June 29	124–222			16	9	1	1
Totals		2		60	49	8	4
Per cent		1.62		88.62		9.76	
July 2	115–194			12	14	1	1
July 4	101–164			9	5		
July 7	87–198	1		12	10	1	
July 14	107–202			16	8		1
July 18	90–161		1	14	5		2
July 21	130–202			13	9	4	4
July 28	78–196	2	1	10	11	1	1
Totals		3	2	86	62	7	9
Per cent		2.94		87.58		9.48	
August 2	125–195			10	12		
August 12	91–183	1	1	8	9		
August 15	97–163		1	3	3		
August 19	92–138		1	1	3		
August 28	128–212			2	6	1	
Totals		1	3	24	33	1	
Per cent		6.45		91.94		1.61	
September 9	77–211	1	1	10	9	1	1
September 11	135–191			4	3		1
September 14	125–176			3	5		
September 22	133–191	1		7	11		
September 24	155–196			3	3		
September 28	139–148			3	3		
Totals		2	1	30	34	1	2
Per cent		4.28		91.43		4.28	
October 9	92–184	1		1	2		
October 15	91–213	1		6	7	1	
October 23	74–179	1	2	4	2		
Totals		3	2	11	11	1	
Per cent		17.86		78.59		3.57	
November 5	99–199		1	2	1		

TABLE 2—Continued

Age Groups in the Angler's Catch

Date 1927-1928	Maximum and minimum lengths in mm.	First year		Second year		Third year	
		Males	Females	Males	Females	Males	Females
December 4	174–256			2	2	3	2
December 10	104–210	2		1	1	1	
December 11	102–254	1	3	7	5	1	
December 17	193–258				2	2	
December 18	122–211			2		1	
December 27	127–191			3	8	1	
December 28	94–184	1		2	2		
December 31	103–251	1	1	8	10	2	1
Totals		5	4	25	30	11	3
Per cent		11.45		70.52		17.94	
January 7	96–256			1	3	4	1
January 8	99–252				2	8	5
January 14	86–217			1	2	8	6
January 21	95–241			1	2	3	2
Totals				3	[illegible]	23	14
Per cent				24.50		75.50	
February 5	114–169			1	1	1	3
February 11	127–301					4	1
February 12	146–232					4	2
February 18	123–201				1	3	1
February 19	110–232			1	1	5	5
February 25	105–185			3		1	1
February 26	110–245				1	2	3
Totals				5	4	20	16
Per cent				20.00		80.00	
March 3	145–179					1	2
March 4	127–215			1	1	7	7
March 10	127–229			1	1	1	2
March 11	112–212			3		1	2
March 18	113–214				1	1	6
March 31	153–184				1	1	1
Totals				5	4	12	20
Per cent				21.95		78.05	
April 7	92–262			3	3	1	4
April 21	134–192			2	1	2	2
Totals				5	4	3	6
Per cent				50.00		50.00	

TABLE 3

Size of Trout in the Angler's Catch, by Age Groups and Months

First Year-Class

Month when caught	Average length in mm.	Average length to nearest eighth-inch
June	84	3¼
July	83	3¼
August	103	3⅛
September	110	4⅜
October	100	4
November	99	3⅞
December	101	4

Second Year-Class

Month when caught	Average length in mm.	Average length to nearest eighth-inch
January	115	4½
February	117	4⅝
March	138	5⅜
April	131	5⅛
May	133	5¼
June	142	5⅝
July	141	5½
August	143	5⅝
September	156	6⅛
October	169	6⅝
November	206	8⅛
December	170	6¼

Third Year-Class

Month when caught	Average length in mm.	Average length to nearest eighth-inch
January	173	6¾
February	167	6⅝
March	168	6⅝
April	178	7
May	141	5½
June	175	6⅞
July	165	6½
August	212	8⅜
September	171	6¾
October	213	8½
November	---	---
December	229	9

When compared with the adult steelheads, these little fish are rather insignificant. Where fishing is intensive, smaller fish are taken in larger numbers, and it is altogether likely that a similar study of anglers' catches in certain other streams would reveal a much larger proportion of the younger fish.

At the present time the legal open season extends from May 1 to the end of October with no size limit. During this time the fish of the year have attained size enough to be caught with ease, and therefore practically no protection is offered the young of the species.

Sex Representation in the Catch

In an attempt to augment the supply of trout available to fishermen in depleted streams, it is the practice to resort to artificial propagation. To supply the eggs for such propagation it is the custom in many places to spawn wild fish collected from their native waters. To gather the eggs it is necessary to place traps across the streams to intercept migrating adult fish on the way to their spawning grounds. The traps are placed in the streams before migration begins and are left there as long as is desired. Frequently they remain until fish no longer approach them. Such traps form effective barriers and are usually constructed in such a way as to lead the fish which enter them into holding tanks from which the males and females are segregated and eventually spawned. Hatchery men attending these traps have reported that this procedure reveals a shortage of male fish and that in some cases this shortage becomes acute. Much speculation has been

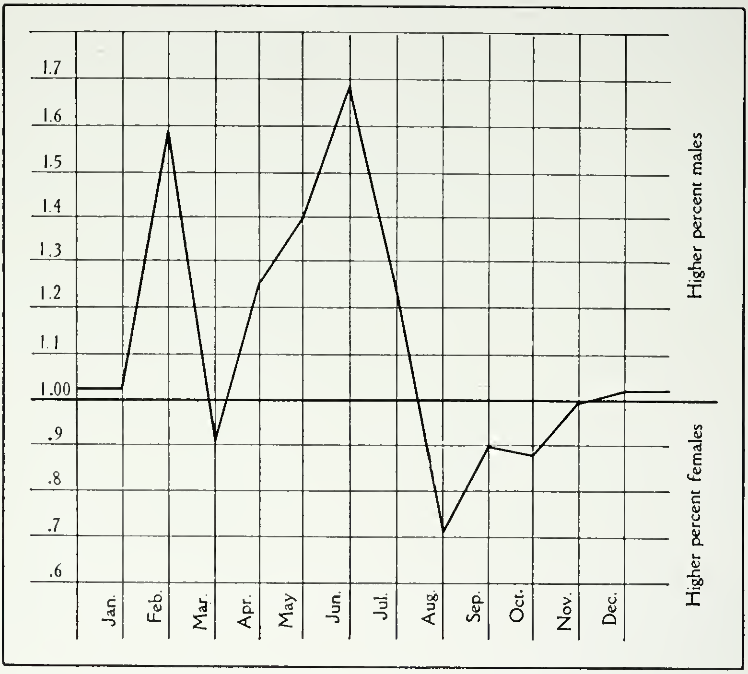

Fig. 124. Seasonal variation in the ratio of males to females, Waddell Creek rainbow trout.

indulged in as to the cause of this shortage. Some claim that the females precede the males in the migration by a considerable length of time, and that the males are more shy than are the females and refuse to approach the traps, remaining downstream and away from them. Others insist that the anglers are responsible for the lack of male fish, assuming that this sex will strike a baited hook more readily than will the female.

As a possible contribution to the ultimate settlement of the angler's responsibility, table 4 has been prepared, showing by monthly periods the number of male and female fish caught in Waddell Creek throughout the year.

TABLE 4

Sex Representation in the Catch

Month	Number of males	Number of females	Month	Number of males	Number of females
May	63	41	November	2	2
June	72	43	December	41	40
July	98	78	January	37	36
August	27	42	February	35	22
September	36	40	March	25	27
October	15	17	April	15	12

It will be seen that in the above table there are the sex records of 866 fish. Of these, 466 are males whereas 400 are females, making an excess of 66 males in the season's catch (53.8 per cent male; 46.2 per cent female). A seasonal variation in the sex ratio is indicated in table 4, and is represented in figure 124, although the numbers involved are too small to warrant definite conclusions.

Summary

The species of trout which inhabits Waddell Creek is *Salmo irideus* Gibbons.

This species is of wide distribution and subject to certain variations.

Waddell Creek is typical of other Coast Range streams, and in miniature it presents most of the prominent physical and biological features of larger coastal streams such as Eel and Klamath rivers.

The fish fauna of Waddell Creek, like that of other coastal streams which enter the ocean between the Golden Gate and Monterey Bay, has no truly fluvial fish.

The more important fishes of Waddell Creek are members of the family Salmonidae, the silver salmon and the rainbow trout.

The life-history of the rainbow trout has a stream and ocean phase. This report is concerned with an angler's catch of the stream phase.

In recent years the trout of the coastal streams have become greatly depleted because of various adverse conditions, principally the activities of anglers.

Very little of an exact nature relating to the ages of the stream trout taken by anglers is available.

The structure of the scales of trout offers reliable data relating to the age and growth of the fish.

Scales first appear on the body in the month of May, when the fish has attained a length of 35 to 40 mm.

Growth is more rapid in the summer than in the winter. Growth progress is apparent in the structure of the scale, rapid growth forming wider circuli, whereas retarded growth such as occurs at some time during the winter forms a narrow area of closely apposed circuli known as an annulus. In determining the age of a trout the presence or absence of an annulus in a scale is an important factor.

In Waddell Creek the annulus generally forms late in January or early in February.

New growth following the completion of an annulus appears early in the spring. Most of the fish begin rapid growth by the middle of April or early in May.

Year groups are represented in the angler's catch as follows: first year group, 3.65 per cent; second year group, 73.84 per cent; third year group, 21.51 per cent; and fourth year group, 1 per cent.

There appears to be a predominance of males in the catch.

Fish remain in the stream from one to three years before migrating to the ocean.

The anglers' catch heavily depletes the younger fish and it appears to the writer that the present legal open season offers very little protection.

References

Much of the literature that concerns itself with rainbow trout is devoted to description and distribution or to the sporting qualities of the fish. The former is to be found mostly in technical papers, whereas the latter is spread throughout the popular papers and magazines. Relatively little of an exact nature, however, has been written concerning life-histories, habits and growth. The following references have proved useful:

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SECOND REPORT OF SARDINE TAGGING IN CALIFORNIA [1]

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Introduction

A thorough knowledge of the migrations of a fish population which is exploited as intensively as that of the California sardine, *Sardinops caerulea* (Girard), is essential to a practical administration of the fishery. One method of tracing migrations is to tag or mark fish in such a way that individuals may be recognized if caught again. Releasing large numbers of tagged fish with subsequent recovery of the tags will yield valuable information, not only concerning the routes and extent of travels, but will demonstrate whether different regions harbor distinct populations or whether the entire population of all regions is homogeneous. It will show as well whether different portions of the population have different habits of migration, and whether a heavily fished region will be replenished by fish from other localities. Furthermore, if tag recoveries are extensive enough, we can approximate the size of the population and the intensity of fishing—the proportion of the entire population removed each year by fishing operations. When a species is fished over a large area this information is of additional value in determining the relative fishing intensity in each region. This is the case with the California sardine. It is caught for canning and reduction purposes or for bait from British Columbia (Canada) along the entire Pacific Coast of the United States to the southern tip of Lower California (Mexico).

Although a definite migration theory had been formulated from various phases of the sardine investigation carried out by the State Fisheries Laboratory of the California Division of Fish and Game, a tagging program was inaugurated to check it. Results from two years of tagging have been entirely in accord with that theory: nearly all spawning takes place off southern and Lower California; the young fish remain in these southern waters until adolescent, when they begin northerly migrations, going at first as far as central California and returning the following spring to southern California to spawn; as the fish grow older they go farther and farther north at the close of each spawning season, so that by the time they are eight or ten years old they make annual migrations as far as British Columbia but return to southern waters to spawn.

A preliminary report on sardine tagging in California was made in 1937 (Janssen, 1937). In it were presented the methods of tagging and tag recovery as well as an enumeration of recoveries from fish tagged up to that time. Since the writing of that report, the California

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[1] Submitted for publication, August 10, 1938.

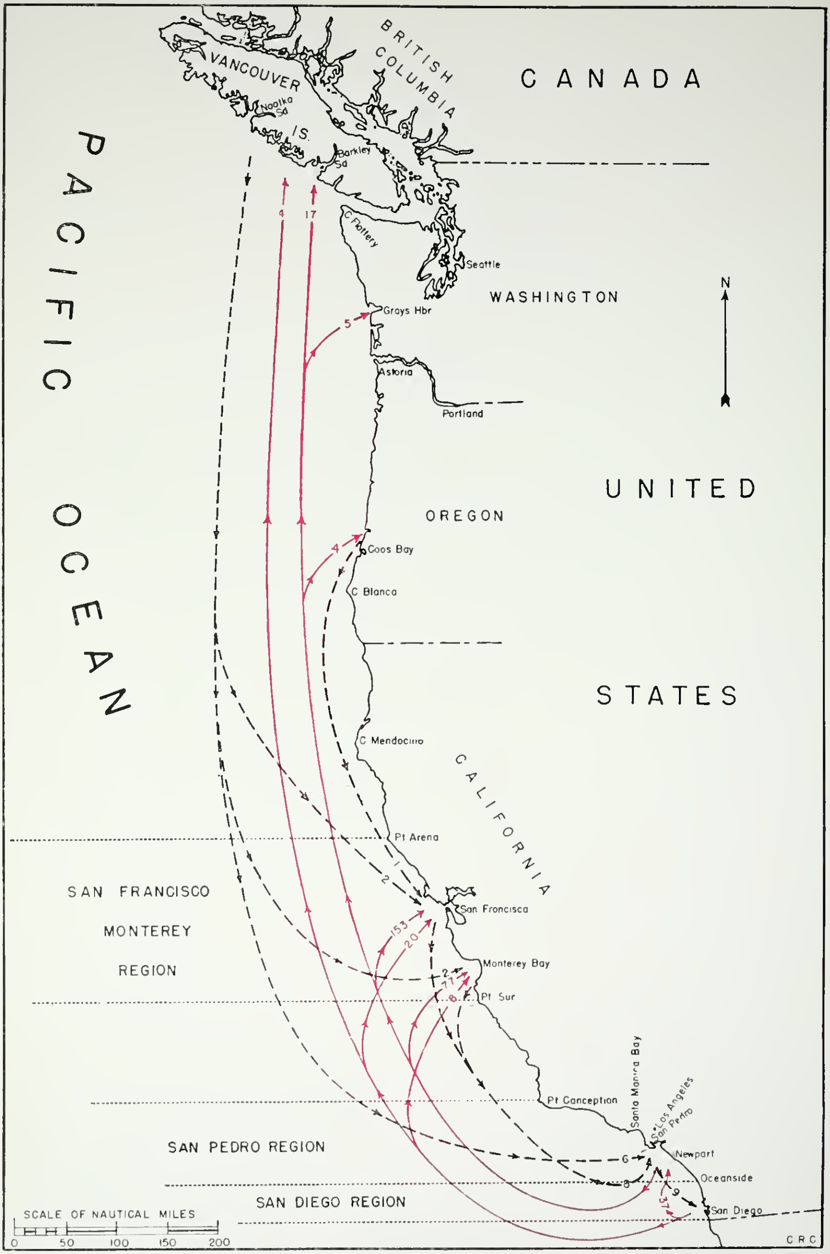

FIG. 125. A section of the Pacific Coast showing diagrammatically major movements of tagged sardines from one fishing region to another, as indicated by recoveries during the period March, 1936-June, 1938.

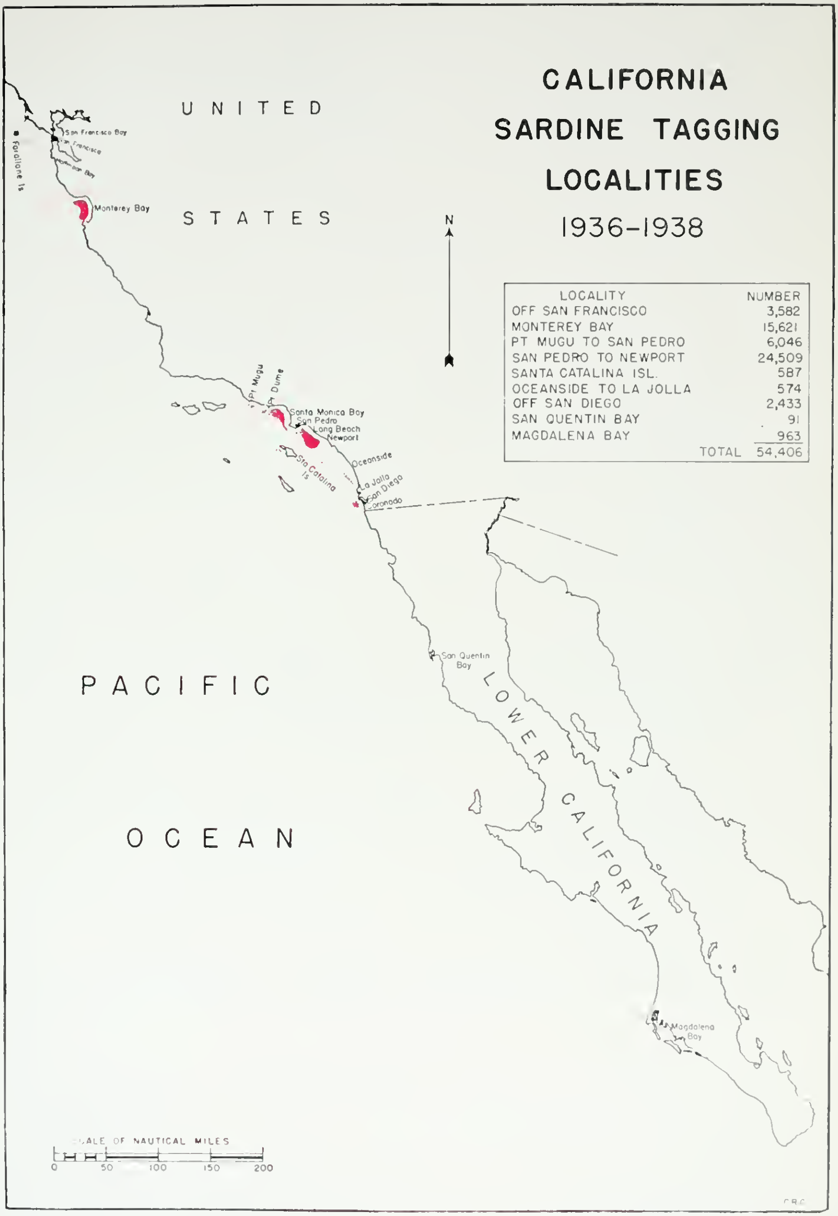

FIG. 126. A section of the Pacific Coast showing the localities where the California Division of Fish and Game has tagged sardines. The number of dots indicates the concentration and range of tagging in each area.

Division of Fish and Game has tagged an additional 28,238 sardines in California waters and 963 along the coast of Mexico. Tags from a great many of these fish have already been recovered as well as additional tags from groups of fish discussed in the previous report. Five more British Columbia tags (Hart, 1938.2) have been recovered in California reduction plants, making a total of ten for two seasons. One Oregon tag has also been taken in our State. Thirty California tags have been recovered in regions north of California (Janssen, 1938) as follows: 21 in British Columbia, 5 in Washington and 4 in Oregon. Of the California tags recovered in British Columbia, one was out only 103 days; the longest period was 208 days; and the average was 169 days. These fish traveled a minimum of about a thousand nautical miles or an average of about 6 miles per day.

There was a decided movement of tagged sardines from southern California into central California waters. (See Table 1 and Fig. 125.) Also many of these fish continued north to the coast of Washington where the major part of the 1937 British Columbia catch was made. A southern movement of tagged sardines is also evident. Too few fish have been tagged in Mexican waters to yield any returns. Until recently there has been no means of recovering tags in Mexico so that it has been impossible to trace movements of sardines south of San Diego.

TABLE 1

Summary of Sardine Tag Recoveries, March, 1936—June, 1938

Tagging region	Total number tagged by regions, March, 1936 to June, 1938	Percentage of total tagged	Number of recoveries by regions							Total number recovered
			Recovered in British Columbia	Recovered in Washington	Recovered in Oregon	Recovered at San Francisco	Recovered at Monterey	Recovered at San Pedro	Recovered at San Diego	
San Francisco-Monterey	19,203	35.30				226	138	8		372
San Pedro	31,142	57.24	17	5	4	153	77	605	9	870
San Diego	3,007	5.53	4			20	8	37	5	74
Lower California	1,054	1.94								
Broken Tags						1	2	15		18
Totals	54,406	100.00	21	5	4	400	225	665	14	1,334
British Columbia	[1]10,449		63	9	9	2	2	6		[1]91
Oregon	[2]606				2	1				[2]3

[1] Fish tagged by British Columbia authorities (Hart, 1938.2). Many of these fish were tagged off the coast of Washington.

[2] Fish tagged by Oregon authorities. Published by permission of the Fish Commission of Oregon.

TABLE 2

Extent of Migration of Tagged Sardines

Distance traveled in nautical miles	Number of fish moving	
	North	South
50 or more	325	28
330 or more	288	19
360 or more	58	11
640 or more	30	10
940 or more	26	6
1000	4	0

The "Small" Tag

The tag used for sardine marking (Janssen, 1937) is of the internal type closely resembling one in use by the U. S. Bureau of Fisheries in its Alaskan herring investigation (Rounsefell and Dahlgren, 1933). It is a flat strip of nickel-plated steel and is recovered by means of electro-magnets placed in the meal lines of reduction plants (Fry, 1937).

A tag identical to but somewhat smaller than the one described in the 1937 report has been tried. It is intended primarily for use in fish considered too small to be tagged with the larger type. The small tag has, however, been used in some large fish as well as in many of the fish for which it was designed, sardines ranging from 135 to 200 mm. total length (115 to 170 mm. body length).

The dimensions of the small tag are $\frac{1}{2}$ inch by $\frac{1}{8}$ inch by 1/40 inch. On one side there is a serial number preceded by a letter and on the opposite side the inscription "C. F. & G."

Because of the small size of these tags it was expected that the electro-magnets used for tag recovery would not pick them up as efficiently as the large tags. Experiments performed in reduction plants with small numbers of tags have borne this out but the difference is too small to be significant. Repeated experiments with large numbers of tags, however, are planned for the future.

Sizes of Sardines Tagged

In discussing sizes of sardines tagged, it is convenient to divide them arbitrarily into three general groups—large, medium and small. We regard as small fish those under 200 mm. total length (170 mm. body length). Medium fish range from 200 to 270 mm. and large fish are those over 270 mm. total length (229 mm. body length).

Since obtaining the small tags in October, 1937, as many small sardines as possible have been tagged. The large tags have seldom been used in fish under 180 mm. total length (153 mm. body length). When using the small tags, all fish above 150 mm. total length (127 mm. body length) have been tagged and a few as small as 135 mm. (115 mm. body length).

Preliminary experiments on tagged fish held in a tank indicate that 135-mm. sardines, and possibly smaller, may be tagged without excessive mortality. However, the smaller sizes lose their scales more easily than larger sardines and consequently suffer considerably more from handling. Further experiments are necessary to definitely determine the size of the smallest fish which may be tagged.

The majority of the sardines tagged during the past year fall into the medium class. Considerably fewer large fish were tagged than during the previous year.

Tag Loss

Tag loss may be considered as the loss of tags by any means whereby they can not later be recovered. Tags may be lost in a variety of ways such as death of the fish due to injury at time of tagging, shedding of tags by the fish, inefficiency of the magnets used to recover the tags, loss of tags in the canning and reduction plants and in many other ways. All of the various sources of error must be considered when attempting to analyze tag recoveries.

It is difficult to determine accurately the mortality due to the effect of the tag as well as that due to handling and confinement of the fish while tagging is in progress. The death rate, as a result of tagging, probably differs between small and large fish. Mortality experiments in a holding tank, which are now under way, should throw more light on this subject. Calmness of the ocean while tagging is being performed is a very important factor, as in rough weather sardines become battered both in the net in which they are caught and in the live box or net from which they are tagged. On a calm sea the fish can usually be released in first class condition. Again, if the sardines are concentrated too tightly in the net or if sea lions get into the net creating a panic, the fish quickly lose their scales and weaken.

Preliminary results from experiments where tagged sardines have been held for over two months in a tank show that some tags are shed, although the proportion is not as yet known. This loss is probably greater among small fish than larger ones, but a final answer must await results of the holding experiments.

Another source of tag mortality which must be quite considerable is from predators. Especially is this true while the fish are still weak from the operation and before they have found a school where they are more or less protected. Frequently the presence of predatory fish is known. In several instances sardines were tagged in the immediate vicinity of pleasure fishermen catching bonito and large mackerel. Live sardines of similar size as those being tagged were used for bait. After the ordeal of acquiring a tag it must have been difficult for a sick sardine to evade such fast swimmers as fish of the mackerel tribe. Unfortunately, in these cases, it was impossible to tag the fish elsewhere, yet a surprising number of these tags were later recovered. Predatory fish must frequently be lurking below without our knowledge. On February 8, 1938, a load of sardines was being tagged from the live box in Newport Harbor. A member of the boat crew caught six rock bass (*Paralabrax nebulifer*) on hook and line, using live sardines as bait. The stomach and intestinal contents of each fish were examined, and in one was found a sardine which had been tagged and released at the same place the day before.

Sea gulls are often a serious menace during the day and especially when fish are being tagged under way. Some of the tagged fish stay near the surface long enough to be picked up by a watchful gull. To verify these observations one gull was shot, and tagged sardines were found in its crop. Cormorants and several other species of diving birds have been observed catching tagged fish when first released. Porpoise and more often sea lions are frequently such a serious menace while fish are being tagged that drastic measures are sometimes necessary to discourage them.

In addition to the fact that not all sardine reduction plants have magnets, the fresh fish market catch unquestionably accounts for the loss of many tags as there are no recovery devices at the markets. To this must be added the loss of tagged fish in the enormous live bait fishery in southern and Lower California waters, not to mention the dead bait fishery farther north.

Every sardine cannery operates a reduction plant to reduce canning offal as well as whole fish. During conveyance of cannery offal to the reduction plant a large proportion of the tags are lost. Consequently for each ton of fish received, plants running straight reduction may be expected to pick up more tags than combined canning and reduction plants.

On the other hand, there is a considerable tag loss even in reduction plants where magnets are installed. No two magnets are equally effective and the efficiency of any one may vary from week to week. Furthermore, the effectiveness of the recovery system depends upon the interest the reduction plant employees take in the experiment. If magnets are cleared of their scrap carefully and frequently a good many more tags are recovered per unit quantity of meal than in plants where no one cares about clearing the magnet. The installation of a magnet, such as its angle of inclination, proximity to other metal, rapidity of meal flow and several other considerations, all affect the number of tags recovered. Several experiments have been performed which demonstrate fluctuations in magnet efficiency. More extensive experiments are planned for the 1938-39 sardine season. They should yield a reasonably reliable measure of the efficiency of each magnet and its changes throughout the season. These data are fundamental if a measure of fishing intensity is to be obtained from tag recoveries.

Mechanical Tabulation of Tag Recoveries

An analysis of tag returns obviously necessitates the tabulation of recoveries in a number of different ways. As returns become more numerous (over 1300 at the present writing) the task of organizing the data becomes increasingly involved. This task has been much simplified by the use of the Division of Fish and Game Hollerith

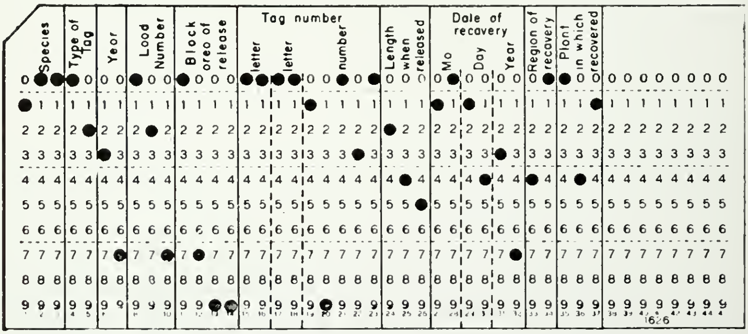

FIG. 127. Facsimile of punched card used in tabulating sardine tag recoveries.

electrical statistical equipment (Conner, 1935) to record tag recoveries on punch cards. Each card has 45 vertical columns of consecutive numbers from 0 to 9. (See Fig. 127.) All pertinent information relating to each recovered tag is coded into numbers. The system is quite flexible so the method may be applied to any species of fish which may be tagged. Space is provided on each card for coding additional information which may be found useful in the future, but has not seemed important at the present time. An electric key punch is used to transfer the code to the card by punching out the code numbers.

A sorting machine arranges the cards in any desired order or separates any group or individual card from the rest. A mechanical tabulator automatically combines and summarizes any desired information appearing on the sorted cards and presents the data in printed form.

Fishing Seasons

Although sardines are tagged to some extent the year around. recoveries can only be expected during the canning and reduction season as tags are recovered by electro-magnets in the reduction plants. During the remainder of the year considerable quantities of sardines are caught for bait but tags in any of these fish are lost. In British Columbia, Washington and Oregon the canning and reduction season starts in June or July and continues as far into October as weather and availability of fish permit. In the San Francisco-Monterey region the season lasts from August 1 to February 15 of the following year. In the San Pedro and San Diego regions the canning and reduction season starts on November 1 and ends the following March 31.

Tagging and Recovery by Regions, June, 1937—June, 1938

San Francisco-Monterey region

During the first season of tagging in the San Francisco-Monterey region a live car was used to hold the sardines to be tagged (Janssen. 1937). Returns from these fish were exceedingly few compared with recoveries from sardines held for tagging by other means. As returns from fish tagged from a live box on the deck of a fast 45-foot cruiser off southern California were highly satisfactory, this method was tried off central California in the fall of 1937. The returns were equally numerous from the fish released during September, October and November in the vicinity of the Farallone Islands and in Monterey Bay. (See Table 4.)

The sardine fishing grounds off San Francisco extend a considerable distance offshore so that tagging in this area was practically all done while cruising on the open ocean rather than carrying the fish to a sheltered cove where the operation could be performed more comfortably. The fish were released one at a time as tagged and consequently spread over a wide area. Sea lions and cormorants are so abundant in the vicinity of the Farallones that it was never practical to lay in their lee when fish were obtained in that vicinity. In Monterey Bay fish were frequently tagged in harbors, but occasionally while cruising at sea.

As shown in table 1, there have been 372 recoveries from the 19,203 sardines tagged in the San Francisco-Monterey region. Of these 350 were from the 10,981 fish tagged during the past year. Although 258 tags have been recovered in central California from fish released in southern California, only eight central California tags have been recovered in the south. This is a satisfactory recovery in view of the fact that relatively few fish were tagged in central California waters compared with the number tagged in the south. In addition the sardines released between San Francisco and Monterey were tagged early in the season and consequently were subjected to an intensive fishery over a period of several months. The tagged fish stock left to move south was therefore quite small.

Disregarding the floating reduction fleet which operated off San Francisco beyond the three-mile limit, there were 22 plants operating on or near San Francisco Bay during the 1937-38 sardine season (Dado, 1938). Of these plants, 12 were equipped with magnets, an increase of 5 magnets over the previous season. Practically all meal from the floating reduction fleet was ground in one plant at San Francisco which is also equipped with a magnet. During the past sardine season the magnets in the San Francisco area accounted for 372 California tags and one Oregon tag.

On Monterey Bay there were 12 plants operating during the 1937-38 season. Of these, 10 were equipped with magnets, an increase of 3 magnets over the previous season. These magnets picked up 193 California tags and 2 British Columbia tags during the past season.

San Pedro region

The 31,142 sardines tagged in the San Pedro region have yielded 870 returns. Of these, 360 were from the 16,427 sardines tagged since June, 1937. A good many of these fish were released since the close of the canning and reduction season so there will be no opportunity for recoveries until the 1938-39 season commences.

Sardines released in the San Pedro region have been recovered in all the major sardine fishing localities on the Pacific Coast. The plants on Vancouver Island, British Columbia, have accounted for 17 tags from this region; Washington, 5; Oregon, 4; San Francisco, 153; Monterey, 77; and San Diego, 9. (See Tables 1 and 4.) Recoveries in central California were more numerous from sardines tagged in southern California late in the 1936-37 season than from those released early the same season. Since the large sizes presumably make the longest migrations this may be partially due to the fact that a greater proportion of large fish were tagged late in the season. But probably more important is the fact that the fish tagged early in the season were subjected to a longer fishery. Therefore the tagged stock was reduced considerably before the northerly migration started.

Methods of obtaining and holding fish for tagging in the San Pedro region were the same as during the previous year. It has been the policy, however, when using the live box to tag and release the fish while cruising at sea whenever possible rather than release the fish at one place or in harbors. The chief advantage of this system is to get the fish back into the ocean quickly and consequently in good condition. Transporting them to a snug anchorage where tagging can be done more conveniently is frequently time-consuming. Returns are usually better from fish held but a short time. Although tagging is slow when the sea is rough, releasing the fish sooner and consequently in better condition, compensates for any disadvantages or inconveniences. On occasion it is possible to lay to and tag on the open ocean but the boat is usually steadier when cruising into or away from the seas.

One more magnet was in operation in the San Pedro region during the 1937-38 season than during the previous season, making a total of 10 magnets for 14 plants. These magnets have accounted for 431 California tags and 3 additional British Columbia tags during the past year.

San Diego region

As during the 1936-37 season, three of the four plants were provided with magnets. These magnets recovered only one sardine tag during the past year. This is explained by the fact that very few sardines were handled in these canneries and reduction plants.

Four of the tags released in the San Diego region in the spring of 1937 were recovered in British Columbia the following summer; and during the 1937-38 season in California, 20 of these tags appeared at San Francisco, 8 at Monterey and 4 at San Pedro.

Since the spring of 1937 only 830 sardines have been tagged in the San Diego region. These were all very small fish and were in comparatively poor condition. The intensive bait fishery in this region will undoubtedly account for a good many survivors making the chance of any recoveries very small.

Lower California

No means were provided until recently for the recovery of sardine tags in Mexico. There is a small sardine fishery out of the port of Ensenada and two plants have installed magnets. However, so few fish are reduced that at best few tags may be expected from that source. There is a good sized bait fishery along the coast of Lower California which unquestionably takes many of the small fish tagged in that territory. Unfortunately, no recoveries can be obtained from fish used as bait.

In April, 1938, 963 sardines were tagged in Magdalena Bay, about 580 miles southeast of San Diego. This is the southernmost locality in which sardines have been tagged.

Differential Movements of Medium and Large Sized Sardines

From the sardines tagged off southern California during the late winter and early spring of 1937, there have been recoveries in all the major sardine fishing areas on the Pacific Coast. Since there was a wide range of sizes tagged during this period, data on these fish were analyzed to determine whether the larger tagged fish made longer migrations than the smaller and medium sizes. From the recovery data, four frequency polygons were made of the lengths of the fish recovered in different areas. (See Fig. 128.) Since it is impossible to determine the length of tagged sardines at the time they are recovered, the total lengths of each fish at the time of tagging were used. To obviate the necessity of a correction for growth, only recoveries obtained over a limited period of time were considered. Frequency polygon I includes all fish caught soon after tagging in the same fishing region as tagged. This curve should represent a cross-section of the survivals from the late winter and early spring tagging in southern California in 1937. The next frequency, II, includes the tagged sardines recovered in British Columbia, Washington and Oregon in the summer of 1937 from this same southern California tagging. Frequency III represents recoveries of these southern tagged

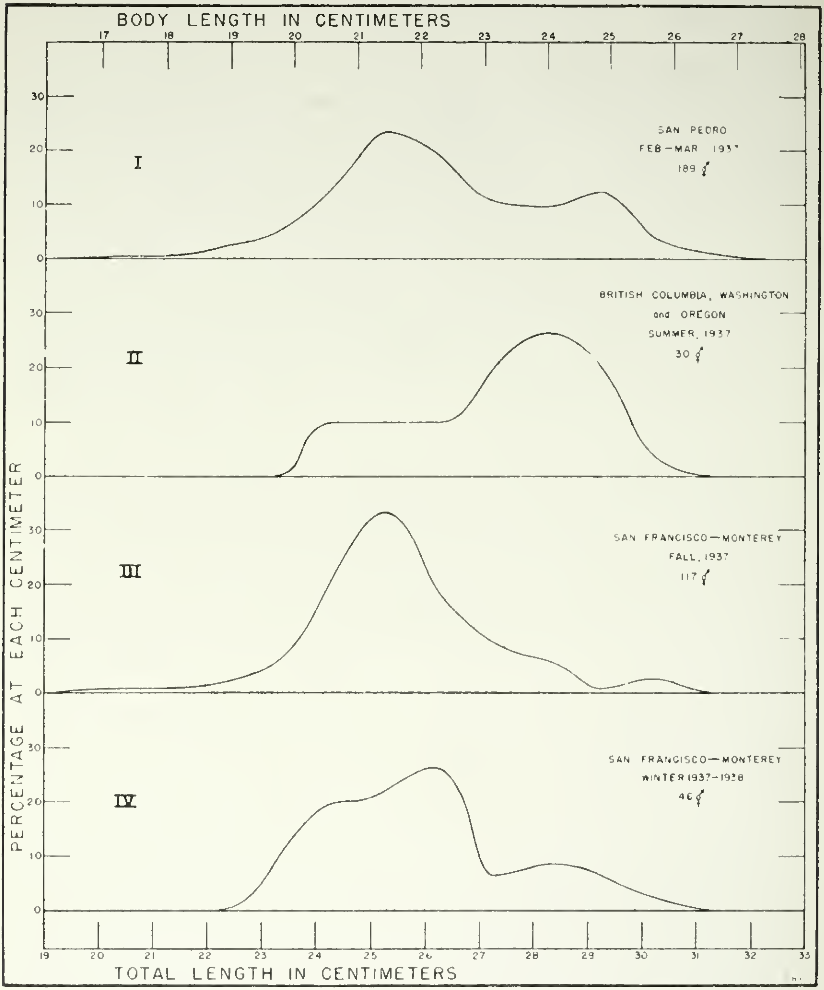

FIG. 128. Length frequency polygons of a group of tagged sardines recovered at different localities along the Pacific Coast. The fish were all tagged and released in southern California waters, January-March, 1937. The lengths given are the sizes at time of tagging, not at time of recovery. Frequency I shows the sizes of fish recovered at San Pedro within a few weeks after tagging; Frequency II, fish recovered in British Columbia, Washington and Oregon in the summer of 1937; Frequency III, recoveries at San Francisco and Monterey in the fall of 1937; and Frequency IV, recoveries at San Francisco and Monterey in the winter of 1937-38.

fish taken in the fall of 1937 at San Francisco and Monterey, and the last curve, IV, includes the recoveries in this same region during the winter of 1937-38.

If all of these fish, irrespective of size, had the same habits of migration, the frequency polygons should obviously be quite similar. Since they are apparently different, a reliability test was applied to aid in the proper interpretation of their differences. χ^2 gives a satisfactory measure of the probability that two frequencies are samples of the same population if each frequency is composed of over 100 individuals. The t test may be applied if small numbers are involved in each frequency. Since we are comparing frequencies containing both small and large numbers, both the χ^2 and t tests were applied to all frequencies. (Pearson, 1914, p. 92; Yule and Kendall, 1937, p. 442; and Treloar, 1935, app., table III.)

TABLE 3

A Comparison of the χ^2 and t Tests Applied to the Four Frequencies.

	I and II	I and III	I and IV	II and III	II and IV	III and IV
P from χ^2	0.03043	0.00497	0.39737	<0.000015	<0.000015	0.30935
2τ from t	0.00677	0.00036	0.18625	<0.0000002	<0.00019	0.20690

From the four frequencies there are six possible comparisons. Table 3 shows a comparison of the values obtained by the two methods. If our theories of sardine migrations are correct, we should not expect small tagged fish to move from southern California into British Columbia, Washington and Oregon waters within a short time interval. Furthermore, the large sizes should dominate the medium sizes in the north. A comparison of frequencies I and II bears out this contention but the number of individuals in frequency II are too few to make the curve very reliable. However, the t test indicates that the differences are significant.

Comparisons of curve II with III and II with IV indicate that during the summer the bulk of the large tagged fish from southern California were in regions north of the San Francisco-Monterey fishing grounds. The differences between these curves are highly significant. On the other hand, if the smaller tagged fish have not moved as far north as the British Columbia, Washington and Oregon fishing grounds they should be taken in the San Francisco-Monterey fall fishery. This is clearly indicated by the comparisons of curves I with III and II with III and the tests of reliability for these comparisons.

According to present theories of sardine migration the large fish from the north are expected to arrive in numbers off central California during the winter. These fish are thought to continue to southern California waters with the medium sized fish. We might expect then that the sizes of fish taken in the winter months at San Francisco-Monterey and San Pedro should be very similar. This is indicated by the similarities of frequencies I and IV and by the measures of reliability.

For the comparisons between the San Francisco-Monterey fall and winter frequencies, curves III and IV, the winter frequency should contain more large fish than does the fall frequency. This is true but the measures of reliability indicate that the differences are not significant.

Acknowledgments

The State Fisheries Laboratory of the California Division of Fish and Game is indebted to the Bureau of Patrol of the Division for their willing cooperation in making available to us their patrol boats, especially the *Yellowtail,* from which most of the past year's tagging has been done. To Captain Edward R. Hyde and the crew of the *Yellowtail* we want to express our appreciation for their able assistance. We are grateful to the many fishermen who have donated sardines for tagging purposes, and to those owners and employees of canneries and reduction plants who have cooperated in the recovery of tags. We appreciate the cooperation extended by the officials in British Columbia, Washington and Oregon who have exchanged tagging data with us and arranged for the recovery of California tags in their localities.

Summary

The migrations of the California sardine, *Sardinops caerulea* (Girard), along the Pacific Coast of North America are being studied jointly by Canadian, Washington, Oregon and California authorities. The present paper deals primarily with the work of the California investigations. From March, 1936, to June, 1938, 53,352 sardines have been tagged in California waters and 1054 on the coast of Lower California (Mexico). Already, these tags have yielded 1334 recoveries along a thousand mile coast line. Since tagged fish were usually released on or near the fishing grounds, most recoveries have been from fish caught soon after tagging in the same fishing region as tagged. However, 258 tags from southern California fish have been recovered in central California, and 30 in Oregon, Washington and British Columbia. Conversely, 10 British Columbia tags and one Oregon tag have been taken in California. In addition, 8 central California tags were recovered in southern California.

An internal or "belly" tag is used. It is a flat strip of nickel-plated steel, 19.05 mm. by 3.97 mm. by 0.63 mm. Each tag bears a serial number. Smaller tags are used for very small fish. The tag is inserted into the body cavity of the fish.

Sardine tags are recovered by means of electro-magnets placed in the meal lines of reduction plants.

TABLE 4

California Sardine Tag Recoveries, March, 1936 – June, 1938

Sardines tagged by locality			Number of recoveries by region and season												
			California 1936-1937 season				North of California 1937 season			California 1937-1938 season					
Date tagged	Locality tagged	Number of sardines tagged	Recovered at San Francisco	Recovered at Monterey	Recovered at San Pedro	Recovered at San Diego	Recovered in British Columbia	Recovered in Washington	Recovered in Oregon	Recovered at San Francisco	Recovered at Monterey	Recovered at San Pedro	Recovered at San Diego	Total number recovered from each lot tagged	Percentage recovered from each lot
Mar. 9, 1936	Santa Monica Bay	881	22	19	13					13	5	3		75	8.51
April 29, 1936	Santa Monica Bay	83	1	1	1					1	2	4		10	12.05
Sept. 16, 1936	Monterey Bay	1,496	4	7						3	2			16	1.07
Sept. 23, 1936	Monterey Bay	80													
Sept. 24, 1936	Monterey Bay	796													
Sept. 25, 1936	Monterey Bay	749	1	2										3	0.40
Oct. 14, 1936	Monterey Bay	897		3										3	0.33
Oct. 15, 1936	Monterey Bay	1,337													
Nov. 19, 1936	Santa Monica Bay	990			21	1				5	6	4		37	3.74
Nov. 20, 1936	Santa Monica Bay	683			9					2	2	2		15	2.20
Dec. 17, 1936	Half Moon Bay	593													
Jan. 14, 1937	Monterey Bay	197													
Jan. 15, 1937	Monterey Bay	988													
Jan. 16, 1937	Monterey Bay	1,089													
Jan. 23, 1937	San Pedro	501			1		1				1	1		4	0.80
Feb. 1, 1937	Newport	489			9									9	1.84
Feb. 2, 1937	Newport	479			3									3	0.63
Feb. 3, 1937	Newport	373			12	4				3				19	5.09
Feb. 3, 1937	Newport	775			11	1	1			1	1	1		16	2.06
Feb. 4, 1937	Newport	1,104			9	1				4	2	2		18	1.63
Feb. 19, 1937	Newport	195			9					3	2			14	7.18
Feb. 20, 1937	Newport	475			8					5	2	3		18	3.79
Feb. 23, 1937	Newport	423			6					3	7	1		17	4.02
Mar. 2, 1937	Newport	795			19	1	4	1	1	5				31	3.90
Mar. 3, 1937	From La Jolla to Oceanside	574			17	4	3			10	4	1		39	6.79
Mar. 9, 1937	Coronado	830			15	1	1			9	4	3		33	3.98
Mar. 10, 1937	San Diego Bay	773			1					1				2	0.26
Mar. 17, 1937	Newport	396													
Mar. 19, 1937	Newport	630			6		1			2				9	1.43
Mar. 23, 1937	Newport	756			12		1			16	3	4		36	4.76
Mar. 23, 1937	Newport	826			7		1			4		2		14	1.69
Mar. 24, 1937	Newport	567			7		3	1	2	5		1		19	3.35

TABLE 4—Continued

California Sardine Tag Recoveries, March, 1936—June, 1938

Sardines tagged by locality			Number of recoveries by region and season											Total number recovered from each lot tagged	Percentage recovered from each lot
			California 1936-1937 season				North of California 1937 season			California 1937-1938 season					
Date tagged	Locality tagged	Number of sardines tagged	Recovered at San Francisco	Recovered at Monterey	Recovered at San Pedro	Recovered at San Diego	Recovered in British Columbia	Recovered in Washington	Recovered in Oregon	Recovered at San Francisco	Recovered at Monterey	Recovered at San Pedro	Recovered at San Diego		
Mar. 24, 1937	Newport	1,030			10			1	1	8	1	1		22	2.14
Mar. 26, 1937	Newport	797			22		3	1		11	6	1		44	5.52
Mar. 27, 1937	Newport	680			3		2	1		30	13	2		51	7.50
April 20, 1937	San Quentin Bay	91													
May 9, 1937	Long Beach	389								3		8		11	2.83
May 9, 1937	Long Beach	398								6	4	8		18	4.52
June 9, 1937	Monterey Bay	1,492								3	2	1		6	0.40
June 16, 1937	Monterey Bay	1,211								24	8	1		33	2.73
Sept. 28, 1937	Farallone Islands	554								19	9	2		30	5.42
Sept. 29, 1937	San Francisco Bay	323													
Sept. 29, 1937	Farallone Islands	571								40	16	1		57	9.98
Sept. 30, 1937	Farallone Islands	671								29	17	1		47	7.00
Oct. 1, 1937	Farallone Islands	348								19	3	1		23	6.61
Oct. 1, 1937	Farallone Islands	522								26	7			33	6.32
Oct. 5, 1937	Monterey Bay	765								41	38			79	10.33
Nov. 2, 1937*	Monterey Bay	1,178								5	7			12	1.02
Nov. 5, 1937	Monterey Bay	557								8	10			18	3.23
Nov. 8, 1937	Monterey Bay	435													
Nov. 9, 1937	Monterey Bay	662								3	4	1		8	1.21
Nov. 9, 1937	Monterey Bay	899								1	2			3	0.33
Nov. 29, 1937	Santa Monica Bay	100										3		3	3.00
Dec. 1, 1937	Santa Monica Bay	785										16		16	2.04
Dec. 2, 1937	From Pt. Mugu to Pt. Dume	413										10		10	2.42
Dec. 2, 1937	Catalina Island	587													
Dec. 14, 1937	Santa Monica Bay	863										21		21	2.43
Dec. 15, 1937	Santa Monica Bay	1,003										2		2	0.20
Feb. 4, 1938	Newport	598										11		11	1.84
Feb. 7, 1938	Newport	655										18		18	2.75
Feb. 7, 1938*	Newport	1,062										4		4	0.38
Feb. 8, 1938	Newport	835										61		61	7.31
Feb. 8, 1938*	Newport	214										8		8	3.74
Feb. 10, 1938	Newport	386										16		16	4.15
Feb. 10, 1938*	Newport	185										1		1	0.54

Feb. 14, 1938	Newport	448										5		5	1.12
Feb. 15, 1938	Newport	623										41		41	6.58
Feb. 16, 1938	Newport	722										47	1	48	6.65
Feb. 17, 1938	Newport	698										30		30	4.30
Feb. 17, 1938*	Newport	493										12		12	2.43
Feb. 18, 1938	Newport	711										32		32	4.50
Feb. 18, 1938*	Newport	394										12		12	3.05
Feb. 21, 1938*	Newport	1,569										9		9	0.57
Mar. 21, 1938	San Pedro	99													
Mar. 21, 1938*	San Pedro	198													
April 3, 1938*	Magdalena Bay	399													
April 3, 1938*	Magdalena Bay	498													
April 4, 1938*	Santa Monica Bay	245													
April 7, 1938*	Magdalena Bay	66													
April 18, 1938*	San Diego Bay	441													
April 19, 1938*	San Diego Bay	389													
May 12, 1938*	Monterey Bay	396													
May 13, 1938*	Monterey Bay	34													
May 14, 1938*	Monterey Bay	363									1			1	0.28
June 5, 1938*	San Pedro	491													
June 5, 1938*	San Pedro	790													
June 12, 1938*	San Pedro	240													
June 12, 1938*	San Pedro	481													
June 12, 1938*	San Pedro	539													
	Broken tags				3					1	2	12		18	
	Totals	54,406	28	32	234	13	21	5	4	372	193	431	1	1,334	
	British Columbia tags recovered in California		2		3						2	3		10	
	Oregon tags recovered in California									1				1	

* Tagged with the small tag.

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REDUCTION PROCESSES FOR SARDINES IN CALIFORNIA [1]

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INTRODUCTION

From an insignificant beginning the reduction of fish and fish offal to scrap, meal and oil has become an industry of magnitude in the State of California. Not only has it contributed to an unprecedented expansion of the sardine fishery, but also it has kept constant pace with an ever improving and increasing fishing fleet. The value of this fishery has been attainable because of the ready market for reduction products, together with the advancement in the mechanical means of utilizing the maximum good from the raw product.

The methods of converting whole fish and fish offal into stable and portable articles of commerce will be described in the following pages.

HISTORY

The present development of the California reduction plants is in part the results of accumulative advancements made elsewhere, mainly on the eastern coast of the United States and in Europe. The history of this development is given briefly, as it makes possible a better understanding of the present day processes.

Foreshadowing the modern use of fish scrap as a fertilizer, the American Indians of the eastern coast are credited with having used whole fish, principally menhaden, to insure a better crop of maize, because the fish buried in the hills with the seed added plant nutrients to the soil. This custom persisted along certain parts of the middle Atlantic coast to, and even beyond, the year 1800, and in the Scandinavian countries and Iceland until 1899.

Following the use of green fish as a fertilizer came the supposedly accidental discovery that it was possible to obtain useful oil from the fish. Hogsheads were partly filled with menhaden, water added, and the recovery of the oil left to the putrefying action which soon set in. Frequent stirring was necessary to facilitate the liberation of the oil globules, which floated to the surface and were skimmed off. After the oil ceased to collect at the surface, the residuary mass was used as a fertilizer, the oil and "guano" thus obtained being utilized by the individual producing it, or disposed of to immediate neighbors. Although fertilizer is at present just one of the minor products of a reduction plant, the term "fertilizer plant" still lingers on in general parlance because of early associations.

[1] Submitted for publication, August, 1938.

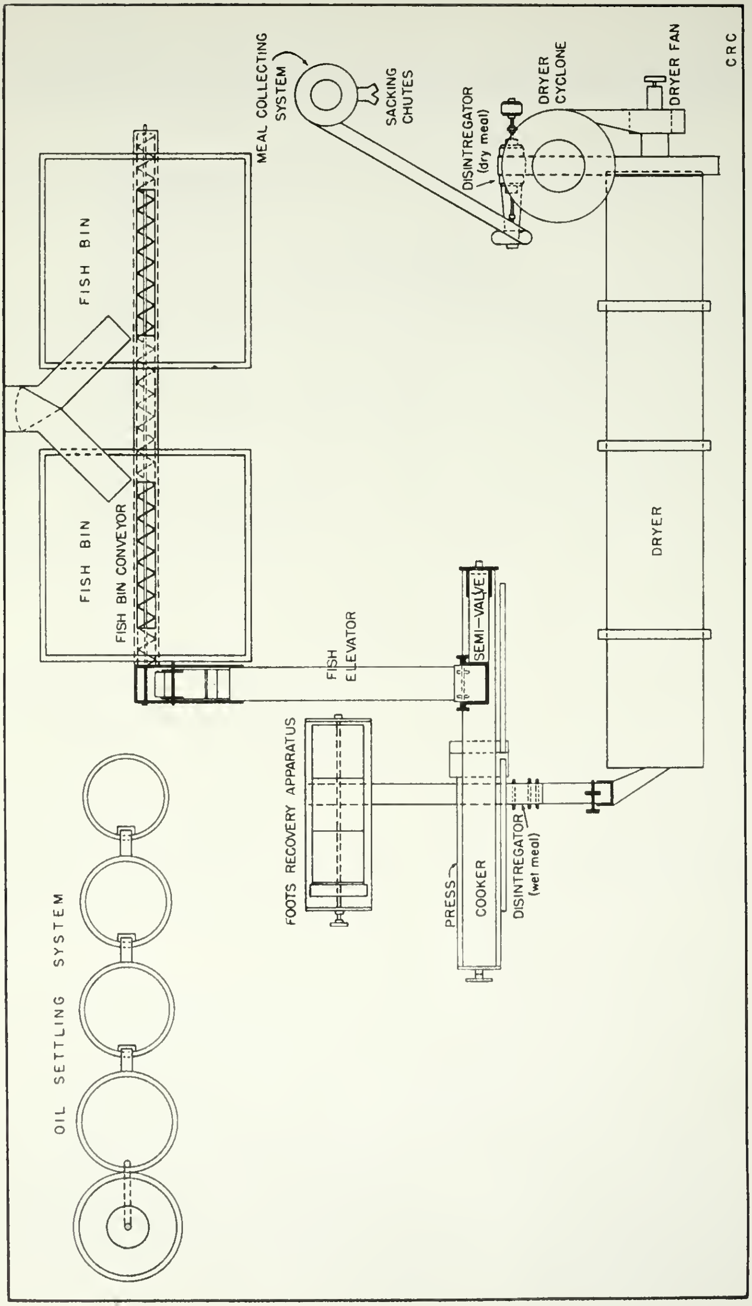

Fig. 129. Diagrammatic drawing of the layout of a sardine reduction plant.

The first improvement made in the foregoing process was boiling the fish in huge kettles, then placing them in casks as noted above. By 1830 the boiling of fish was general among the few farmers who attempted to bolster their incomes by this crude reduction method.

Beginning about 1850, the extraction of oil from menhaden, together with the preparation of fish scrap as a fertilizer and of meal as a stockfood, can be considered as an industry. During the period from 1850 to 1865, about 15 plants were built and operating, the majority of them in Maine. By this time steam cooking was used generally, a process which made a greater oil yield possible. Another distinct advancement was the use of presses to extract the oil, instead of the old skimming method. At first the cooked mass of fish was placed in a perforated wooden stave container and weighty objects laid on top for several days. Soon this method became obsolete with the introduction of hand lever presses; then the screw type of press was used, and in 1858 the hydraulic press was adapted to the industry, and a few years later was in general use.

Paralleling the mechanical improvements made in fish reduction processes was the increasing efficiency of the menhaden fishing fleet. The development of the purse seine and the adoption of the steam-driven fishing vessel gave encouraging indication of a dependable source of raw material.

The first menhaden oil produced was used as a substitute for, or to adulterate linseed oil in outdoor paints. This use dominated the oil market prior to 1865, when the product began to be used for currying or filling leather. Another early use of the oil was as a burning oil in the safety lamps of coal miners and in cordage manufacture. A European export market was established around 1875, where the oil was used in the manufacture of cheap soaps and as a sheep tick repellent. Present day industries find many and varied uses for fish oils; they are utilized largely in the manufacture of soap, paint and varnish, linoleum, felt-base paper industries and waterproof fabric industries. Lesser amounts are used in the tanning of leather and in making artificial leather, for quenching steel, for insecticide sprays; in the manufacture of candles, rubber substitutes, printer's ink and textiles; and as a constituent of core oils. Rather more recent developments tend to show that the oil can be used as vitamin concentrates in human and animal nutrition; likewise by hydrogenation the oil is finding uses as lard substitutes, lubricating greases and powders, and buffing compounds.

One of the persistent obstacles in the path of the developing industry was the disposal of the meal or scrap. Because of the high moisture content the press residue had to be used almost immediately; otherwise decomposition set in and made it practically valueless. The first attempt to insure stability and portability of the meal was to dry the press cake on platforms in the sun. This was in 1853. While the method by no means solved all the difficulties, it was a definite improvement.

Another method of preparing the meal for shipment before the advent of artificial dryers was acidulation by sulphuric acid. The action of the acid "fixed the ammonia, prevented fermentation, and dissolved the bones." This method of treating with acid was common in the Maine plants, whereas in the South sun-drying, when weather permitted, was the common practice.

Although the need for artificial drying was recognized early, it was not until 1880 that dryers came into general use in the menhaden plants. Hot air and steam dryers were both used and contributed greatly to the stability of the industry. Both types are in use today and will be described on subsequent pages.

The use of fish scrap or meal as an animal food has only in recent years become of importance, although this use was anticipated at an early date, in various parts of the world, by feeding stock whole fish. Extensive studies in the United States and Europe around 1875 showed the value of such fish products for stock feeding. However, prejudice and custom combined to prevent the general use of the meal prior to the World War.[2] The high price and actual scarcity of feeds at that time forced the farmers of America to use feed materials which had been neglected previously. A stimulated demand for fish meal in preference to the coarser scrap accelerated the installation of machinery necessary to produce the more desired article, so that at present the bulk of the dried product finds its way into various mixed rations for poultry and live stock.

Gradual development of the reduction processes followed, until about 1914, when plants became essentially as we know them today. Bucket elevators, automatic conveyors, continuous steam cookers, hydraulic presses, artificial dryers, and other forerunners of the most modern of present day equipment were in general use. The industry is, however, by no means stalemated, for continued improvements and changes are resulting in an ever more economical operation and improvement of its products.

It should not be inferred from the above account that the industry in California has not undergone a period of development and advancement. Independent, to a large extent, of the much earlier established industry in the East, California reduction methods have become today as mechanically efficient as those in use in other places. Here again is an interesting and instructive developmental period to be considered.[3]

Fish offal, rather than whole fish, was first used in California for the production of scrap; the offal was handled as a sideline to the regular treatment of slaughter house tankage. Beginning about 1900, the Excello Grease Company, located in Butchertown, San Francisco, obtained fish offal from the fresh fish markets of the city and produced a fish scrap which was disposed of to the Hawaiian Fertilizer Company and blended with the latter's product obtained from whale meat to produce a commercial fertilizer. The offal was cooked in a large steam vat under a few pounds pressure. After each batch was cooked, the

[2]The first attempts at using fish meal for stock feeding were discouraging because of the high oil content of the meal available at that time.

[3] The authors are indebted to the following for much of the information contained in this article, especially in the following section: Messrs. Max N. Schaefer, K. Hovden, Fred Mullins, Harry Berggen, William Baumbacker and George Harper. To this roster of men who were instrumental in establishing the reduction industry in California, we would like to add the names of Messrs. Wilbur Wood and F. E. Booth, although we had no opportunity to contact them personally. We are also indebted to many reduction plant foremen and workers, and also to the representatives of the various companies engaged in the manufacture of reduction plant machinery—a list too numerous to accord individual recognition. Lastly, we wish especially to thank Mr. Ralph Classic and Mr. Harry Berggen for many helpful criticisms of the manuscript.

mass was removed to a blanket press (a hydraulic press in which a "blanket" served as the straining surface) to remove the moisture, and the press cake was further dehydrated in a direct fire dryer.

A few years later the Miller and Lux Company, operating a slaughter house in San Francisco, began using fish offal to make fish scrap. Their product was mixed with dried meat offal and marketed as a fertilizer. It is very probable that the use of fish offal became a common sideline in many meat packing establishments where the raw material was available at this time.

The first venture in California made for the sole purpose of reducing fish was at McNear's Point on San Pablo Bay in 1914. Max N. Schaefer constructed a plant costing $15,000, primarily for the purpose of handling salmon offal from the G. W. Hume cannery at Benicia. Considerable buck shad were also used during the season. Strangely enough, about the only fish used throughout in the round were sharks and skates, which were easily obtainable in the Bay.

This plant differed in several interesting details from the modern plant. Cooking and drying were accomplished in one operation by means of the steam-batch dryer.[4] The green material to be used was placed directly in the dryer and heated under partial vacuum until sufficiently dry. The dryers, in actual operating details, were very similar to the present day batch dryers; for those in Schaefer's plant were long steel cylinders (18 feet by 4 feet), mounted on two end rollers, with the cylinder encased in a steam jacket having controllable feed lines. During the drying, a partial vacuum was maintained by means of a small vacuum pump. The cylinder revolved slowly (nine revolutions per minute), tumbling and spreading the material throughout the length of the dryer; it was equipped with small flights projecting inward from the cylinder to assist in mixing the material. Two counter-balancing heads served for feeding and discharging. A dryer of the above size is capable of handling 3500 pounds of material in $3\frac{1}{2}$ hours when the customary temperature of 160° F. is maintained during the process.

Oil was extracted from the "crackling" or unfinished meal which had been cooked and dried by the gasoline extraction method. This process has been described by Scofield (1921) and is here quoted:

"**Extraction tank**

The extraction tank is a heavy cylindrical steel tank about nine feet in diameter and about fourteen feet high. The tank is filled through a door in the top to within eighteen inches of the top with the dry unfinished meal. Gasoline is then sprayed in from the top through a perforated pipe till the tank is filled with gasoline sufficient to cover the meal. The tank full of meal and gasoline is then heated by introducing steam at the top of the tank. The heat is said to be about 325 degrees and is continuous for an average of about eight hours. The gasoline begins to take up the oil of the fish meal even before the meal is thoroughly heated, so that the process of draining off the mixed gasoline and oil is begun soon after the steam is introduced. The bottom of the tank is a sheet of steel perforated to allow liquid to drain through it. Under this metal sheet there are alternating layers of charcoal and gunny sacking to catch and hold particles of meal, so that the liquid may be drained off as pure as possible. After this oily

[4] Dryers may be separated into the batch type and continuous type. In the first, each charge of the dryer is finished before any additional material is introduced, and in the continuous type, charging and discharging are one continuous operation.

gasoline is drained out, the tank is again flushed with a fresh supply of gasoline, which is also drained off. A small door in the side of the tank, even with the metal floor, is then opened and the meal pulled out.

"**Recovery of oil**

The liquid drained from the extraction tank is carried by pipe into a smaller tank called the evaporating tank, which is about 12 feet long and 5 feet in diameter. It is provided with a large steam coil capable of heating the liquid to 300 or 325 degrees. The heat volatilizes the gasoline and a pipe at the top of the tank carries off the gas thus formed. After about four hours practically all the gasoline is driven off, leaving only the fish oil remaining in the tank. If much gasoline is left in the oil and the oil is later refined, a serious explosion is apt to result, so that it is essential to drive off all the gasoline possible. The oil is then blown out of the tank by steam pressure and conducted by pipe to a storage tank. The oil is later deodorized by heating to about 600 degrees, which also removes practically all of the moisture and other volatile impurities. The oil is then ready for shipment to the paint manufacturer.

"**Recovery of gasoline**

The volatilized gasoline escapes from the evaporating tank in a pipe that is run through a condenser or coiled pipe in a bath of running cold water. Ocean water is particularly good for cooling the condenser pipe. The condensed gasoline drains into a storage tank and is ready for use again in the extraction tank."

The two plants using the forgoing described method of oil extraction discontinued operation in 1920.

In addition to the plant just described, there is another phase to the beginning of the industry that has continued uninterrupted up to the present time. From the outset of the fish canning industry in California, offal disposal became a problem; and, prior to the installation of reduction units, the waste from the canning lines was loaded on barges and dumped several miles at sea. The hygienics of this procedure became a hotly debated problem to civic authorities, and at times a severe financial drain to cannery operators. It was not uncommon for the cost of such disposal to reach $3.00 a ton. Disposal costs and the conviction that the offal could profitably be used were the incentives that started an industry which has since become of considerable magnitude.[5]

Reduction of offal was begun on an experimental basis at the F. E. Booth Company plant at Pittsburg in 1910. The first unit installed was a so-called bottle digester of eastern manufacture. This steam-jacketed bottle unit was stationary but was equipped with a center shaft and a series of paddles. Raw material to a capacity of 750 pounds was placed directly into the digester and cooked, while being constantly agitated. After the mass was sufficiently cooked, the water and liberated oil were drawn off into a series of settling tanks, while continued heat applied to the mass removed still more moisture. From the container, the material was placed in a blanket press for additional moisture removal and oil recovery. Drying was completed by solar radiation.

The success of this venture led in 1912 to the installation of a Dayton Garbage Dryer of the type commonly used in municipal

[5] The World War, with the ensuing demand for canned goods, made reduction units more or less an actual necessity. The prevailing prices of meal and oil at the time were also incentives to the expansion of the industry. Meal sold for $60.00 a ton, and oil for $1.10 a gallon.

garbage disposal plants throughout the Middle West. Essentially, the apparatus was of the same general construction as our present day steam-batch dryers, the greater length being vertical rather than horizontal, however. The cylinder, 5 feet in diameter and 7 feet high, was stationary, but the material being dried was kept in motion by paddles, connected to a center shaft. This dryer was installed in the Booth Company plant at Monterey.

In the same year (1912) the screw press was first installed and used in a California reduction plant. This unit was made by Toulouse & Delorieux Company of San Francisco and had previously been used as a wine press.[6] (A solid bronze, double screw press, originally made as a wine press, is at present still giving satisfactory service in a reduction plant.)

Credit must also be given to the F. E. Booth Company for equipping and operating the first floating reduction unit in California for cannery offal, when, in 1913 and 1914, the *Newark*, a converted lime-kiln barge was used for this purpose for one season at Monterey and one at Pittsburg. Her equipment consisted of an open steam vat cooker, a hydraulic press and a steam-batch dryer.

The next attempt to effect improvements was the installation (1915) in Monterey of a direct flame rotary dryer. Oddly enough, the shell was constructed of cement and it was discarded after one season.

Up to this time cooking of the offal had been done in open steam vats or in a digester as mentioned above; however, in 1915 F. E. Booth designed and installed in Pittsburg the continuous spiral cooker, which differed only in minor details from present day cookers.

In 1915 Schaefer established his second California plant, this one at Monterey. His raw material was obtained from the several canners operating there at the time and was handled by the same method as described elsewhere.

The first meal produced in California from sardine offal was sold unground,[7] because the hammer type disintegrators (dry meal) were not in use prior to 1916. Like the majority of fish reduction units, the hammer mill was also adapted to fish meal processing from types used in other manufacturing lines.

By 1916 the mechanical means of utilizing fish offal to produce meal and oil had in general been perfected to a surprising degree, at least as far as the individual units were concerned. In the following year the first continuous reduction installation in California was completed and operating in the Booth Company plant at Monterey. This

[6] As suggested by Scofield (1921), it is very probable that the screw press was first developed in the olive oil extraction industry.

As a humorous insight into some of the mechanical difficulties encountered in these first presses, it is worth recalling that the mentioned firm was invariably referred to as "Too-loose and Too-tight." The name was the operators' way of expressing an opinion that the presses were never correctly adjusted, and no two adjusted alike. As the effect of cooking and condition of the offal prior to cooking came to be better understood, this difficulty was somewhat removed. But perhaps the most important step in converting wine presses to use in fish reduction was a change in speed of the two screws. By retarding the press screw to a speed less than that of the hopper screw, much more satisfactory results were obtained.

[7] The early fish meal producers met a prejudiced market until the public became familiar with their product. Petaluma poultrymen, a group which made up one of the first established markets, had previously tried salmon meal in their mixed rations. This Alaskan product had a very high oil content, and for feeding purposes gave unsatisfactory results.

was a decided improvement over any existing plant, as it effected a considerable saving in operating expense and greatly increased the plant capacity.

With the exception of the dryer, this plant differed but little from present day units; for conveying screws and buckets, spiral cookers, screw presses, hammer-type disintegrators (dry meal) were all essentially modern. The dryer consisted of two stationary, long steel drums, one placed directly above the other; both were surrounded by firebrick with the ends resting on a firebrick arch. The firebox was beneath the lower drum, with vents leading from the box proper to spaces built around each drying unit for the conduction of the heated air. At one end of each tube was a cyclone fan forcing the air in the same direction as the meal was moving. The fans were so placed that they had no connection with the heated air from the furnace, but served only to spread auxiliary heat from the surrounding firebrick and helped to pull the meal through the length of the tube. A center shaft equipped with projecting paddles to agitate the material traversed each tube. Meal entered the uppermost tube, was carried throughout its length by the forward throw of the paddles and the air current created by the fan, then fell into a hopper feeding the lower tube and was discharged at the opposite end. This two-drum unit had a capacity of two tons of press cake per hour.

In the following year (1918) several canneries installed reduction machinery patterned after the Booth unit. Among them were the International Packing Company at San Pedro and Steele Bros. at San Diego. At the same time there were six operating plants in Monterey, some of which were established prior to 1918. Some early operators in Monterey were the K. Hovden Canning Company, J. Madison of the Pacific Fish Company and George Harper of the Monterey Canning Company.

About 1920 the wet meal disintegrator, a so-called nutrition mill to be described later, was introduced.

From that time to the present the handling of meal has followed rather conventional lines, the greatest changes having taken place in the dryers, where the earlier beneficial developments in these units are ascribed to eastern ideas.

From the beginning the press liquor has been handled by the flotation system, the method being practically the same as that used today. One interesting change was that the first settling tanks used (generally six) were made, for economy of floor space, quite high and narrow. Considerable difficulty was experienced in separating the oil from the water-oil emulsion just beneath the flash oil layer. It was a common practice to add salt to the mixture, for the greater weight of the salt water aided the separation. However, when tanks were used in which the diameter was greater than the height, a much better separation was obtained.

In 1927 the first centrifugal system (to be described later) for separating the press liquor into its components was installed.

Additional equipment for oil recovery is a recent innovation. The foots machine (so-called because it supposedly represents the foot or end of the recoverable solids) came into general use in 1932, although this device was anticipated some years earlier by a similar machine which was never widely adopted. The vibrating screen has been in use for only two or three years.

Prior to 1930, the only material available for reduction in any amount was offal from the canning lines. In that year, by a legislative act allowing reduction of whole sardines under permit, an impetus was given to the industry which may be realized from the number of plants operating today: 70 at the time of writing (1937-38 season).

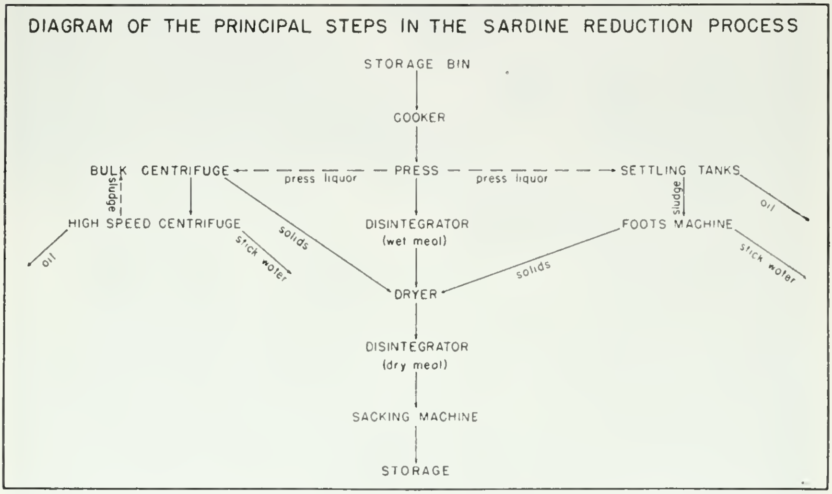

Fig. 130. The principal steps in the sardine reduction process. The solid arrows indicate successive steps; the dashes indicate alternative steps (the press liquor is treated either in settling tanks or in centrifuges).

PROCESSING UNITS

As an aid in following the continuity of the reduction process, figure 130 has been prepared, showing the successive steps in the treatment of the raw material. Alternate steps are indicated by dotted lines. The relative positions of the various units are shown in the outline drawing of a generalized plant in figure 129.

The following descriptions of reduction machinery in use today apply only to one installation, and the installations are not necessarily from the same plant. It should be understood that all measurements, speeds, temperatures, etc., may, and certainly do, vary according to plant capacities and personal ideas of the operators; likewise, there may be considerable difference in detailed items of construction in the same units of different manufacture.

Cookers

Cookers are of one general type, descriptively called the continuous spiral worm cooker or digester. A cooker is essentially a long steel tube, equipped with a conveying screw worm, which carries the material to be cooked past a series of live steam jets, supplying steam at 8-inch intervals from a manifold beneath the cooker. In some cookers the jets are staggered, every other jet entering above the bottom of the cooker shell. A number of Eastern plant operators prefer, in addition to the jets along the bottom, a hollow shaft jet arrangement, wherein steam is discharged through small continuous openings in the revolving shaft.

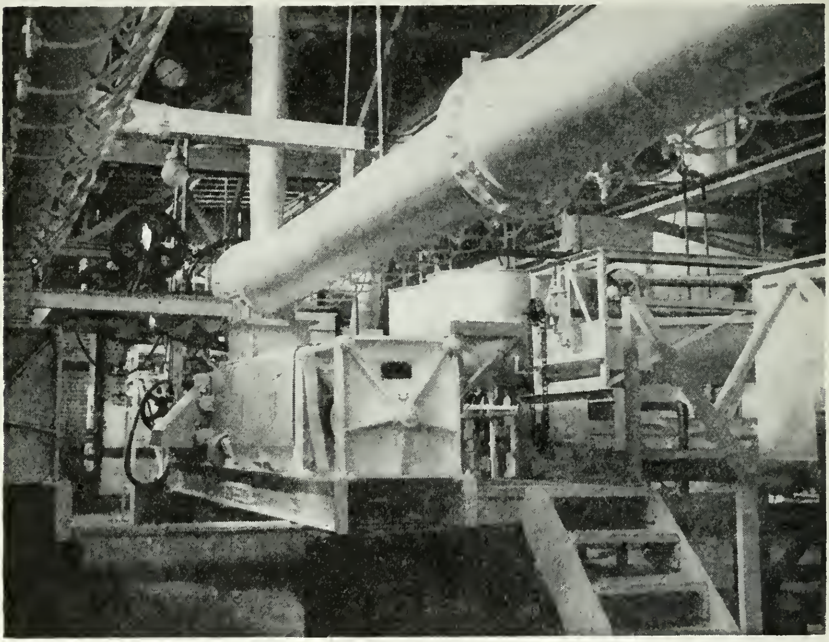

FIG. 131. A spiral cooker and directly below it, in the square housing, the screw press. As may be seen on either cooker, the steam jets, in this installation are staggered, and the manifold is to one side, rather than below the cooker. The view is toward the discharge end of the press. Photograph by E. L. Macaulay.

The size of the cooker varies according to the press capacity; extreme lengths are 30 to 100 feet, with outside diameters of 17 or 19 inches, allowing a 16- or 18-inch screw, as the case may be.

The fish are conveyed from the bins by a bucket conveyor, each bucket holding 6 to 10 pounds of fish, which are delivered into the semi-valve, allowing the entrance of the material into the cooker without loss of steam pressure. The material is then carried forward by the slowly revolving screw, past the numerous steam feeds in the bottom of the shell and after 20 to 25 minutes of cooking arrives at the discharge end. The pressure (and subsequent rate of cooking) varies from 3 to 25 pounds, the pressure being determined by the nature of the material to be handled; for instance, fresh solid fish require more pressure than stale fish. At times, when the operator wishes to hasten the process, the speed of the spiral worm, as well as the steam pressure, may be increased. However, thorough cooking is essential at all times to free the oil globules and to obtain the maximum oil yield. Over-cooking is to be avoided also, for when the fish are too soft, pressing is more difficult.

Some three feet from the discharge end of the cooker, the bottom half of the solid cooker shell is replaced by a screen with a bleeder to carry away what oil and moisture may have separated from the mass during cooking.

Presses

The next step is pressing the cooked fish to remove as much of the oil and water as possible. The pressing unit is located directly under the cooker, because it is necessary that the material be pressed before any cooling of the mass takes place; so the fish are received in the press hopper as they emerge from the discharge end of the cooker.

The press consists of an 8-foot continuous cast steel worm, forming the horizontal axis, which is surrounded by a cylindrical screen. The screen is divided into two sections, each with two pieces of screen, top and bottom. The first section, known as the hopper screen, is 24 inches long, with 32 holes to the square inch. The second, or press screen, is 64 inches long with a screen size of 64 holes per square inch.[8] Flights on the worm are machined to fit closely against the inside of the screen, especially at those points directly beneath the curb-slats, which form reinforcing collars around the outside of the screen

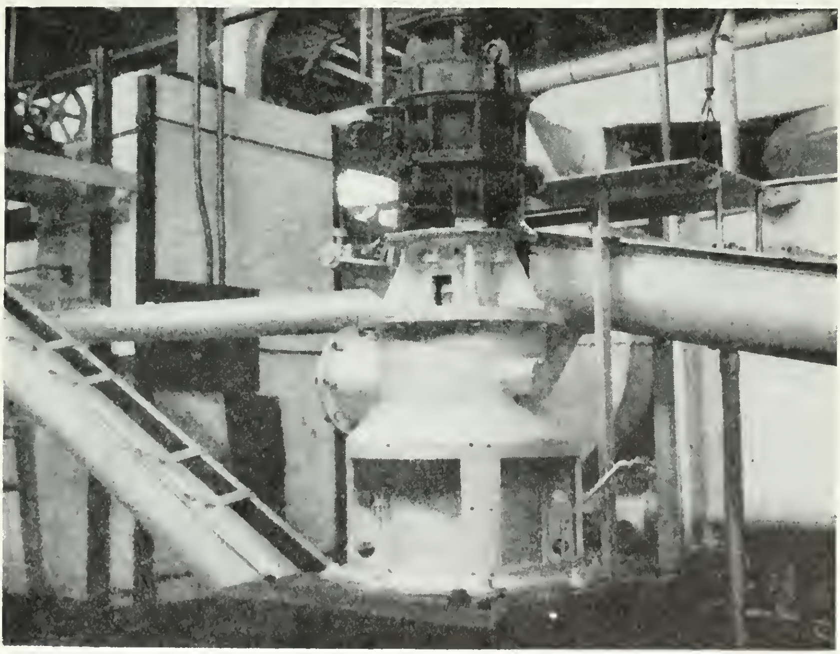

FIG. 132. The vertical wet meal disintegrator. In the left background is part of an 'L' furnace, and the round tube in the left center is a water-jacketed meal conveyor. Photograph by E. L. Macaulay.

that may be adjusted to make regulation of the distance between the flights and the screen possible. The worm is cone-shaped at the dis-

[8] A press of different manufacture from the one here described has holes of uniform size throughout.

charge end, fitting closely against the beveled end of the press casting.[9] Pressure is exerted as the continuous flights carry the mass against the restricted area (core block) between the cone and its beveled counterpart. The position of the cone and, hence, the discharge opening and the pressure may be varied. Motive power for both the cooker and the press screw is supplied by an electric motor of 20 to 25 horsepower, and the speed of the two units is synchronized.

Moisture and oil are forced from the material and collected in drip pans below the press. The subsequent treatment of the press liquor will be described later.

Wet Meal Disintegrator

The material from the press, known as press cake, is led by a screw conveyor into the wet meal disintegrator (also called hasher, beater and fluffer), which is designed to pulverize it completely before it enters the dryer. The speed of the drying process and the economy of operation are furthered when the material at this stage is finely divided.

One type of disintegrator is essentially of the same construction as the common household meat grinder (nutrition mill), consisting of a worm which forces the meal against a revolving knife, which cuts against a flat steel plate, perforated with holes of one-inch diameter.

Another type of disintegrator, the vertical hammer type, consists of a battery of hammers enclosed by a heavy screen. The hammers are short, wedge-shaped castings, rigidly mounted at regular intervals on a vertical shaft that turns at a speed of 3600 revolutions per minute, "whipping" the meal and literally throwing it through the surrounding screen.[10]

In a very similar disintegrator, of different manufacture, solid sheets surround the hammers, the latter fitting closely against the sheets. As the material is thrown outward by the revolutions of the shaft, it is pulverized between the sheet and the ends of the hammers; it is then collected in a hopper directly below and conveyed to the dryer.

Dryers

The adaptation of artificial dryers to the production of fish scrap and meal was one of the most important steps in the development of the industry. During the years of expansion this unit became of increasing importance, with a resulting variety of types, and even modifications of the general types being produced. The effect of drying

[9] The diameter of the worm continuously increases toward the discharge end, with a corresponding decrease between the outer and inner diameter of the flights. As the flights near the cone end, their angle of inclination more nearly approaches the vertical; thus as the mass nears the discharge end, it travels more slowly and under greater pressure. In some presses the worm is divided into two sections, constructed so that the sections may be turned at different speeds. Increasing the revolutions of the section near the intake over that of the following section has a comparable effect to that produced when the angle of the flights is decreased in the last section. The majority of the first presses used were double screw. (See footnote 6.)

[10] The screen is 18 inches in diameter, 18 inches deep and $\frac{1}{4}$ inch in thickness. The holes are $\frac{3}{8}$ inch in diameter.

Each hammer is 6 inches long and $\frac{1}{2}$ inch thick; at the point of assembly to the center shaft they are 2 inches wide and are wedged to $1\frac{1}{4}$ inches at the free end. They are spaced at 2-inch intervals on the shaft and are "staired," *i.e.*, no succeeding hammers are in alignment. The hammers of some units are not rigidly mounted to the center shaft but are movable along the horizontal plane.

upon the finished product is a carefully considered factor in the successful operation of a plant, for complete drying is of foremost importance; but at the same time, scorching and burning of the material must be avoided. Likewise the loss of heat-labile nutritive elements must be kept at a minimum.

With the increasing tendency of plants to locate close to an available labor supply, especially when reduction is carried on in conjunction with canning, the odor problem is also considered in the selection of a dryer. Most of the gases which have given to reduction plants a certain (and in some cases a justifiable) olfactory stigma, arise from the meal during drying. So, many of the alleged points of superiority of one type of dryer over another are based upon this one factor.

The variety in the types of dryers reflects the importance of careful handling at this stage of the process, as well as the diversity of opinions as to how this need may be best satisfied. Though each type of dryer in use can be assigned to one of several general types, many individual operators have had their dryers constructed according to personal specifications. Comparative merits of the different dryers are highly controversial; for this reason, the authors have avoided writing anything that might be interpreted as indicating a personal preference.

Steam-batch dryer

The first dryer adjusted to fish reduction needs was the steam-batch dryer, a form of which was described in a previous section. In connection with this dryer it should be recalled that raw fish were placed directly in the dryer, and the oil extracted later. This method has been found practicable only when the material to be handled was of very low oil content; the rather high oil content of sardines requires cooking and pressing first.

A modification of the first mentioned steam-batch dryer, the agitator type, consists of a stationary cylinder, 5 feet in diameter by 20 feet in length. The interior of the dryer is fitted with a large shaft running from the feed to the discharge end, with specially designed arms and paddles attached to mix thoroughly, agitate and convey the material through the heated interior of the cylinder. A fixed temperature is held in the cylinder by a surrounding steam jacket, where a steam pressure of 100 pounds is maintained. In a dryer of the given size, at the given pressure, 1500 pounds of dry meal may be delivered in three hours. The dryer shaft and paddles are clutch-controlled; and, by reversing the shaft, the meal is delivered at the discharge door in the lower section of the cylinder head. Such dryers may or may not be equipped with a spray condenser and a vacuum pump.

The dryers of this type are used in a series; that is, from six to twelve dryers are necessary in the average plant, the discharge from each of the units in the series being picked up by a common conveying screw and carried to the grinder.

Continuous steam rotary dryer

Another application of the steam drying principle has been utilized in the steam rotary dryer. In this form, a cylinder, 56 feet long and 6 feet in diameter, is mounted on two or more sets of trunnions. Running the length of the inside of the cylinder are 74 steam pipes, placed in circles concentric and adjacent to the dryer shell. Four-inch pipes are near the inside of the dryer, with $2\frac{1}{2}$-inch pipes placed next to the shell wall so as to leave an open space about 4 feet in diameter in the center of the cylinder. A steam pressure of 70 pounds

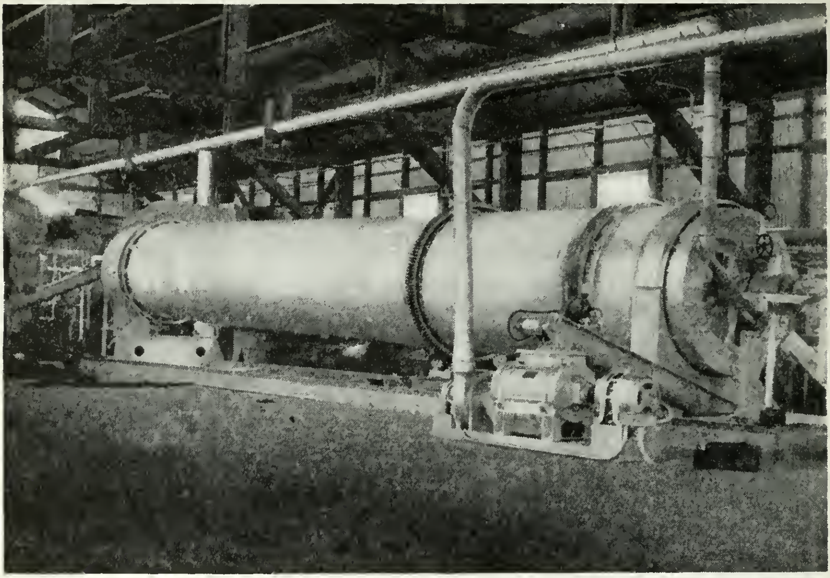

FIG. 133. A continuous steam rotary dryer. The longer overhead pipe is the steam feed pipe entering the cylinder through a control valve. The points of attachment of the inner steam pipes may be seen on the right end of the dryer. In the right foreground is the dry meal disintegrator, showing the screw conveyor leading from the dryer, and also the blower which forces the ground meal through the upright tube that leads to the sacking chutes. Photograph by S. Ross Hatton.

is maintained within the pipes, which results in a temperature of 242° F. Meal enters the slowly revolving (7 revolutions per minute) dryer and is tumbled over the pipes and through the heated atmosphere. A slight inclination of the cylinder is sufficient to move the meal to the discharge end. When meal first enters the dryer, it takes from 25 to 30 minutes for the dried material to appear at the discharge end; however, with a continuous flow of meal, the drying time is shortened to about 20 minutes at which rate 7300 pounds of wet meal may be handled per hour.[11] The vaporized moisture from the material is removed at the intake end by a cyclone fan.

[11] The following information is added to clarify the data relating to capacities of the various units, and it may be used where conversion factors are desired. These factors are approximations only, and vary markedly according to the plant, season and locality. (Clark, 1937.)

One ton of fish will yield from 40 to 47 gallons of oil. One hundred and seventy gallons of press liquor are obtained from each ton of fish, consisting of 12 to 16 per cent recoverable solids and 23 to 27 per cent oil. The meal ratio (number of tons of raw fish required to produce a ton of meal) is a fairly constant factor, being about $5\frac{1}{2}$ or 6 to 1. The press cake contains about 50 per cent moisture, and after the drying process the amount of moisture is reduced to 8 or 10 per cent.

Semi-super heated steam dryer

In contrast to the dryers previously described, the furnace of a semi-super heated steam dryer is built in connection with, and forms a conspicuous part, of the installation. The furnace is an L-shaped structure of firebrick (9 x 12 x 12 feet). One wing serves as a mixing chamber for steam and hot air; the other wing is the firebox proper. Between the two chambers is an arch of firebrick, with a number of bricks omitted to allow for the passage of heated air into the mixing chamber, where steam is also introduced and mixed with the air from the firebox to produce a temperature of about 500° F.

Piercing one wall of the furnace and abutting closely against the arch is a small, rotating cylinder, which in turn enters the head of the conventional large rotating cylinder. The other essential part of the dryer is a large cyclone fan with damper control.

The meal first enters the mixing chamber in a water-jacketed screw conveyor. This cooling device is necessary to prevent the meal

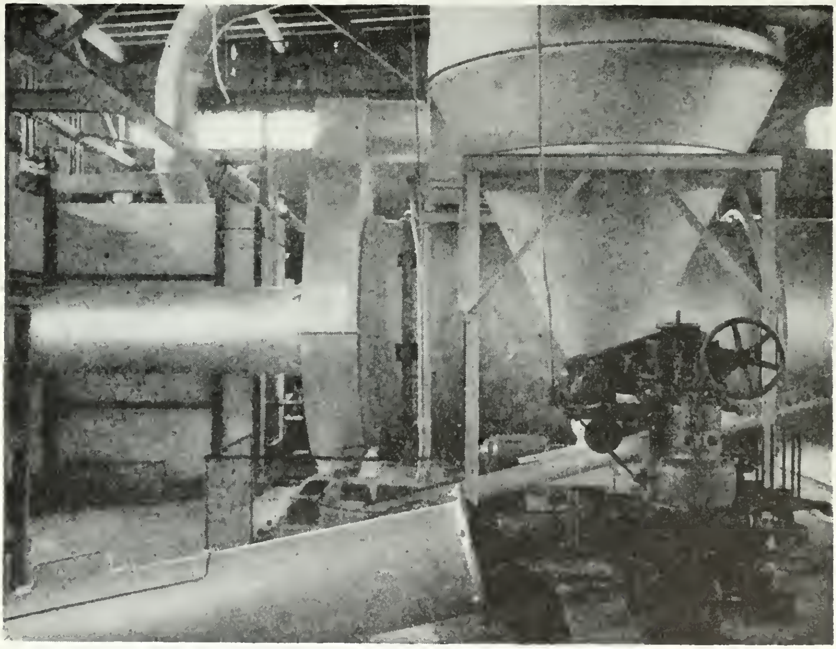

FIG. 134. A semi-super heated steam dryer. On the left is the "L" furnace and connecting horizontally with it the first and smaller drying tube entering the large drum. The collar at the point where the two tubes join houses the cyclone fan and its vents. The large funnel at the right and the machinery and conveyor tube in the foreground are part of the canning equipment. Photograph by E. L. Macaulay.

from burning at this point as well as to protect the conveying tube from the high temperature. From the conveying tube the meal enters the small cylinder (3 feet in diameter and 24 feet long). Some 14 feet from the arch, the small tube pierces the head of the larger one and continues inside it for 10 feet; so that the dryer is essentially a tube within a tube, and, as the material in each tube travels in opposite directions, the same drying area is maintained as in the longer, single-tube dryers. Within each tube are small projecting baffle plates with an almost neutral throw, *i.e.*, the meal is thrown neither forward nor backward. After traveling the length of the small tube, the meal falls into the larger one; it then goes in the opposite direction and is discharged at the end where it first entered the drying unit.

The meal is moved along its course by the large cyclone fan, which also draws the vaporized moisture and spent gases from the chamber. It is interesting to note that when any particle of material has lost sufficient moisture, it is almost immediately carried to the discharge end, regardless of its position in either tube; but the heavier, moisture-laden particles continue until they are likewise removed by the air current. It takes the main mass from 20 to 25 minutes to dry. The capacity of this installation is 10 tons of press cake per hour.

Direct heat dryer

This type of dryer is somewhat similar to the above, consisting of a furnace built in connection with a large steel cylinder, and a cyclone fan. The furnace is of steel, cylindrical in shape (55 inches in diameter and 12 feet long) and lined with firebrick. Between the furnace and the drying chamber is a firebrick arch, with perforated walls for the passage of the heated air into the cylinder. The arch is removed sufficiently far from the combustion chamber to prevent the flames coming into actual contact with the meal.

The dryer proper is a long steel tube (4 feet in diameter and 53 feet long), mounted on two sets of trunnions, which connects directly with the furnace behind the arch. Meal enters through an overhead hopper or on an underfeed screw conveyor. On the inside of the dryer are baffle plates, or spiral shelves, which serve to drop the material continuously through the heated air as the drum slowly revolves. A large cyclone fan moves the dried material to the discharge end and removes all spent gases.

About twenty minutes are required to dry the meal when the temperature in the dryer is 195° F. and the capacity of a dryer of this size at this temperature is 15 to 20 tons of press cake per hour.

Grinder (Dry Meal Disintegrator)

From the dryer the meal, which is now nearly processed, is conveyed to the grinder for final sizing before sacking. This unit resembles the wet meal grinder so closely that it may aptly be described by comparison. The most notable difference is that the dry meal grinder is horizontal in position; consequently the meal enters at one side of the hammers, rather than directly above them. The hammers are also differently shaped, being trapezoidal instead of wedge-shaped, and shorter than the others described. The hammers, attached to a center shaft by pins, are slightly movable in the vertical plane and surrounded (except at that point where meal enters) by a screen with openings $\frac{3}{8}$ inch in diameter.

An integral part of the dry meal grinder is a cyclone fan situated at the end opposite the driving motor. As the meal is forced through the screens, it is picked up by the cyclone fan and conveyed to a storage bin just above the two sacking chutes. Extending from the grinder is a 10-inch conveying tube which goes upward, along the ceiling, and then down to some convenient point where the actual sacking is done. In the majority of plants, sacking, weighing and sewing are done by hand, whereas others are equipped with automatic sackers.

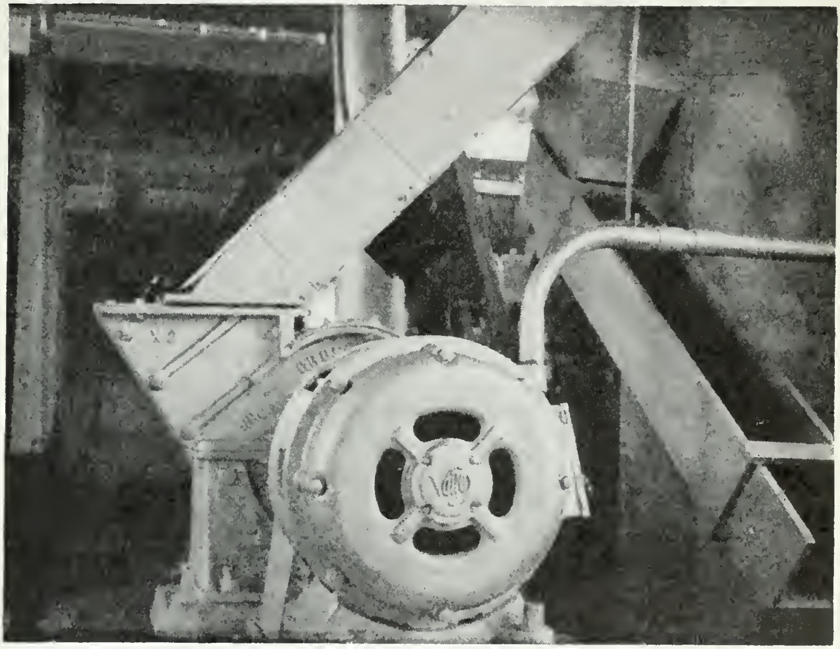

FIG. 135. The dry meal disintegrator, showing in the center background the tube that conveys the meal to the sacking chutes. Suspended underneath the conveyor feeding the disintegrator is the coil of an electro-magnet for recovering sardine tags. Photograph by E. L. Macaulay.

Floor Curing

Some plant operators subject the meal to a curing process before sacking. This consists of spreading the material to a depth of about 6 inches over a suitable surface for a 24-hour period. During this time the meal is turned at intervals, after which it is ready for sacking. This additional treatment supposedly gives the meal a lighter, better color and removes any possibility of its caking in the sack because of "sweating."

The spreading is accomplished by a reversible screw conveyor running the length of the curing room, where numerous trap or sliding doors along its length permit the material to be deposited on the floor below. After curing is completed, the meal is shoveled into a movable accessory conveyor to enter the overhead conveyor, whence it is taken to the sacking discharge. Some few years ago spreading was a general procedure in all plants, but the advent of more efficient dryers has largely removed the necessity of floor curing.

Separation of Press Liquors

We return now to the liquors which were separated from the mass during cooking and pressing. For every ton of fish handled, approximately 170 gallons of liquor are obtained, which consists partly of condensed steam added during the cooking, the natural oil and water content of the fish, and flesh particles which were forced through the apertures of the press screen. Economy of operation requires a nice separation of this liquid into its marketable oil and solids.

In contrast to the fairly standardized way of handling the meal, oil recovery is effected in a number of ways, many of which are recent introductions and others still in the experimental stage. Regardless of the methods employed for separation, they all work on one principle; the different specific gravities of the components of the press liquor allow their separation by simple flotation (settling tank system) or, if the force of gravity be superseded by centrifugal force, the same principle still operates. The respective levels of these different components are free oil on top, oil and water emulsion with some suspended solids next, then waste water, and solid particles on the bottom.

Settling tank system

The majority of California plants use the settling tank system for oil recovery, though vibrating screens and centrifuges may or may not be used in conjunction. Generally five tanks are used, the first being the largest and also the highest; the others are decreasingly smaller and lower, so that a continuous flow from one tank to the succeeding one is possible. Each tank except the last is equipped with an adjustable overflow regulator to maintain a continuous flow regardless of the amount of liquor to be handled. Liquor from the press and cooker is introduced into the first tank, and, by the time it has risen to the discharge opening, a primary separation has already taken place; thus, the next tanks receive free oil (flash oil) in addition to some water and solids, although the great part of the solids is retained in the first tank. Each tank in the series is filled to overflowing, and the separation continues in the succeeding tank; but the last tank is for receiving only, from which the oil is pumped into storage. Two or more of the tanks are equipped with steam heating pipes to maintain a temperature of 165° F. in the mixture.

This process leaves in the bottom of the four tanks a mixture of water, finely divided flesh particles and a little oil.

Foots recovery apparatus

A recently devised machine, the foots machine, which consists of a rotating hexagonal screen, a collecting pan and a small screw press, is used to recover the solids remaining in the sludge.[12] Sludge from the tanks is pumped into the rotating screen, where the solids are retained; a slight inclination of the screen is sufficient to cause the material to collect at the lower end, where it drops into the hopper of the press, directly below the screen. The foots press is identical in construction with the main press but noticeably smaller. Press cake

[12] The screen is of 60-mesh wire, 10 feet long and 3 feet in diameter. The foots press is 4 feet long and has 8 flights.

from the foots press is returned to the conveyor feeding the wet meal disintegrator.

Situated between the screen and the press is a collecting pan which receives the liquor that has passed through the screen; the liquor from the foots press also joins the same discharge. This so-called stick water from the foots machine is generally discarded, but present indications are that further separation of oil and solids from the stick water can be made profitably. One attempt at present is being carried out commercially with every indication of success; it is still however rather experimental and will not be described in this paper.

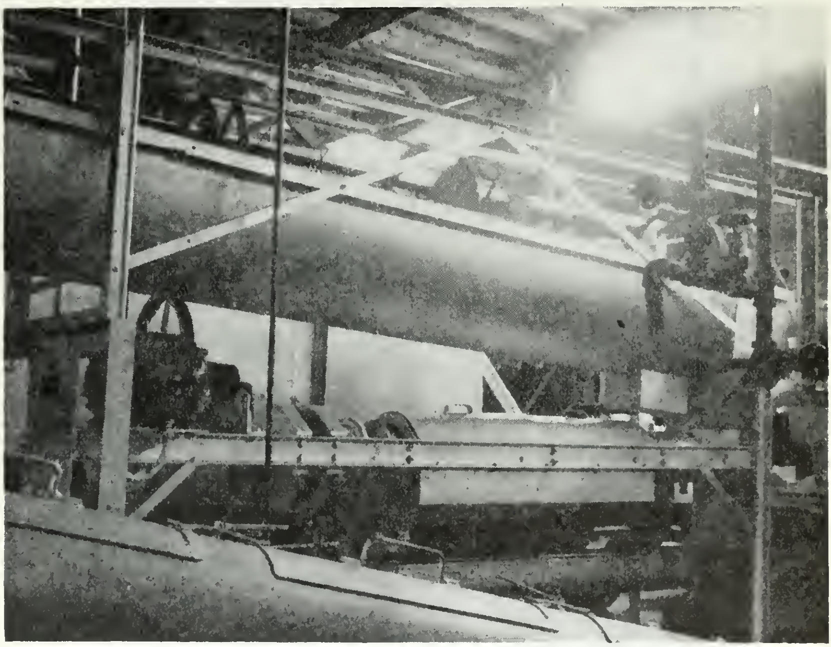

FIG. 136. The foots machine, showing the drip pan beneath the frame for the screen, and the press directly under the pan. The press hopper may be seen to the right of the photograph. (As is customary the screen is removed during the off season, at which time the photograph was taken.) Photograph by E. L. Macaulay.

Vibrating screens

Vibrating screens have only recently been installed in California plants and so far but few are in use. They may be used for the primary removal of solids from the press liquor or in conjunction with the foots machine. They may also serve to recover solids from the centrifugal or settling tanks waste liquor. In recovering solids in the settling tank system or in conditioning the liquor fed to centrifugal separators, from 60-mesh to 80-mesh is used in the screen; for recovering solids from the centrifugal discharge, where the material to be sized is much smaller, a 150-mesh screen is used. Sizing of the particles is made possible by the rapid vibrations of the screen. The vibrator shaft runs at 1800 revolutions per minute and imparts a circular motion to the screen with a one-eighth inch throw. Liquor hits the screen from an overhead feed, and because of a slight inclination the solids collect at the bottom of the screen to be returned later to the press. The liquor is collected below in drip pans, whence it enters the centrifuges or is discharged, as the case may be.

Better results are obtained when the material to be screened is first heated to a temperature of 190° F.

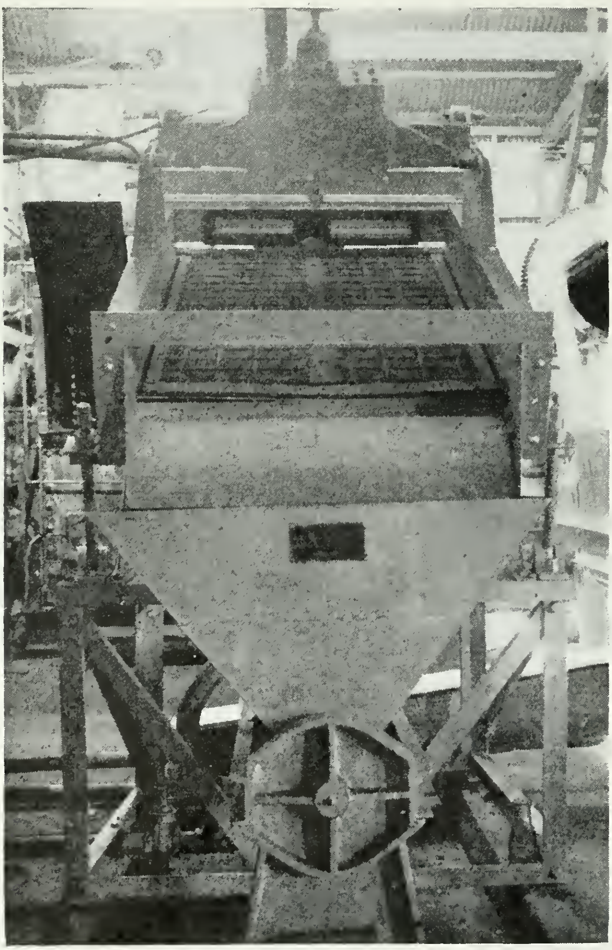

Fig. 137. A vibrating screen. The triangular receiving hopper is in the foreground. Attached to the frame of the screen is the motor, and the vibrator shaft leading from it. (The actual sizing screen which fits above the one shown had been removed at the time the photograph was taken.) Photograph by S. Ross Hatton.

Centrifugal process [13]

Many advantages are claimed for the centrifugal method of handling press liquor over the settling tanks system. In actual practice the claims seem to be well substantiated. The application of this method to the fish reduction industry in the East and in Europe and Asia seems to be more general than in California. Its success in our own plants is apparently indicative of a more general application on the Pacific coast. It is claimed that this method greatly reduces the free fatty acid content of the oil, produces oil of a better color and lower moisture content, and reduces the oil and solid content of the stick water.

This process of oil recovery consists essentially of two steps: first, the bulk of the solids is removed from the press liquor; and second, the oil and water are separated from each other, and some additional solids are recovered. The solids in the first step are removed by a motor-driven suspended solid basket centrifuge, commonly called the bulk centrifuge, developed to meet the need of removing solids so that the liquid components of the discharge could be handled by ordinary mechanical separating methods.

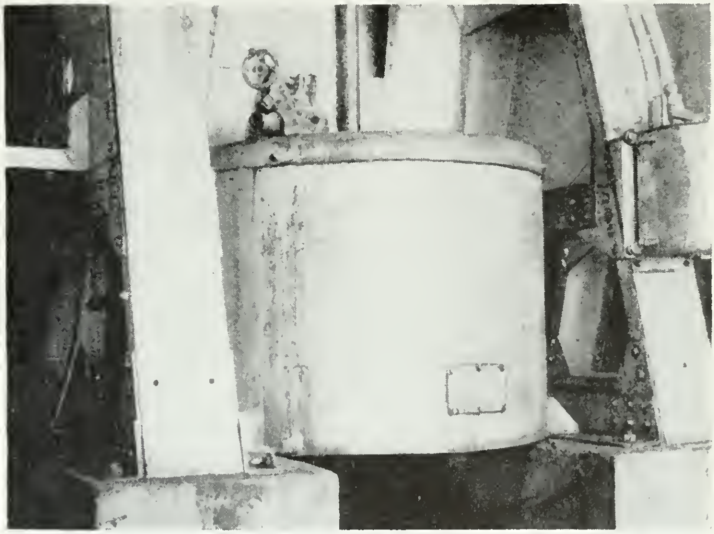

FIG. 138. The bulk centrifuge. The motor shaft is between the uprights. The skimming nozzle and its adjusting device are attached to the outer shell of the basket. Photograph by S. Ross Hatton.

Press liquor enters a feeding tank, then flows into the basket of the bulk centrifuge. As the name indicates, this basket is suspended on a center shaft attached to an overhead motor, and under operating conditions it revolves at a speed of 1200 revolutions per minute, a speed which gives a centrifugal force equal to about 800 times the

[13] The authors wish to express an indebtedness to Mr. T. J. Griffin for much of the material contained in this section and also for his help in revising this part of the manuscript.

force of gravity. Solids, being the heaviest components of the material, are collected on the side of the basket in the form of a bowl cake, with a moisture content sufficiently low to allow the bowl cake to be returned directly to the moist meal entering the dryer. Along the sides of the basket, projecting about four inches inward, are six vertical vanes that serve to prevent slippage of the liquid, *i.e.,* if the vanes were not present the liquid would have a tendency to rotate at less speed than the basket. After the bowl cake has built up to a sufficient thickness, the basket is braked to a stop and a scraper run between the vanes to remove the cake through the bottom of the basket. Under normal operating conditions, the cake of approximately 375 pounds of 60 per cent solids is removed twice hourly, requiring from seven to eight minutes for each discharge. Some baskets are equipped with five horizontal vanes, which serve the same purpose as the vertical

FIG. 139. Two high speed centrifuges ready to be installed. Photograph by S. Ross Hatton.

vanes. When the vanes are horizontal, the bowl cake is removed by a scraper plow, consisting of a flat scraper of sufficient width to fit between two vanes. The scraper is suspended from a shaft that may be raised or lowered to correspond to the different levels of the vanes. In order to empty the basket, the scraper is placed in position between two vanes while the basket is slowed to 50 revolutions per minute; after a few revolutions the scraper is removed and placed between the next two vanes, and so on until the collected solids are completely discharged.

The accumulation of heavy solids on the basket wall leaves an almost clear liquid in the center of the bowl, which is removed by a surface-skimming collection nozzle to a feed tank and then to a flash heater.

The basket is 40 inches in diameter and 18 inches deep, and has a capacity of 15 tons per hour, or, roughly, 3000 gallons of press liquor. The number of bulk centrifuges employed depends of course on the press capacity.

From the bulk centrifuge the liquid effluent now enters a flash heater, where the temperature of the material is raised to 200° F. by injection under pressure of live steam into the oil as it is passing into the receiving tank for the high speed centrifuges.

The high speed centrifuge is designed to separate two immiscible liquids of different specific gravities and simultaneously to remove any remaining solids. This operation and its accomplishment will be familar to a great many readers, at least to those who have had experience with the ordinary cream separator. The actual separating parts are contained in a bowl and consist of 30 identical disks or curved plates, placed close together, for the purpose of dividing the liquid into thin layers. Material enters the bowl through a central tubular channel, and under the action of centrifugal force the heavier components (mainly stick water) are flung to the outside of the bowl, while the lighter portions (oil) rise up the center. A continual inflow of material creates sufficient pressure to force the oil and waste water through separate outlets, while some few remaining solids are also discharged in the form of a sludge from the bottom of the bowl during the unloading operation.

A notable feature of the modern high speed centrifuge is the automatic sludge unloading arrangement, which operates at full running speed. By introducing water into a special chamber beneath the bowl proper, hydrostatic pressure is generated in this chamber by the rotation of the bowl. This pressure forces the bowl to slide upwards, uncovering a slot which extends around the bowl, through which the accumulated sludge is forced out. The actual unloading time requires about 10 seconds and is necessary every 20 minutes under usual conditions. This sludge may be returned to the tank feeding the bulk centrifuge and re-run.

Three high speed centrifuges, each of 5 tons capacity, operating at 6400 revolutions per minute and creating a centrifugal force 7000 times the force of gravity, are required to handle the liquid discharge from the bulk centrifuge. From the press to the completion of the centrifugal separation the oil is in process from 5 to 10 minutes.

Some operators retain the foots machine, vibrating screen, or some device to accomplish the equivalent of the work, and substitute high speed centrifuges for settling tanks, thus making the bulk centrifuge unnecessary.

Ordinarily the high speed centrifuges accomplish the last step in handling the press liquor. The oil is run into storage, and the stick water discarded. Some operators, however, before marketing the oil, subject it to additional treatment by a continued purification or by fortification with other oils, generally fish liver oils, to increase the vitamin content. In no event is it necessary to cook sardine oil before storage, as is the case with menhaden oil.

7—62500

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CALIFORNIA SEA LION CENSUS FOR 1938 [1]

By Paul Bonnot, G. H. Clark and S. Ross Hatton

Bureau of Marine Fisheries
Division of Fish and Game

Two species of sea lions are found along the coast of California. Steller's sea lion (*Eumetopias stelleri*) ranges from Santa Cruz Island northward to Alaska while the California sea lion (*Zalophus californianus*) occurs from the Farallone Islands southward into Mexico.

As a result of periodically recurring interest in these animals and their activities, five surveys of the sea lions occurring on the coast of California have been made during the past ten years by the California Division of Fish and Game. The rookeries and hauling grounds have been located and counts and estimates have been made to determine the numerical strength of the population during the breeding season, at which time the sea lions are concentrated on the rookeries.

Many commercial and sport fishermen maintain that the sea lions destroy vast quantities of fish and do extensive damage to fishing gear. It is seldom that a friendly voice defends these animals. However, in 1937 several individuals and societies protested vigorously because of the activities of a company engaged in killing and canning, for dog and cat food, California sea lions in Mexican waters. The commercial fishermen in the southern part of the State during the period of the operation of the dog and cat food company were unusually vociferous in their claims of sea lion damage and in their insistence that the herds had greatly increased. It was thought possible that there might have been a northward migration of California sea lions to the California coast from Mexican waters in order to escape persecution. The present survey, between June 13th and 26th, 1938, was primarily to determine the validity of this supposition.

The survey was made with the patrol boat *Bluefin* and was conducted in the same manner as were the previous counts, except that three observers, instead of one, covered the coast line, hence the population figures for 1938 represent averages of three individual counts or estimates. It can be seen readily from the appended table that the data for the 1938 season do not vary appreciably from those of the earlier surveys.

Sea lions are not such slaves to habit as are their cousins, the fur seals, who return year after year to the same rookery where they were born. The sea lions change their rookery sites fom time to time for reasons which are sometimes obscure. Rookeries which may have flourished for years on the same beach or rock will be found abandoned whereas a rookery will suddenly appear where no sea lions have ever been observed. It is necessary, therefore, in making a survey to touch not only at all the known rookeries and hauling grounds but also

[1] Submitted for publication, September, 1938.

to visit many likely places on a chance that a new rookery may have appeared. Two such changes were noted during the present season. The Point Arena rookery was abandoned by the Stellers usually found there, while a small group of Californias was found at Cochie Point on Santa Cruz Island, adding a new rookery to the list. Sea lions were not found at Cochie Point during any of the previous surveys but old records report them as occurring at this point.

During the last few years the Chinese market for sea lion trimmings has practically disappeared, and as the present California law gives the sea lions complete protection no evidence was seen of any systematic hunting at any of the offshore rookeries where the trimming hunters formerly worked. Because of these conditions there has been a comparatively large increase in the number of adult bulls and several localities which were formerly merely hauling grounds have now become rookeries.

The absence of persecution may also account for the appearance of two species of marine mammals not observed during the previous surveys. Three Guadalupe fur seal (*Arctocephalus townsendi*) bulls were seen at one place, and four yearling sea elephants (*Mirounga angustirostris*) were noted at another. Both these species were once abundant on the California coast and the present suspension of human predatory activities on the offshore areas may afford them a chance to again become part of the natural fauna.

A great deal of misinformation concerning sea lions is actively promulgated by sport and commercial fishermen and by casual observers. It is claimed that the animals destroy vast quantities of fish and damage a great deal of fishing gear. While it is conceded that sea lions occasionally destroy or damage fishing gear and that they do eat fish, sometimes commercially valuable ones, no evidence has ever been produced which shows that they do any extensive damage in either respect. Evidence on these points, obtained by trained men, tends to show that the animals may sometimes be of benefit to commercially valuable species of fish by destroying predatory fish.

Marine commercial and sport fishing along the California coast has expanded very rapidly during the last twenty years. There has been a great increase in fishing equipment and in fishing effort. So enormous has been the tonnage of fish landed yearly that several species are showing signs of depletion. It is possible that with this great increase in human fishing effort and the consequent removal of great quantities of fish that the fishing competition of the sea lions, although always present, has simply become more noticeable, as the animals are forced to extend their efforts to maintain themselves in the face of a diminishing food supply. It is human nature to shift responsibility. The growing scarcity of some species of fishes and consequently the greater effort required to take them, makes it expedient to find some destructive agency unrelated to human activity.

During the last ten years the sea lion population has remained at about the same numerical level. Although the trimming hunters have stopped killing the adult bulls and the State law protects the animals, still a good many are killed annually by sportsmen and fishermen. The environment in which the sea lions live is not conducive to a long existence. A sick or crippled sea lion is a rarity and old specimens are scarce; the supposition being that any physical weakness marks the individual for prompt elimination. Although this is true for most animals living in a natural environment, it seems to be unusually so in the case of marine mammals. The breeding cows produce a single pup each year and while the number of pups on any rookery may be fairly large at the termination of the pupping time, about 25 per cent are eliminated on the rookery by accidents and drowning. Not more than 50 per cent of any year's crop of pups reaches the age of one year, and as the death rate among the adults is comparatively high, the present birth rate seems to about balance the death rate.

FIG. 140. Sea lions on Turtle Rock, near Trinidad Head, California. Photograph by G. H. Clark, June, 1938.

Most of the protests dealing with the destructive activities of sea lions include the complainant's idea of the numerical strength of the population, usually some figure between 50,000 and 100,000 or more. These statements represent a few casual observations at one or two points along the coast by untrained observers. The figures in the tables appended to this report, representing counts and estimates made during five surveys, over a period of ten years, and including the whole California coast, may be taken as a close approximation of the actual numbers found in State waters.

The California sea lion population is not increasing. The depredations of the animals are nowhere as extensive as is claimed, and for the present there seems to be no reason to reduce their numbers.

NUMERICAL COMPARISON OF SEA LION ROOKERIES AND HAULING GROUNDS FOR YEARS IN WHICH CENSUS WAS TAKEN

Rookery or hauling ground	Steller					California				
	1927	1928	1930	1936	1938	1927	1928	1930	1936	1938
St. George Reef	1,500	611	700	652	325	-------	-------	-------	-------	-------
Turtle Rocks	200	200	-------	100	93	-------	-------	-------	-------	-------
Cape Mendocino	700	700	900	700	500	-------	-------	-------	-------	-------
Point Arena	300	206	300	142	-------	-------	-------	-------	-------	-------
Point Reyes	-------	-------	-------	45	6	-------	-------	-------	9	-------
Farallon Islands	700	540	900	500	357	6	-------	28	25	90
Purissima	150	42	-------	4	2	-------	-------	-------	-------	-------
Ano Nuevo	1,500	1,500	2,500	1,000	2,000	-------	-------	-------	200	-------
Bird Rock	-------	-------	-------	25	53	-------	-------	-------	250	1
Cypress Point	-------	-------	-------	-------	1	-------	-------	-------	-------	15
Point Lobos	-------	200	49	60	120	-------	70	160	3	1
Cape San Martin	-------	50	-------	-------	-------	-------	-------	-------	20	-------
Piedras Blancas	212	100	34	6	73	86	1	23	35	21
Lion Rock	86	-------	-------	60	243	21	6	-------	20	10
Pecho Rock	135	95	300	70	3	7	75	-------	-------	3
Point Sal	-------	-------	-------	75	35	10	-------	-------	150	25
Point Arguello	-------	-------	-------	50	2	-------	10	-------	20	-------
San Miguel Island	595	592	620	1,359	1,992	149	429	205	520	714
Sandy Point	49	38	12	52	20	-------	-------	-------	-------	-------
Frazer Point	2	-------	40	-------	15	63	88	95	-------	25
Gull Island	18	10	5	-------	-------	150	105	68	200	25
Cochie Point	-------	-------	-------	-------	1	-------	-------	-------	-------	75
Anacapa Island	-------	-------	-------	-------	-------	34	27	11	11	10
Santa Barbara Island	-------	-------	-------	-------	-------	125	327	8	600	500
Castle Rock	-------	-------	-------	-------	-------	29	23	7	35	15
Seal Harbor	1	-------	-------	-------	-------	235	228	340	400	475
Catalina Island	-------	-------	-------	-------	-------	-------	-------	-------	-------	15
Totals	6,148	4,884	6,360	4,900	5,841	915	1,389	945	2,501	2,020

POPULATION OF SEA LION ROOKERIES AND HAULING GROUNDS IN CALIFORNIA—1938

Location	Steller			California		
	Bulls	Cows	Totals	Bulls	Cows	Totals
St. George Reef	32	293	325	-------	-------	-------
Turtle Rocks	9	84	93	-------	-------	-------
Cape Mendocino	150	350	500	-------	-------	-------
Point Reyes	1	5	6	-------	-------	-------
Farallone Islands	97	260	357	40	50	90
Purissima	1	1	2	-------	-------	-------
Ano Nuevo	500	1,500	2,000	-------	-------	-------
Bird Rock	4	49	53	1	-------	1
Cypress Point	1	-------	1	15	-------	15
Point Lobos	15	105	120	1	-------	1
Piedras Blancas	5	68	73	5	16	21
Lion Rock	28	215	243	10	-------	10
Pecho Rock	3	-------	3	3	-------	3
Point Sal	5	30	35	5	20	25
Point Arguello	2	-------	2	-------	-------	-------
San Miguel Island	526	1,466	1,992	254	460	714
Sandy Point	3	17	20	-------	-------	-------
Frazer Point	2	13	15	4	21	25
Gull Island	-------	-------	-------	5	20	25
Cochie Point	1	-------	1	12	63	75
Anacapa Island	-------	-------	-------	-------	10	10
Santa Barbara Island	-------	-------	-------	100	400	500
Castle Rock	-------	-------	-------	3	12	15
Seal Harbor	-------	-------	-------	100	375	475
Catalina Island	-------	-------	-------	8	7	15
Totals	1,385	4,456	5,841	566	1,454	2,020

DETAIL OF ROOKERIES ON SAN MIGUEL ISLAND, 1938

Rookery	Steller			California		
	Bulls	Cows	Total	Bulls	Cows	Total
Richardson Rock	50	400	450			
Wilson Rock	3	17	20			
Flea Island	100	500	600	50	200	250
Offshore Rock	5	15	20			
Isthmus Rock	8	14	22	4	10	14
Lion Rock	10	20	30			
Point Bennett	350	500	850	200	250	450
Totals	526	1,466	1,992	254	460	714

WHALE SHARKS STRUCK BY FISHING BOATS OFF THE COAST OF LOWER CALIFORNIA [1]

By E. W. GUDGER

Honorary Associate in Ichthyology
American Museum of Natural History

The Hydrographic Office of the United States Navy has for a number of years been collecting from the reports of ships' officers notes on the occurrence of whale sharks in various parts of the world and forwarding these to me. In this way there have come into my hands invaluable data on the occurrence of *Rhincodon typus* in various waters and on its unusual capture by being impaled on the bows of vessels. Latest of these courtesies is the transmission by Captain L. R. Leahy, Hydrographer, of a brief account of a whale shark struck (but not impaled) by a fishing vessel off the coast of Lower California. This, which also gives interesting data on the habits of *Rhineodon*, is from Mr. P. Nielsen of Nestor, California, who has been good enough to give me some further details from his private log, made while acting as navigator of the vessel.

Mr. Nielsen writes that he has seen whale sharks as far north on the outer coast of Lower California as Hipolito Point in about 27° north latitude. Farther south they are more common. The tuna fishermen all know them, since they are often found associated with schools of tuna. When a whale shark is seen close at hand, the fishermen often throw bait overboard to bring the tuna to the surface. *Rhineodon* will often eat this bait of sardines and anchovies. These great sharks are quite abundant around Cape San Lucas and are so unafraid that they circle around the fishing boats and almost come within reach. This agrees with Dr. William Beebe's account of his experiences in this region two years ago.

Mr. Nielsen was serving as navigator of the tuna boat whose collision with a whale shark is now to be noted. He did not see the fish, but since the fishermen all know the whale shark as well as they do the tuna, there can be no doubt of the accuracy of their observations. Mr. Neilsen unreservedly vouches for them. He assures me that such collisions are by no means uncommon to vessels of the tuna fleet in these waters, and that if one could talk with the tuna fishermen at San Diego, California, one could collect many such accounts. Here is the brief story of the incident which happened to his vessel, and for which he has notes in his log.

On September 19, 1932, the M. S. *Funchal* struck a whale shark about 2.00 P.M., while in latitude 25° 30′ N. and longitude 113° 20′ W. (approximately). Mr. Nielsen was below but went immediately on deck since the impact made him fear that the vessel had struck a

[1] Submitted for publication, May, 1938.

rock. One of the crew saw the fish, declared that it was a whale shark, and that as it swam away he saw a large smear of red copper paint across its back.

That the shark was bumped rather than rammed is due to the fact that while the *Funchal* is a wooden vessel, 106 feet long and draws about 12 feet aft, the stem is cut away forward so that she draws only about 5 feet there.[2] This conformation of the stem brought it about that the blow was a glancing one instead of the ramming blow when the stem is vertical. Since the whale shark has a thick skin (about 4 inches thick in a 30- to 40-foot specimen), such a glancing blow from a wooden vessel might arouse and annoy the shark, but it could do little or no hurt.

Illustrative of the fact that these bumpings are not uncommon in his experience, Mr. Nielsen communicates this further incident. In 1933, he was on the *Santa Margarita* of about the same size, build and draft as the *Funchal.* One night, when about 25 miles southeast of Cape San Lucas, in a locality abounding in whale sharks, he was aroused and brought on deck by a shock which brought the vessel to a dead stop and made him think that she had struck an uncharted rock. However, after a moment, the vessel continued on her course. Now since it was not a rock, nothing but a whale shark (or an uncommonly found whale) would have brought the vessel to a standstill, and, although the fish was not seen, everybody accepted the whale shark explanation and thought no more of the matter.

Since this article was submitted for publication, Captain G. S. Bryan, Hydrographer, has kindly communicated a report of a whale shark which had a violent encounter with the American schooner-yacht *Navigator* of San Pedro. Captain Fred K. Klebingat, master of the *Navigator*, writes that on May 8, 1938, in latitude 24° 25′ N. and 110° 13′ W., near Cape San Lucas:

"The vessel was struck on the starboard side by an immense shark. The wheel was wrenched out of the hands of the man at the wheel. The tail of the fish rose eight feet above the rail of the ship and about 14 feet above the waterline. The engine was stopped [since] the fish struck the propeller. The fish was distinctly seen when it went astern, was of a mottled color and was at least 30 to 35 feet long. After going into drydock, it was found that considerable damage had been done to the hull and rudder of the ship. Two more sharks [of the same kind] were seen in the same locality the next day."

Here again is more first hand evidence that this largest of living sharks is harmless, sluggish and unafraid. Its entire fearlessness and its desire to eat the bait thrown out by the fishing boats as "chum" for tuna, lead it to "hang around" these boats, and its sluggishness not infrequently leads to its getting "bumped" by them. In the cases cited, the fish may have swum across the bow of the boat or may have lain inert in her course. I have a record of a *Rhineodon* which swam so leisurely across the path of a vessel that it was missed by a few feet only. These habits tie up with all the evidence that I have gotten in 25 years' study of the behavior of *Rhineodon* all over the oceans.

[2] The *Funchal* was destroyed by fire, March 13, 1938.

NOTES

NOTES ON THE RIBBON-FISH, *TRACHYPTERUS REX-SALMONORUM*

During the summer of 1938, six specimens of the ribbon-fish, *Trachypterus rex-salmonorum* Jordan and Gilbert, have been brought to the attention of staff members of the California State Fisheries Laboratory. This "king-of-the-salmon" is one of the most unusual of the fishes inhabiting the eastern Pacific and it and the several other species known from various parts of the world form a group about which we have little information. Extremely delicate, such specimens as have been found are usually damaged to some extent, and a well-preserved specimen is a rarity. That these fishes undergo a pronounced metamorphosis is known (Hubbs, Mich. Acad. Sci., Pap., 1925, **5**:469), but as to other particulars of their life-history and habits we know very little. They are commonly supposed to be rare inhabitants of great depths; that they are probably neither is indicated in an inconspicuous note written by W. F. Thompson in 1919 [Calif. Fish and Game, 1919, **5** (2):95], in which we read: "[*Trachypterus*] is supposedly very rare. But in the explorations of the *Albacore* numerous young have been taken." A few of the *Albacore* hauls were made at depths of 50 to 100 fathoms, but for the most part they were made much nearer the surface.

Further indication that these fish are not uncommon is accorded by the discovery of five specimens in the stomach of a wolf-fish, *Alepisaurus aesculapius*, taken at Redondo Beach, Santa Monica Bay, California, on June 13, 1938. They could be readily identified although they were partially digested. It was impossible to obtain exact measurements on these specimens, but standard lengths ranged from approximately 10 to 20 cm. The stomachs of all five were intaet. Mr. Howard McCully examined their contents and identified the following material:

Specimen A: Large numbers of copepods, seemingly of one species.
B: Many annelid worms; a few copepods representing at least two species, one the same as found in "A."
C: Two copepods, the same species as in "A."
D: Three loricate fish larvae.
E: Empty.

The sixth specimen to come to our attention was given to the Laboratory by Mr. Harry Evans of San Pedro. The manner in which he caught the fish is most unusual. While working on his boat which was tied at the foot of Twenty-second Street, San Pedro, well inside of Los Angeles Harbor, he noticed the fish swimming by. Recognizing it as something out of the ordinary, he landed it in a dip net. This was on March 20, 1938. A remarkably fine specimen, about 19 cm.

standard length, it has been deposited in the Stanford University collection. Before preservation it was an extremely beautiful fish. All of its fins were a bright red while its silvery body was accentuated by a series of four dark blotches situated dorsally along the sides. The front of the head was darkened as well. Mr. Evans reported that the first dorsal ray had terminated in a red knob, but this was missing when we received the specimen. Except for the lack of ventral blotches, the fish answered well to the description given by Jordan and Evermann [Fishes of North and Middle America, 1898 (3):2599].—*Phil M. Roedel, California State Fisheries Laboratory, August, 1938.*

RECORD-SIZE MACKEREL IN SANTA MONICA BAY

It is very probable that fish attaining record sizes are often taken but as a rule are not brought to the attention of ichthyologists who are naturally interested in such occurrences. However, there are occasions when unusual specimens are turned over to the Division of Fish and Game. A Pacific mackerel (*Pneumatophorus diego*), larger than ever recorded before at the California State Fisheries Laboratory, was caught on hook and line by James Putters, a commercial fisherman, on June 8, 1938, in Santa Monica Bay. This fish measured 24.8 inches and weighed 6.36 pounds, which is slightly larger than the mackerel reported by J. B. Phillips as landed at Monterey in August, 1937 (Calif. Fish and Game, vol. 23, p. 337). The Monterey specimen, of record size at that time, measured 24.5 inches and weighed 6 pounds. A mackerel of half that weight and 20 inches in length is considered large.

The Santa Monica fish was a female with running eggs and its measurements (prior to preservation) were: total length, 630 mm.; length of head, 137 mm.; distance from tip of snout to insertion of dorsal fin, 182 mm.; tip of snout to anus, 357 mm.; weight, 2886 grams.—*Phil M. Roedel, California State Fisheries Laboratory, August, 1938.*

REVIEWS

The High Seas Tuna Fishery of California

By H. C. Godsil. California Division of Fish and Game. Fish Bulletin, no. 51, 41 pp., 20 figs., 1938.

The author, a member of the staff of the California State Fisheries Laboratory, has had considerable experience in tuna fishing, having made frequent trips into southern seas with vessels fishing commercially for tuna. In addition to this intimate knowledge of the subject, Mr. Godsil has written in a direct simple style that results in a text that is packed with information but arrestingly interesting and easily read. An account of the tuna fishery has long been needed and this bulletin admirably describes the fishing methods, the gear used and the fleet of boats engaged in this spectacular fishery off the coasts of Mexico and Central and South America.

This account of the tuna fishery concerns itself chiefly with the operations of the fleet of live bait boats which catch most of the tuna landed in California for canning. It is this fleet of large high sea ships, numbering about 50 vessels, that has caught about three-fourths of the tuna (yellowfin and skipjack) delivered to our canneries. There is a brief account of the small boat fleet of about 25 vessels that use live bait for catching yellowfin tuna and skipjack when these fish are within their cruising radius, but at other seasons of the year they necessarily must turn to the catching of yellowtail and bonito. This bulletin does not discuss the local small scale tuna fishing as carried on by purse seine boats during a part of the season.

The high seas fleet of larger boats includes those vessels, 90 to 130 feet or over in length. It is these vessels, with crews of 12 to 20 men, that make the long trips of six to eight weeks down to and occasionally beyond the Equator and return to Southern California canneries with loads of 150 to 350 tons of tuna, after cruises of 6000 to 8000 miles. The insulated fish hold is equipped with refrigeration machinery for holding low temperatures where the fish are packed in chipped ice or held in chilled brine. Live bait is carried on the stern deck in huge tanks with circulating sea water.

The report covers the complete fishing operation from provisioning the ship for the long voyage, obtaining bait and landing tuna on deck, to icing down the catch and delivery to the canning plant. This account is well illustrated, many of the action photographs having been taken by the author. In addition there are two maps of the fishing areas covered and a graph of the trend of annual catches of yellowfin and skipjack. A brief list of references is included.—*W. L. Scofield, California State Fisheries Laboratory.*

Improvement of Lakes for Fishing—A Method of Fish Management

By Carl L. Hubbs and R. W. Eschmeyer. Michigan Department of Conservation, Institute for Fisheries Research, University of Michigan. Bulletin, No. 2, 233 pp., 74 figs., annotated bibliography, index. Lansing, Mich. $1.25.

Michigan has long been noted as one of the leaders in the improvement of fishing as a result of practical fisheries research. The appearance in 1932 of "Methods for the Improvement of Michigan Trout Streams," by Carl L. Hubbs, John R. Greeley and Clarence M. Tarzwell (Institute for Fisheries Research. Bulletin, no. 1, 54 pp.) was instrumental in prompting active fisheries management work in many other states which were quick to follow Michigan's lead. This second bulletin, "The Improvement of Lakes for Fishing," is a sequel to the earlier handbook, and is the result of many years of trying to evolve ways to improve lake fishing. The bulletin lists all of the devices and expedients that can possibly be used to "shorten the time between bites." As a guide to the improvement of lakes, the bulletin will prove invaluable, as it is the first comprehensive publication on this subject. The authors are outstanding fish management experts and they have had the assistance of a great many other able scientists so it is no wonder the bulletin has turned out so well.

The first part of the publication lists the necessity for improving conditions in lakes to provide better fishing, and how this can best be accomplished. Following are detailed accounts of how to provide the best conditions, together with discussions of the desirability of each device. Twenty methods of improving conditions for lake fishes are discussed: improving the shelter (including details of shelter construction), managing the plant growths, bettering the spawning conditions, regulating the abundance of fish, altering the depth, regulating the fluctuations of water level, increasing the natural food, decreasing algal nuisances, retarding destructive wave action, preventing erosion and silting, controlling pollution, aerating lakes and removing causes of oxygen deficiency, modifying the temperature, managing fish movements, handling populations with stunted growth, managing competitors, removing the excess of coarse fish, controlling predators, treating and preventing diseases, and preventing depletion from overfishing.

Accompanying the text are some very fine descriptive photographs and drawings, many of which show the construction of improvement devices in such detail that they would serve as models.

A well-illustrated chapter on the very important subject of the improvement of artificial lakes has been contributed by Walter W. Aitken and J. Clark Salyer II. This section describes the work done by the Iowa State Conservation Commission in creating artificial lakes to provide fishing. Man-made lakes lend themselves readily to improvement projects because shelters, spawning beds, rip-rapping, etc., can be installed before the lake fills with water.

The words of the authors themselves best tell the place of lake improvement in fish management—its possibilities, practicability and limitations:

"At least for the near future, lake improvement can not be foreseen as a substitute for the long-recognized practices in fish management (restrictive and protective legislation, law enforcement, and the introduction of fish and the stocking of artificially propagated and reared fish). Methods of lake improvement would need to be enormously perfected, before this new practice, if ever, could be expected to replace the older means of maintaining the fish supply.

''Moreover, other new methods of fish management are being developed, and the older methods are being modernized and made more effective.

''As announced on the title page, 'Improvement of Lakes for Fishing' will continue to be 'A Method of Fish Management.' The text has been restricted largely to a consideration of the physical, chemical and biological factors responsible for a good fish crop, and to suggestions for the design, construction and installation of devices by which these environmental factors can be controlled and altered so as to maintain or increase the fish crops. Despite this purposeful limitation of the subject matter, the treatment has required frequent reminders that other methods have been and will continue to be of large importance in the development of the theory and practice of fish management. Indications are also given, with perhaps inadequate accent, to the importance of the economic and social phases, which no doubt will frequently prove to be the dominant factors in determining the extent and kind of fish management to be practiced. The very sketchy treatment or bare mention of these other methods and relations is not the result of an assumption that they are unimportant. These other phases now deserve or within a few years will become fit subjects for specific bulletins and texts, which will take their place among many similar treatises in the field of game and still other aspects of wildlife management.

''Theory and practice in fish management, as in the management of any wildlife or domesticated crops, involve the deliberate and skillful control of populations, not only of the crop species being cultivated or favored, but also of the other species of animals and plants which have or might have an important effect on the desired yields. Usually the populations of several other species will need be controlled in order to increase the production of the species to be favored, because the interrelationships between competition, predation, disease and the environment are ordinarily complex. Among fishes, some species often bear the same relation to the game fishes that weeds bear to the cultivated plant crops. In managing fish and other animal crops, control of the population (abundance) of certain plant species is also apt to be of particular importance, because in any natural association all the animals are permanently dependent on plants as the basic source of food material, and because the plants also aid in providing facilities for shelter and reproduction.

''In the culture of any crop, the weed and crop species are controlled only in part by modification of the environment—as by plowing, cultivating, fertilizing, cutting fire lanes, growing cover along fence rows, installing brush shelters, improving the facilities for natural reproduction, etc. The planting, thinning, harvesting and marketing of the crops, or similar procedures, are often of greater moment in making the crop pay. Whether under given conditions, the most effective and economical results in the control of wild populations can be obtained by the indirect methods of environmental control (as by lake improvement in fish management) or by the more direct procedures such as stocking and regulating the take, or (more likely) by a combination of these methods, can only be determined by repeated trials and checks.

"In general the technical phase of fish management is chiefly concerned with devising and testing new and better ways to control the production of desired species; and in devising new and better tools and procedures for measuring with precision the results and practicability of each operation or procedure, old or new.

"In controlling the production of desired fish (as of other crops), it is of vital importance to determine the populations of each species, at different ages, and from season to season and year to year. Almost nothing has been known of the standing crop or of the annual take of fish in inland lakes, or of the carrying capacity of the lakes. Little actual data has been obtained on the great natural destruction of fish that takes place at different stages of the life cycle, from eggs and fry through yearlings and half-grown to breeding adults. With such ignorance of natural fish populations, much current fish management practice is equivalent to planting trees without consideration of the number and kind and size of trees already present, or of the amount of timber annually cut and removed. Or it compares with putting a certain number of calves into a pasture without taking into account the number of cattle already there, the carrying capacity of the field or the number of animals annually marketed from the pasture. It is like planting seed without considering the standing crop or the harvest.

"Slowly but surely, however, it is being shown through creel census records what kinds, numbers and sizes of fish are being removed from different types of waters. Even more slowly, investigators are beginning to show through population studies what is actually available for the angler. They are finding that in some waters of southern Michigan only a very small percentage of the available adult fish are removed each year by the fishermen, that fishing is poor in some lakes, especially in the north, because there is too little food for the number of fish present, and because these fish, though typically very abundant, do not often reach legal size.

"Technical work in agriculture has indicated that many of the old methods were futile or inadequate and has suggested new and better ways of obtaining the desired crops in larger quantities. As compared with agriculture, the technical phase of fish management has hardly been started, but already it is suggesting that by no means all stocking has been effective, that some laws have at times proved detrimental instead of helpful, and that the unintelligent or too little understood application of lake 'improvements' may be ineffectual or even injurious to fishing.

"Quite obviously, all wildlife managers should become familiar with the pertinent aspects of the technics of population control and the methods of checking which have become established in the older lines of crop production. The control of plant and animal populations since prehistoric times has resulted in modern agriculture. Control technics have now been elaborately developed and tested for many of the preferred farm, garden, range and forest species. Agronomy, horticulture and forestry are consequently much farther advanced than are the corresponding technics for growing wildlife crops, such as game, fur and fish. Wildlife workers should thus profit, on occasion, by avoidance as well as by duplication.

"The methods of the agriculturist and the forester should in general prove applicable in wildlife management and investigation. The difference between the culture of domesticated and wild crops seems to be largely one of degree rather than kind. The domestic crops are of course much more intensively cultured, as would be shown by computing the typical, annual per-acre investments in dollars and in labor, for the several crop species—farm, ranch, orchard, forest, game and fish. But there is the identical objective: frequent, generous and dependable yields of the desired species, year after year from the same units of land or water; obtainable at practicable costs, and readily available for human use or enjoyment."—*Richard S. Croker, Editor, California Fish and Game.*

REPORTS

DEPARTMENT OF NATURAL RESOURCES, DIVISION OF FISH AND GAME, STATEMENT OF REVENUE

For the Period July 1, 1937, to June 30, 1938, of the Eighty-ninth Fiscal Year

Revenue for the Fish and Game Preservation Fund, Current Year

	Detail	Total
License sales:		
Hunting, 1936-1937	$20,000 50	
Hunting, 1937-1938	418,934 53	
Hunting, 1938-1939	142 00	
Angling, 1937	391,848 35	
Angling, 1938	237,733 19	
Trapping, 1937-1938	2,574 00	
Trapping, 1938-1939	3 00	
Deer tags, 1937	124,109 68	
Deer tags, 1938	80 00	
Market fisherman, 1937-1938	45,020 00	
Market fisherman, 1938-1939	25,380 00	
Game breeders, 1937	117 50	
Game breeders, 1938	982 50	
Fish breeders, 1937	40 00	
Fish breeders, 1938	355 00	
Fish importers, 1937	20 00	
Fish importers, 1938	95 00	
Fish packers and wholesale shellfish dealers, 1937-1938	1,070 00	
Fish packers and wholesale shellfish dealers, 1938-1939	30 00	
Kelp license, 1937	20 00	
Kelp license, 1938	20 00	
Commercial hunting club, 1937-1938	900 00	
Commercial hunting club operator, 1937-1938	280 00	
Fishing party boat permit, 1937	186 00	
Fishing party boat permit, 1938	377 00	
Fish tags	3,815 97	
Game tags	243 41	
Total license revenue		$1,274,377 63
Other revenue:		
Fish packers tax	$237,688 40	
Salmon packers tax	37,284 65	
Kelp tax	253 45	
Lease of kelp beds	1,666 36	
Court fines	42,212 25	
Interest on bank balances	712 73	
Publication sales	15 01	
Other miscellaneous sales	5,285 45	
Total other revenue		$325,118 30
Total revenue Fish and Game Preservation Fund		$1,599,495 93

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to June 30, 1938, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
OPERATING EXPENDITURES, EIGHTY-NINTH FISCAL YEAR					
Administration:					
Accident and death claims			$2,255 29		$2,255 29
Cashier	$1,200 00				1,200 00
Executive	5,000 00	$233 08	3,352 10	$919 13	9,504 31
Exhibits			1,200 00		1,200 00
General office	7,523 38	6,399 93	19,748 61	521 21	34,193 13
Legal			6,894 17		6,894 17
Library	1,800 00	43 23	143 15	696 69	2,683 07
Property inspection	741 33	35 27	137 29	818 44	1,732 33
Pro rata department administration	10,000 00		6,000 00		16,000 00
Pro rata General Fund expense			9,990 89		9,990 89
Publicity			2,035 88		2,035 88
Total Administration	$26,264 71	$6,711 51	$51,757 38	$2,955 47	$87,689 07
Patrol and Law Enforcement:					
Cannery inspection	$17,403 27	$1,009 04	$2,740 14	$266 48	$21,418 93
Executive	14,220 00	874 22	2,634 29	680 81	18,409 32
General office	5,947 80	940 25	1,947 08	1,031 32	9,866 45
Junior patrol	2,626 02	330 04	677 64		3,633 70
Land patrol	191,731 55	37,471 22	64,147 88	35,203 03	328,553 68
Marine patrol	52,800 61	20,210 59	33,517 21	17,786 67	124,315 08
Pollution patrol	7,047 52	1,917 47	4,122 47	738 10	13,825 56
Total, Patrol and Law Enforcement	$291,776 77	$62,752 83	$109,786 71	$55,706 41	$520,022 72
Marine Fisheries:					
Executive	$7,320 00	$185 85	$503 21	$791 69	$8,800 75
Field supervision	3,200 00	353 72	1,894 81		5,448 53
Fish cannery auditing			2,697 46		2,697 46
General office	8,555 59	142 30	924 85	297 54	9,920 28
Research and statistics	40,512 68	5,870 99	11,275 58	2,834 75	60,494 00
Total Marine Fisheries	$59,588 27	$6,552 86	$17,295 91	$3,923 98	$87,361 02
Fish Conservation:					
Cooperative Research, Stanford University	$3,869 67	$289 43	$804 04	$696 82	$5,659 96
Executive	6,460 00	235 61	602 22	1,026 58	8,324 41
Field supervision	10,059 15	1,307 04	3,788 47	3,123 86	18,278 52
Fish planting	2,683 87	1,418 54	1,970 42	4,334 24	10,407 07
Fish rescue	5,407 85	561 22	1,507 10	2,179 29	9,655 46
General office	4,756 40	1,003 86	55 84	452 27	6,268 37
Pollution inspection	3,120 00	390 87	763 87	38 56	4,313 30
Research	2,142 10	404 47	1,004 08	428 46	3,979 11
Statistical	2,280 00	105 54	1,050 50	109 09	3,545 13
Alpine	1,313 04	729 68	304 26	550 65	2,897 63
Basin Creek	4,690 42	2,532 17	440 69	568 04	8,231 32
Bear Lake Egg Collecting Station	433 87	105 47	29 80		569 14
Beaver Creek Egg Collecting Station	250 00		75 00		325 00
Beaver Creek	148 55	46 90	8 58		204 03
Big Creek	3,331 67	2,600 55	326 80	557 36	6,816 38
Blackwood	302 81	218 39	1 00		522 20
Blue Lakes Egg Collecting Station	590 00	7 08	16 00	105 55	718 63
Bogus Creek Egg Collecting Station	407 09	79 94	177 10		664 13
Brookdale	3,285 32	1,846 21	438 10	19 78	5,589 41
Burney Creek Hatchery	5,500 09	3,369 62	885 77	611 62	10,367 10
Carmen Lake Egg Collecting Station	312 00	2 24	10 43		324 67
Central Valleys	3,565 14	1,544 46	1,913 70	2,202 68	9,225 98
Cold Creek	2,492 27	1,807 59	617 71	579 48	5,497 05
Cottonwood Lakes Egg Collecting Station	263 04	43 05	75 23		381 32
Deep Creek Egg Collecting Station	200 00				200 00
Fall Creek Egg Collecting Station		29 21	85 00		114 21
Fall Creek	6,178 55	5,002 96	256 99	6 06	11,444 56
Feather River	4,048 21	2,063 92	500 73	247 05	6,859 91
Fern Creek	1,667 89	373 61	62 97		2,104 47
Fishing Creek Experiment Station	358 06	22 25	155 31		535 62
Forest Home	10,754 02	9,385 21	3,049 02	293 39	23,481 64
Fort Seward	4,294 71	1,210 22	156 55	708 72	6,370 20
Hat Creek Egg Collecting Station	130 00	113 98			243 98
Hornbrook Egg Collecting Station	243 84	58 63	112 97	20 77	436 21
Hot Creek Hatchery	2,928 56	2,455 29	194 10	14 32	5,592 27

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1937, to June 30, 1938, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued					
Huntington Lake	$731 99	$594 20	$256 76	$30 18	$1,613 13
June Lake Egg Collecting Station			3 96		3 96
Kaweah	4,583 23	2,015 94	1,175 08	150 32	7,924 57
Kings River Hatchery	4,257 61	1,327 01	1,336 25	47 87	6,968 74
Klamathon Egg Collecting Station	1,412 91	121 48	321 76	12 21	1,868 36
Kosk Creek Egg Collecting Station		8 44			8 44
Lake Almanor	5,989 13	2,077 00	1,007 02	167 22	9,240 37
Lake Eleanor Egg Collecting Station		18 94			18 94
Little Walker Lake Egg Collecting Station	259 03				259 03
Madera	1,170 00	697 22	326 41	11 02	2,204 65
Marlette Lake Egg Collecting Station	713 17	4 79	56 90		774 86
Mt. Shasta Experiment Hatchery	1,061 29	619 29	33 59		1,714 17
Mount Shasta	28,990 38	17,345 83	2,915 92	235 65	49,487 78
Mount Tallac	1,705 65	1,509 42	100 52		3,315 59
Mount Whitney	11,012 85	4,474 64	2,329 00	882 21	18,698 70
Mud Creek Egg Collecting Station	259 49	17 97	3 00	4 50	284 96
Pasadena Reservoir Egg Collecting Station	325 00	4 81	17 25		347 06
Prairie Creek	5,528 15	1,659 84	557 18	640 09	8,385 26
Rush Creek Egg Collecting Station	511 21	49 81			561 02
San Lorenzo Egg Collecting Station	8 00	128 72	1 00		137 72
Scott Creek	1,500 00	140 40	148 25		1,788 65
Shackleford Creek Egg Collecting Station	456 00	36 55	70 00		562 55
Shasta River Experiment Station	152 00	94 74	184 20		430 94
Shasta River Egg Collecting Station	853 54	150 33	49 23	6 64	1,059 74
Snow Mountain Egg Collecting Station	2,305 61	257 91	223 02	19 68	2,806 22
Tahoe	5,730 35	1,959 63	677 48	895 66	9,263 12
Taylor Creek Egg Collecting Station					
Upper Truckee Egg Collecting Station	254 84	48 34			303 18
Waddell Creek Station	831 94	31 24	53 09	21 95	938 22
Warner Creek Station	402 53	54 35	2 40		459 28
Yosemite	3,926 25	1,388 35	313 47	155 83	5,783 90
Yuba River	3,176 64	1,252 10	318 02	3 12	4,749 88
Total Fish Conservation	$186,576 98	$79,454 50	$33,921 11	$22,158 79	$322,111 38
Hydraulics:					
Engineering	$4,911 43	$652 56	$1,965 65	$1,571 77	$9,101 41
Executive	4,140 00	348 52	857 49	623 41	5,969 42
Fish screens	3,449 16	3,145 28	130 28	3,684 25	10,408 97
General office	1,920 00	93 43	158 86	201 16	2,373 45
Total Hydraulics	$14,420 59	$4,239 79	$3,112 28	$6,080 59	$27,853 25
Game Conservation:					
Elk refuge	$2,176 32	$407 45	$539 33	$180 12	$3,303 22
Executive	12,122 50	979 54	2,334 68	578 03	16,014 75
Field				17 06	17 06
Game bird distribution	800 00	3,166 56	1,114 27	734 65	5,815 48
Game bird trapping		56 95			56 95
General office	4,278 89	152 31	28 45	103 06	4,562 71
Grey Lodge refuge	3,880 00	1,547 34	1,994 19	1,155 36	8,576 89
Imperial refuge	1,895 16	367 46	86 13	492 26	2,841 01
Los Banos refuge	3,111 10	585 25	632 50	633 39	4,962 24
Los Serranos game farm	14,732 39	6,644 53	2,825 56	2,439 73	26,642 21
Predatory animal control	31,771 73	5,018 98	14,332 33	2,472 05	53,595 09
Research	496 43	74 22	295 57	718 05	1,584 27
Statistics	1,412 74	57 97	1,103 37		2,574 08
Suisun refuge	2,151 77	742 68	523 54	132 00	3,549 99
Winter feeding and salting of game		475 12			475 12
Yountville game farm	16,836 55	11,075 72	4,281 75	1,735 07	33,929 09
Total Game Conservation	$95,665 58	$31,352 08	$30,091 67	$11,390 83	$168,500 16
Licenses:					
Executive	$3,300 00	$60 43	$168 68	$1,071 20	$4,600 31
General office	1,543 67	171 22	1,828 99	4,172 24	7,716 12
License distribution	10,987 63	17,856 78	60,973 23	355 15	90,172 79
Total Licenses	$15,831 30	$18,088 43	$62,970 90	$5,598 59	$102,489 22

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1937, to June 30, 1938, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Special Items:					
Cons. of research boat				$37,804 00	$37,804 00
Improvement of office, Ferry Bldg., San Francisco			$25,000 00		25,000 00
Total Special Items			$25,000 00	$37,804 00	$62,804 00
Total 89th fiscal year expenses paid from Support appropriations					$137,830 82
Claim of Chief Accounting Officer, Dept. of Finance, Ch. 772-37					3,293 65
Expenditures for Additions and Betterments:					
Permanent Improvements:					
Purchase of game refuges and public shooting grounds and C. I. E., Ch. 157-37	$3,603 09	$8,968 02	$2,036 29	$1,690 85	$16,298 25
Contributions to Employees' Retirement System					23,948 80
Total current biennium					$1,422,371 52
89th fiscal year:					
Special Item: Expenses of California Code Commission, Ch. 645-33				$0 37	$0 37
Support:					
Eighty-eighth fiscal year				$53 57	
Eighty-fifth fiscal year				106 50	
Total Support					$160 07
Special Item: Predatory animal control, 85th fiscal year				—$106 50	—$106 50
Total prior biennium appropriations					$53 94
Grand total					$1,422,425 46

SEIZURES OF FISH AND GAME

April, May, June, 1938

Game:	
Beaver skin	1
Bird traps	2
Brant, black sea	1
Deer	1
Deer meat, pounds	954
Doves	17
Ducks	4
Duck eggs	11
Goose, Canada	1
Meadow lark	1
Pheasants	12
Pigeon	1
Quail	5
Rabbits	36
Sandpiper	1
Sparrows	17
Squirrels	2
Squirrel hides	2
Turkey	2
Fish:	
Abalone	738
Abalone, pounds	40
Barracuda, pounds	11
Bass—	
Black	153
Black, pounds	34
Large Mouth Black	18
Sand, pounds	200
Striped	351
Striped, pounds	288
Bass traps	6
Bluegills	149
Carp, pounds	40
Catfish, pounds	16¼
Clams	3,522
Crabs	51
Crabs, dozen	4
Crab nets	8
Crappie	75
Fyke nets	4
Halibut	17
Lake Tahoe trout, pounds	40
Lobsters	55
Lobsters, dozens	4
Lobster pots	3
Lobster traps	13
Perch	32
Rainbow trout	35
Salmon, pounds	4,666
Steelhead trout	124
Sturgeon	2
Sunfish	473
Trout	516

GAME CASES

April, May, June, 1938

Offense	Number arrests	Fines imposed	Jail sentences (days)
Beaver; using sawtooth traps	1		
Bird nets; possession	1	$50 00	
Brant; black sea, closed season	1	50 00	
Deer; possession of, deermeat, closed season, illegal light and rifle in deer country, killing female, possess parts of spike buck, allowing dogs to run deer, possess venison, closed season	54	3,295 00	1,260
Doves; taking, possession, closed season, no license	6	55 00	
Ducks; possession closed season, shoot closed season, take wild duck eggs	11	175 00	
Firearms; possession in game refuge	1	75 00	
Game birds; shoot at in game refuge, take, possession closed season	4	40 00	
Goose; illegal possession	2	50 00	
Hunting; no license, with spotlight, night	20	245 00	17½
Killdeer; taking	1		
Net; larger than 6 feet to take bait	1	25 00	
Nongame birds; possession	3	20 00	
Pheasants; possession closed season, no license, shoot from auto, male close season	19	530 00	72½
Quail; desert, closed season	6	144 00	43
Rabbits; no license, take cottontails during closed season, shoot from auto, take with spotlight, night hunting	30	327 50	10
Shore birds; possession avocet	2	40 00	
Squirrels; possession portions, possession grey squirrel hides	4	70 00	
Trapping; no license	2	20 00	
Totals	169	$5,211 50	1,403

FISH CASES

April, May, June, 1938

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones; undersized red, closed season, overlimit, no license	104	$1,740 00	
Angling; no license	62	632 00	42½
Barracuda; take with net during closed season	1	100 00	
Bass; sell striped, take striped in salmon net, possession black bass during closed season, striped no license, possession overlimit striped, possession black bass less than 9 in. in length, striped less than 12 in	83	1,315 00	14½
Bluegills; closed season	7	104 00	
Catfish; retaining catfish less than 9 in. in live box, possession for sale less than 7 in. dressed, seining	5	50 00	
Clams; overlimit pismo, take cockles no license, possession in clam refuge, possession implement capable of digging clams in a clam refuge, out of shell, overlimit razor clams, overlimit, undersize cockles, overlimit Washington	53	795 00	65
Cockles; taking, no license	2	20 00	
Commercial fishing, no license	31	110 00	12½
Crabs; possession undersized, remove from District 1½ to District 2	23	530 00	
Crappie; taking closed season, no license	16	130 00	
Crustaceans; fail to show on demand	1		
Diving for commercial purposes in less than 20 feet of water	1	100 00	
Drift gill net; illegal mesh, operate in Sacramento River without floats or buoys	6	70 00	
Fail to keep record of fish bought	5	1,800 00	50
Fail to show license on demand	37	275 00	
False statement in procuring an angling license	1	5 00	
Fishing within 150 feet of the lower side of dam, within 250 feet of the lower side of fishway, in fish refuge, in closed district, in inlet of lake, in closed stream, night, closed season, too close to fish ladder	31	365 00	
Fyke nets in District 12-A, closed season	1		
Gaff; possession of	1	10 00	
Game fish; possession during closed season, take without license	36	415 00	
Gill net in closed district, in District 20	3	50 00	
Illegal fishing; perch, crappie, calico bass	1	5 00	
Illegal gear	1	10 00	
Lobsters; possession unmarked during closed season, possession spiney less than 10½ in. long, closed season, take in trammel net, operate trap in closed district	7	175 00	
Mackerel; take with illegal net in District 20	14	850 00	
Perch; closed season	12	153 00	15½
Pollution	12	1,650 00	
Salmon; possession undersized Chinook	2	25 00	
Set lines; operating with 100-hook in San Joaquin River	5	25 00	185
Steelhead; gaffing, possessing unlawfully taken	6	25 00	20
Sturgeon; possession	1		
Sunfish; take closed season, no license	43	690 00	37
Transferring license to another angler, using another's license	6	38 00	
Trout; closed season, no license, set line, fishing for trout in a fish refuge, overlimit, take with set line	53	957 00	47
Totals	673	$13,219 00	489

FRESH FISH IMPORTATIONS FROM OTHER STATES AND FOREIGN COUNTRIES

April, 1938

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore	5,538		
Tuna, Skipjack			698,188
For fresh fish markets:*			
Cabrilla		26,555	
Corbina, Mexican		76,648	
Sea-bass, Totuava		227,996	
Total pounds	5,538	331,199	698,188

May, 1938

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore	500		
Tuna, Oriental			4,328
Tuna, Skipjack			1,102,028
For fresh fish markets:*			
Cabrilla		26,141	
Corbina, Mexican		1,897	
Sea-bass, Totuava		293,407	
Crustacean:			
Shrimp		3,282	
Total pounds	500	324,727	1,106,356

June, 1938

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore			366,662
Tuna, Skipjack			1,227,115
Tuna, Yellowfin			49,924
For fresh fish markets:*			
Cabrilla		10,847	
Sea-bass, Totuava		115,270	
Total pounds		126,117	1,643,701

* This record includes only that fish which is voluntarily reported to the Division of Fish and Game and does not represent all importations.

FRESH FISH LANDINGS OF CALIFORNIA BOATS FOR APRIL, 1938

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters South International Boundary		Total landings of California boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds	Region 70, Los Angeles	Region 80, San Diego	
Anchovy			16,200	23,440		2,339		41,979			41,979
Barracuda						88,188	5,183	93,371	1,280	15,181	109,832
Cabezone			400	317	43			760			760
Carp		23,769		46				23,815			23,815
Catfish		42,593		50		14		42,657			42,657
Cultus, Pacific	22,911		21,506	6,164	196	121		50,898			50,898
Eel						32		32			32
Flounder, Starry	4,657		50,255	1,971				56,883			56,883
Flying Fish						788		788			788
Grouper										11,029	11,029
Hake	460		150			153		763			763
Halibut, California			2,430	619	24,594	40,099	31,005	98,747		55	98,802
Halibut, Northern	42,630							42,630			42,630
Hardhead		2,555						2,555			2,555
Herring, Pacific				370				370			370
Kingfish				14,731	32	60,323		75,086			75,086
Mackerel, Horse				8,732		183		8,915			8,915
Mackerel, Pacific				1,143		2,013	527	3,683			3,683
Mullet						84	270	354			354
Perch	7,503		21,360	8,321	2,628	16,590		56,402			56,402
Pike		220						220			220
Pompano, California						29		29			29
Rock Bass					2,690	6,780	8,737	18,207	265	2,635	21,107
Rockfish	63,455		67,419	245,922	32,106	45,760	7,709	462,371		41,105	503,476
Sablefish	5,529		6	3,035		31,680		40,250			40,250
Salmon	139,955	12,160		68,907				221,022			221,022
Sand Dab	23,601		8,930	13,420		654		46,605			46,605
Sardine				201,118		227,870	112,035	541,023			541,023
Sculpin					81	5,043	22,656	27,780		17	27,797
Sea-bass, Black					509	2,148	258	2,915	4,037	10,777	17,729
Sea-bass, Short-fin							34	34			34
Sea-bass, White					2,324	4,177	404	6,905		4,293	11,198
Shad		620,685		5				620,690			620,690

Shark	2,035		61,007	7,264	11,661	12,696	3,325	97,988		205	98,193
Sheepshead					30	10,729	98	10,857		298	11,155
Skate	7,035		26,950	23,653	3,209	1,120	68	62,035			62,035
Smelt			37,428	221	12,712	22,066		72,427			72,427
Sole	450,263		141,804	170,779	35,812	504	8	799,170			799,170
Split-tail		2,431						2,431			2,431
Sucker		95						95			95
Tuna, Bluefin						38	309	347		7,083	7,430
Tuna, Bonito						454	160	614		1,634	2,248
Tuna, Skipjack									240,488	2,043,626	2,284,114
Tuna, Yellowfin									767,803	3,279,923	4,047,726
Turbot	260		11,401	2,364				14,025			14,025
Whitebait	18,306		1,268	80				19,654			19,654
Whitefish					64	534		598	230	1,008	1,836
Yellowtail						4,111	24,401	28,512	194	89,796	118,502
Miscellaneous Fish	7,365		3,370	2,275	365	800		14,175			14,175
Crustacean:											
Crab	36,466		383,696	2,498				422,660			422,660
Prawn				204				204			204
Shrimp			72,009					72,009			72,009
Mollusk:											
Abalone				146,875	102,975	1,702		251,552			251,552
Clam, Cockle			37			1,801		1,838			1,838
Clam, Gaper			424	100				524			524
Clam, Pismo				983	12,522			13,505			13,505
Clam, Razor	10							10			10
Clam, Soft-shell	3		7,295					7,298			7,298
Clam, Washington	2,451		285					2,736			2,736
Octopus	1,181		603	2,921				4,705			4,705
Oyster, Eastern			21,702					21,702			21,702
Oyster, Japanese			115,426					115,426			115,426
Oyster, Native			4,640					4,640			4,640
Squid				5,105				5,105			5,105
Total pounds	836,076	704,508	1,078,001	963,633	244,553	591,623	217,187	4,635,581	1,014,297	5,508,665	11,158,543

*The eight geographical regions of the State are as follows:
Regions 10 and 20, Del Norte and Eureka: Del Norte, Humboldt and Mendocino counties.
Region 30, Sacramento: The Sacramento and San Joaquin River systems with the delta areas, including Suisun Bay and Lake County.
Region 40, San Francisco: Sonoma, Marin, San Francisco and San Mateo counties, including San Francisco and San Pablo bays.
Region 50, Monterey: Santa Cruz and Monterey counties.
Region 60, Santa Barbara: San Luis Obispo, Santa Barbara and Ventura counties.
Region 70, Los Angeles: Los Angeles and Orange counties.
Region 80, San Diego: San Diego and Imperial counties.
These tables are subject to slight revision due to belated supplemental items.

FRESH FISH LANDINGS OF CALIFORNIA BOATS FOR MAY, 1938

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Oregon waters	Waters South International Boundary		Total landings of California boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds	Regions 10 and 20, Del Norte and Eureka	Region 70, Los Angeles	Region 80, San Diego	
Anchovy			129,400	2,850		2,812		135,062				135,062
Barracuda					813	149,438	56,970	207,221			13,400	220,621
Cabezone			600	150				750				750
Cabrilla											260	260
Carp		799						799				799
Catfish		3,882						3,882				3,882
Cultus, Pacific	6,801		15,090	5,430	190			27,511	150			27,661
Eel						8		8				8
Flounder, Starry	1,820		9,850	289				11,959				11,959
Flying Fish						32,846		32,846				32,846
Grouper											1,549	1,549
Hake	115		6,665	1,950		170		8,900				8,900
Halibut, California	320		207	512	21,096	16,025	8,603	46,763			6,051	52,814
Halibut, Northern	41,348							41,348	175			41,523
Kingfish			2,824	10,613	55	44,922		58,414			14	58,428
Mackerel, Horse				8,572		60	7,765	16,397				16,397
Mackerel, Pacific				50,478	159	4,259	12,375	67,271				67,271
Mullet							1,147	1,147				1,147
Perch						1,403		1,403				1,403
Pompano, California						42		42				42
Rock Bass					1,046	15,442	6,169	22,657			2,241	24,898
Rockfish	18,144		30,157	186,523	13,818	22,192	13,866	284,700			3,084	287,784
Sablefish	5,851		82	5,840	4	7,924		19,701				19,701
Salmon	50,905	33,689	4,374	89,764	38			178,770				178,770
Sand Dab	13,950		50,939	1,517		259		66,665	175			66,840
Sardine			88,500	328,835	445	20,523	68,487	506,790				506,790
Sculpin					21	12,568	7,189	19,778			89	19,867
Sea-bass, Black					252	5,967	582	6,801		8,544	8,555	23,900
Sea-bass, Short-fin							806	806				806
Sea-bass, White					953	10,703	2,766	14,422			6,253	20,675
Shad		704,858						704,858				704,858
Shark	88		2,670	2,182	51,569	36,638	6,421	99,568			761	100,329
Sheepshead					262	6,746	167	7,175				7,175
Skate	7,620		20,770	9,537	3,616	1,092	70	42,705			85	42,790

Smelt	1,705		29,147	1,560	14,509	17,246	180	64,347				64,347
Sole	204,025		241,858	40,109	25,636	422	40	512,090	14,665			526,755
Swordfish, Broadbill						354		354				354
Tuna, Bluefin						2,306	53,181	55,487		72	1,739	57,298
Tuna, Bonito						1,480	63,970	65,450		16	1,646	67,112
Tuna, Skipjack										825,383	3,111,288	3,936,671
Tuna, Yellowfin										2,524,675	6,946,107	9,470,782
Turbot	280		10,962	765				12,007				12,007
Whitebait	9,048		2,279	411				11,738				11,738
Whitefish					77	839		916			502	1,418
Yellowtail						7,885	30,226	38,111		341	142,975	181,427
Miscellaneous Fish	6,604		6,711	342	794	1,771		16,222	140		80	16,442
Crustacean:												
Crab	73,672		398,484	7,170				479,326	1,680			481,006
Crab, Rock						500		500				500
Prawn				10				10				10
Shrimp			117,810					117,810				117,810
Mollusk:												
Abalone				251,500	189,775	1,640		442,915				442,915
Clam, Cockle			20			1,986		2,006				2,006
Clam, Gaper			518	80				598				598
Clam, Pismo					16,770			16,770				16,770
Clam, Razor	165							165				165
Clam, Soft-shell	38		8,388					8,426				8,426
Clam, Washington			332					332				332
Mussel				150				150				150
Octopus	123		1,421	3,399		1		4,944				4,944
Oyster, Eastern	550		16,907					17,457				17,457
Oyster, Japanese			73,876		117			73,993				73,993
Oyster, Native			4,639					4,639				4,639
Squid				151,080				151,080				151,080
Total pounds	443,172	743,228	1,275,480	1,161,618	342,015	428,469	340,980	4,734,962	16,985	3,359,031	10,246,679	18,357,657

*See footnote to table for April.

FRESH FISH LANDINGS OF CALIFORNIA BOATS FOR JUNE, 1938

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters South International Boundary		Total landings of California boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds	Region 70, Los Angeles	Region 80, San Diego	
Anchovy			73,850	200		3,439		77,489			77,489
Barracuda					816	218,165	95,817	314,798		3,200	317,998
Cabezone			32	673				705			705
Cabrilla									9,088	2,261	11,349
Carp		416						416			416
Catfish		5,650						5,650			5,650
Cultus, Pacific	49,721		25,483	8,412	68	18		83,702			83,702
Eel						10		10			10
Flounder, Starry	31,090		16,138	1,485				48,713			48,713
Flying Fish						13,245		13,245			13,245
Grouper										3,950	3,950
Hake			3,900	14,400				18,300			18,300
Halibut, California	2,720		7,006	4,592	27,415	26,975	2,394	71,102		7,525	78,627
Halibut, Northern	159,509		290					159,799			159,799
Herring, Pacific					42			42			42
Kingfish			2,494	10,705		34,256	100	47,555			47,555
Mackerel, Horse				12,555		3,401	61,936	77,892			77,892
Mackerel, Pacific				63,353		324,847	738,732	1,126,932		90	1,127,022
Mackerel, Spanish									155	667	822
Mullet							628	628			628
Perch						8,720		8,720			8,720
Pompano, California						200		200			200
Rock Bass					2,218	17,740	15,740	35,698	345	4,447	40,490
Rockfish	41,011		36,088	231,760	9,613	13,285	19,155	350,912		4,936	355,848
Sablefish	38,983		1,898	12,805		9,457		63,143			63,143
Salmon	393,994	9,394	15,342	23,864	145			442,739			442,739
Sand Dab	39,997		24,980	12,654		856		78,487			78,487
Sardine			102,200	338,465	43	4,415	4,435	449,558			449,558
Sculpin						14,379	611	14,990			14,990
Sea-bass, Black					1,115	1,740	92	2,947	14,770	12,395	30,112
Sea-bass, Short-fin							1,339	1,339			1,339
Sea-bass, White			28		629	5,977	6,257	12,891	32	1,033	13,956
Shark	238		8,104	94,775	428,494	49,360	1,922	582,893		8,610	591,503

Sheepshead					287	4,105	10	4,402			4,402
Skate	9,680		8,370	8,809	3,056	1,464		31,379			31,379
Smelt	542		16,896	11,111	1,328	16,297	532	46,706			46,706
Sole	459,657		207,697	68,824	12,599	1,379	15	750,171			750,171
Swordfish, Broadbill					2,009	13,968	14,863	30,840		348	31,188
Tomcod	130							130			130
Tuna, Bluefin						2,307,250	542,977	2,850,227		75,057	2,925,284
Tuna, Bonito						13,886	362,963	376,849		562	377,411
Tuna, Skipjack									935,517	1,772,327	2,707,844
Tuna, Yellowfin									1,859,193	8,323,313	10,182,506
Turbot	350		6,144	10				6,504			6,504
Whitebait	25,343		210	1,532				27,085			27,085
Whitefish					21	629		650	200	145	995
Yellowtail						6,008	56,627	62,635	1,669	174,949	239,253
Miscellaneous Fish	12,885		1,757	2,451	2,306	4,602		24,001			24,001
Crustacean:											
Crab	43,446		261,796	6,868				312,110			312,110
Crab, Rock						775		775			775
Shrimp			282,313					282,313			282,313
Mollusk:											
Abalone				124,775	84,100	450		209,325			209,325
Clam, Cockle			23			2,513		2,536			2,536
Clam, Gaper			360	180				540			540
Clam, Pismo					20,133			20,133			20,133
Clam, Razor	280							280			280
Clam, Soft-shell			7,789					7,789			7,789
Clam, Washington			238					238			238
Octopus	4		1,285	4,800				6,089			6,089
Oyster, Eastern			16,780					16,780			16,780
Oyster, Japanese			61,717					61,717			61,717
Oyster, Native			4,113					4,113			4,113
Squid				440,987				440,987		155	441,142
Total pounds	1,309,580	15,460	1,195,321	1,501,045	596,437	3,123,811	1,927,145	9,668,799	2,820,969	10,395,970	22,885,738

*See footnote to table for April.

INDEX TO VOLUME 24

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9—62500 11-38 3M

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"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 24 San Francisco, January, 1938 Number 1

51868

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Volume 24 San Francisco, April, 1938 Number 2

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R. Remley, Warden, Flying Squad........Willits
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