CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 32 San Francisco, April, 1946 Number 2

STATE OF CALIFORNIA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF FISH AND GAME

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(Continued on inside back cover)

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TABLE OF CONTENTS

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TWENTY-FIVE YEARS OF THE CALIFORNIA FISH AND GAME COMMISSION[1]

By J. S. Hunter
Bureau of Game Conservation
California Division of Fish and Game

In the April, 1921 issue of California Fish and Game, Dr. H. C. Bryant told of the work of the Commission during the first 50 years of its existence and pointed out its outstanding accomplishments during that time. It is the intention of the writer, who has had the privilege of being an employee of the Commission for more than half of the 75 years of its existence, to carry on for the 25 years since the doctor's article was published. It will be necessary, however, to review somewhat the happenings of the first fifty-year period.

In the beginning, the Commission was a fish commission only. In the late 70's authority was extended to it to include game, but the appropriations for game work were so meager (averaging until the Hunting License Act was adopted in 1907 less than $3,000 per year) that little could be accomplished. In the early 90's, for example, the deer situation was so bad that the legislature saw fit to close the season entirely for a period of two years.

During the first 37 years, that is, until 1907, all revenue for support was by appropriation and averaged approximately $18,000 per year—about the same as is now spent in five days' operation. The last appropriation from the general fund was made in 1910. Since that time the Commission has been entirely self-supporting, obtaining no money whatsoever from the general taxpayer. Income is derived chiefly from hunting and fishing licenses, from deer tags, and from taxes on the commercial fishing industry.

The passing of the Hunting License Act in 1907 really sets the date when serious conservation work started. Its passage was due to the very sincere work of the Chief Deputy, Chas. Vogelsang, and to the cooperation of the serious-minded members of the senate and assembly. The result was that more money went into the Fish and Game Preservation Fund ($118,247.00) than had been appropriated for game work in all the previous years.

At that time the work of the Commission consisted of law enforcement and fish culture. The Chief Deputy was the secretary of the board and the directing head. With additional money coming in, the Commission broadened its work. A game farm was created at Hayward and operated during the ten-year term of the lease. Trout and salmon culture increased greatly with the passing, in 1913, of the Angling License Act. The Commission realized the importance of the commercial fishing industry and in 1915 created the Department of Commercial Fisheries. The control of mountain lions as an additional measure for increasing the deer population was instituted. The Bureau of Education and Research, and the publication of California Fish and Game, were

[1] Submitted for publication, January, 1946.

put under the direction of Dr. H. C. Bryant. Throughout the state the conservation work of the Commission was intensified.

In 1913 the State Civil Service Act was passed and all employees were placed under its protection.

In 1921 the annual expenditures of the Commission were $593,963.00. In the report of that year, the distribution of this amount was given as follows: administration 7.3%; commercial fish culture and conservation 19.4%; sporting fish culture and conservation 46%; game conservation 27.3%. It is not possible to compare in detail the 1921 figures with those of 1945. In the above figures, under commercial fish culture and conservation are included commercial fish investigations and research; and under sporting fish culture and conservation and game conservation are included the cost of law enforcement.

By 1945 expenditures had increased 236% to a total of $1,392,217. These expenditures, which do not include capital investments, were distributed as follows:

Administration	7.3%
Patrol and law enforcement	33.2%
Marine fisheries	6.8%
Fish conservation	26.1%
Engineering (dams and ladders)	1.9%
Game conservation	10.5%
Game farms	5.6%
Licenses	8.6%

In 1921 an attempt was made in the legislature to take the Commission into the Department of Agriculture. This bill did not pass, but in 1927 the Commission was absorbed by the newly created Department of Natural Resources under the title of Division of Fish and Game.

There have been many changes of personnel of those directing the work of the Commission since 1921. Operating at that time under the original 1870 law, commissioners were appointed by the governor to serve at his pleasure, and in general each new governor appointed new commissioners. They received no salary but were reimbursed for expenses. In 1937 the legislature provided for a five-man commission; and in 1940 a constitutional amendment was adopted providing for a five-man commission with six-year staggered terms. Definite dates were set for the retirement of the members of the first Board appointed under the new law and at such times new appointees were to serve for a full six year period. The combination of a five-man board with six-year terms means that every sixth year there is no outgoing member and therefore no change in the Commission. Commissioners now receive, in addition to expenses, $10 for each day actually spent on state business up to a limit of $50 in any calendar month.

The 57 men who have been appointed to the Commission by the governors of our state are listed herewith. They have created the policy and laid down the foundation that the working staff has followed. The state has been fortunate in having, with very few exceptions, outstanding men as commissioners. Their devotion to the work has been sincere and constructive. Until recent years no compensation was allowed and their only reward has been in knowing that their acts were in accordance with their best judgment. If their work has been good, the conservation structure erected on the foundation laid down by them will reflect to their credit and to the credit of the commissions that will follow.

FISH AND GAME COMMISSIONERS, 1870-1945

B. B. Redding 1870-85
S. R. Throckmorton 1870-85
J. D. Farwell 1870-85
R. H. Buckingham 1885-86
A. B. Dibble 1885-86
T. J. Sherwood 1885-86
Joseph Routier 1886-91
J. Downey Harvey 1886-91
Chas. Josselyn 1886-91
Jos. D. Redding 1891-95
Raymond E. Wilson 1891-91
Joseph Morizio 1891-92
Hugh L. MacNell 1892-95
Wm. C. Murdock 1892-96
H. F. Emeric 1895-97
J. M. Morrison 1895-99
Alex T. Vogelsang 1896-01
C. B. Gould 1897-01
H. W. Keller 1899-03
W. W. Van Arsdale 1901-07
W. E. Gerber 1901-07
John Bermingham 1905-08
George Stone 1907-10
F. W. Van Sicklen 1907-10
M. J. Connell 1908-27
Lendal N. Gray 1910-10
David Starr Jordan 1910-11
F. G. Sanborn 1911-12
Frank M. Newbert ..... 8/ 4/11 to 12/ 7/25
Carl Westerfeld ..... 1/ 2/12 to 12/ 8/16
E. L. Bosqui ..... 12/ 8/16 to 12/12/22
I. Zellerbach ..... 5/ 5/25 to 1/ 1/39
G. H. Anderson ..... 12/12/22 to 5/ 5/25
Ralph H. Clock ..... 12/ 7/25 to 9/ 2/27
Geo. B. Clarkson ..... 9/ 2/27 to 8/ /30
Reginald S. Fernald ..... 9/ 2/27 to 1/ /31
C. S. Bell ..... 8/18/30 to 1/ 1/32
Earl B. Gilmore ..... 1/ 1/32 to 12/12/34
J. Dale Gentry ..... 1/ 1/32 to 2/ 4/35
Chas. N. Cotton ..... 12/14/34 to 2/ 4/35
Dr. E. C. Moore ..... 2/ 2/35 to 1/ /39
Elmer Honchin ..... 2/ 5/35 to 1/ /36
A. T. Jergens ..... 1/ 7/36 to 4/ 5/38
Newton A. Booth ..... 4/15/38 to 1/13/39
Raymond Gray ..... 4/ 5/38 to 1/ /39
E. L. McKenzie ..... 4/15/38 to 1/ 1/39
K. I. Fulton ..... 1/ 1/39 to 2/ 8/40
F. W. Clark ..... 1/ 1/39 to 9/19/39
Phil S. Gibson ..... 1/ 1/39 to 9/19/39
E. L. Carty ..... 9/19/39 to 1/15/43
Germain Bulcke ..... 9/19/39 to 1/15/44
Nate Milnor ..... 9/19/39 to 1/15/45
Lee F. Payne ..... 9/19/39 to 1/15/46
W. B. Williams 9/19/39
(term to expire 1/15/47)
H. L. Ricks ..... 3/ 6/44 to 1/31/46
Dom A. Civitello 3/15/44
(term to expire 1/15/50)
Harvey Hastain 3/23/45
(term to expire 1/15/51)
Lee F. Payne 1/25/46
(term to expire 1/15/52)

During the period of this report the following men have served as executive offieer and secretary of the Commission:

Chas. A. Vogelsang ..... Resigned March, 1922
George Neale ..... March 1922 to Dec. 31, 1925
B. D. Marx Greene ..... Jan. 18, 1926 to Dec. 1, 1927
Eugene D. Bennett ..... Dec. 1, 1927 to April 1, 1929
John L. Farley ..... April 1, 1929 to Nov. 5, 1934
Herbert C. Davis ..... Dec. 15, 1934 to Sept. 19, 1939
Lester A. McMillan ..... Sept. 20, 1939 to Aug. 19, 1940
George P. Miller ..... April 1, 1941 to Dec. 15, 1944
Emil J. N. Ott, Jr. ..... Dec. 16, 1944 to ———

An extremely important change in the functions of the Commission was made at the 1945 session of the State Legislature when Sections 14 to 19.6 were added to the Fish and Game Code. These gave to the Commission wide regulatory powers, up to that time reserved to the legislature, over the wildlife of the state, *except with respect to species taken for commercial purposes.* With respect to species taken for sport, the Commission may now regulate seasons, bag and possession limits, size limits, territorial limits, means of capture, and restrictions based on sex, maturity or other physical distinctions.

A tabulation of the various bureaus and other titular divisions, showing their chiefs and the changes in their appellations, is presented at the end of this paper and shows that of the six bureaus now in existence, only

three were functioning in 1921, the Bureau of Patrol, the Bureau of Fish Conservation, and the Bureau of Marine Fisheries; and these three were then called by different names. Of the other bureaus which existed in 1921 or have been created since, some still stand as integral parts of the organization, but others have vanished; the record, to one who can read between the lines, suggests much of interest.

Bureau of Patrol and Law Enforcement

In the early 20's the patrol force numbered 46 deputies. These worked from three district offices: Sacramento, Los Angeles and San Francisco, under the direction of the man in charge of the respective office. With the reorganization of the Commission under the leadership of I. Zellerbach, its president, the number of deputies increased to 89. Patrol districts were created and a captain was placed in charge of each district, the captain being responsible to the Chief of Patrol in San Francisco. Later three district inspectors were appointed with headquarters in Sacramento, Los Angeles and San Francisco and the patrol force increased to 108.

During the biennial period of 1920-22, there were 2258 arrests for violations of the fish and game laws, and fines totalling $66,421.50 were imposed. During the biennium just previous to World War II there were 7262 arrests, and fines imposed amounted to $202,590.96. During the last biennium the force was greatly handicapped by war conditions and there were only 4298 arrests with fines totalling $152,508.00. At the present time there are 166 employees in law enforcement work.

Transportation has been one of the difficult problems of the Bureau of Patrol. Twenty-five years ago the bureau possessed one Ford and the deputies used their own private cars on a mileage basis. The results were not satisfactory and when money was available cars were purchased and transportation provided. Since the beginning of World War II Patrol, as well as all other bureaus, has been greatly handicapped by war restrictions and the loss of personnel to the armed forces.

Bureau of Fish Conservation

With the continually increasing demands from sportsmen for more and larger fish, and with a 200% increase in the state's population during the past 25 years, the problem confronting the Bureau of Fish Conservation has been most complex. Larger fish can only be produced economically where water temperatures are right and where food can be secured at a reasonable cost. Many of the hatcheries and egg-collecting stations that were in operation 25 years ago have been abandoned and replaced by others in more advantageous localities. In some instances, egg-collecting stations have been made into hatcheries. The expenditure for fish food alone under present conditions practically equals the total cost of maintaining the hatcheries and egg-collecting stations of 25 years ago. During the 25-year period a total of 709,123,258 trout and 194,147,807 salmon have been planted in our streams and lakes, and 61,521,897 of numerous other species, mostly spiny rayed, rescued from overflowed areas for transfer to permanent waters. The total weight of trout planted in 1944 was 321,321 pounds, exceeding by half the weight of trout planted in any year prior to 1942.

In this increase of total weight planted three factors have been of major importance. One is the development of a brood stock of fall spawning rainbows. The second is the development of abundant hatchery water supplies of such a temperature that offspring of the fall spawning stock can be grown to 6 inches and up by the following May. Hot Creek, Fillmore and Black Rock are outstanding in this respect. Third is the development of low cost food supplies, largely in the form of hitherto unutilized materials such as fluky beef liver, condemned canned fish and fresh fish of varieties not favored for human consumption.

In the distribution end a great step forward has been the installation of aerating devices on all planting equipment so that the crews can distribute their loads of fish in an orderly manner without fear of losses due to insufficient oxygen in the water.

And to provide the information needed for a planting program and for other fish conservation measures, the Bureau established in 1937 a staff of trained biologists, decentralized in such a way as to provide geographical coverage for the state. Among other things they have carried on a census based on voluntary reports from a sample of the angling licensees which has shown an annual catch in the neighborhood of 16,000,000 trout in recent years.

Bureau of Marine Fisheries

The importance of the commercial fishing industry was realized many years ago by the Commission but it was not until 1915 that the Department of Commercial Fisheries was created, now known as the Bureau of Marine Fisheries. It was realized that only by regulations based on sound scientific research could the industry be developed and maintained. No better man to head this important department could have been found than N. B. Scofield. During the first few years the legislature passed laws requiring the fishing industry to render reports from which statistical data could be secured to show just what was happening to our commercial fisheries resources and what was needed for their preservation, and providing that funds necessary to carry on the work be collected from the industry.

Early in the 1920's the California State Fisheries Laboratory was erected at Terminal Island where the research staff would have all the facilities necessary for carrying on its work. Many of the men trained here are now known as outstanding authorities in fisheries conservation. Space will not permit going into detail of the work of the department. Those interested may find full records in the Biennial Reports of the Commission, and in the "Fish Bulletins" of which 62 have been published. It will be sufficient to point out the fact that our fisheries have been developed to yield an average of approximately 170 pounds of fish annually for each one of the nine million residents of the state, and that California records show that one-third of all the fish taken in the United States and Alaska are brought into our California ports. The sardine catch, which seemed large at 30,000 tons in 1921, exceeded 548,000 tons in the 1944-45 season, the latest for which figures have been published.

Bureau of Licenses

This bureau is charged with distribution of all licenses. As has already been stated, the Division of Fish and Game is entirely self supporting, the necessary revenue coming principally from hunting and fishing license sales and commercial fish taxes. The successful enforcement of a license law depends on how simple it is to secure the license. It has therefore been the policy of the Commission to place licenses within easy reach of the applicant and for that reason it has endeavored to have them available even in the most remote places. All the agents are bonded and it is essential that they have on hand approximately the number of licenses the locality will require. Licenses were formerly distributed through county clerks and agents on a 10 per cent commission basis. This has been reduced to 5 per cent, thus effecting a saving of thousands of dollars. In 1921 there were issued: angling licenses 176,873; hunting 225,454; commercial fishing 4,462. In 1945 the sales had increased to: angling over 500,000 (final figures not available); hunting 321,888; commercial fishing 10,871. The issuance of deer tags and of special antelope, elk, and other seasonal licenses set up by various laws during recent years is also the responsibility of this bureau.

Bureau of Game Conservation

Game conservation was not set up as a separate bureau until 1935. Part of the work that it now carries on was previously done by the Patrol Department and later by the Bureau of Game Refuges. Everything that affects game other than law enforcement is the responsibility of this bureau: predatory animal control, including mountain lions; the investigation of field conditions; game censuses; management of game refuges and public shooting grounds; and all federal aid in wildlife restoration, or Pittman-Robertson, programs.

The Commission has paid for the killing of mountain lions since 1907. Until 1918 the bounty was $20 on either sex. In that year it was increased to $30 on females. During the legislative session of 1945 this was again increased to $50 on males and $60 on females.

The first lion hunter was employed in 1918, and three other hunters later. Coyote and wildcat control was instituted in 1928. From time to time the number of trappers has been increased as money was made available. Twenty-two men are now trapping and about that same number will be added as soon as equipment can be secured. Predatory animal work has resulted in the taking of nearly 10,000 lions. By December 31, 1945, trappers had accounted for 27,437 coyotes, 7,806 bobcats and 16,688 other predators, mostly feral housecats.

In the late 20's it was apparent that waterfowl were on the decrease and that additional protection was needed. Duck hunters had become so numerous that practically every waterhole had one or more guns to keep the birds from the resting areas. Through the assistance and recommendations of the Advisory Committee on Waterfowl Refuges appointed by the governor in 1927, 4 refuges totalling approximately 10,000 acres located in the duck areas of the state were purchased. On these the birds could find a haven on which they would be undisturbed. This act of the Commission was prior to the refuge program of the federal

government and resulted in the preservation of thousands of birds that returned to the northern breeding areas and later came back to California many fold for the benefit of our hunters.

From time to time the study of the diseases and epidemics that occasionally occur in wildlife has been undertaken by the division but it was not until recent years that this important part of the game management program was given the attention it deserves. The future of our game depends on thorough knowledge of the relationship between game and livestock and the determination of the extent to which game in the field acts as a carrier of livestock diseases. We now have in Berkeley a reasonably well equipped laboratory where this study is carried on. Real progress has been made but it will be a long time before we know all the answers.

With the passage of the Pittman-Robertson Act by Congress and the adoption by our legislature of enabling acts, California began in 1939 to participate in the benefits of the federal appropriations for the acquisition of land and the study of wildlife problems. Under the authority of this act we have acquired approximately 31,000 acres of land; have completed several development projects; and have under way management studies of quail, deer and fur bearing mammals.

Prior to the war, in order that we might have definite information regarding the game take, we sent out in cooperation with the Terminal Island Laboratory questionnaires to hunters in all counties asking them to send us a record of their year's kill. In 1940 11,000 replies were received; in 1941, 13,000. From these replies have been estimated the total take. By species, the kill in the two-year period was:

	1940	*1941*
Quail	1,290,487	1,208,788
Doves	1,711,862	1,368,464
Ducks	1,520,207	1,579,651
Geese	138,709	140,399
Pigeons	116,614	123,969
Pheasants	167,035	245,666
Rabbits	1,017,956	962,852
	5,962,870	5,629,789

In 1927 the deer tag law was adopted requiring deer hunters to report their kill. These cards have been tabulated and show a total kill of 542,560 since that date.

Bureau of Game Farms

Responding to the demands of sportsmen, the Commission in 1925, with the cooperation of the Department of Finance, secured a deficiency appropriation of $50,000 for the construction of a game farm in Napa County near Yountville. In 1929 a southern California game farm was established near Chino. The farms have operated continuously and have raised thousands of pheasants, quail, chukar partridges and turkeys. These have been liberated in practically every county of the state. In order that the output of the farms could be increased, hundreds of holding pens have been constructed in numerous counties where pheasants and other game birds could be received by sportsmen and employees of

the Commission for liberation. Due to the excellent work in releasing pheasants, an open season on these birds was declared by the legislature in 1933. Since that time California hunters have harvested thousands of pheasants annually.

Administration of the details of the game management area law has been a responsibility of the Bureau of Game Farms since its enactment in 1939. This program was designed to increase pheasants and quail by encouraging private owners to release birds on their properties. The proportion of the planted birds which they may take, but in no case to exceed 80 per cent, is set by the Commission, as is the hunting season.

Bureau of Hydraulics

The Bureau of Hydraulic was established in June, 1926, as the "Bureau of Screens and Ladders." It continued to have charge of these problems until June, 1933, when its work was taken over by the Bureau of Fish Culture. In 1935 a law was passed requiring the Commission to pay half the cost of fish screen construction and Hydraulics was again set up as a bureau.

In 1939 the name of the bureau was changed to Engineering and all construction and engineering work was placed under its direction. It installed many screens, ladders and other structures and completed various land surveys. In 1945 it was decided that the construction work of the Division should be carried on by the State Department of Public Works and the Bureau of Engineering was dissolved.

California Fish and Game Magazine

The first number of the quarterly magazine of the Division was issued in October, 1914 with Dr. Bryant as editor. On his resignation in 1930 to enter the National Park Service he was replaced by Leo K. Wilson, who served through 1932. James Moffitt was editor in 1933; J. O. Snyder from 1934 to 1936; and Richard Croker from 1937 until his entry into the Army in 1942, since which time the work has been carried on by Brian Curtis.

It has not been the policy of the Commission to make a sporting magazine of CALIFORNIA FISH AND GAME but rather a medium in which to record the activities of the Division and to report its progress in scientific and other fields. Among conservationists the magazine is regarded as one of the best published; and it is continuously referred to in the bibliographies of scientific papers.

Library

In the years since the library was created in 1927, the Commission has built up one of the best conservation libraries in the country. On the shelves in San Francisco are well over 3500 volumes and more than 10,000 pamphlets on conservation subjects. At Terminal Island the State Fisheries Laboratory maintains a library containing thousands of volumes and pamphlets, published in the United States and in foreign countries, on fishery problems. This is considered the best fisheries library in the west.

Legal Department

The legal department during the past several years has handled many cases that have a bearing on conservation both in the present and in the future. Until recently this branch of our work was carried on by attorneys appointed by the Commission in cooperation with the Attorney General's office. Now the work is done entirely by the Attorney General through his deputies. The cases have been well conducted and reflect to the credit of the legal staff. Most of them have been recorded in previous issues of CALIFORNIA FISH AND GAME. A complete survey will be made the subject of future articles.

HISTORY OF EXISTING BUREAUS
1921-1945

Year	Name of bureau	Chief
1921-25	Patrol Service	No chief*
1926-27	Patrol Service	Hunter, J. S.
1927-29	Patrol Service	Allred, K. P. (Acting)
1929-45	Bureau of Patrol and Law Enforcement	Macaulay, E. L.
1941-45	Bureau of Patrol and Law Enforcement	Chappell, L. F. (Acting; Macaulay on military leave)
1921-28	Department of Fish Culture	Shebley, W. H.
1928-31	Bureau of Fish Culture	Shebley, W. H.
1932-35	Bureau of Fish Culture	Snyder, J. O.
1935-36	Bureau of Fish Conservation	Soyder, J. O.
1937-45	Bureau of Fish Conservation	Taft, A. C.
1921-28	Department of Commercial Fisheries	Scofield, N. B.
1928-37	Bureau of Commercial Fisheries	Scofield, N. B.
1937-39	Bureau of Marine Fisheries	Scofield, N. B.
1940-41	Bureau of Marine Fisheries	**
1941-45	Bureau of Marine Fisheries	Van Cleve, R.
1926-33	Bureau of Finance and Accounts	Dunbar, H. R.
1933-45	Bureau of Licenses	Dunbar, H. R.
1926-35	Bureau of Game Farms	Bade, August
1935-37	Assigned to Bureau of Game Conservation	
1938-45	Bureau of Game Farms	Bade, August
1929-35	Bureau of Game Refuges	Hunter, J. S.
1935-45	Bureau of Game Conservation	Hunter, J. S.

* Patrol Service had no single chief prior to 1926, the Commissioners acting as Patrol Heads in their respective parts of the State.

** Position of Chief, Bureau of Marine Fisheries, was vacant December 1, 1939 to February 28, 1941.

HISTORY OF BUREAUS WHICH HAVE CEASED TO EXIST
1921-1945
(Including independent titles)

Year	Name	Chief
1921-23	Department of Water Pollution	Fairfield, A. M.
1926	Bureau of River and Harbor Pollution	Watkins, R. G.
1921-25	Bureau of Education, Publicity and Research	Bryant, H. C.
1926	Bureau of Education and Research	Bryant, H. C.
1927-28	Bureau of Education	Bryant, H. C.
1929-30	Bureau of Education and Research	Bryant, H. C.
1930-33	Bureau of Education and Research	Wilson, Leo K.
1934	Bureau of Education and Research	Snyder, J. O.
1924-26	State Lion Hunter	Bruce, Jay C.
1927-28	Assigned to Patrol Service	Bruce, Jay C.
1929	Transferred to Bureau of Game Refuges	Bruce, Jay C.
1926	Bureau of Screens and Ladders	Spencer, John
1927-33	Bureau of Hydraulics	Spencer, John
1935-36	Bureau of Research and Engineering	Davis, H. C.
1936-40	Bureau of Hydraulics	Spencer, John
1940-45	Bureau of Engineering	Spencer, John
1926	Bureau of Publicity	Watkins, R. G.
1927-29	Bureau of Public Relations	Vore, Frank H.
1929-30	Bureau of Publicity	Vore, Frank H.
1930	Bureau of Publicity	Wilson, Leo K.
1927	Commercial Fisheries Patrol	
1928-31	Assigned to Department of Commercial Fisheries	
1932	Transferred to Bureau of Patrol	
1927	Bureau of Statistics and Game Problems	Ludlum, R. E.
1927-28	Bureau of Research	Ludlum, R. E.
1929-34	Bureau of Fish Rescue and Reclamation	Neale, George

A PRELIMINARY REPORT ON THE FISHERY OF MILLERTON LAKE, CALIFORNIA[1]

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Introduction

Millerton Lake, impounded by Friant Dam on the San Joaquin River, was opened to fishing for the first time in 1945. Its advance publicity—both as a key project in the Central Valley Plan and as a recreational area—destines it to be one of the State's important fishing waters. For this reason, and especially because many similar reservoirs in California have had disappointing histories after an initial short period of high fish production, it is desirable to present a description of Millerton Lake and its fishery during its early years. Aside from the collection of catch records no detailed studies have as yet been made. The material presented here is considered to be of value principally in that it may be used as a basis for initial management and future studies.

Most of the detailed information on Friant Dam and its operation has been secured from members of the United States Bureau of Reclamation: Messrs. R. S. Calland, Nelson B. Hunt, R. B. Williams, and L. E. Cramer. Special thanks are due Mr. Williams, former Construction Engineer of Friant Dam, and Mr. Everett A. Pesonen, Recreation Specialist of the Bureau of Reclamation, for their continued interest in the fishery of the lake.

Mr. L. R. Bryan, Chief Guard at Friant Dam, was in charge of the collection of catch records. He and other guards of the Bureau of Reclamation were assisted in this work by wardens of the California Division of Fish and Game under the supervision of Captain S. R. Gilloon.

The photographs used in this report were furnished through the courtesy of the *Fresno Bee*.

Friant Dam, Its Physical Features and Use

The character of a reservoir's fishery depends in large part upon its physical features and its mode of operation (storage and draw-off). While but little correlation between these factors and the productivity of Millerton Lake is attempted here, the following descriptive data are considered to be indispensable for a full understanding of the lake's present and future problems.

Friant Dam is located on the San Joaquin River, in Madera and Fresno Counties, just above the town of Friant, 20 miles from Fresno. It is owned and operated by the Bureau of Reclamation and water is stored here for subsequent release for irrigation and flood control. It is a straight gravity-section concrete structure rising 295 feet above the

[1] Submitted for publication, December, 1945.

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streambed to a spillway crest at elevation 578 feet. Water can be discharged in several ways.

(1) Through four 110-inch river outlet pipes at elevation (invert) 375.4 feet. These outlets are equipped with needle valves and have a combined discharge capacity of about 15,000 c.f.s. under full reservoir.

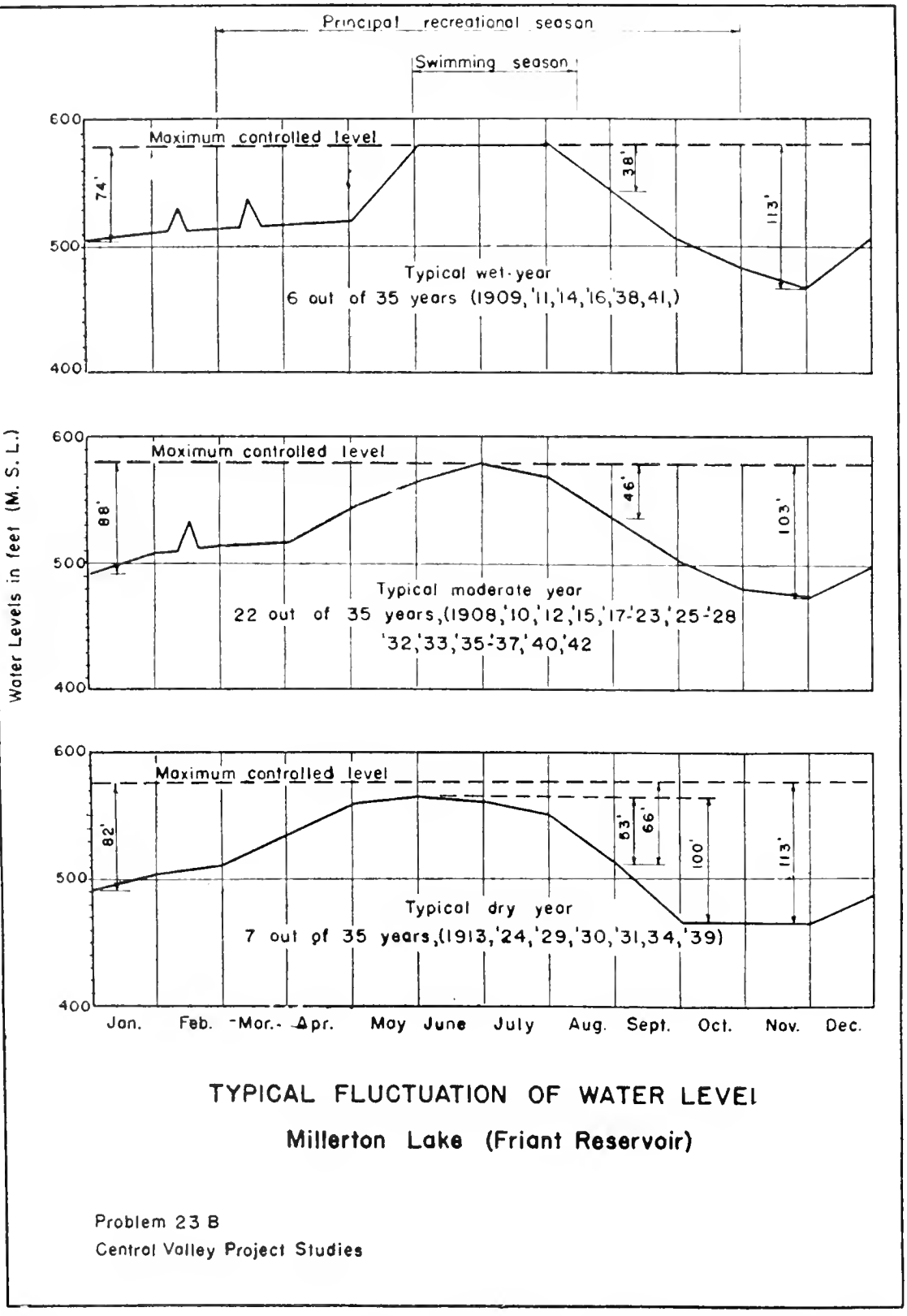

FIG. 10. After Fig. 11 of Central Valley Project (1944). Note that a typical wet or dry year is anticipated after a series of wet years or dry years, not as an isolated phenomenon.

(2) Over a spillway with a lip elevation of 560 feet and eventual crest at elevation 578 feet. (It has been uncontrolled to date but will be equipped with 18-foot drumgates in early 1946.) Its maximum discharge capacity is 92,000 c.f.s.

(3) Through two irrigation canals. The Madera Canal is supplied by two 91-inch outlet pipes, at invert elevation 442.2 feet, controlled by needle valves. This canal, with a full capacity of 1,000 c.f.s., leads north for about 37 miles to Ash Slough, a branch of the Chowchilla River. It furnishes irrigation water either directly (through laterals) or indirectly (percolation through river beds into the ground water supply), and has been in partial operation since June, 1944. The larger Friant-Kern Canal will be supplied with four 110-inch outlet pipes at invert elevation 459.4 feet. These are also controlled by needle valves and will have a combined discharge capacity of 5,000 c.f.s. Construction of this canal started in September, 1945, but it will not be completed for several years. It will convey water as far south as Bakersfield (160 miles) with lateral outlets for irrigation and domestic water supply. The river outlets and the canal heads are equipped with trash racks but not with fish screens.

The general plans call for almost continuous operation of the canals, only short periods of spill, and comparatively small discharges through the river outlets. However, the ultimate operation of Friant Dam will be dependent upon its over-all relationship to Shasta Dam and to the many contemplated units of the gigantic Central Valley Project.

Under the expected plan of operation the reservoir will be filling during the winter and spring months to reach a peak by June or July. During the summer and autumn it will be drawn down to supply the demands of irrigation. Sudden rises may occur when winter floods are being controlled. A more detailed description of water fluctuation in the reservoir will be found in Central Valley Project studies (1944). Even in the most favorable years a vertical fluctuation of at least 100 feet is anticipated, and this alone makes the continuance of good fishing dubious.

Description of the Reservoir

Millerton Lake lies in the foothills of the Sierra Nevada Mountains in the Upper Sonoran life zone. It will be about 16 miles long when filled and is narrow and winding with its greatest expansion at the lower end. Here, at high water it will have a maximum width of about $2\frac{1}{2}$ miles. About $3\frac{3}{4}$ miles above the dam it narrows perceptibly. From these narrows to the head much of the lake is confined to a canyon and is less than 1,000 feet in width. In places the lake shelves off quite rapidly but there are still many shallow coves and bays. The greatest development of shoal area is at the lower end. Some idea of the extent of these areas is shown by the fact that a 25-foot drop of water (from the flow line) will reduce the surface area of the lake 13 per cent; a 50-foot drop will reduce it 26 per cent.

At maximum elevation (578 feet) the reservoir will have a surface area of 4,900 acres, a capacity of 520,550 acre-feet of water, and a shoreline of about 43 miles. At minimum expected elevation (466 feet) it will have an area of only 2,111 acres and a capacity of 129,745 acre-feet.

The lake basin is primarily one of alluvium (cobbles, gravel, and sand) with outcrops of igneous and metamorphic rocks. The slopes are

FIG. 11. Millerton Lake from dam, April 6, 1944. *Fresno Bee.*

grassy. Predominant trees are blue oak, interior live oak and digger pine. Chaparral is especially common in the upper canyon. The reservoir site was cleared of brush and trees between elevations 400 and 583 feet. Consequently, there is but little shelter for fish except in the form of tree stumps, rocks, and some driftwood. A fairly good plant cover of turkey mullein (*Eremocarpus setigerus*), filaree (*Erodium botrys* and *E. moschatum*), tumble weed (*Amaranthus graeczans*), vinegar weed (*Trichostema lanceolatum*), and other plants has followed the shoreline down as the water has receded during the first years. However, the steeper slopes are losing their soil cover to assume the barren character common to fluctuating reservoirs.

The only permanent stream entering Millerton Lake is the San Joaquin River. Controlled by six other reservoirs and 11 hydroelectric power plants, its inflow is subjected to considerable artificial regulation. As measured near Friant its average discharge during the 1907-40 period was 2,316 c.f.s., with a maximum recorded flow of 77,200 c.f.s.[2] Kerckhoff Powerhouse, a stream flow plant of the Pacific Gas and Electric Company, is situated on the river about three-fourths mile above the lake. About eight miles above this plant is its diversion point, Kerckhoff Dam, which is impassable to the upward migration of fish. In some seasons the section between this dam and its power plant is reduced to standing pools with but little flow.

All of the other tributaries are intermittent foothill streams with wide variations in flow, and only one of these has a considerable drainage or fish fauna—Fine Gold Creek, a permanent trout stream near its headwaters but often dry in its lower reaches. During the 1936-43 water years

[2] These figures include the flow from other tributaries of the lake.

its discharge varied from over 10,000 c.f.s. to no flow at all. Much of the fishing in Millerton Lake is done in the coves where the tributaries enter. Some of these streams may provide spawning areas for trout and some of the native fishes. Otherwise they will play but a minor role in the lake's fishery.

Air temperatures in the Millerton basin are decidedly high during the summer months. Records for Fresno, 20 miles away, show that during July and August the average maximum temperature is about 98° F. and the average minimum is about 64° F. The mean annual temperature at Fresno is 63.3° F. (recorded extremes range from 17° F. to 115° F.), and the so-called agricultural growing season extends from February 16th to December 1st or for 289 days. Precipitation is light; the average annual rainfall at Friant is only 12.56 inches. Strong winds are common at the lake, and in 1945 they resulted in wave action which endangered some boat fishermen and made the water so turbid at times that fishing was poor.

Friant Dam was completed, except for control valves and spillway drumgates, in December, 1942. During the period September 6 to November 11, 1941, closure of the temporary diversion conduits was in progress. Since then the river has flowed through the outlet pipes and the level of the reservoir has fluctuated with the flow of the stream and the requirements of downstream water users. The first complete control by the river outlets commenced on February 21, 1944. In that year the reservoir rose to elevation 526.6 feet on July 7th and then descended to elevation 453.5 on October 26th. It again rose and in 1945 attained an elevation of 560 feet to overflow the spillway from June 23d to July 17th followed by subsidence to 501.5 feet on October 29th.

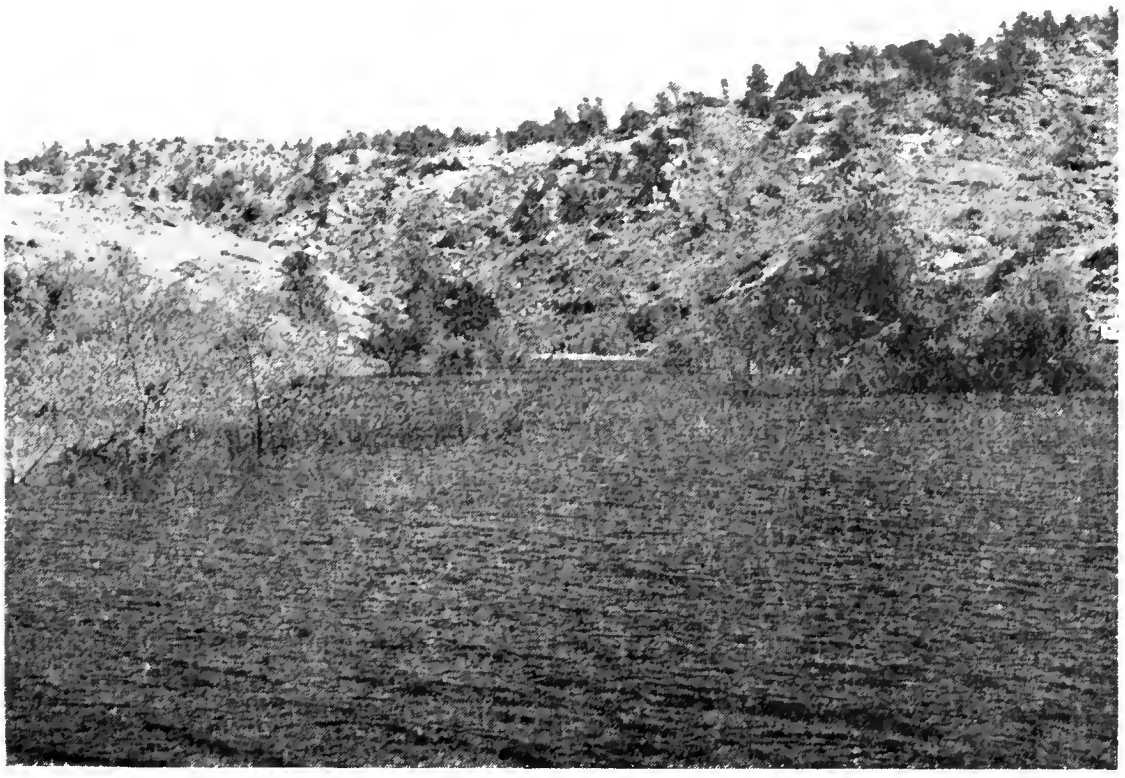

FIG. 12. A creek mouth on Millerton Lake, September, 1943. *Fresno Bee.*

During each of these successive rises much organic matter was inundated and the lake appeared to be rich in plankton. When the spillway drumgates are installed an additional marginal area will be flooded for the first time. This new fertilization (from the plant cover) will create additional planktonic food, but it is not known how long land vegetation will continue to reestablish itself after the top soil has been removed.

No extended series of water temperatures has yet been taken. Occasional readings made at the lower end of the lake in 1945 indicate that the surface water had attained a temperature of 74° F. by April 23d and did not drop below this point until sometime after September 17th. The maximum recorded surface temperature in this year was 79° F. on August 2d. Such records show that the lake belongs to the "warm-water type," more suited for bass-like fishes than for trout, and has favorable growing conditions.

While rather detailed recreational plans have been made for Millerton Lake (see Central Valley Project, 1944) no special facilities for fishermen such as docks or rental boats had been provided up to the close of 1945.

The Fish Fauna

In recent years prior to the construction of Friant Dam the following fishes had been observed in the San Joaquin River near Friant. Those marked with an asterisk are not native to California.

Family Petromyzonidae. Lampreys

Pacific lamprey, *Entosphenus tridentatus*
Brook lamprey, *Lampetra planeri*

Family Salmonidae. Salmons and Trouts

King salmon, *Oncorhynchus tshawytscha*
Rainbow trout, *Salmo gairdneri*
*Brown trout, *Salmo trutta*

Family Catostomidae. Suckers

Sacramento large-scaled sucker, *Catostomus occidentalis*

Family Cyprinidae. Minnows or Carps

Sacramento blackfish, *Orthodon microlepidotus*
Hardhead, *Mylopharodon conocephalus*
Hitch, *Lavinia exilicauda*
Sacramento squawfish, *Ptychocheilus grandis*
California roach, *Hesperoleucus symmetricus*
*Carp, *Cyprinus carpio*

Family Ameiuridae. Catfishes and Bullheads

*Unknown species (probably *Ameiurus nebulosus* and/or *Ictalurus catus*)

Family Poeciliidae. Top Minnows

*Western mosquitofish, *Gambusia affinis affinis*

Family Gasterosteidae. Sticklebacks

Three-spined stickleback, *Gasterosteus aculeatus*

Family Centrarchidae. Black Basses and Sunfishes

*Black crappie, *Pomoxis nigro-maculatus*
*Green sunfish, *Lepomis cyanellus*
*Bluegill, *Lepomis macrochirus*
*Largemouth bass, *Huro salmoides*
*Smallmouth bass, *Micropterus dolomieu*

Family Cottidae. Scaleless Sculpins

Sculpin, *Cottus* sp.

Family Embiotocidae. Viviparous Perches

Fresh-water viviparous perch, *Hysterocarpus traski*

* Not native to California.

Other species have been recorded from this area but had not been noted in recent years. Aside from the sport fish those species noted most frequently by anglers were the large minnows, *Ptychocheilus* and *Mylopharodon*, and the sucker. The first two are frequently confused by fishermen who know them variously as: "hardheads," "river trout," "lake trout," "pike," "whitefish," "steelhead," etc.

The predominant sport fishery in the river here was for king salmon, but Friant Dam cut off about 16 miles of stream in which the salmon spawned and confined it to the river below. The last run above the dam was made in 1941.[3]

In the immediate vicinity of Friant the next most important game species was the smallmouth bass while farther upstream rainbow trout increased in abundance. There was a limited amount of fishing for catfish, and some largemouth bass, sunfishes, and crappie may have been caught here. However, it is believed that only a few of these centrarchids were present.

Our knowledge of the fishes now found in Millerton Lake is limited almost solely to the examination of fishermen's catches in 1945. Those taken by angling only are known to have included: rainbow trout, Sacramento sucker, hardhead, Sacramento squawfish, green sunfish, bluegill, largemouth bass, and smallmouth bass. Carp have been observed in the lake and sculpins have been seen in bass stomachs. The abundance of the various sport fishes as shown by the catch records is discussed later.

Fish Stocking and Early Management

During the time of construction work only a small "pond" existed above the dam site, but in anticipation of the new reservoir it was stocked with largemouth bass and sunfish in 1941 and 1942. During these two years 32,440 largemouth bass, 317,750 green sunfish, and 375 bluegill were planted through the combined efforts of the California Division of Fish and Game and the Fresno County Sportsmen's Club. (See Table 1.) Some of the bass were raised in the sportsmen's rearing pond; the other bass and the sunfish were rescued from overflow areas. There were requests from some sportsmen for further fish planting, but this was disapproved by the Division of Fish and Game on the grounds that natural propagation by the seed stock would suffice to stock the lake.

TABLE 1

Summary of Stocking Records for Millerton Lake

Species	Size	Number of fish stocked		
		1941	1942	Totals
Largemouth bass	Adults	----------	377	377
	Fingerlings*	14,270	17,793	32,063
Green sunfish	Adults	1,750	----------	1,750
	Fingerlings	316,000	----------	316,000
Bluegill	Adults	----------	375	375

* Fourteen thousand of the 1941 plant of bass averaged about 7½ inches in length. Of the 1942 plant, at least one-half were about 3 inches long, but several thousand ranged from 7 to 11 inches in length.

[3] No fishway was recommended for Friant Dam because of the very limited salmon spawning areas left above the reservoir. The construction of Kerckhoff Dam in 1920 had already barred salmon from farther progress up the San Joaquin River.

Occasional observations during the 1941-44 period disclosed the presence of many fish but fishing was not permitted. At first, the Bureau of Reclamation kept the lake closed because of the war emergency; and even when this danger had subsided, public entry was prohibited because of a fire hazard (on the grasslands) and the fact that no agency had offered to take over recreational management of the area.

In 1945 the Division of Fish and Game recommended that Millerton Lake be opened to fishing, pointing out that satisfactory fish populations often became established very quickly in new lakes and that it was inadvisable to delay their cropping. In May the National Park Service took charge of the recreational administration of the lake and the Bureau of Reclamation opened the reservoir under temporary regulations for *sport fishing purposes only*. The lake was opened on very short notice and a great deal of credit must be given to the Reclamation Service's workers for their immediate installation of safety measures, traffic control, and a catch record system. About two miles of shoreline were burned off on the southern side near the dam to reduce the fire hazard, and some grass

FIG. 13. Parked cars of boat fishermen at Millerton Lake, May, 1945. *Fresno Bee.*

was also burned off on the opposite shore. An attempt was made to concentrate the entrance points of fishermen by announcing that all boats were to be launched at one point near the south end of the dam, and that cars (other than those belonging to boat fishermen) were to be parked just outside the lake area near a checking station. However, there were no restrictions on people who wished to park their cars elsewhere and walk over to the lake to fish from the burned-off area. Moreover, it was

permissible to take boats into the upper end of the lake at Sullivan Flat over a county road, and shore fishermen were allowed to fish here even though the grass had not been burned. A few people also entered the lake area over private roads. Nevertheless, the wording of the regulations as well as the convenience of entry did concentrate most of the fishermen at one entrance gate.

The 1945 Catch Records

Methods

The detailed methods used in collecting records will not be described here. Briefly, one or more checkers (sometimes as many as five during the first few days of the season) were stationed at the gate where most of the anglers entered and left the lake. These men kept a record of most anglers entering the gate and examined the catch of most of those leaving. Fish were recorded only as "bass," "sunfish" and "trout" except during periods when sample counts of the individual species were made. Fish were not measured nor weighed. No separate record was kept of "zero catches" nor of the number of hours fished. As a general criticism it should be noted that during the first weeks of the count (up to about July 10th) both the total catch and the catch per fisherman-day were probably somewhat higher than the records show. (During a portion of this period an unknown number of fishermen were checked in but their catch was not recorded as they left.)

It is quite true that this creel count lacked the precision which would have been desirable. However, limited personnel and the sudden open-

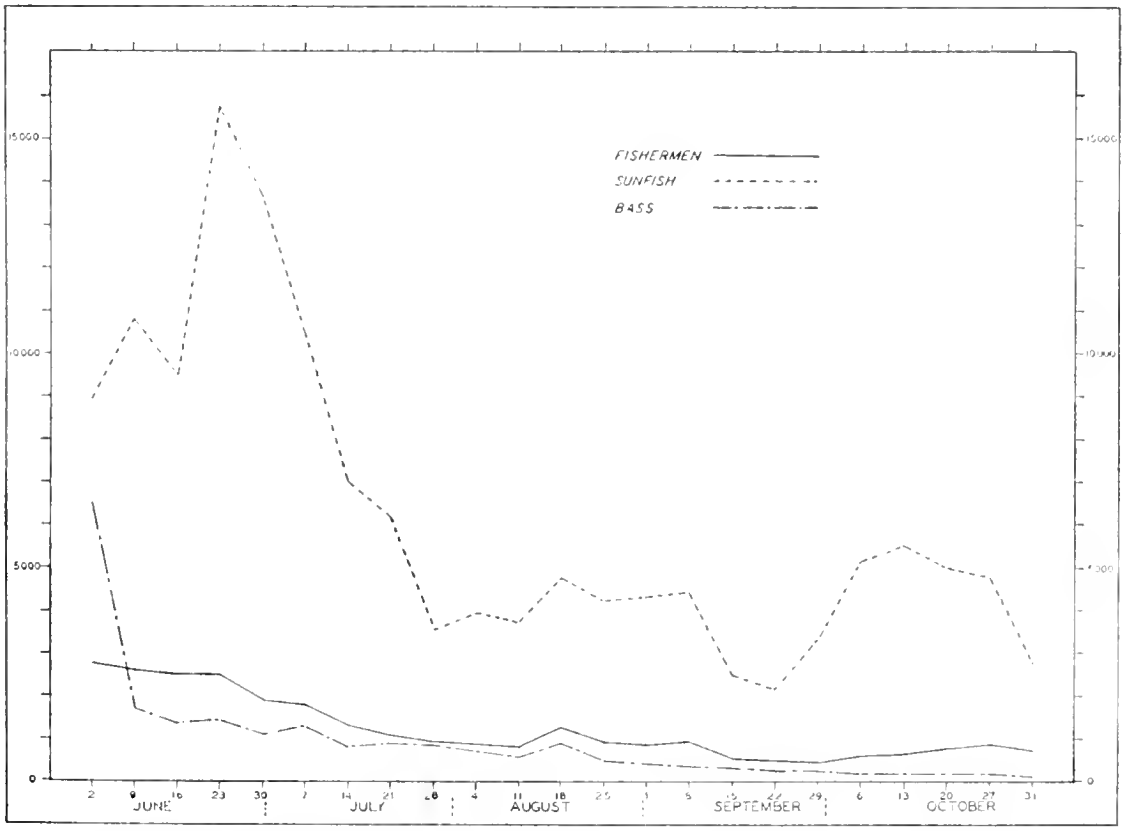

FIG. 14. Weekly fluctuations in the number of fishermen and in the number of bass and sunfish caught at Millerton Lake during the 1945 fishing season. The dates represent the last day of each calendar week. Each plotted point represents the total number of men fishing or number of bass or sunfish taken during a full calendar week except for the May 29-June 2 period and the October 28-31 period.

ing of the lake made it impossible for the two agencies involved to work out a fully unified plan of procedure. It has proved impossible to apply any statistical methods which would convert the figures into "accurate estimates." For all practical purposes, however, the records may be considered to provide a *reasonably accurate "picture"* of the species composition, intensity of fishing, and degree of fishing success throughout the season.

Sufficient personnel was not available to make enough counts of the number of unchecked fishermen to arrive at a satisfactory estimate of the completeness of the catch records. Various observers from both the Bureau of Reclamation and Division of Fish and Game have agreed that the records cover at least 75 per cent of the fishing effort in 1945, and the few actual counts of unchecked fishermen indicate to the writer that they are about 90 per cent complete.

Number and Kind of Fish Caught

During the five-month season of 1945 (May 29th to October 31st, inclusive) a total of 162,166 sport fish were recorded as taken by 27,396 anglers (fishermen-days). Sample counts of complete catches indicated that almost all of the bass taken were largemouth, and that at least 10 out of every 11 sunfish taken were bluegills.[4] It is believed that all trout caught were rainbow. The species composition of the total recorded catch as estimated on the basis of these counts is shown in Table 2. A few Sacramento squawfish, hardheads, and suckers were also caught. Most people discarded them and no count was made of the few which were taken out. No crappie nor catfish are known to have been taken.

TABLE 2

Estimated Species Composition of Recorded Catch at Millerton Lake in 1945

Species	Number caught	Per cent of total catch
Bluegill	129,349	80—
Largemouth bass	19,638	12+
Green sunfish	12,935	8—
Smallmouth bass	148	0.1
Rainbow trout	96	0.06
All sport fish	162,166	

Angling Success

Sport fish were caught at the average rate of 5.92 per fisherman-day for the entire season. Weekly averages varied from 4.51 to 9.13 fish per fisherman-day. Obviously the catch of sunfish alone (i.e., bluegill and green sunfish combined) coincided closely with these figures varying

[4] Unfortunately, only a few sample counts could be made. The ratio of largemouth bass to smallmouth (133:1) used here was based on a complete count of only 402 black bass. General observation indicated that the percentage of smallmouth bass taken during the season was much less than this. The ratio of bluegill to green sunfish (10:1) was based on complete counts for 4,386 sunfish on seven sample days. The proportion of bluegills to green sunfish rose steadily until on the last day of sampling (when 2,320 individuals were examined) the ratio was over 33 to 1. It is probable that the calculated number of bluegills taken throughout the season should be much higher.

from 3.22 to 8.95 with an average seasonal catch of 5.19 sunfish per fisherman-day. Bass fishing showed a decided variation, dropping from a weekly high of 2.35 bass per fisherman-day during the first week to only 0.13 at its lowest point. The average seasonal catch of bass was 0.72 per fisherman-day.[5] (See Fig. 15.)

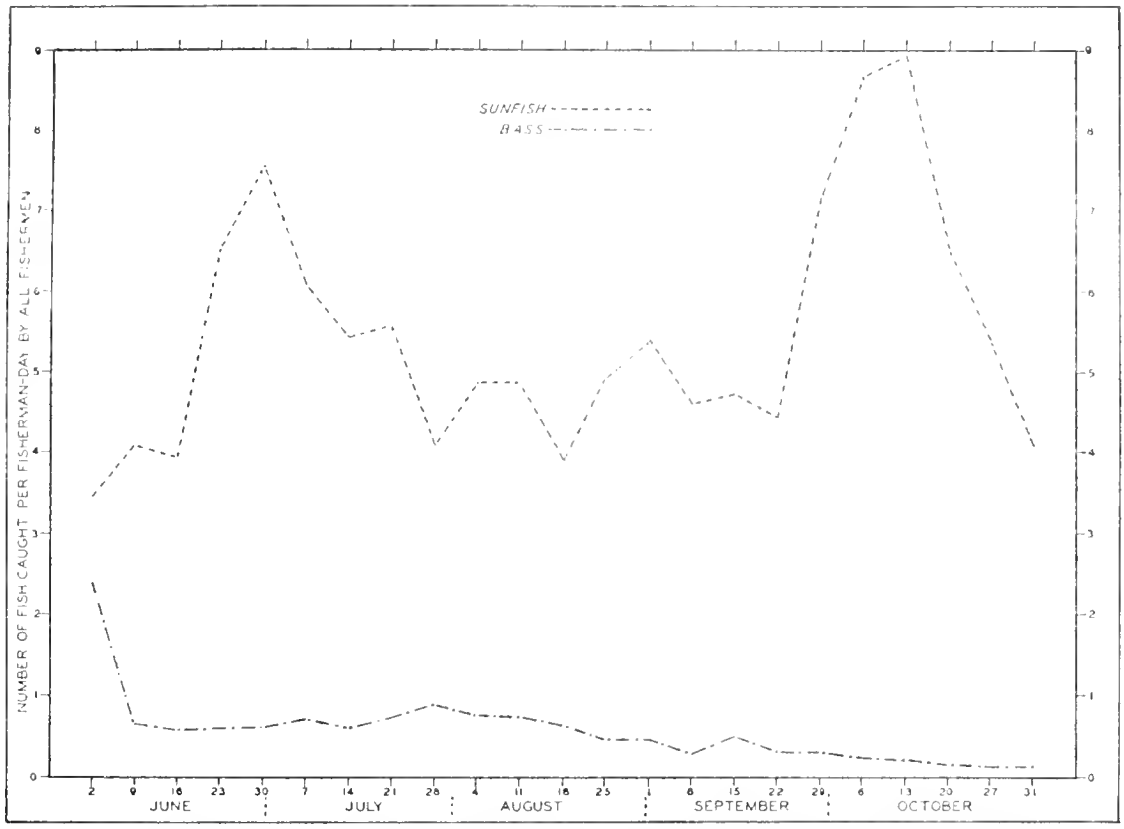

FIG. 15. Weekly fluctuations in average catch per unit of fishing effort (fisherman-day) at Millerton Lake during the 1945 fishing season. The dates represent the last day of each calendar week. Each plotted point represents the average number of fish caught per fisherman-day during a full calendar week except for the May 29-June 2 period and the October 28-31 period.

Seasonal Variations in the Catch

Although the average catch of bass was comparatively high during the first few days of fishing it descended very rapidly, fluctuated close to the seasonal average until about the middle of August, and then showed a more or less constant decline throughout the remainder of the period. On the other hand, the catch of sunfish per fisherman-day showed two well-separated major peaks (at the end of June and in mid-October) and never dropped far below the seasonal average.

It is of considerable interest to note that a large portion of the total seasonal catch of bass was removed shortly after the fishing season opened. By the close of the first week (five days) one-third of the bass caught during the season had already been taken. Three-quarters had been removed after only eight weeks of fishing. The removal of the sunfish did not proceed at such a rapid rate. Only one-sixteenth had been caught by the close of the first week, and 14 weeks elapsed before three-quarters of the seasonal total had been removed.

[5] All of these averages are, of course, based on the catch of all fishermen as no segregation could be made between "bass fishermen" and "sunfish fishermen." Obviously, anglers fishing primarily for bass took more than an average of 0.72 bass per fisherman-day throughout the season.

This phenomenon—the removal of a large percentage of the seasonal catch of bass within a short period of time—is similar to that reported for all fish in Norris Reservoir in 1940 by Eschmeyer (1942). At that lake 71 per cent of the fish caught during six months of the 1940 season were taken in the first month of fishing (June), and the average catch per unit of effort dropped decidedly after the first month. The decline in fishing success at Norris Reservoir during the remainder of the season was at first attributed to the heavy removal during the first month. However, later work attributed the summer decline in the catch to a sudden and decided increase in food (young fish) which made the game fish less easily caught. (See: Eschmeyer, 1944, and Eschmeyer and Manges, 1945.)

A third interpretation is also possible at Millerton Lake. During the first few days of the season the majority of the anglers appeared to be "bass fishermen"; i.e., most of them were equipped with plug rods and used large artificial lures designed to catch bass and of little value as lures for small pan fish. Furthermore, many of the first fishermen were known to be fairly expert and bass fishing was uppermost in the minds of most people. In other words, during the first days of the season most people fished for bass only. (The fact that the opening day's count showed 3,617 bass and only 1,753 sunfish is a good indication that these observations are correct.) However, the percentage of good bass fishermen soon declined and a correspondingly large percentage of "bluegill," "cane pole," and inexpert fishermen visited the lake, resulting in an increase in the sunfish catch. Other factors may, of course, have operated here also: fish frightening due to concentration of shore fishermen on a relatively small area of the lake; seasonal changes in temperature and turbidity; fluctuation of the lake; etc. For example, shore fishing for bass was greatly disturbed on windy days and when the rising water washed charred material into the coves.

Fishing Intensity and Fishing Yield

On the basis of the recorded figures alone the number of fisherman-days during the five-month season of 1945 averaged 6.2 per acre of lake. The recorded yield of sport fish (bass and sunfish) during this same period was 36.58 fish per acre.[6] Obviously, both the total fishing intensity and total yield per acre were somewhat higher.

We have very few catch records for other warm-water lakes in California. Curtis (ms.) states that in four warm-water reservoirs in San Diego County there was an average catch of six fish per fisherman-day and a yield of 48 fish per acre per 12-month season during the 1929-44 period, under a fishing intensity of eight fishermen-days per acre. Fishing is considered to be good in these reservoirs.

A six-month creel census in 1940 at the heavily fluctuating Norris Reservoir, Tennessee, showed an average catch of 1.2 sport fish per fisherman-day or 4.5 per acre. The fishing intensity during this period amounted to four fishermen per acre. (Eschmeyer, 1942.) At two natural lakes in Wisconsin, Frey, et al. (1939) reported that in the most heavily fished one (Waubesa) there was an average catch of 8.85 sport fish per fisherman-day, a yield of 37 per acre, and a fishing intensity of

[6] The surface area of the lake varied between 2967.5 and 4,433 acres during the fishing season. The maximum area attained during this period has been used in these computations.

4.2 fishermen per acre during a five-month season in 1938. Twelve natural lakes in southern Michigan were reported by Hazzard and Eschmeyer (1938) to have a yield of 31.6 fish per acre and a fishing intensity of about 7 fishermen-days per acre during a five-month period in 1936.

FIG. 16. Fishermen on Millerton Lake, May, 1945. *Fresno Bee.*

Without attempting detailed comparisons it can be said that the fishing success at Millerton (as based on numbers of fish caught per fisherman-day) and its yield in number of fish per acre compared favorably with that recorded for other warm-water lakes both in California and other states. The fishing intensity was reasonably high for a warm-water lake but not excessively so. Both the yield per acre and the fishing intensity was decidedly lower than at many California trout lakes. The 310-acre June Lake, for example, had a fishing effort of almost 64 fisherman-days per acre and a yield of 180.5 trout per acre during a five-month season in 1942. However, the average catch per fisherman-day was only 2.8 trout. (Vestal, 1943.)

Size and Condition of Fish

Only general statements can be made regarding the size of the fish taken at Millerton Lake. It is probable that the size of the largemouth bass retained did not greatly exceed the range of 9 to 20 inches in total length. Many of these bass were between 9 and 11 inches, but there was also a fairly large number around 15 or 16 inches or over two pounds in weight. All largemouth bass seen were in excellent condition. Many catches of bluegills averaging about six inches in total length were

checked and some are known to have reached 10 inches. Although a few green sunfish up to nine inches long were seen, their average size was considerably less than that of the bluegills. All of the sunfish were in good condition. Ten of the 96 rainbow trout reported as caught averaged 17 inches in length (range, 11.0-22.25 inches from tip of snout to fork of caudal fin). These were all splendid deep-bodied fish, pale silver in color with hardly a trace of a rainbow stripe. (They were confused with salmon by some anglers.)

There were complaints by some fishermen that there were too many small bass in the lake, i.e., fish close to or less than the legal size of nine inches. Specific reasons for complaint were various. Some men believed that the 1945 opening was a mistake and that it should have been delayed for one or two more years in order to give these small bass a chance to grow up. Others claimed that "thousands" of less than legal-sized bass were thrown back in a mutilated condition, or that part of the catch of legal but small-sized fish was discarded after larger fish had been caught. A considerable number of people simply seemed to be "bothered" by the large number of small bass regardless of whether or not they could catch "keepers."

Preliminary study indicates that most of the "small" bass caught in early 1945 belonged to the 1944 year-class. Such fish would be expected to reach desirable size very soon. Furthermore, if the spawning season of 1945 were successful we might expect the fisherman to be "bothered" by another crop of small fish in 1946. It is readily agreed that many thousands of small bass (less than desirable size for catching or eating) were found in Millerton Lake. However, it was entirely possible for good fishermen to make very satisfactory catches, and many "limits" (10 bass) were comprised of no fish under 12 inches in length and included several bass 15 inches or over in size.

Fishing Methods

Almost every conceivable type of sport fishing tackle was used: bait casting rods with artificial lures; fly rods with spinners, bass bugs or flies; surf rods; cane or willow poles; handlines. The use of live bait fishes was not permitted, and worms were the most popular natural bait—especially for sunfish.

Generally speaking the smaller bass were taken by people who fished from shore using short casts with flies or small spinners in shallow or top water, or who used bait. Those who fished from boats and/or with large artificial lures or (at times) who fished deep were the ones who caught the larger bass.

Problems of Management

Many forms of fisheries management have been devised and a long list of suggestions might be offered here. However, since neither the need for nor the feasibility of utilizing most of these measures at Millerton Lake has been demonstrated, the discussion which follows will concern itself with only a few major considerations.[7]

It is believed that we should attempt to manage the lake primarily for largemouth bass and for bluegill. The former is an attractive game fish while the bluegill is highly desirable both as a pan fish and as a

[7] A more extended discussion will be found in Dill (1943).

forage fish for bass. Furthermore, its ease of capture has made it possible for many inexpert fishermen to enjoy good fishing at the lake.

There is some question as to the desirability of the green sunfish here. At the State's Central Valley Hatchery it seems to be a preferred forage fish by the bass, and perhaps it has a place at Millerton on this account. However, the average size of those caught at the lake was far less than that of the bluegill, and in some waters their slow growth rate and/or predatory habits do not compensate for their other values. Bennett (1943) considers this species to be undesirable in artificial lakes, and it is classed as a "coarse fish" in Michigan. In 1944 it was classed as an undesirable fish to be used for stocking in California although it still retains its status as a "game fish" under State laws.

It is considered impracticable to try to increase the supply of either smallmouth bass or rainbow trout. This bass has never been very successful in California reservoirs, and it would be surprising if it were to become abundant except in the swifter waters at the head of the lake. Similarly, the catch of rainbow trout is not expected to be of much importance except in the river above the lake.

Stocking

The introductory stocking appears to have been very successful in establishing three species of fish in Millerton Lake, and there is every indication that the population of these fishes is high. It has not been California's usual policy to stock warm-water fish for maintenance; i.e., to plant them continuously in waters where desirable breeding populations have been established. And it is the general agreement among fisheries workers today that such stocking is not only of little value but may even be harmful. (See Hazzard, 1945.)[8]

The natural productivity of such warm-water sport fishes as are present in Millerton is extremely high. Some indication of the enormous reproductive potential of these fish may be gained by noting that the catch of at least 130,000 bluegill in 1945 occurred only three years after the stocking of only 375 adults. (The ratio of these stocked bluegill to those recorded as caught was 1:345.) Such an increase may seem phenomenal, and since a few bluegill had been reported from the Friant area prior to the time of stocking there is no certainty that all of these fish resulted from the plant in 1942. However, calculations based on more than reasonable assumptions (a production of 16,000 fry per female, maturation at one year, a 50 per cent natural mortality of the 375 adults which were planted, and natural mortalities of 99 per cent for each year-class produced in 1943 and 1944) show that more than 1,200,000 bluegills might have survived for the 1945 fishing season from the 1944 year-class alone. On the basis of such estimates the fisherman's recorded catch in 1945 would have accounted for only a little more than one-tenth of the bluegills produced in the previous year alone. Some of the work in other states indicates that from one-quarter to one-half of the standing crop of warm-water fish may be removed safely each season. Hence it might be better to worry about overpopulation by bluegills at Millerton rather than underpopulation.

No such similar increase of either the bass or the green sunfish which were stocked is indicated by the catch records. In fact, the number of

[8] This excellent summary on warm-water fish management was reprinted in California Fish and Game, Vol. 32, No. 4, pp. 19-26.

FIG. 17. Catch of sunfish from Millerton Lake, May, 1945. *Fresno Bee.*

these fish caught in 1945 was considerably less than the number stocked. (The ratio of stocked fish to fish recorded as caught was as follows: largemouth bass, 1:0.6; green sunfish, 1:0.04.) However, frequent observations at Millerton Lake make it a certainty that the number of bass caught represented only a fraction of the standing crop. Thousands of yearling and adult bass were observed near the surface especially in April, May and early June, and they appeared to be the most abundant fish in the lake.

Fluctuation of Water Level

The effect of the extreme fluctuation at Millerton may be visualized more easily if one realizes that the normally expected annual drop in water level of at least 100 feet reduces the surface area 50 per cent. With such a rise and fall of water elevation we can not expect the establishment of rooted aquatic plants (valuable as cover and as a habitat for food organisms), nor of an abundant fauna of bottom foods. Possibly plankton production will compensate for the scarcity of bottom organisms as it does in some other fluctuating reservoirs, and the latter's absence will not be as serious as it might be in a trout lake. The lake will drain down well and but little stranding of fish is expected.

Luckily, the damage to the eggs or fry of bass and sunfish may not be great since the lake will normally be rising rather than falling during most of the anticipated spawning period. There is not much accurate information on the spawning seasons of centrarchids either at Millerton

Lake or anywhere in California.[9] Observations at the lake in 1945 indicated that almost all of the largemouth bass had spawned before June 1st and it is probable that most of this spawning occurred in May. Many nests of bluegill and green sunfish were noted in early June of 1945 and many ripe fish of both species were still being caught at the end of this month (when observations were terminated). Both of these fish are known to have a rather extended spawning season.

Apparently but little information exists as to the harmful effect of rising water on centrarchid nests. However, it may be noted that a very good crop of young bass was produced during the 1944 season when the water level rose 63.6 feet during the month of May. Unfortunately, no observations on spawning time were possible in that year, and the bulk of the spawning might have occurred during April, a month when the total fluctuation did not exceed 1.5 feet.

If future studies should show that fluctuation is harmful to spawning in Millerton Lake, and if it is also true that some regulation of water level is possible without affecting the usefulness of the reservoir for storage—it would be desirable to plan such regulation. (In 1945 the total rise in water level was held to only 10.6 feet during the anticipated largemouth bass spawning season of April-May.)

Whether or not the over-all effect of fluctuation or other factors associated with draw-off is harmful to the fishery, it must be realized by the fisherman that Millerton was not designed to be a fishing lake and that its primary purpose demands that it rise and fall.

Regulation of Fish Populations

If spawning should continue to be successful, a major problem may actually be that of controlling populations or achieving a better balance between competing species. Since no netting operations have been carried on at the lake we have but little knowledge of the abundance of fishes other than the centrarchids and trout. And even here it is quite possible that the catch was not a true reflection of their comparative numbers or abundance. It is impossible to say now what changes may occur in the population at Millerton. Different species will probably have their periods of ascendancy and their periods of decline, and a minor species in 1945 may be a dominant species within a year or so.

Preliminary observation indicates that neither the native coarse fish, such as minnows and suckers, nor the introduced carp are numerous. This is in decided contrast to the situation at Shasta Lake, a somewhat similar reservoir on the upper Sacramento River. Here, in 1944 (less than a year after storage commenced) the abundance of squawfish and hardheads was very striking. However, no centrarchids are known from Shasta. A few observations on older California reservoirs have suggested that the native minnows have not held up well after the establishment of black bass and other centrarchids. Carp have become numerous in some of these lakes, however, and in some a decline in bass fishing has been coincident with a rise in the populations of sunfishes, crappies, or catfishes.

[9] The general range of the largemouth bass' spawning season in the San Joaquin Valley and foothills of central California is known to extend throughout most of the March-July period, but it is commonly assumed that most spawning in the warmer waters is completed by the end of May.

If a similar pattern of events should follow at Millerton, major attempts at regulation may have to be directed against the sunfishes or carp rather than against the native coarse fish. The fecundity of such fishes is high and if they should gain the upper hand it may be difficult to readjust the picture. The stocking of more bass does not appear to improve fishing in such lakes and the direct reduction in numbers of the undesirable fishes—coupled, perhaps, with attempts to increase the natural productivity of the bass—seems to be the most advisable measure. Whether such reduction should be accomplished by seining, trapping, poisoning, or removal of catch restrictions on the undesirable species may be a problem for future study. Luckily, Millerton Lake—unlike some California lakes—will probably always have a high percentage of sunfish fishermen which will help to keep them under control.

Fishing Regulations

The present State regulations at Millerton Lake include the following laws for taking warm-water sport fish: fishing season from May 29th to October 31st, inclusive; a daily bag limit of 10 black bass (of all species in the aggregate) and 25 sunfish (bluegill and green sunfish in the aggregate); a size limit of nine inches on black bass and none on any other species. Trout may be taken here (under State law) from May 1st to October 31st, inclusive. The daily bag limit is 25 fish; there is no size limit.

These bag limits should allow an ample daily catch for any fisherman—whether his interest lies in sport or food. It is entirely possible, however, that the limit on sunfish may prove too severe for the good of the fishery and promote overpopulation. And while the five-month season for bass may *allow* a good daily catch of bass during this period, it may not *afford* one except at the start of the season. That is, if the season were to be opened earlier it might afford a higher catch per fisherman-day and a much fuller utilization of the lake's resources without harm to the fishery. With this in mind, an experimental year-round open season is now being tried at Norris Reservoir and other T. V. A. impoundments. (See Eschmeyer, 1944.) Various warm-water lakes in California have had a 12-month open season for many years, and some of these provide excellent fishing despite their proximity to large centers of population and a heavy fishing effort.

Although no changes are recommended for Millerton Lake at present it is probable that more lenient rather than stricter regulations will be called for here eventually.

Interference With Fishing by Speed Boats

A potential menace to fishing here is the use of high-speed motor boats. Their effect at Bass Lake, a nearby reservoir in Madera County, is well known: they cause large waves which roil the water when they reach the shore and both the silting and turbulence spoil fishing. There is a considerable and well-founded antipathy to their unrestricted use among many local fishermen.

Under the temporary fishing regulations at Millerton no speeding or boat racing was permitted, and the few offenders of this notice received heavy criticism from anglers. The extent to which speed-boating would be injurious at this lake is unknown, but it might be expected to be great

especially in the narrow passages and shallow bays. It would be of value to conduct actual experiments on the lake (test runs) before allowing speeding or making specific regulations. Among the suggested measures of control (or alleviation of harmful effect) are: establishment of periods during which speeding is prohibited; closure of certain sections of the lake to speed boats; barring of certain areas by log booms designed to break the wash as it piles inshore.

Other Problems

Some fish have escaped into the Madera Canal and a few were washed over the spillway in 1945. Such escapes are not of as much importance as if the lake supported migratory fishes, but checks on such losses are contemplated both on the Madera and on the Friant-Kern canals. Both canals may be considered as potential fishing water but such conduits afford but few resting places for fish and it is probable that fishing will be confined mainly to checks and headings where the water is quieter.

Rainbow trout fishing is reported to have improved in the San Joaquin River immediately below the dam and catfish are said to have "moved out." Trout have always been present in this area but their increase can be attributed to the somewhat colder water now being released from the dam.

The effect of the dam on salmon is well known and has been discussed in several reports appearing in California Fish and Game. The question of whether or not sufficient water will continue to be released from Friant Dam for fish life has not yet been answered satisfactorily.

Above the lake the river has been made more accessible through creation of the reservoir and the fishing intensity has increased here.

Summary of 1945 Catch Records

(1) Various observers have estimated that the 1945 catch records for Millerton Lake are from 75 to 90 per cent complete. The following figures are based solely on the recorded catch of 27,396 anglers (fisherman-days) during the five-month season May 29th to October 31st, inclusive. Even these records are subject to some error due to faults in sampling but the amount of error is not sufficient to change any of the conclusions markedly.

(2) During the five-month season these 27,396 anglers caught 162,166 sport fish. It is estimated that 129,349 (80– per cent) were bluegill, 19,638 (12+ per cent) were largemouth bass, and 12,935 (8– per cent) were green sunfish. A few smallmouth bass (0.1 per cent) and rainbow trout (0.06 per cent) were also taken as well as a few Sacramento squawfish, hardheads and suckers.

(3) Sport fish were taken at the average rate of 5.92 fish per fisherman-day throughout the season, with the weekly average rate varying from 4.51 to 9.13 fish per fisherman-day. Sunfish (both bluegill and green sunfish) were caught at an average seasonal rate of 5.19 fish per fisherman-day; the weekly average rate ranged from 3.22 to 8.95. Black bass were taken at an average seasonal rate of 0.72 bass per fisherman-day; the weekly average rate ranged from 0.13 to 2.35.

(4) The average catch of bass per unit of fishing effort was high during the first few days of the season but descended rapidly. The catch

of sunfish per fisherman-day showed two well separated peaks (at the end of June and in mid-October) and never fell far below the seasonal average.

(5) A large portion of the total seasonal catch of bass was removed very quickly: one-third of the bass caught during the season were taken during the first five days; three-quarters had been taken after eight weeks of fishing. Removal of the sunfish proceeded at a much slower rate: one-sixteenth of the sunfish caught during the season were taken during the first five days; 14 weeks elapsed before three-quarters had been taken.

(6) During the five-month season 6.2 fisherman-days were spent on each acre of the lake.

(7) During this same period the lake had a recorded yield of 36.58 sport fish per acre. (Both the fishing intensity (6) and the yield per acre are based on the maximum area which the lake attained during the 1945 season.)

Conclusions

With the erection of Friant Dam to form Millerton Lake, a considerable fishery for largemouth bass and sunfish has been established on a section of the San Joaquin River which formerly contained only a limited supply of warm-water sport fishes. The dam has cut down the spawning grounds for king salmon, however, and the future of this species is uncertain until minimum releases from the reservoir have been established.

The first year of fishing at Millerton Lake provided satisfactory fishing for largemouth bass and sunfish, and their success has answered the question of sportsmen as to whether this was a "bass lake" or a "trout lake." Fishermen in general were well pleased with the opening of the lake and their fishing, although there were complaints by some because of the abundance of small bass (close to or below legal size). Apparently most of these smaller bass were the result of the 1944 spawning season and were a prediction of a good crop in 1946 rather than an indication of a slow growth rate.

The fish caught in largest numbers (bluegill, largemouth bass and green sunfish, in this order) apparently resulted in large part from the introduction of these species in 1941 and 1942 as seed stock. However, from the standpoint of numbers alone the ratio of stocked fish to fish recorded as caught was decidedly uneven. That is, while approximately three-fifths of a largemouth bass was caught for every bass planted, there were 345 bluegill caught for each planted bluegill, and only one twenty-fifth of a green sunfish caught for each one planted. The other sport fish taken from the lake (smallmouth bass and rainbow trout) had not been planted in this area for many years.

The total yield of desirable fish in 1945 (as measured in number caught per acre) was reasonably high and compares well with the yield from other reservoirs and natural lakes containing warm-water species. The average degree of fishing success (as measured by the number of fish taken per fisherman-day) was reasonably high for all fish.

The removal of approximately one-third of the seasonal yield of largemouth bass during the first five days of the season, with a subsequent decided drop in the average catch of bass per unit of fishing effort, seems

to have been due in part to concentrated fishing for bass only during the first days, but other coincidental factors may have contributed. It is quite possible that the sudden decline in fishing success for bass at Millerton may be similar to the phenomenon observed in other waters where the fish simply refuse to bite as readily with the onset of summer. Fishermen have made such observations on many waters both in California and in other states. At Norris Reservoir, Tennessee, a decided drop in the catch after early June has been correlated with a shift in feeding habits. (With an increase in the supply of easily available forage fish, young-of-the-year, the adult game fish show a reluctance to take the lures of anglers.) If subsequent studies at Millerton Lake should show that a large percentage of the standing crop of bass is left untouched simply because the fish can not be caught readily during the summer there will be reason to consider a lengthening of the fishing season here.

Detailed plans can not yet be made for the management of the lake and will always be subject to change. Further stocking, either of additional species or of the resident species, is believed neither necessary nor desirable. Maintenance of good fishing depends far more upon the continuance of a good food supply, good conditions for natural reproduction, and freedom from undue competition by undesirable fishes. At present the number of coarse fish in the lake seems to be quite low; but the number of sunfish is very high and unless these fish are kept under control by the bass and by heavy fishing they may become detrimental to the fishery.

Recreational planners should realize that the greatest recreational use of Millerton Lake will be made by fishermen, and that the latter's pleasure should be given great consideration if conflict develops between the use of the lake by fishermen and its use by speed boaters.

The initial success of fishing should not blind us to the fact that this reservoir is still not operating under its "normal" working conditions. It has not yet reached its highest level nor has it undergone the severe annual fluctuation which may be expected shortly. Many similar reservoirs have had a short period of flourishing production followed by a decline.

Millerton Lake offers an admirable opportunity for the close study of a heavily fished warm-water reservoir subject to extreme fluctuation. No other California reservoir of this type has ever been studied intensively, and the projected plans for other lakes on Central Valley streams requires us to have a greater knowledge of their fishery problems. Sufficient observations, including an improved system of catch records, should be made on the lake and its fishery to furnish such information.

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DUCK DISEASE AT TULARE LAKE[1]

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Fig. 18. Flooded grain fields at Tulare Lake, 1938.

After the spring floods following the heavy winter of 1937-38, a great area of agricultural land in the Tulare Lake Basin was left inundated with varying amounts of water. Levees had broken one after another in front of the torrents coming down the Kings River, the Tule River, and various smaller channels. Many were broken by crews to relieve the pressure on other more important ones. The Cohn Levee, on the west side, was the only major one remaining, and at one time it was doubted that it would hold. To the north, east, and south, the water spread out over a great area of both agricultural and waste land. Access roads were closed because of flooding and the town of Corcoran was threatened. Hundreds of thousands of dollars worth of wheat, cotton, and other crops were lost as field after field was inundated.

As the water in these flooded fields began to recede, either from evaporation or from being pumped back into the lake bed proper, the water temperature began to increase in the shallower parts and decomposition of vegetable and animal matter set in. This resulted in providing an ideal medium for the development of *Clostridium botulinum*, Type C. This bacterium produces a toxin which, when ingested by birds, results in a highly fatal disease known as western duck disease.

According to a U. S. Department of Agriculture release of December 26, 1930, western duck disease "is a form of botulism, caused by the poison elaborated by a bacterium known to science as *Clostridium botulinum*, Type C. Experimental work has shown that duck sickness symptoms including all the reactions characteristic of that disease may be imparted to healthy, nonimmune birds by feeding certain body tissues of birds that had died of the sickness after these tissues had undergone a period of incubation. The product of this process of incubation is highly toxic.

The uniformity with which duck sickness symptoms may be produced through this means has not been equalled in other experimental work of the investigation.

[1] Submitted for publication, December, 1945.

Cultures of muds from infected areas, and of the tissues of birds themselves have yielded results that fully corroborate theories entertained by field workers."

Birds infected with the disease become weakened in the wing, leg and neck muscles. The inability to fly is ordinarily the first incapacitating symptom, followed by the loss of ability to walk and the swinging of the head from side to side or back and forth. The nictitating membrane of the eye and in advanced cases the eyelids fail to function and the eyes remain closed and sealed by excretions. The bird finally remains prone and breathing is slow and in gasps.

The disease has been found in most of the birds of all species feeding upon the water or muddy ground in infected areas and also in most of those species feeding on the carcasses of sick or dead birds.

We found the most effective treatment methods were the removal of the sick bird from the infected area. The digestive tract was washed out with fresh water pumped through the bird by use of a glass tube attached to a rubber bulb and inserted down the gullet into the crop. A little mineral oil was added in severe cases. The excretion on the eyes was washed off and continually treated until the use of the movable parts of the eye mechanism had been restored.

Plenty of fresh running drinking water was available at all times and those birds unable to drink were watered by hand with the glass tube and bulb. Care must be taken to get the water into the crop as the very sick birds are easily strangled by getting a drop or two into the respiratory passages.

As soon as the bird is able to walk, it begins to feed and from then until release food and grit are consumed in quantities.

Pens should be flushed out to prevent reinfection.

1938 Season

By the first of October, 1938, the duck disease epidemic in the Tulare Lake Basin had spread to include about 50 sections of land. Men were put in the field to pick up sick birds. Although there were five men on the job all of the time and 10 about one-half of the time, it was estimated that there was a loss of from 15,000 to 20,000 ducks that year. Certain sections of land had 1,000 sick or dead ducks to the square mile, but the average was about 350.

It was estimated that there were about 100,000 ducks in the region at the beginning of the hunting season on October 15th. One thousand three hundred and ninety-one sick ducks were picked up, of which 131 died and 1,260 were released after recovery. The loss after treatment was 9.4 per cent.

Record of Sick Birds Treated in 1938

Species	*Picked up*	*Loss*	*Release*
Sprig	845	72	773
Green-winged Teal	435	44	391
Spoonbill	60	12	48
Cinnamon Teal	27	2	25
Fulvous Tree Duck	20	1	19
Mallard	4	0	4
Totals	1,391	131	1,260

Great difficulty was encountered in capturing the sick birds in the boggy fields with the high temperatures encountered even as late as October. The members of the crew would be completely worn out after a day of chasing flapping sick birds through the mud and water.

The outbreak in 1938 had apparently run its course by October 28th. By that date the surface water temperature had dropped from an average high each day of 82° F. at 1 p.m. to 64° F. at the same hour. We noted little disease at surface temperatures under 70° F., and heaviest incidence where the surface temperatures ranged above 72° F.

1939 Season

Conditions in 1939 were about the same as 1938, except that the flooded area was lessened in extent. Duck disease was active from late July into the last week of October. About 45 sections of land were infected, but the degree of infection was much less than in 1938.

It was estimated that there were about 250,000 ducks in the area at the beginning of the hunting season. A total of 1,394 birds was retrieved, of which 215 died, making a total of 1,179 released. Of these, 855 were banded. The loss after first treatment was 15.4 per cent of the total birds picked up.

The worst areas were the same as in 1938, but considering the number of birds present the loss was not as high, nor were sick birds as evident to the observer in the field. All in all, it was a better year.

Record of Sick Birds Treated in 1939

Species	*Picked up*	*Loss*	*Release*	*Banded*
Sprig	689	99	590	266
Green-winged Teal	548	71	477	477
Spoonbill	85	23	62	62
Cinnamon Teal	45	12	33	33
Mallard	8	3	5	5
Ruddy Duck	11	4	7	7
American Widgeon	4	2	2	2
Gadwall	1	–	1	1
Blue-winged Teal	1	–	1	1
Eared Grebe	2	1	1	1
Totals	1,394	215	1,179	855

1940 Season

The duck disease situation in 1940 was much worse than in either of the two previous years for two obvious reasons: first, the increase in the amount of flooded land to about 70 sections; and, second, a duck population of over 600,000 birds on the first of September, the most critical period of the botulinus season that year. There were about 8,000 ducks August 7th, 600,000 September 1st, and 100,000 October 14th. The decrease during the latter part of September was due to the drying up of the fields after the irrigation was completed following harvest.

Five thousand one hundred and seventy-six birds were retrieved and treated; 1,219 died; and 3,957 recovered and were released, of which 3,211 were banded. The loss after the first treatment was 23.5 per cent.

Record of Sick Birds Treated in 1940

Species	*Picked up*	*Loss*	*Release*	*Banded*
Sprig	2,697	611	2,086	1,905
Green-winged Teal	1,526	341	1,185	829
Spoonbill	652	184	468	327
Cinnamon Teal	121	34	87	57
Mallard	78	23	55	52
Ruddy Duck	57	20	37	9
American Widgeon	17	3	14	7
Gadwall	4	--	4	4
Redhead	3	--	3	3
Fulvous Tree Duck	3	3	--	--
Mudhen	15	--	15	15
Dowitcher	2	--	2	2
Godwit	1	--	1	1
Totals	5,176	1,219	3,957	3,211

1941 Season

This year was by far the worst of any during recent times. Approximately 125 sections were infected, nearly twice the average in any of the previous years. There were probably 2,000,000 ducks in the region during the peak of the irrigation season in mid-September. We estimated a loss of 250,000 ducks.

Two crews were maintained, one working out of Hauser Camp Hospital pens at the south side of the lake and the other working out of the newly constructed Stratford pens. The crew working out of the Stratford pens assisted the other on the south and southeast sides of the area, since the north and west sides were not as heavily infected and cleared up early. The crew at Hauser consisted of five men and the one at Stratford of from three to four.

Five thousand seven hundred and eleven sick birds were retrieved, of which 799 died during treatment, and 4,912 were banded and released. The loss was 13.9 per cent after first treatment. This improvement in the recovery rate over the 1940 season was because of more manpower and better care of the birds. Hours were long and strenuous. From 6:30 to 7:30 a.m. we doctored and fed the birds in the pens. We then went to the fields after sick birds, returning at about 6 p.m., and from 6 to 9 p.m. we doctored the birds just brought in and those in the pens requiring further treatment. The men comprising the rescue crews are to be commended for their excellent work, not only during this particular year, which was by far the worst, but for the other years also. Never once did anyone complain of the hours or the miserable conditions under which the work was carried on. Their one goal was to save as many ducks as possible.

Record of Sick Birds Treated in 1941

Species	*Picked up*	*Loss*	*Banded and released*
Sprig	4,505	524	3,981
Green-winged Teal	604	139	465
Spoonbill	324	65	259
Mallard	146	31	115
Cinnamon Teal	71	17	54
Ruddy Duck	6	3	3
American Widgeon	3	3	1
Redhead	9	4	5
Fulvous Tree Duck	3	—	3
Mudhen	5	2	3
Eared Grebe	3	2	1
Stilt	14	2	12
Bittern	1	—	1
Great Blue Heron	2	—	2
Godwit	4	2	2
Western Grebe	2	—	2
Black-bellied Plover	5	3	2
Avocet	4	3	1
Totals	5,711	799	4,912

1942 Season

In 1942 the ranchers adopted a new system of irrigation. The water was not, as formerly, allowed to remain on the flooded fields for long periods of time. As soon as a field was soaked, a matter of only a few days, the small, retaining levee was broken to allow the water to run into the next lower field. This kept the water moving and did not allow time for the decomposition of vegetative matter.

The duck population was greater than during any previous year, but the birds did not remain on individual fields to feed for considerable periods of time. Instead, they followed the water's edge as it flowed from field to field and thus kept moving to new, uninfected territory. Most of the duck disease was encountered on fields which had low areas where small flocks remained to feed after the water had drained from the higher parts. Most of the fields had been leveled with land planes and few such spots remained.

The estimated duck population was:

August 6	8,000
August 7	9,000
August 14	12,000
August 22	25,000
August 30	50,000
September 5	90,000
September 10	200,000
September 15	500,000
September 20	850,000
September 25	1,500,000
September 27	2,000,000
October 4	2,500,000
October 8	3,500,000
October 15	3,000,000
October 16	2,500,000

The peak population was present at the end of the irrigation season.

A total of 461 sick birds was picked up, of which 73 died after the first treatment, leaving 388 to be banded and released. The loss was 15.6 per cent.

Record of Sick Birds Treated in 1942

Species	*Picked up*	*Loss*	*Banded and released*
Sprig	257	47	210
Green-winged Teal	108	17	91
Spoonbill	54	6	48
Mallard	34	1	33
Cinnamon Teal	5	–	5
Ruddy Duck	2	2	–
Blue-winged Teal	1	–	1
Totals	461	73	388

There were about the same number of square miles irrigated by flooding as in previous years, the same kinds of stubble, weeds, and trash on the ground, and weather conditions were comparable. It was therefore obvious to those of us who were on the ground that the decrease in the incidence of duck disease was due to the new method of irrigation.

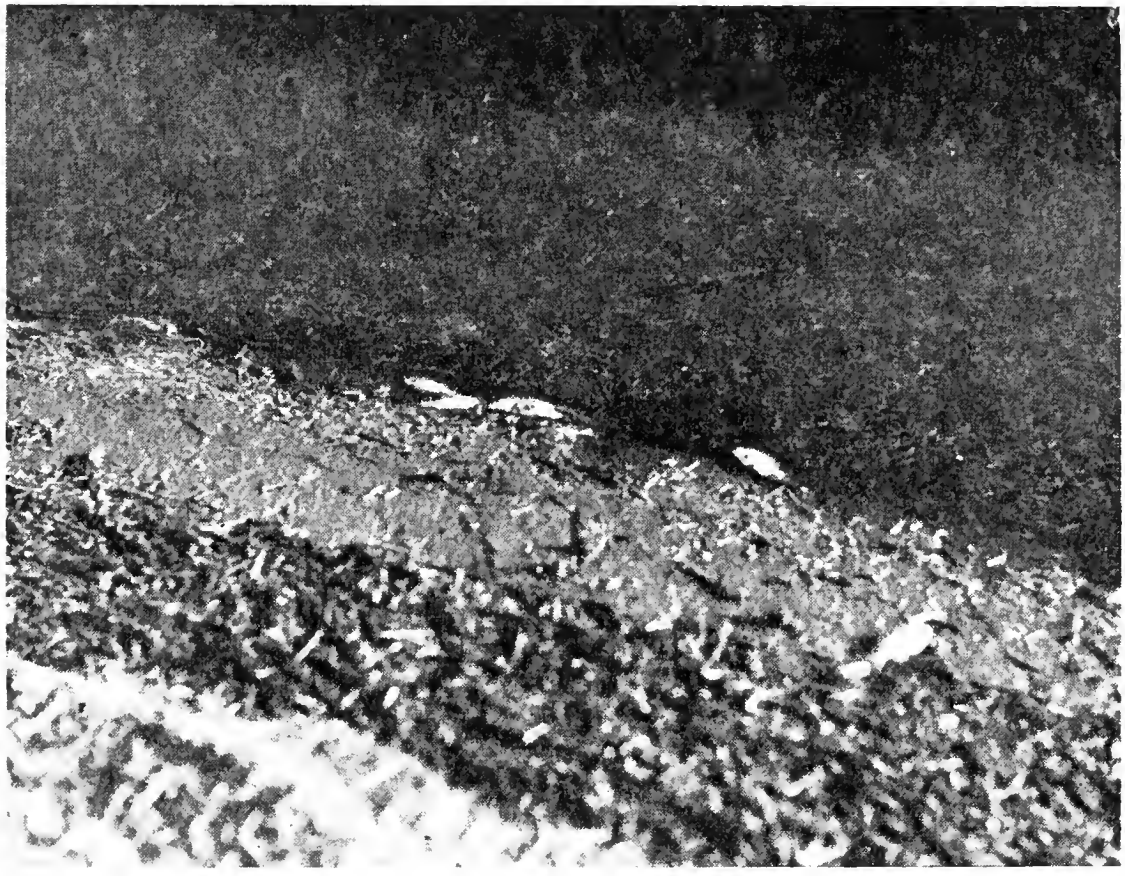

FIG. 19. Decaying vegetation and dead carp, Tulare Lake, 1940.

1943 Season

The season of 1943 was not much different from that of 1942. The new irrigation method continued to be practiced by the farmers which again resulted in holding down the loss of birds. As in 1942, most of

the losses which did occur were in the borrow pits and low spots in various fields which did not drain properly.

The duck population in the region was estimated on the following days:

August 11	15,000
August 18	20,000
August 25	75,000
September 2	100,000
September 9	250,000
September 16	650,000
September 24	2,000,000
October 2	3,000,000
October 10	4,000,000
October 15	3,500,000

A total of 576 birds was retrieved, of which 92 died after being brought in for a loss of 16.2 per cent, leaving 484 that were banded and released.

Record of Sick Birds Treated in 1943

Species	*Picked up*	*Loss*	*Banded and released*
Sprig	418	69	349
Green-winged Teal	107	10	97
Spoonbill	31	6	25
Mallard	10	2	8
Cinnamon Teal	7	3	4
Redhead	2	1	1
Ruddy Duck	1	1	
Totals	576	92	484

1944 Season

The fall of 1944 was much the same as that of 1943. The irrigation was carried on the same way. More extensive land leveling operations, with gradual sloping of the fields toward the lake bed, made for better drainage and an almost complete run-off of water from flooded fields. This left fewer low spots with standing water remaining behind to form foci of duck disease infection.

There was an almost complete lack of duck disease as far as fatalities were concerned, but a number of birds showed typical symptoms of disease, particularly on the west side of the lake in the old Goodfellow tract now operated by Hill and Howe. Few of these birds became sick enough to capture.

There were large numbers of birds in the region with estimated populations as follows:

August 8	50,000
August 15	150,000
August 20	500,000
August 25	1,100,000
August 30	1,400,000
September 14	2,750,000
September 19	2,750,000
September 24	2,750,000
September 29	3,500,000

A total of 91 sick birds was retrieved during 1944, all of which recovered. Only 10 were very sick; the others were unable to fly but were active enough to require some hard chasing to capture them. Twelve dead birds were seen on the west side of Tulare Lake during the total

period of operations and no sick or dead birds were seen on the east side at any time.

Record of Sick Birds Treated in 1944

Species	*Picked up*	*Loss*	*Banded and released*
Sprig	47	–	47
Green-winged Teal	30	–	30
Redhead	6	–	6
Mallard	4	–	4
Fulvous Tree Duck	2	–	2
Ruddy Duck	1	–	1
Cinnamon Teal	1	–	1
Totals	91		91

1945 Season

Three trips were made to the Tulare Lake area during the late summer and fall of 1945. Only two birds were noted that showed any indication of duck disease and these were not sick enough to be flightless. The same methods of irrigation were in operation.

The peak of the duck population was about the twenty-fifth of September, when there were probably 2,500,000 to 3,000,000 present in the region. On October 10th and 11th, when most of the irrigation was over, there were about 1,500,000 ducks present.

Summary

The outbreak of duck disease, caused by the toxin produced by the baccillus *Clostridium botulinum,* Type C, started in the Tulare Lake area in 1938 after the heavy run-off floods of that spring and summer. It continued each late summer and fall through the years following until 1945 when little or no disease was in evidence. The peak years were 1940 and 1941.

During the years immediately following the first flood and through 1941, the local farmers irrigated their land following the harvest by flooding the fields and withdrawing the water slowly. This resulted in extensive decomposition of vegetable and animal matter, producing a medium in which the anaerobic botulinus bacillus found ideal conditions. The water temperatures remained high since the water was either stagnant or moved very slowly. The worst spots were those where the water was less than a foot deep and nearly motionless. When fields remained in that condition for some time and were then stirred up by a wind, a heavy incidence of sick birds would show up immediately. Little new infection was noted after the surface water temperature dropped below 70° F. in the fall. Sick birds could still be found but were apparently those that had been sick for some time. Infection seemed to be most prevalent when the surface water temperatures went above 72° F. during the day.

Air temperatures as high as 120° F. were recorded in the sun and 116° F. in the shade. The maximum surface water temperature of 96° F. was recorded on several occasions on larger bodies of water, and over 100° F. in some shallow spots.

A fairly complete record was kept of the weather, water temperatures, air temperatures, wind velocities and directions during the rescue

season each year. Except as noted above, these data can not be correlated with the development of the disease.

In 1942 the methods of irrigation were changed. Water, instead of being allowed to remain on a field, was drained off as soon as the land was soaked by breaking the levee to the next lower field. This kept the water in motion and did not give stubble and other vegetation an opportunity to decay. Also, the continued land leveling operations filled in various low spots where water formerly remained to cause trouble. Water now is pumped out of the lake bed to the highest part of each farm and is pumped back into the lake at the lowest end after progressively passing through one field after another. This movement also keeps water temperatures down. It is the writer's opinion that this improved water manipulation has had more to do with the reduction of duck disease in the Tulare Lake Basin than any other factor or group of factors.

In the case of future floods during which levees will be broken and lands flooded for long periods, we can expect additional duck disease outbreaks, but as long as the present system of irrigation and water control is practiced, the situation will probably remain pretty well in hand.

TABLE 1

Summary of Operations at Tulare Lake From 1938 to 1944 on all Birds Retrieved

(Including 60 of species other than ducks)

Year	Pick up	Loss	Release	Banded	Per cent loss
1938	1,391	131	1,260		9.4
1939	1,394	215	1,179	855	15.4
1940	5,176	1,219	3,957	3,211	23.5
1941	5,711	799	4,912	4,912	13.9
1942	461	73	388	388	15.6
1943	576	92	484	484	16.2
1944	91		91	91	
Totals	14,800	2,529	12,271	9,941	17.07

TABLE 2

Summary of Sick Duck Pick Up in Tulare Lake Area

Species	1938	1939	1940	1941	1942	1943	1944	Total ducks picked up
Sprig or Pintail	845	689	2,697	4,505	257	418	47	9,458
Green-winged Teal	435	548	1,526	604	108	107	30	3,358
Spoonbill	60	85	652	324	54	31		1,206
Mallard	4	8	78	146	34	10	4	284
Cinnamon Teal	27	45	121	71	5	7	1	277
Ruddy Duck		11	57	6	2	1	1	78
Fulvous Tree Duck	20		3	3			2	28
American Widgeon		4	17	3				24
Redhead			3	9		2	6	20
Gadwall		1	4					5
Blue-winged Teal		1			1			2
Totals	1,391	1,392	5,158	5,671	461	576	91	14,740

TABLE 3

Summary of Duck Loss in Tulare Lake Area After Pick Up

Species	1938	1939	1940	1941	1942	1943	1944	Total ducks lost
Sprig or Pintail	72	99	611	524	47	69		1,422
Green-winged Teal	44	71	341	139	17	10		622
Spoonbill	12	23	184	65	6	6		296
Cinnamon Teal	2	12	34	17		3		68
Mallard		3	23	31	1	2		60
Ruddy Duck		4	20	3	2	1		30
American Widgeon		2	3	2				7
Redhead				4		1		5
Fulvous Tree Duck	1		3					4
Gadwall								
Blue-winged Teal								
Totals	131	214	1,219	785	73	92		2,514

Percentage of loss in ducks, 17.05 per cent.

TABLE 4

Summary of Duck Release in Tulare Lake Area After Hospitalization

Species	1938	1939	1940	1941	1942	1943	1944	Total ducks released
Sprig or Pintail	733	590	2,086	3,981	210	349	47	7,996
Green-winged Teal	391	477	1,185	465	91	97	30	2,736
Spoonbill	48	62	468	259	48	25	6	916
Mallard	4	5	55	115	33	8	4	224
Cinnamon Teal	25	33	87	54	5	4	1	209
Ruddy Duck		7	37	3			1	48
Fulvous Tree Duck	19			3			2	24
American Widgeon		2	14	1				17
Redhead			3	5		1		9
Gadwall		1	4					5
Blue-winged Teal		1			1			2
Totals	1,220	1,178	3,939	4,886	388	484	91	12,186

TABLE 5

Summary of Operations at Tulare Lake on Species Other than Ducks From 1938 to 1944*

Year	Pick up	Loss	Release	Banded	Per cent loss
1939	2	1	1	1	50
1940	18		18	18	
1941	40	14	26	26	35
Totals	60	15	45	45	25

* Of these 60 birds, 20 were mudhens and 14 were stilts. Black-bellied plover, eared grebe, and a few other species occurred in small numbers.

WANDERING OF PINK SALMON AND OTHER SALMONID FISHES INTO SOUTHERN CALIFORNIA[1]

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A pink or humpback salmon, *Oncorhynchus gorbuscha* (Walbaum), was speared in the ocean at La Jolla, California, on September 30, 1945, by Ramiro Cómas, one of the group of expert boy divers who call themselves the "Manta Rays." Through his goggles he saw the large silvery fish, of a kind unknown to him, as it swam slowly and alone about a foot above the plant-covered rocky bottom and about seven feet below the surfaec, off Goldfish Point at the west end of the famous La Jolla Caves. Diving down, he impaled the rare prize with his spear. At the suggestion of Curtis Zahn, outdoor writer who happened to be at the scene, Ramiro brought his catch to the Scripps Institution of Oceanography and kindly presented it for preservation as a specimen (S. I. O. No. 1453).

Various characters proved the oddity to be a pink salmon. The caudal fin was prominently marked with the large oblong dark spots that are diagnostic of the species. There was a light tip on the anal fin, which had a base decidedly longer than the longest of the 13 principal anal rays. The branchiostegals numbered 13 on each side; the gill-rakers, $13 + 17 = 30$ on the left side and $13 + 20 = 33$ on the right. The scales were very small, numbering 198 on the left side and 204 on the right, in about the second row above the lateral line.

The specimen was a rather small adult female 450 mm. in standard length. Its body cavity was filled with mature eggs about 7 mm. in diameter. The jaws were slightly hooked and the canine teeth near the tip of the mandible were considerably enlarged. The scales lacked a central nucleus, of close-set circuli, that would have indicated a period of stream growth. This observation is in line with expectation, for this species passes downstream to the sea early in its first year of life and does not form a stream-growth nucleus on the scales (Gilbert, 1913, p. 21, pl. 10, fig. 17 and pl. 17, fig. 29; and subsequent studies by others). The single definite winter ring showed that the fish was completing its second year of growth and hence was approaching the age at which, as a characteristic life-history feature, this species invariably spawns, insofar as is known from the extensive studies by Gilbert and subsequent investigators. The one annulus is located nearly halfway out on the scales. Not far beyond there is another mark that is interpreted as an accessory annulus rather than as another winter mark, because it lies so close to the true annulus and is often weak or barely evident on some fields of the scale. From the focus to the accessory line the ridges are rather closely spaced, but beyond this mark they are stronger and more widely separated. About midway in this outer area of the scale an accessory

[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 278. Submitted for publication, December, 1945.

cheek appears on some of the scales, but its failure to completely encircle any of the scales examined, its indefinite appearance as well as inconsistency and its failure to involve more than three circuli indicate rather definitely that it is not a winter mark. This is the opinion of A. L. Pritchard, of the Pacific Biological Station at Nanaimo, British Columbia. Scales from marked salmon of known age, sent for comparison by Pritchard, are remarkably similar to those of the La Jolla specimen in all items described above. Leo Shapovalov, of the California Division of Fish and Game, who has also checked the determination, remarks that the scales of one specimen "show some spawning absorption or erosion along the outer margin." The scale characters confirm the species identification.

Within the history of the salmon fishery *Oncorhynchus gorbuscha* has apparently never been a common fish anywhere in California. Even in the years when salmon catches in the Sacramento River were large, it is reported that this species was so rare as to be dubbed "the lost salmon." Taft (1938) reported that prior to 1937 the last known capture of the species within the state was in Mill Creek, a Sacramento River tributary, in 1933. In 1937, however, he found evidence of a run into several coastal streams of northern California. Scofield (1916) mentioned specimens from San Lorenzo River, Santa Cruz County, as constituting a southward extension of known range. It is probable that the species occurs farther south chiefly or entirely as a migrant in the sea, for the two or three known occurrences in southern California are marine. Leo Shapovalov tells me that in Asiatic waters also the species wanders in the sea far south of its breeding streams, according to Pravdin (1940). The only previous definite locality record for southern California is for an adult that was caught off Santa Monica on September 12, 1927 (Walford, 1928). Later Walford (1937, p. 160) stated that the habitat of the species extends northward "from the coast of southern California off Catalina Island," but gave no definite basis for the establishment of this southern limit (which is now extended).

It is quite possible that pink salmon wander southward as far as San Diego County more frequently than the lone record would suggest. Fish thought to be salmon but not checked for species identification are caught from time to time in salt water near San Diego. Curtis Zahn estimates that in recent years he has heard of a dozen such catches in Mission Bay and in the sea between Pt. Loma and Los Coronados Islands. In the spring of 1945 a member of the exclusive "Bottom Scratchers Club" speared a "salmon" off the Beach Club not far from where the pink salmon was taken later in the year. This fish, as described to me by Jack Prodanovich, was certainly a salmonid, but it was not examined to determine which species of *Oncorhynchus* it represented, or whether it might have been a steelhead trout. Some of the other locally caught "salmon" may also have been *Salmo gairdnerii,* but some were probably pink, king or silver salmon.

The king salmon, *Oncorhynchus tshawytscha* [2] (Walbaum) has also been recorded from southern California. Jordan and Gilbert (1881 : 39) gave its range as extending northward from Ventura River, I believe on the basis of an observation by Evermann. Subsequent authors

[2] I follow the original spelling of the specific name as given by Walbaum (1792 :71).

repeated this statement of southern limit. Croker (1930) reported one that was caught near San Pedro and later (1936) stated that "nearly every summer a few are caught by commercial net fishermen in the neighborhood of San Pedro" and gave records for specimens of this species that were caught by anglers in Santa Monica Bay, off San Clemente in Orange County, and from the Scripps Pier near La Jolla. Anita E. Daugherty (MS) of the California State Fisheries Laboratory will supply one other record, for an 18-pounder that was caught in San Pedro Harbor in a net, by the fishing boat "President."

There appear to be no published records of the dog or chum salmon, *Oncorhynchus keta* (Walbaum), or of the silver salmon, *Oncorhynchus kisutch* (Walbaum), from southern California. A specimen of the silver salmon, however, was reported by Scofield (1937) as having been taken near Los Coronados Islands, in Baja California just south of the international border. Furthermore, a fish that was caught from the bridge near the mouth of Mission Bay just before the war was identified as a silver salmon by Tom Smith and E. H. Glidden, wardens of the Division of Fish and Game.

Steelhead trout (*Salmo gairdneri*, subspecies) must occur in some numbers along the coast of southern California. The Division of Fish and Game reports large and consistent runs into Ventura and Santa Clara rivers, and Division employees have recorded runs into several streams of Orange and San Diego counties. Carl I. Johnson and other anglers, as well as E. H. Glidden, local warden, tell of steelhead catches in the estuary of San Juan Creek in Orange County and of consistent runs into San Mateo and San Onofre creeks in San Diego County. Alan C. Taft reports that rescue operations for young steelheads are carried out in San Mateo Creek and that an effort is made to keep the run in this stream under annual surveillance. Mr. Glidden states that trout weighing up to about 20 pounds run far up the San Mateo, and that he has personally observed the runs in San Mateo and San Onofre creeks for 20 years. He knows of steelheads having been caught in San Diego River and about 1927 saw two that were taken in the lower flowing part of Tijuana River, on the California side of the international border. Local anglers have reported catching fish, thought to be steelhead trout, in San Luis Rey River, in the estuary of San Dieguito River, and in Mission Bay and connected waters, such as the slough near the Cudahy packing house.

There appear to be few records for the capture of steelheads in coastal waters of southern California, though its occurrence there must be inferred. An immature female specimen 211 mm. in standard length was caught by S. Carmen with smelt and kingfish in the Los Angeles Harbor area on March 16, 1938. It was thought by J. F. Janssen, who made the entry in the files of the State Fisheries Laboratory, that this fish had been washed down to sea during the preceding torrential rain.

Salmo gairdnerii was no doubt a native species in southern California. A specimen was collected in Ojai Creek, Ventura County, in 1875 (Jordan and Henshaw, 1878, pp. 195 and 200). Records were given by Smith (1880) for "fresh water streams at Pala, and near Smith's Mountain, San Diego county." Eigenmann (1892, p. 142) wrote that "it is abundant in the streams rising in Smith Mountain and emptying into the San Luis Rey River." A specimen from Pala which I examined

about 1915 in the collection of the San Diego Society of Natural History was deep-bodied and unusually coarse-scaled and may have represented a slightly differentiated fresh-water race. In all probability any native trout in the region, whether land-locked or sea-run, has long since been supplanted by or mixed with introduced stock.

It is not known to what extent the present occurrence of steelheads in southern California coastal waters is due to the stocking of trout in the streams of this region rather than to a southward wandering from central California. Nor is it known, or predictable with assurance, whether the southernmost vagrants are capable of establishing regular trout runs south of San Mateo and San Onofre creeks. Perhaps other stream conditions and ocean conditions would permit the establishment of such runs near the Mexican border, if the flow of the streams could be stabilized. Possibly small runs of salmon would also eventuate, although Monterey Bay is regarded by Davidson and Hutchinson (1938) as the natural southern limit of common occurrence for the Pacific salmons as a group. It will be noted by examining the data of those authors (p. 167, fig. 2), however, that if the salmons extended into as warm water in the eastern Pacific as they do in eastern Asia, they would range down to the middle of Baja California.

Southward wandering steelheads may occasionally migrate into the streams along the northern part of the outer coast of Baja California, though no such runs seem to have been definitely recorded. Leo Shapovalov states (in letter) that he has received reports of "trout" from various places in Lower California (but it should be remembered that the name "trucha" or "trout" is also applied to other fishes, including the mountain mullets, *Agonostomus*. The establishment of rainbow trout in tributaries of Río Santo Domingo (Eigenmann, 1892, p. 142; Evermann, 1908; Snyder, 1926; Needham, 1938) may well have resulted from such southern vagrancy, at some relatively recent time. Since steelheads occur in the ocean as far south as Tijuana River there is no reason to doubt that they may range considerably farther. During at least some years the waters close inshore along the northern part of the outer coast of the peninsula may be very cool locally, even during August and September (McEwen, 1916, p. 260, pl. 9). That these coastwise waters are ordinarily relatively cool is further suggested by recent studies, respectively by E. Yale Dawson and the present writer. These investigations indicate that the algae, the fishes, and at least some of the invertebrates of the intertidal reefs of northern Baja California are of an even more northern assortment than are the corresponding types of the San Diego region. We may expect therefore that trout (and salmon) wander at least occasionally a considerable distance down the coast of Baja California, from which in times of high water in the winter they may occasionally run into the intermittent streams as far south as the San Antonio, as trout do in San Diego County, California. It may be objected that the Baja California trout has been regarded as a distinct species, *Salmo nelsoni* Evermann, and is therefore probably of ancient origin. Shapovalov (1941, p. 443), however, regarded it as "a good possibility" that *Salmo nelsoni* will eventually be regarded as a subspecies or even as a synonym of *S. gairdnerii*. I find nothing in the published accounts of *S. nelsoni* to justify its separation even as a subspecies from the coarse-scaled rainbow trout (*S. gairdnerii irideus*) of coastal streams in California. Nor do speci-

mens of the Baja California trout recently collected by Carl I. Johnson appear distinctive. There is therefore neither systematic nor oceanographical evidence to confirm the belief that the stock of trout in the Río Santa Domingo system in the San Pedro Mártir Mountains was originally landlocked at a very remote, perhaps Glacial period. Possibly it still runs to and from the sea. Whether this stock has the expected fish-cultural values—nonmigratory habits and resistance to warm water—remains to be thoroughly tested.

Acknowledgments

Appreciation is expressed to Ramiro Cómas, Curtis Zahn and Carl I. Johnson for specimens and information and to W. I. Follett for many literature references. Leo Shapovalov of the California Division of Fish and Game has been most helpful with criticisms. Other employees of the Division, including Frances N. Clark, Anita E. Daugherty, A. C. Taft and E. H. Glidden, have contributed comments or additions to the manuscript. Dr. A. L. Pritchard of the Pacific Biological Station at Nanaimo, British Columbia, has also offered useful suggestions.

Summary

A mature female pink salmon caught at La Jolla in September provides a southern extention of the known range. The species probably ranges in the sea south of the streams in which it spawns. King salmon also straggle southward to San Diego County. A silver salmon has been reported from Los Coronados Islands. Steelhead trout must occur in numbers along the southern California coast, as there are regular migrations into some of the streams and a few individuals run up rivers as far south as the San Diego and the Tijuana. These salmonid fishes probably straggle a considerable distance southward into the cool waters of the northern part of the outer coast of Baja California. Such wanderers may have given rise in relatively recent times to the stock of trout that inhabits the San Domingo river system. There is no warrant for the specific separation and probably no good reason for the subspecific recognition of *Salmo nelsoni,* the trout of that Baja California stream.

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A PROGRESS REPORT ON BEAVER MANAGEMENT IN CALIFORNIA[1]

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Introduction

Those who have been acquainted with beavers in California during the last decade find it difficult to realize that in their present numbers they are only a remnant of a once great population that played an extremely important role in the early exploration and development of this State.

The purpose of this paper is to review briefly the history and present status of beavers in California and to discuss the steps that are being taken to develop a plan of management for the five kinds of beaver now to be found in the State (see Fig. 20). There are the three native beavers, the Shasta beaver (*Castor canadensis shastensis* Taylor), the golden beaver (*Castor canadensis subauratus* Taylor), and the Sonora beaver (*Castor canadensis repentinus* Goldman), and two nonnative races, one from Idaho (*Castor canadensis taylori* Davis), and another from Oregon (probably *Castor canadensis pacificus* Rhoades). The latter have been introduced into the State during recent years by the U. S. Forest Service and the Division of Fish and Game.

For much of the material pertaining to the history, distribution, and present status of beavers in California, the writer has drawn heavily on a report recently published by the Museum of Vertebrate Zoology of the University of California and the Division of Fish and Game in cooperation with Federal Aid in Wildlife Restoration Project California 2-R (Tappe, Donald T., The status of beavers in California. Game Bulletin No. 3, State of California, Division of Fish and Game, pp. 1-59, 26 figs. 1942).

The author wishes to express his sincere appreciation to Howard Twining and Donald T. Tappe, co-workers with him in beaver management, who would have collaborated with him in the preparation of this paper were they not in the armed forces. Thanks are also due to the many other employees of the Division of Fish and Game, particularly those members of the Bureaus of Game Conservation and Patrol who have suggested planting sites and assisted in trapping and transporting beaver, and to Gordon H. True, Jr., of the Bureau of Game Conservation who assisted in the preparation of this report.

History of Beavers in California

The exploitation of California beaver, which began early in the nineteenth century, was at first limited to sporadic trapping expeditions on the part of individual groups of "mountain men," but soon this new source of beaver skins attracted the attention of the large trading com-

[1] Submitted for publication, January, 1946.

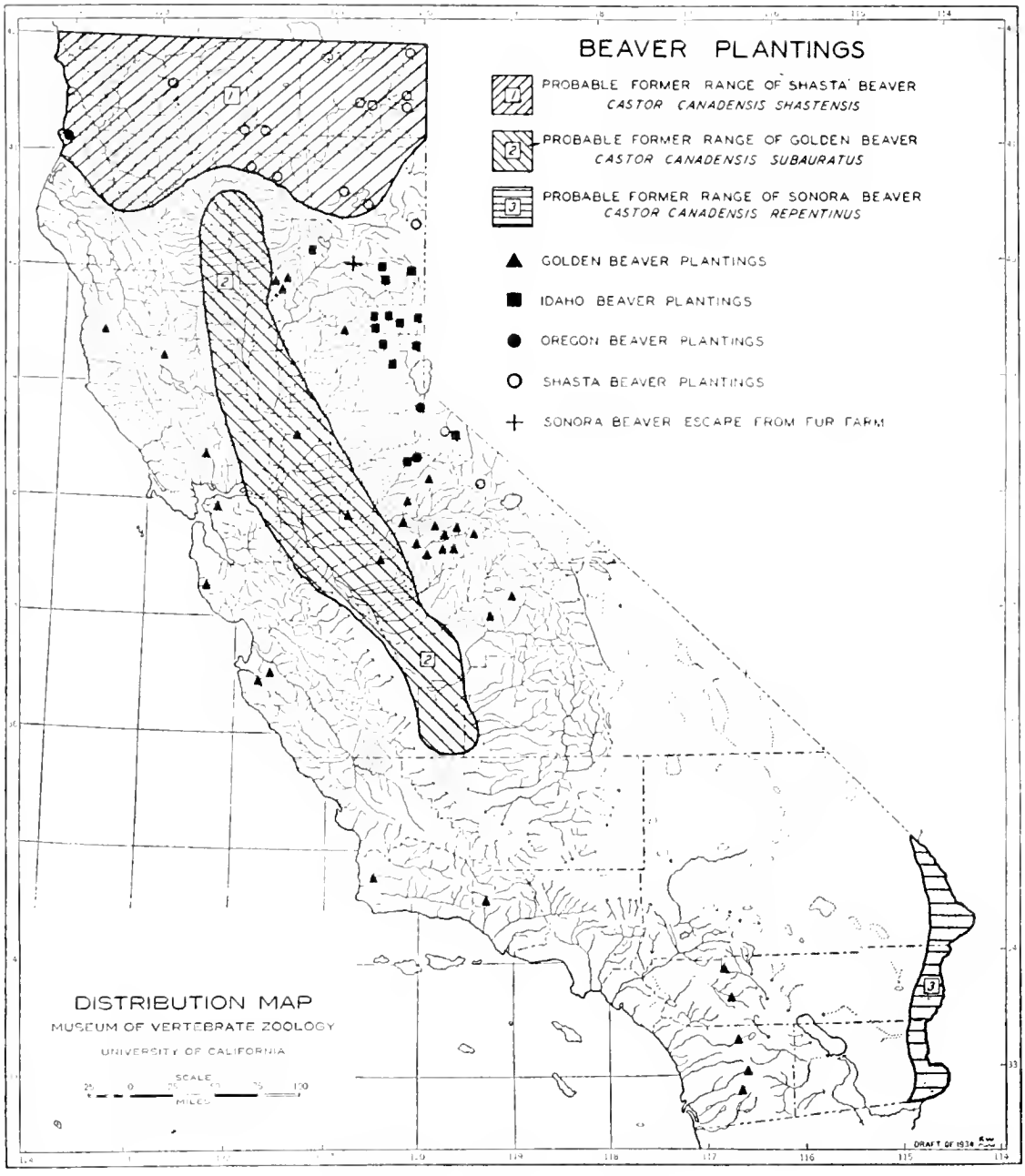

FIG. 20. Distribution map of beaver plantings in California.

panies, particularly the Hudson's Bay Company. These companies sent into California well-organized "fur brigades" that systematically trapped the available beaver territory until about the middle of the century when it became no longer profitable.

James Ohio Pattie, who, with a party of seven, trapped the Colorado River in 1827, was probably the first to enter what is now California in search of beavers. A year later, in 1828, Jedediah Smith entered the Great Valley and traversed its length as far as the present site of Red Bluff, taking beavers on the American and Feather Rivers and on Butte Creek. He also found them in goodly numbers along the Sacramento River in the vicinity of Stony Creek, Deer Creek, and Toomes Creek. Smith also visited the Trinity and Klamath Rivers finding beaver signs near what was apparently the mouth of the latter.

The Hudson's Bay Company first sent an organized "fur brigade" into California in 1828. This group of trappers, under the leadership of

Peter Skene Ogden, trapped in the Great Valley during the winter of 1828-29 and returned to the Hudson's Bay Company headquarters at Fort Vancouver with a fine collection of pelts. Ogden also visited the upper Klamath and Sastise (Shasta) Rivers, and, according to his journal, apparently found beavers in both streams.

In 1832, another Hudson's Bay Company "brigade," under the leadership of John Work, was sent to California (Maloney, Alice Bay, Fur brigade to the Bonaventura. Special Publication No. 19, California Historical Society, pp. 1-112, 5 ill., Westgate Press, Oakland, 1945). The party crossed the present northern boundary of the State near Goose Lake and followed the Pit River to its junction with Hat Creek, taking a number of beavers along the way. The route then followed Hat Creek eastward for a short distance, crossed the Cascades between Burney Mountain and Stony Butte, and entered the valley of the Sacramento by way of Cow Creek. Work's party trapped the Great Valley as far south as the mouth of the Stanislaus and explored the San Francisco Bay region and the north coast from Fort Ross to Tenmile River.

It is interesting to note that Work reports a total absence of beaver in north coast streams such as the Gualala and Tenmile, in spite of the fact that they appeared well adapted for them (Maloney, 1945, pp. 45-50). Although Work visited the north coast during the rainy season, he advanced the theory that the absence of beavers might be due to the fact that the coastal streams "take their water not far off in the first range of Mountains and that there is [probably] little or no water in them during the dry season" (Maloney, 1945, p. 47). We are faced with precisely this same situation today in attempting to establish beavers in that part of the State.

After this unsuccessful visit to the north coast, Work's party returned to the valley and traveled south into the lower end of the San Joaquin. In the delta region, Work's trappers found the beavers shy and difficult to trap due to the effect of the tides. These same difficulties are met by trappers today.

Work's journal states that another Hudson's Bay Company party, under the leadership of Michel Laframboise, was trapping beavers in California during the winter of 1832-33 and that at least one party of Americans was also encountered. It is very evident that, even at that early date, the beaver population was showing evidence of depletion.

The power of the Hudson's Bay Company began to wane about 1839 when General Sutter, who was also interested in the fur trade, induced the government to impose an export tax on beaver pelts. This act, coupled with the fact that beaver were becoming scarce, made trapping so unprofitable that by 1845-46 the Hudson's Bay Company had ceased trapping operations in California.

During the last half of the nineteenth century individual trappers continued to take beavers in California with varying degrees of success. Unrestricted exploitation continued until 1911, when beavers were first afforded protection.

History of Beaver Legislation

Legislation pertaining to beavers was enacted for the first time in California in 1911 when, realizing that the beaver population was facing certain extermination, the State Legislature enacted a law providing com-

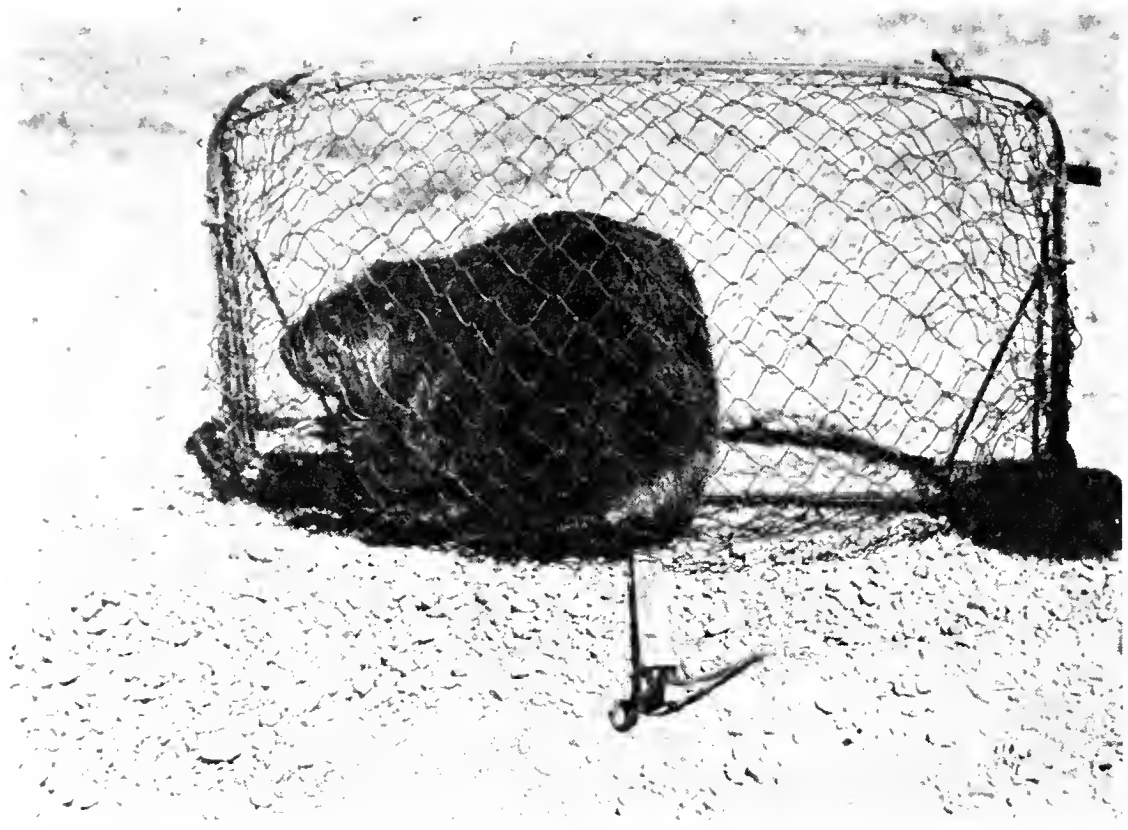

FIG. 21. Bailey live trap with captive Shasta beaver. August 28, 1940.

plete protection. This law remained unchanged until 1917, by which time beavers, particularly in the delta region, had increased in numbers to a point where they were becoming a menace to reclamation works. The law was then amended to provide for the trapping of nuisance beavers under permit from the Fish and Game Commission in cases where the safety of levees and other reclamation works was being threatened. This law was still further liberalized in 1925, when it was amended to permit the trapping of beavers and the possession of pelts in Fish and Game Districts One, Two, and Three.

Due to the fact that in 1925 beavers were not legally defined as fur bearers, the legislation enacted in that year had the effect of making it possible to trap them in the districts involved at any time of the year. It was not until two years later that this mistake was corrected. Meanwhile, wholesale trapping brought about rapid reduction of the beaver population and by 1933 the situation had become so alarming that beavers were again placed on the protected list, with the added provision that nuisance beavers could be taken under permit where satisfactory evidence of damage, actual or threatened, was presented.

Under protection, the beaver population curve once more began to climb until, by 1939, owners and operators of reclaimed delta lands were clamoring for relief again. In response to their demands, the 1939 Legislature added a new provision to the beaver laws requiring the Fish and Game Commission to establish beaver control in areas where it could be demonstrated that beavers were damaging or threatening to damage or destroy lands, crops, levees, or other irrigation structures. The commission was required to define the boundaries of such areas and to promul-

gate the rules and regulations under which the nuisance beaver could be taken. There has been no change in the laws pertaining to beavers since 1939.

Beaver Investigations

In 1940, the Museum of Vertebrate Zoology of the University of California and the Division of Fish and Game, in cooperation with Federal Aid in Wildlife Restoration Project California 2-R, began a survey to determine the status of beavers in California. The main objectives of this study were: To determine the numbers of beavers in California and the location of existing colonies of both native and introduced varieties; to ascertain the habitat requirements of beavers in California; to learn as much as possible of their economic status; and to obtain information that might provide a basis for a beaver management plan.

The report published upon completion of this survey (Tappe, 1942) indicated that there were probably no more than 1300 beavers in the State at that time, the Shasta beavers and golden beavers, in particular, occupying only a small fraction of their original ranges. The report stated that in spite of the fact that California beavers can not be reestablished throughout much of their former range because of the inevitable conflict with agriculture, there still exist many opportunities for beaver range extension without interfering with the interests of the farmer.

Following the publication of this report, it was considered advisable to begin immediately an experimental beaver transplanting program aimed not only at the restoration of beavers in portions of their former range, but the extension of beaver range into suitable areas not previously occupied. Federal Aid in Wildlife Restoration Project California 5-R, "A Survey of the Fur Resources of the State of California," a project which up to that time had been devoted to the investigation of fur bearers other than beaver, was consequently amended in 1941 to provide among other things for a survey of the State to determine the location of suitable sites for beaver colonies, and for a limited amount of experimental transplanting. One of the principal objectives of this study was to explore the possibility of successfully transplanting golden beavers from their native range on the valley floor to coastal streams and to those draining the Pacific slope of the Sierra-Nevada. Another objective was to continue the investigation of the status of the Sonora beaver along the Colorado River and in adjacent irrigated areas.

The results of the transplanting experiments were so satisfactory that, in 1945, it was decided to go one step further and initiate a large scale beaver transplanting program.

Beaver Transplanting

Prior to entering into a general discussion of the beaver transplanting program that has been carried on by the Division of Fish and Game with Federal Aid funds since 1941, mention should be made of the beavers that were planted by both the U. S. Forest Service and the Division of Fish and Game between 1934 and date of inception of the present program (see Table 1).

In 1934, the U. S. Forest Service made two plantings of Idaho beavers, one in Plumas and another in Tuolumne County. In 1938 they

FIG. 22. Bailey live trap being set in place.

FIG. 23. Beaver transplanting equipment. The trailer formerly in use is in left foreground, shipping boxes in the background, and the holding pen in the right foreground. September 25, 1941.

planted two pairs of Oregon beavers in El Dorado County and two in Tuolumne County. The Plumas County plant was particularly successful and has since served as a valuable source of stock for transplanting elsewhere on the Plumas, Tahoe, and Mono National Forests. Also, migrants from this same colony have established other colonies in the immediate vicinity without the assistance of the transplanting crew. In addition to introducing nonnative beavers from Idaho, the Forest Service made several plants of native Shasta beavers in Modoc and Siskiyou Counties (Table 1).

All of the golden beavers that were transplanted between 1938 and 1941 were nuisance beavers taken from the Sacramento and San Joaquin Valley regions and planted in coastal streams at low elevations.

When the experimental transplanting program under Project 5-R was first contemplated, the project staff corresponded with the game departments of other western States that have had experience in beaver management for the purpose of securing information on methods of live trapping and kinds of equipment used in transplanting beavers. These were tested and the ones that were found to be geared to California requirements were finally adopted (see below) for use by the present beaver transplanting project, Federal Aid in Wildlife Restoration Project California 18-D.

Experimentation with various types of automotive equipment has finally demonstrated that a three-quarter ton stake-side truck with a four-speed transmission is the best for transporting beaver trapping and transplanting equipment over the steep, rough roads that must necessarily be traversed in this work. Power, load capacity, and high clearance combine to make it the ideal vehicle, far superior to the cumbersome trailer formerly in use (Fig. 23).

In trapping beavers it is essential that a live trap be employed. During early trapping operations in the delta region, steel traps were used and it is estimated that at least 75 per cent of the animals taken by that method perished after transplanting. Since the live trap has been standard equipment, losses have been negligible.

The Bailey live trap (Figs. 21 and 22) now in use is sturdily constructed and may be depended on to operate with a minimum of failures. It is light in weight, about 35 pounds, and is consequently easy to handle and transport. It is constructed so as to be adapted to a wide variety of sets, being far more versatile in this respect than the ordinary steel trap. If the live trap is set carefully and visited frequently, at least once in the morning and again before dark each day, there will be practically no trapping fatalities.

The removal of the beaver from the live trap must be done with care in order to prevent injury to the animal, the trapper, or both. To facilitate this operation the California beaver trapping crew makes use of a contrivance consisting of a circular piece of ½″ galvanized pipe, 12″ in diameter, fitted with a 4′ wooden handle. Spaced at regular intervals around the inner circumference of the pipe are four hooks from which an ordinary 100-pound burlap bag is suspended to form a net. When removing a beaver from a trap the net is placed directly opposite the opening of the upended trap with the sack extended. The trap is then opened slowly and the beaver will usually crawl directly into the dark-

ened tunnel formed by the sack. It is then an easy matter to pick the animal up and transfer it from the sack to the shipping box. The alternative method, that of picking the beaver up by the tail and holding the wriggling animal at arm's length, is a hazardous one and not to be recommended.

The shipping box (Fig. 23), 24″ x 44″ x 24″ in size, is made of 20-gauge galvanized sheet iron braced around the top with 1″ x ⅛″ angle iron. Additional support is provided by 1″ x 4″ wooden pieces bolted to the sides and 2″ x 4″ pieces on the bottom of the box as shown in the illustration. The box is fitted with a divided lid of hardware cloth stretched on iron frames. Adequate ventilation and drainage apertures are provided in the sides and bottom. Each box will accommodate from four to six adult beavers or from eight to twelve kits. In transit, the bottom of the box is cushioned with a layer of damp leaves, hay, or burlap, which serves not only to absorb road shock but to keep the tails and feet of the beaver moist, an essential to their survival. When the trapping crew is moving camp and the boxes are empty of beaver, each box will hold six Bailey live traps nested together.

A portable holding pen (Fig. 23) is used to contain beavers during the short interval that frequently intervenes between trapping and transplanting operations. This pen is 4′ x 6′ x 44″ in size. It is made of 20-gauge galvanized sheet iron braced with 1″ x ⅛″ angle iron and so constructed that it may be taken apart for shipment. It has no top or bottom. When in use it is placed on a piece of chicken wire slightly larger than the pen. This effectively prevents the beavers from digging out. A heavy tarpaulin is placed over the top of the pen for shelter

FIG. 24. A pack train taking beavers into the high country. Alpine County, 1943.

against light and cold. A water pan, 18″ x 36″ x 8″, holding approximately 30 gallons of water, is placed in the pen when it is in use.

Beavers held in the pens are supplied with the same foods that they were eating under natural conditions, and the diet is supplemented by a few cut carrots and apples which tend to prevent the often severe constipation caused by the lack of normal exercise. The water in the pan is changed at least twice daily. Under these conditions beavers can be held safely for several days.

Before beavers are placed in the holding pen they are weighed and the sex determined. The two sexes are marked for later identification with colored string or by clipping the fur at the base of the tail. It is considered that a well-balanced plant of beavers should consist of not less than two pairs. An attempt is made to liberate beavers of uniform size and they must, of course, be in first-class physical condition.

After beavers have been selected for planting, they are lifted from the holding pen with the net and transferred to shipping boxes for transportation to the planting site. However, where access to the planting site can not be gained by truck it is necessary to transfer the animals again, this time to individual carrying cages. The carrying cage is 12″ x 12″ x 18″ in size, made of sturdy wire mesh, fitted with a hinged door at one end, and equipped with a convenient handle. It is light and can either be carried like a suitcase, or when pack horses are used, can be placed in a pack bag or box (Fig. 24).

Upon arrival at the planting site and just prior to liberation, each beaver is tagged for future identification. The tag is a small metal disk which is attached to the right ear. Each tag bears a serial number and the legend "Notify Cal. D. F. and G." The actual planting operation is simple since the beavers are merely released from confinement at the selected site. They usually enter the water immediately and are quickly lost from sight.

Beavers establish themselves at the selected site, or at least close to it, frequently enough so that the investigator can justifiably feel that he has made a reasonably accurate estimate of their requirements. In numerous instances, however, the animals completely ignore the opinions of others and sometimes travel long distances to establish themselves at other sites that for some unknown reason are better suited to their requirements. It is essential that the history of each planting be studied carefully and that the data obtained from these records be applied so that the ratio of successful to unsuccessful colonies may be increased as the beaver transplanting work progresses.

Management Problems

The management of beavers in California involves the problem of development on the one hand and that of control on the other.

The object of the development program is to extend the range of California beavers in nonagricultural areas throughout the State, not only for the purpose of producing a valuable fur crop, but with the hope that full advantage may be taken of the water storage, erosion control, and aesthetic values that may be derived from the presence of properly located beaver colonies. Certain existing colonies have already clearly demonstrated these values, and land management agencies such as the

FIG. 25. End view of beaver dam showing portion of pond. This picture was taken at a time of year when the flow of the stream would normally be reduced to a mere trickle. Plumas County, August, 1944.

U. S. Forest Service and U. S. Soil Conservation Service are actively interested in the transplanting program—to the point at which we are as yet unable to furnish enough breeding stock to supply present demands.

There are other colonies, however, that due to habitat deficiencies may seriously deplete their food supplies if they are not brought under control. Beaver, unlike many other kinds of wild animals, are easily controlled and colonies that get out of hand may either be removed or reduced to the population level at which they are in balance with their environment. Thus far, all beavers that have been removed from colonies that contain surplus animals have been used for transplanting and this situation will persist for some time to come. In the meantime, a plan must be worked out for a carefully controlled harvest of beaver in non-agricultural areas.

In agricultural areas, particularly in the delta region of the Great Valley, a different situation exists. The entire problem there is one of

FIG. 26. Beaver pond with house in foreground. Plumas County, August, 1944.

control. There is no question that the golden beavers in the delta are a definite menace to levees and other reclamation works and their numbers must be limited. At the present time, the control of beavers in the delta is being handled entirely by the owners or lessors of reclaimed agricultural lands, who, under permit from the Division of Fish and Game, employ trappers and market beaver skins with little or no supervision. This haphazard system has resulted in a spotted pattern of control. There is a need for the development of a management plan under which delta beavers may be controlled on an area-wide basis that will give a sustained yield.

The Sonora beaver which inhabits the Colorado River presents still another problem. Along the river the presence of beaver is desirable and the States of Arizona and California are presently developing a joint management plan designed to maintain the maximum beaver population consistent with the available food supply. However, in irrigated areas adjacent to the river, such as the Palo Verde Irrigation District in California and the Gila Irrigation District in Arizona, beavers are definitely undesirable and must be trapped intensively in order to prevent damage to irrigation works.

In 1940 (Tappe, 1942, pp. 23-27) a survey was made of the Colorado River by California and the numbers of beaver present were estimated. Joint surveys of the river from the Nevada line to the Mexican border were made by California and Arizona in 1943, 1944, and 1945, and a number of beavers were taken from the river and adjacent areas under the supervision of the Arizona Game and Fish Department. The problem of beaver management on the Colorado River between California and Arizona will be discussed in a later paper.

Conclusion

In concluding this discussion of beaver management in California, the writer wishes to emphasize the necessity for proceeding with caution in the much needed development of a State-wide plan of management. It is felt that a sound plan, carefully followed out, can not help but prove beneficial to the land manager, the sportsman, the licensed trapper, and all lovers of the out-of-doors.

TABLE 1

Beaver Plantings in California

Date of plant	Kind	Male	Female	Sex unknown	Total	County trapped	County planted
Sept. 3, 1923	Sonora[1]			23	23	Riverside	Plumas
Aug. 27, 1934	Idaho[2]	2	2		4	Blaine County, Idaho	Plumas
Sept. 15, 1934	Idaho[2]	2	2		4	Blaine County, Idaho	Tuolumne
Sept. 22, 1936	Shasta[3]	1	3		4	Modoc	Siskiyou
Sept. 5, 1936	Shasta[2]	2		4	6	Modoc	Modoc
Sept. 11, 1936	Shasta[2]			4	4	Modoc	Modoc
Oct. 17, 1936	Shasta[2]		1	4	5	Modoc	Modoc
Aug. 27, 1938	Oregon[2]			4	4	Crooked River, Oregon	Tuolumne
Aug. 27, 1938	Oregon[2]			4	4	Rogue River, Oregon	El Dorado
Aug. 29, 1938	Golden[3]			7	7	San Joaquin	Stanislaus
Sept. 15, 1938	Golden[3]			29	29	San Joaquin	Napa
Oct. 29, 1939	Oregon[6]			5	5	Wheeler County, Oregon	Humboldt
April, 1940	Golden[3]	2	1		3	Merced	Tuolumne
Aug. 30, 1940	Shasta[2]			3	3	Modoc	Siskiyou
Aug., 1940	Golden[3]			6	6	Merced	Lake
Aug., 1940	Shasta[3]			2	2	Modoc	Modoc
Sept., 1940	Golden[4]	2	1		3	Merced	Contra Costa
Dec., 1940	Golden[4]	3	1	2	6	Merced	Contra Costa
Aug., 1941	Golden[4]			5	5	Merced	Plumas
Aug., 1941	Shasta[4]	1	1	3	5	Modoc	Mono
Aug., 1941	Shasta[3]			2	2	Modoc	Siskiyou
Oct., 1941	Golden[4]	1	1	3	5	Yuba	Mendocino
Jan., 1942	Golden[4]			6	6	Merced	Ventura
Feb., 1942	Golden[4]			5	5	Yuba	Monterey
April, 1942	Shasta[4]	1			1	Siskiyou	Siskiyou
July, 1942	Golden[4]	2	2		4	Merced	San Mateo
July, 1942	Shasta[4]	2			2	Modoc	Alpine
Aug., 1942	Golden[4]	1	1		2	Merced	San Mateo
Aug., 1942	Golden[4]	2	1		3	Yuba	Butte
Sept., 1942	Idaho[4]	2	2		4	Plumas	Alpine
Sept., 1942	Golden[4]		3		3	Merced	Mariposa
Nov., 1942	Golden[4]	1	3		4	Stanislaus	Butte
Feb., 1943	Golden[4]	1			1	Merced	Merced
April, 1943	Golden[4]	2	1	1	4	Stanilsaus	Mariposa
May, 1943	Golden[4]	2	1		3	Yuba	Butte
June, 1943	Golden[4]	3	1	1	5	Merced	Mariposa
July, 1943	Idaho[4]	3	2		5	Plumas	Sierra
July, 1943	Idaho[4]	1	1		2	Plumas	Plumas
Aug., 1943	Golden[4]	1	2	1	4	Merced	Mariposa
Nov., 1943	Shasta[4]	1			1	Modoc	Modoc
Nov., 1943	Golden[4]	1	3		4	Merced	Mariposa
April, 1944	Golden[4]	2	2		4	Merced	San Diego
April, 1944	Golden[4]	1	1		2	Merced	Mariposa
May, 1944	Golden[4]	1	1	1	3	Merced	Mariposa
May, 1944	Golden[4]	1	1	2	4	Merced	Mariposa
May, 1944	Golden[4]	1	1	1	3	Merced	Mariposa
Aug., 1944	Golden[4]	1	1	1	3	Monterey	Tuolumne
Oct., 1944	Golden[4]	3	2		5	Stanislaus	Mariposa
Oct., 1944	Golden[4]	2	3		5	Stanislaus	Mariposa
Oct., 1944	Golden[4]	1	2		3	Stanislaus	Mariposa
May 17, 1945	Golden[5]	3	2	1	6	Stanislaus	Fresno
May 28, 1945	Golden[5]	1	1	1	3	Stanislaus and Merced	Sacramento
June 5, 1945	Golden[5]	3	3	1	7	Stanislaus and Merced	Fresno
June 14, 1945	Golden[5]	2	1	3	6	Stanislaus and Merced	Tuolumne
June 19, 1945	Golden[5]	2	3		5	Stanislaus and Merced	Riverside
July 6, 1945	Golden[5]	1	1	2	4	Monterey	Santa Barbara
July 9, 1945	Golden[5]	1	1		2	Monterey	Monterey
July 24, 1945	Idaho[5]	1	1		2	Plumas	Lassen
July 26, 1945	Idaho[6]	1	1	1	3	Plumas	Sierra
July 26, 1945	Idaho[5]	2	2	1	5	Plumas	Sierra
July 29, 1945	Idaho[5]	2	2		4	Plumas	Nevada
Aug. 3, 1945	Idaho[5]	1	1		2	Plumas	Sierra

TABLE 1—Continued

Beaver Plantings in California

Date of plant	Kind	Male	Female	Sex unknown	Total	County trapped	County planted
Aug. 8, 1945	Idaho[5]	3	1		4	Plumas	Placer
Aug. 14, 1945	Idaho[5]	3	2		5	Plumas	Sierra
Aug. 15, 1945	Idaho[5]	2	2		4	Plumas	Nevada
Aug. 30, 1945	Idaho[5]	1	1		2	Plumas	Plumas
Sept. 14, 1945	Shasta[5]		1	1	2	Modoc	Siskiyou
Sept. 14, 1945	Shasta[5]	2	2		4	Modoc	Siskiyou
Sept. 21, 1945	Shasta[5]	1	1	2	4	Modoc	Shasta
Sept. 25, 1945	Shasta[5]	1	2		3	Modoc	Lassen
Oct. 6, 1945	Shasta[5]	3	1		4	Modoc	Shasta
Oct. 6, 1945	Shasta[5]	1	2		3	Modoc	Lassen
Oct. 8, 1945	Shasta[5]	1	2		3	Modoc	Lassen
Oct. 22, 1945	Golden[5]	2	2		4	Merced	San Diego
Oct. 22, 1945	Golden[6]	2	2		4	Merced	San Diego
Oct. 28, 1945	Golden[5]	3	1		4	Merced	Tuolumne
Nov. 10, 1945	Golden[5]	2	3		5	Stanislaus	Riverside
Totals		102	94	142	338		

[1] Accidental escape from commercial fur farm.
[2] Planted by U. S. Forest Service.
[3] Nuisance beaver transplanted by Division of Fish and Game.
[4] Experimental plants made by Project 5-R.
[5] Planted by Project 18-D.
[6] Donated to California Division of Fish and Game from Oregon Exhibit, Golden Gate International Exposition.

EDITORIALS AND NOTES

EFFECT OF RED WATER ON MARINE LIFE IN SANTA MONICA BAY, CALIFORNIA

During the first half of June, 1945, red water occurred in abundance off southern California from San Luis Obispo south to Los Angeles Harbor and on June 19, dead and dying fish and shellfish were observed in Santa Monica Bay. The period of mortality lasted five or six days and reached a peak on the fourth day.

Various marine animals were affected but the most conspicuous was the spiny lobster, *Panulirus interruptus*. These crustaceans appeared in the surf in a weakened condition and were picked up in large numbers by people along the beaches. Mr. Carmi Savage, California Fish and Game Warden, and members of the Los Angeles County Health Department made a survey of the loss and estimated that four or five tons of lobsters were killed. In addition many spider crabs and various fishes were affected. These included halibut, sting rays and sharks. Bait fishermen reported that they experienced difficulty in keeping their bait alive. The fish would die in the net before they could be transferred to the bait tank.

To ascertain the cause of this sudden mortality of marine animals and to be certain that the weakened lobsters were fit for human food, Mr. Savage and Dr. R. V. Stone, Los Angeles County Health Department, notified the Bureau of Marine Fisheries, California Division of Fish and Game, and the George Williams Hooper Foundation. The senior author took numerous water and shellfish samples between Redondo Beach and Santa Monica on June 22d and 23d, and on June 24th and 25th representative samples were collected betweeen Santa Monica and Monterey Bays.

One of the chief causes of concern was the possible presence of *Gonyaulax catenella* and the paralytic Gonyaulax poison. No paralytic poison could be demonstrated in any mussels and clams in Southern California as far north as Ventura. Traces were found in all samples between Pismo Beach and Santa Cruz. *G. catenella* was observed in the Santa Cruz water sample only, but in very small numbers.

Inspection of Santa Monica beach on June 23d indicated that the disturbance had essentially passed as no lobsters were found. There was, however, still a good deal of dead sea life on the beach including many large sheep crab, *Loxorhynchus grandis*. The water between Redondo and Santa Monica was essentially of normal color, but showed frequent isolated red streaks. Water samples from Crystal Pier at Santa Monica contained an unusual number of the dinoflagellate, *Polykrikos schwartzi*, 10,000 to 50,000 per liter, with very few other species of dinoflagellates or diatoms present. There were also a large number of ciliates (tintinnids). Water samples to the south as far as Redondo Beach showed essentially the same picture, although the number of organisms was smaller.

Although the senior writer is not too familiar with the plankton picture in southern California, it would seem that the ciliates may be expected normally in considerable numbers, due to the pollution in near-by waters. On the other hand, mass cultures of *Polykrikos* appear to be quite unusual and may be the direct or indirect cause of the disturbance in the sea life near Santa Monica. *Polykrikos* is a large, faintly colored, colonial organism which feeds upon other dinoflagellates and diatoms and in mass culture would be expected to deplete the water of oxygen. Furthermore a mass culture of this species would logically presuppose the previous occurrence of some other colored form in large numbers, as food for *Polykrikos*. A great abundance of either *Polykrikos* or of some other colored form could decidedly disturb the shore animals, a fact which has been repeatedly observed.

The digestive glands of the shellfish, mussels and clams, collected along the southern beaches were bulging with nutrients and of an unusually strong reddish color. This would also indicate that mass cultures of some colored dinoflagellate must have preceded *Polykrikos*. Water samples from Santa Barbara and Pismo beaches contained in large numbers almost pure cultures of the dinoflagellate, *Ceratium* (probably *C. tripos*) and it is not unlikely that this is the organism which preceded *Polykrikos* in Santa Monica Bay, since a few organisms of this species were found in this locality also.

The disturbance in the shore animals and the large number of deaths among fish and shellfish along Santa Monica Bay in mid-June was probably due therefore to an unusually heavy growth of *Ceratium tripos* and subsequently of *Polykrikos schwartzi* with an accompanying disturbance in the oxygen-carbon dioxide equilibrium. The presence of *Gonyaulax* or its poison could not be demonstrated—*Hermann Sommer, George Williams Hooper Foundation for Medical Research, University of California, and Frances N. Clark, California Division of Fish and Game*, November, 1945.

RECOVERY OF A TAGGED SOUPFIN SHARK

During 1943 the Bureau of Marine Fisheries tagged 80 soupfin shark with numbered celluloid disks fastened to the dorsal fin by german silver pins. Thirty-six soupfin were liberated in the region of Santa Barbara and Ventura during July and August. Forty-four were tagged in San Francisco Bay during October and November. Recently Tag A 3272, originally attached to a 110 cm. (43½-inch) female six miles south of Ventura, California, on July 18, 1943, was returned to the Division of Fish and Game by Mr. W. H. MacKenzie of the British Columbia Packers Limited at Hecate, B. C., who informed us that the tagged individual was taken by Mr. G. Johnson above Nootka Sound inside Bajo Reef on the west coast of Vancouver Island, B. C., on September 11, 1945.

Although the shark could have covered a greater distance during the 26 months of freedom, it definitely migrated 1,000 miles up the coast between the time of tagging and recapture. The inside faces and edges of each of the two disks showed a slight amount of wear from constant contact with the shagreen of the base of the dorsal fin. No wear or corrosion could be detected on the pin. Judging from the external condition of the returned tag and pin, it would be safe to estimate that the tag could have remained out four to six times as long.

The return of this one tag alone does not prove a general migratory movement of the shark population, however it does corroborate other evidence indicating that the soupfin shark population along the West Pacific Coast is homogenous.

It is requested that in the event that any other tagged soupfin are captured the following information accompany the returned tag: date, locality of capture, length of shark from tip of the nose to the end of the tail, sex, total weight and liver weight.—*William Ellis Ripley, Bureau of Marine Fisheries, California Division of Fish and Game,* October, 1945.

IN MEMORIAM

HIRAM L. RICKS

The death of Hiram L. ("Toppy") Ricks, President of the Fish and Game Commission, occurred on January 31, 1946, in Eureka, after a period of treatment for a heart ailment. He had served on the commission since March 6, 1944, and been president since December 1, 1944.

Mr. Ricks was born in Eureka on August 4, 1890, and received his earlier education at the local schools. He went to the University of California, from which he graduated with the degree of B.Sc. in 1913, after which he continued at the School of Jurisprudence, receiving the Degree of Doctor of Jurisprudence in 1915. He was admitted to practice in that same year.

He served with distinction in the First World War, going overseas with the 91st Division as Captain of Field Artillery. On completion of his military duties in June 1919 he returned to Eureka, and spent the rest of his life there in practice of the law. In World War II he served as appeal agent for the draft board.

He owned and operated a ranch; and had many hobbies, all connected with the out-of-doors, high among which ranked hunting and fishing. He will be greatly missed by his associates in the work of the Fish and Game Commission, whose respect he gained by his sound judgment and wide knowledge, and whose esteem and affection he held by his fair-mindedness, his friendly spirit and his sense of humor.—*Brian Curtis,* Editor, California Fish and Game.

REPORTS

FISH CASES

October, November, December, 1945

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: no license, failure to show license; overlimit, undersize, refusal to show; unlawful possession, removal of abalone from shell below high tide	48	$1,117 50	
Angling: use of more than one line, spear on Mokelumne River, gaff hooks and spear; night fishing; other than hook and line, operating set line in Clear Lake, fishing 100 feet lower side of dam, possession of fish spear while fishing for mullet on Alamo River, of spear within 300 feet of stream; purchase of citizen license while an alien; transferring license	55	1,590 00	
Bass, striped: overlimit, undersize, no license, using more than one outfit	64	1,572 50	
Bass, black: undersize, closed season	3	75 00	
Catfish: using set line	1	25 00	
Clams: undersize, refuge, no license	29	810 00	
Commercal: no party boat license, no license, taking salmon commercially closed season, using set line closed area, selling clams no commercial license and failing to keep recording triplicate	13	670 00	
Crabs: closed season	1	25 00	
Lobsters: undersize, no license	9	158 00	
Salmon: shooting, closed season, illegally taken, near dam, night fishing, snag hooks, sale of salmon, gaff, spawning area	83	2,690 00	45
Trout: no license, overlimit, undersize, more than one line, closed waters	13	290 00	
Pollution	5	275 00	
Totals	324	$9,298 00	45

GAME CASES

October, November, December, 1945

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope: illegal, transfer license and tag, altering license and tag, refuge, closed season	3	$375 00	
Avocet	1	25 00	
Curlew	1	25 00	
Deer: female, fawns, transfer deer tags, spotlighting, failure complete deer tags, spike buck, remove deer tag from antlers, mutilate deer tag, forked horn deer District 1¾, carrying deer tags issued to another, night hunting, using 1944 deer tags, 2 deer in a 1 deer district, failure to validate deer tag, no tags, remove tag from antlers before expiration of ten days after closed season	91	4,930 00	30
Deer meat: illegal possession, selling, failure to stamp, no permit	17	1,310 00	
Doves: overlimit, no license, shooting from auto, unplugged gun	43	1,160 00	
Ducks: shooting ducks from airplane, late shooting, herding, closed season, overlimit, refuge, shooting from power boat, unplugged gun	121	3,992 00	
Geese: late shooting, unplugged gun	9	220 00	
Grebe	2	40 00	
Grouse	1	50 00	
Hunting: night hunting, late shooting, no license, firearms on refuge, unplugged gun, false statement to secure license, shooting from public road, failure to show license, closed season, nongame birds	72	1,935 00	
Jacksnipe	3	75 00	
Non-game birds	2	35 00	
Pheasants: early shooting, using license of another, closed season, hen, shooting from vehicle	75	4,802 50	
Pigeons: no license	3	27 50	
Quail: early shooting, closed season, no license, shooting from vehicle	40	646 50	
Rabbits: spotlighting, closed season	9	130 00	
Robins	2	40 00	
Sage hens: closed season	1	50 00	
Shorebirds	3	110 00	
Squirrels	1	50 00	
Swans	7	400 00	
Totals	507	$20,428 50	30

SEIZURES OF FISH AND GAME

October, November, December, 1945

Fish:

Abalones	405
Bass, striped	26
Bass, black	5
Clams	534
Lobsters	117
Lobster traps	36
Salmon	53
Salmon, pounds	1,400
Trout	31

Game:

Deer	29
Deer meat, pounds	280
Doves	129
Ducks	120
Geese	23
Pheasants	6
Pheasants, hen	24
Pheasants, cock	52
Quail	93
Rabbits	26
Robins	9
Swans	3
Wilson snipe	1

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(Continued from inside front cover)

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