SACRAMENTO - SAN JOAQUIN DELTA FISHERY RESOURCES: Effects of Tracy Pumping Plant and Delta Cross Channel

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 56

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

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No. 56

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INTRODUCTION

Water for domestic and commercial use, irrigation, and for the production of electrical energy in California is perhaps the most important and vital commodity regulating the growth and well-being of the State. The most efficient use of California's limited supplies of water has been the concern of planning agencies and the citizenry since before the turn of the century. Federal and State governmental bodies have authorized extensive studies of the water problems, many of which still are in progress. As a result of certain state investigations, the California Division of Water Resources published a series of bulletins (1929-31) which presented what has been known since then as "The State Water Plan".

This report consists principally of observational data which have not yet been fully analyzed. Although the analyses are now being carried out, it will be some time before technical reports embodying them will be published. In the meanwhile, there is need for publication of the data for use by administrators, fishery biologists and engineers who are actively engaged in planning, constructing and evaluating fish protective devices.

For the Central Valley of California, this plan recommended storage of excess Sacramento River water and its ultimate transport to the San Joaquin Valley, where water deficiencies were especially acute (Fig. 1). This Central Valley water development came to be known as the Central Valley Project when Federal assistance was obtained in its construction. Essentially, the project consists of a large (4,500,000 acre-foot capacity) reservoir above Shasta Dam on Sacramento River about fifteen miles upriver from the city of Redding, California; controlled flow of Sacramento River downstream from the reservoir; the discharge of stored water into the Sacramento-San Joaquin Delta; the pick-up on the south side of the Delta of a maximum of 4,600 second feet by huge pumps; the delivery of that water through the Delta-Mendota Canal extending some 120 miles up the San Joaquin Valley, and its distribution to farms below the Mendota Pool on the San Joaquin River. Provision of this water to the San Joaquin Valley will make possible the use of San Joaquin River water, stored above Friant Dam, in the southern end of that valley where agricultural potentials are high and water quantities are very low. Water will be transported from Friant Dam to farms in the area by two canals: the Madera Canal leading northward a short distance, and the Friant-Kern Canal which will course southward toward Bakersfield, California, to bring water to lands now arid.

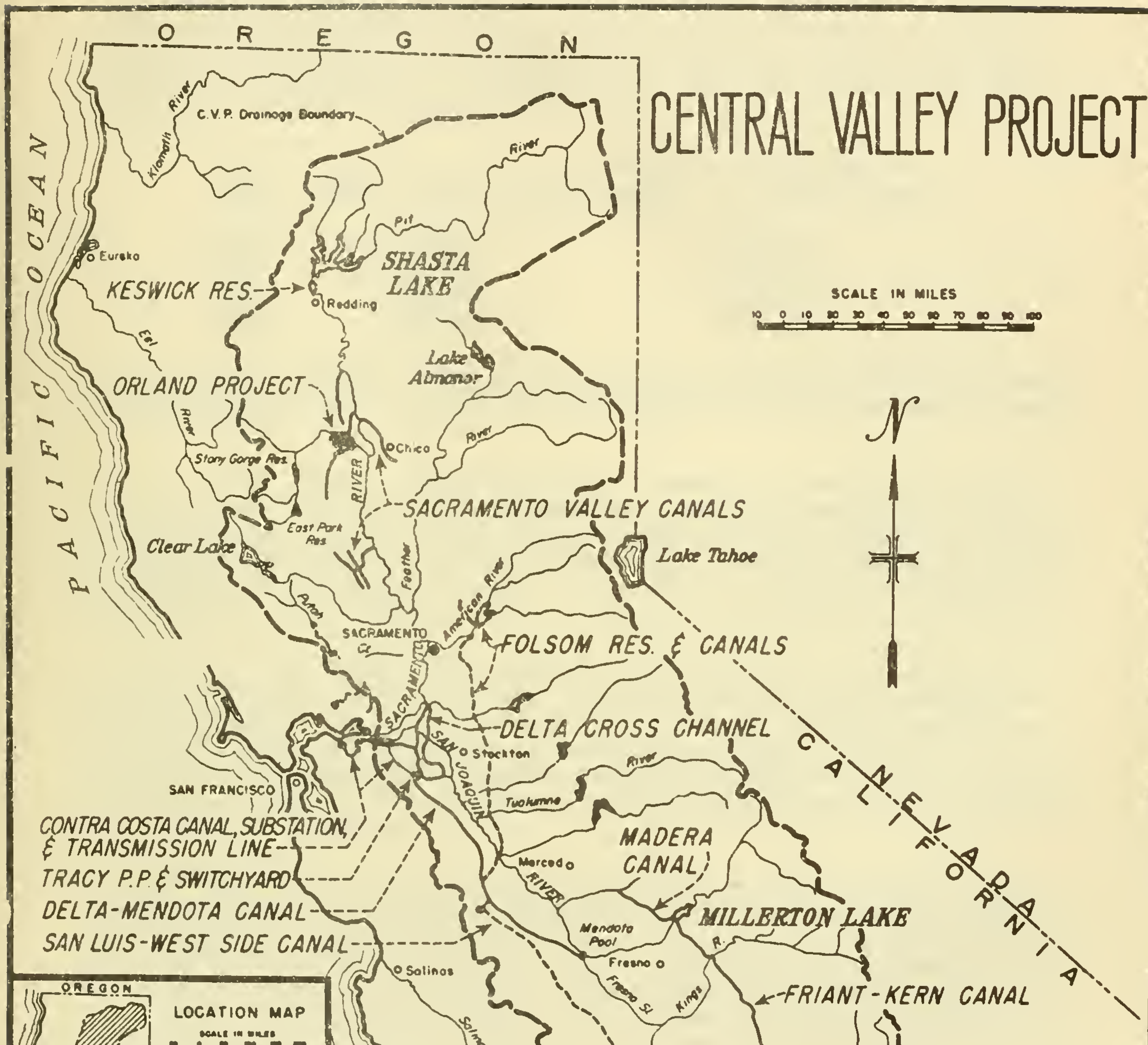
The original plan proposed the transport of water from Sacramento River to the Delta-Mendota Canal lift pumps through a closed channel, a large canal sufficient to transport water for salinity control in the Delta and to fill the requirements of farms dependent on the Delta-Mendota Canal. Excessive construction costs and technical difficulties involved in the closed channel forced a change of plans. Studies were instituted by the U. S. Bureau of Reclamation and the State of California to determine the feasibility of water transport through existing Delta Channels in quantity and quality adequate for project operation. Although certain engineering problems in the Delta are somewhat imperfectly known, it has been decided to draw water required for the Delta-Mendota Canal from existing Delta channels increased in volume by greater discharges down Sacramento River, and to cut a channel from Sacramento River to the center of the Delta to increase and improve the water supply available at the Delta-Mendota intake. If insufficient water is obtained by gravity through the initial channel, supplemental water will be diverted through additional gravity channels or a low-lift pump system.

The Sacramento-San Joaquin Delta is a sea-level maze of channels, low islands, and levees. It forms the uppermost extension of San Francisco Bay and constitutes a common terminus for the two main river systems in the Central Valley. Approximately 500 miles of channels in the Delta network mix the waters of Sacramento and San Joaquin Rivers thoroughly; especially since the entire Delta system is influenced by tidal action. Water in the Delta is generally fresh or only slightly brackish, although seasonal and cyclic changes in salinity do occur. Salinity is higher in late summer and fall, and lower in winter and spring. In periods of drought, salinity increases in the Delta area sufficiently to cause crop damage and to change the fauna inhabiting the waters.

The Sacramento-San Joaquin Delta is an especially important key in the life history of anadromous fishes utilizing the streams of the Central Valley as spawning areas. Adult and juvenile king salmon, striped bass, shad, and two species of smelt pass through, spawn, or temporarily reside in Delta waters. The Delta stream complex is also an extremely vital nursery ground for the young of these species. Anything which threatens to change the dynamics of Delta waters constitutes a potent threat to the continued existence of these species which are valuable segments of the well-developed fishery resources of the State of California and the Pacific Coast in general.

Salmon resources of California which are directly attributable to Central Valley and which will be endangered by the Central Valley Project amount to an average annual commercial catch of 5,600,000 pounds. This average is derived from catch statistics covering the years 1916 through 1946. It was calculated according to methods established by the California Division of Fish and Game from tagging experiments which fix proportions of the troll catch attributable to the Central Valley Streams. It also involves the total catch of the gill-net fishery in Sacramento and San Joaquin Rivers. During the 30-year period the annual calculated catch has ranged between 1,936,800 pounds in 1939 to 11,390,600 pounds in 1946. In addition to the commercial catch, there is a large sport fishery for salmon both in the ocean and in the rivers. The total size of this fishery is unknown. However, creel census studies show sport catches of about 62,400 pounds in the 1947-48 season and 136,200 pounds in the 1948-49 season in the upper 100 miles of the Sacramento River alone. According to the California Division of Fish and Game, approximately 20,000 salmon were caught offshore on party boats during 1948. Using the methods applied to the commercial catches discussed above, we derive a figure of approximately 14,000 fish which originated in the Central Valley.

<u>Opposite: Figure 1 - Map of Central Valley Project</u>



CENTRAL VALLEY PROJECT
OREGON
PACIFIC OCEAN
C.V.P. Drainage Boundary
Klamath River
River
Pit
Eureka
KESWICK RES.
SHASTA LAKE
Redding
Eel
Lake Almanor
ORLAND PROJECT
River
Stony Gorge Res.
Chico
River
RIVER
SACRAMENTO VALLEY CANALS
East Park Res.
Clear Lake
Feather
Lake Tahoe
American River
Putah
SACRAMENTO
FOLSOM RES. & CANALS
SACRAMENTO
DELTA CROSS CHANNEL
SAN JOAQUIN
Stockton
River
SAN FRANCISCO
Tuolumne
CONTRA COSTA CANAL, SUBSTATION, & TRANSMISSION LINE
TRACY P.P. & SWITCHYARD
DELTA-MENDOTA CANAL
SAN LUIS-WEST SIDE CANAL
MADERA CANAL
Merced
RIVER
MILLERTON LAKE
Mendota Pool
R.
Fresno
Salinas
Fresno Sl.
Kings
FRIANT-KERN CANAL
Salinas
River
Tulare Lake Sump
NEVADA
CALIFORNIA
SCALE IN MILES
10 0 10 20 30 40 50 60 70 80 90 100
N
Kern River
Bakersfield
San Luis Obispo
LEGEND
Approved/Completed Features
Proposed Features
OREGON
LOCATION MAP
SCALE IN MILES
N
CENTRAL VALLEY PROJECT
NEVADA
CALIFORNIA
San Francisco
Los Angeles
PACIFIC OCEAN

The striped bass fishery has been a sport fishery since 1931, when the commercial fishery was made illegal. Existing estimates of the size of this fishery in terms of numbers and poundages of striped bass taken have been derived from a postal card survey conducted by the California Division of Fish and Game. That agency has supplied the following estimates for inclusion in this report.

Year	Number of Bass Taken	Weight of Bass Taken as Based on a 4-Pound Average
1943	1,650,000	6,600,000
1944	1,420,000	5,680,000
1946	1,381,000	5,524,000
1948	1,660,000	6,640,000

The California Division of Fish and Game estimates that approximately 225,000 anglers fished a total of 2,250,000 days for striped bass in California in 1948.

Poundage figures available from the commercial fishery of the entire Atlantic Coast indicate that approximately 6,100,000 pounds of striped bass were taken in 1948. This highly valued east coast commercial fishery can be compared with the 1948 sport fishery in California waters, amounting to more than 6,600,000 pounds, most of which originated in waters of and tributary to the Delta.

In a recent publication, Calhoun (1949) analyzed the catches of striped bass reported by party boat operators in Delta waters during the period 1938-1948. He demonstrates that the striped bass are maintaining their numbers and are providing satisfactory angling in the Delta. A slight decrease in catch per angler since 1944 is demonstrated in Calhoun's data (p.247); however, this change is attributed to a minor and natural fluctuation in abundance.

Shad are taken from Central Valley waters by commercial fishermen almost entirely. A small sport fishery exists on the Sacramento and San Joaquin Rivers, but it is insignificant. The commercial catches of shad are subject to rather violent fluctuations which arise from abundance of the fish and economic conditions. State of California records since 1926 show annual catches ranging between the extremes of 113,101 pounds in 1941 and 4,103,423 pounds in 1927. The mean annual catch during the 1926-1948 period is 1,460,000 pounds.

The gravity of the problem of fish protection in the Delta was recognized by State and Federal fishery agencies as early as 1938, and preliminary steps to solve the problem were taken by the State of California in 1939. Results of this undertaking are published in two papers: Hatton (1940) and Hatton and Clark (1942). Many conferences were held between personnel of the U. S. Bureau of Reclamation, the California Division of Fish and Game, and the U. S. Fish and Wildlife Service in an attempt to solve the fish protection problem. Tentative plans for protective devices were formulated on the basis of biological work done prior to 1945. The efforts of Hatton and Clark indicated an abundance of young salmon and the young of other anadromous fishes entering the Delta seasonally in their seaward migration or originating there from eggs spawned in Delta Channels. It was not difficult to define the problem in fish protection posed by the Delta-Mendota pumping plant. The main questions to be answered were: What can be expected to happen, how much damage will be done, and when will it occur? Existing information gave little assistance in the resolution of these fundamental questions. However, many of the fishery agencies were convinced that some measure of fish protection would have to be provided at the entrance to the pump channel intake. Ideas regarding desirable fish protection centered around three main possibilities:

1. The first and most desirable plan involved construction of the closed channel across or around the Delta with a screen at the head of the canal. This possibility was overruled and the position favoring it was made untenable by the changes in plans of the U. S. Bureau of Reclamation.

2. A satisfactory screen at the entrance to the pump intake channel and a by-pass originating in the San Joaquin River, passing the screen and ending in Dutch Slough, were to be constructed. The by-pass was to be a channel capable of carrying 500 second feet of San Joaquin River water through the southern part of the Delta. It was to empty into Dutch Slough, which was considered to be outside the influence of the pump draft.

3. A satisfactory screen was to be constructed as in number 2, but the by-pass, instead of originating in the San Joaquin River, was to begin at the screen and the water volume was to be reduced to 200 cubic feet per second. The by-pass was to course to a point outside the pump draft influence, which was tentatively set at Dutch Slough.

These plans and certain preliminary engineering specifications were discussed by representatives of the California Division of Fish and Game, the U. S. Fish and Wildlife Service, and the U. S. Bureau of Reclamation during a lengthy conference at Denver, Colorado, in February of 1946. Efforts to bring about realization of the tentative plans for fish protection were unsuccessful mainly because of a lack of sufficiently convincing and basic evidence. Consequently, a study of the Delta fisheries problems, recommended in 1945, was undertaken in August of 1946 by the U. S. Fish and Wildlife Service. This report presents the main features of the investigation, which was conducted under the sponsorship and with the financial assistance of the U. S. Bureau of Reclamation. The California Division of Fish and Game cooperated in the study and made valuable contributions to present knowledge of Delta fisheries from independent studies which they undertook.

Dr. James W. Moffett, Chief, Central Valley Investigation, U. S. Fish and Wildlife Service, gave general supervision to the project from its inception to its termination. During the preliminary and exploratory work of the first year, Charles B. Wade was in charge of the field program, assisted by Kenneth Legg and Joseph Bender. In June, 1947, Leo F. Erkkila assumed charge of the field program, and assisted by Bernard R. Smith, held this capacity until termination of the study. Other personnel active in the field program were: Millard H. Coots, Louis H. Carufel, Jr., Eugene S. Cupernell, William A. Rush, and James R. Thrailkill. Stanford office personnel participating in the studies were Reed S. Nielson and Oliver B. Cope. Irene L. Krieshok gave valuable assistance in the preparation of the report.

Throughout the study, contact has been maintained with the U. S. Bureau of Reclamation, the agency which financed the bulk of the study, and the California Division of Fish and Game, whose biologists gave invaluable advice and assistance in many phases of the work. The U. S. Bureau of Reclamation supplied engineering assistance, maps, and data relative to flow and project operation. The U. S. Corps of Engineers provided certain funds which helped support the study during its first year.

OBJECTIVES

When the study was inaugurated in 1946, the basic objective was recognized as being the development of measures to protect and manage the fishery resources in the Sacramento-San Joaquin Delta in relation to the Delta Cross-Channel, the Tracy Pumping Plant, and their appurtenant works. In order to obtain the essential information necessary for meeting the main objective, the following plan of study was organized as a guide for operations planned for a five year period, beginning in 1947:

1. Learn the biology, magnitude, and composition of the fishery resources that depend upon or utilize Delta waters.

2. Determine the present hydrodynamics of the Delta.

3. Determine the details of the proposed project and its operation.

4. Determine the possible effects of project operation on present hydrodynamics.

5. Determine the effects on fishery resources of hydrodynamics altered by project operation.

6. Devise ways and means to mitigate damage to, or improve conditions for, present fishery resources.

7. Assess the degree of success of ways and means, adopted for the protection and improvement of fishery resources.

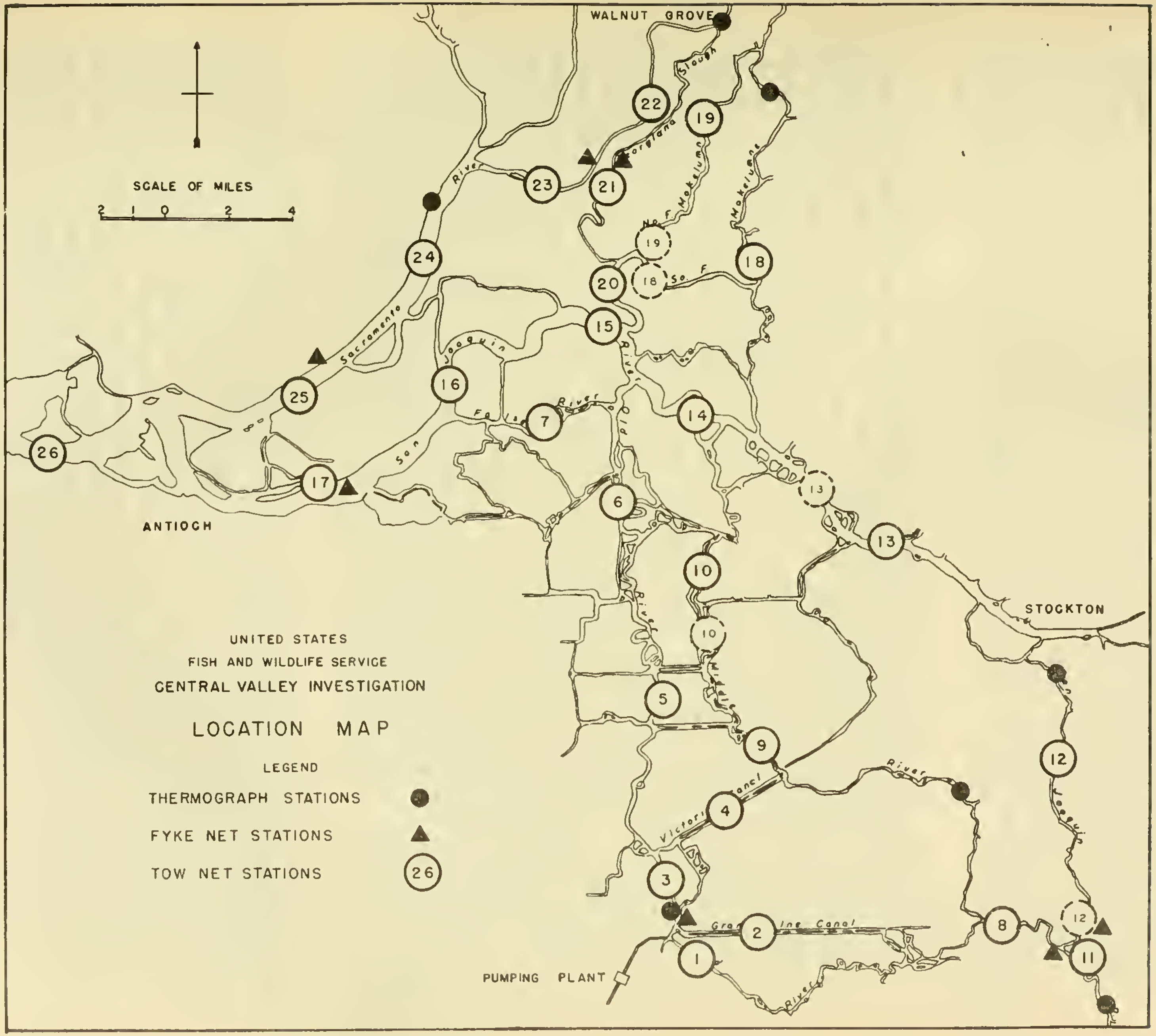
Termination of the project in 1949 made impossible completion of any of the lines of investigation listed above. However, considerable information was obtained on several of the investigations; on other phases, very little information was obtained. This report presents a summary and discussion of those findings on which reliable data have been obtained and which are pertinent in resolving the main problem.

Standard methods of fishing the various nets were adopted. The eggs, larvae, and juvenile fish taken by these methods are considered indicative of their relative abundance and distribution in the Delta. Two types of plankton net hauls were made: surface tows just below the water surface, and deep tows at depths of 13 and 14 feet. The net was towed fifty feet astern of the launch for five or ten minute periods, depending on the amount of detritus in the river. The five-foot tow-net hauls were made just below the surface with the net towed 100 feet astern of the launch for 30 minutes. The towing speed was kept constant by tachometer readings. During 1949, a Price current meter suspended in the water from the bow of the launch was used in conjunction with the tachometer readings to keep the towing speeds as nearly constant as possible under operating conditions. The towing speed of the plankton hauls was approximately four feet per second. The five-foot surface net was hauled through the water at an approximate rate of six feet per second. In determining the relationship of the velocity of the water strained through the nets to the velocity of the flow past the nets, a series of tests were made with a Price current meter mounted in the center of the mouth of the nets and another suspended from the bow of the towing vessel as in actual operation. The mean velocity of the flow through the standard five-foot tow-net with bobbinet lining computed from 185 readings was 5.8 feet per second compared to 5.95 feet per second, the velocity of the net through the water. Similar tests with the half-meter plankton net computed from 49 readings gave a mean velocity of 3.36 feet per second through the net compared to 3.92 feet per second, the velocity of the net through the water.

Exploratory net towing operations were conducted in the Delta channels for several months. This preliminary work permitted (1) selection of standard methods of sampling for each type of net, (2) reconnaissance of Delta channels for suitable stations, and (3) observations of the hydrodynamics within the Delta.

As a result of the exploratory work, twenty-five stations were selected as the minimum number necessary to obtain reasonable coverage of the Delta. The locations of the stations are illustrated in Figure 1. Stations 1 to 5 were established during the preliminary operations and the remainder were included in the operation schedule after March, 1948. One complete coverage of all stations is referred to as a cycle. During 1948, nineteen cycles were completed. The cycles varied from 7 to 14 days in duration and were repeated as frequently as possible. Four stations in the central Delta area were relocated in 1949 in order to give better coverage, and an additional tow-net station was established on April 11, 1949 in the main stem of the Sacramento River off Chipps Island. The relocations were not drastic in nature, as demonstrated by subsequent checks. The 1948 locations of the stations which were relocated are indicated in Figure 1 with broken line circles. The following list sets forth the old and new locations of the tow-netting stations in the Sacramento-San Joaquin Delta:

Opposite: Figure 2 - Location map of stations in Sacramento-San Joaquin Delta


UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LOCATION MAP
LEGEND
THERMOGRAPH STATIONS
FYKE NET STATIONS
TOW NET STATIONS
SCALE OF MILES
WALNUT GROVE
ANTIOCH
STOCKTON
PUMPING PLANT
Sacramento River
San Joaquin
Victoria Canal
Old River
Middle River
Mokelumne
No. F. Mokelumne
So. F.
Georgiana Slough
False River
Grant Line Canal

METHODS

Work carried on in 1946 and 1947 was preliminary and exploratory in nature. As a result of these preliminary studies, a work program was designed, having as its essential features: (a) sampling juvenile populations of fishes by tow-netting from motor launches at stations located in representative parts of the Delta and fished at regular intervals according to a standard procedure; (b) sampling juvenile populations of fishes with one to six fixed fyke-nets at strategic locations; (c) sampling invertebrate faunae and fish eggs by towing plankton nets from motor launches; and (d) collecting data on temperature, turbidity, salinity, flow, and water quality.

The study of the biology, size, and composition of the fishery resources that depend upon or utilize the waters of the Sacramento-San Joaquin Delta, required the development and operation of several types of collecting gear. In the early course of the investigation fyke nets provided the most expedient means of studying movements of the young anadromous fishes within the Delta channels. These nets, a trap type of gear, were fished from a fixed position. The nets were half-inch stretched mesh, No. 9 cotton webbing framed on three rings, 5, 4, and 3 feet in diameter and constructed into a conical trap fifteen feet long. An inner funnel tapering to a ten-inch opening provided the entrance into the trap. Tidal action in the Delta made it necessary to operate the fyke nets from inter-connecting lines either between buoys anchored from the bottom, or between bridge dolphins and piling when these were available. This method permitted the net to fish counter to the direction of the current. Fyke nets were fished daily at several strategic locations for periods of six months to a year (Fig. 2). One net, located in the San Joaquin River, one half mile below the Antioch Bridge, was operated from August, 1946 to November, 1949. The information from the fyke-net operations on the time of appearance of the young anadromous fishes in the Delta and the extent of their movements was invaluable, particularly in corroborating the results obtained in tow-net operations. However, the introduction of improved methods of sampling, resulting in more complete information on the fishes in the Delta has precluded the use of the fyke-net data in this report.

The acquisition of a motor launch in July, 1947, permitted adoption of more thorough methods of studying the spawning, distribution, and abundance of the early life stages of the fishes within the Delta. Three types of nets were selected for the sampling operations from the launch. A plankton net a half-meter (20 inches) in diameter at the mouth, and constructed of bolting cloth 30 meshes to the inch in the cone was used for collecting eggs and larvae. The tow net, a fifteen foot conical net of half-inch stretched mesh, No. 9 cotton netting, five feet in diameter at the mouth, was used for collecting juvenile fish. The same net with a lining of bobbinett, 8 meshes per inch, was used in collecting post-larval specimens of fish. An adaptation of a trawl net, using half-inch stretched mesh netting, was used periodically for bottom tows.

Station	Location
1	Old River, Livermore Yacht Club upstream two miles.
2	Grant Line Canal, Grant Line Bridge to Old River.
3	Coney Island Cut, entire length.
4	Victoria Canal, entire length.
5	Old River, Woodward Canal to Santa Fe Railroad Bridge.
6	Holland Cut, entire length.
7	False River, overhead cables to Fishermen's Cut.
8	Middle River, San Joaquin River to Salmon Slough.
9	Middle River, Borden Highway Bridge to North Victoria Canal.
10 (1948)	Middle River, Santa Fe Railroad Bridge to Empire Cut.
10 (1949)	Middle River, Empire Cut to Connection Slough.
11	San Joaquin River, 1/2 mile below Southern Pacific Railroad Bridge, Mossdale, to Middle River.
12 (1948)	San Joaquin River, 1/2 mile below bifurcation of Middle River for two miles downstream.
12 (1949)	San Joaquin River, Brandt Bridge to Borden Highway Bridge.
13 (1948)	San Joaquin River, Navigation Light No. 21 to Light No. 17.
13 (1949)	San Joaquin River, Turner Cut upstream to Navigation Light No. 35.
14	Venice and Mandeville Cuts, Navigation Light No. 5 to Light No. 2.
15	San Joaquin River, Mouth of Mokelumne River to 7 Mile Slough.
16	San Joaquin River, Three Mile Slough to False River.
17	San Joaquin River, Blind Point to Mayberry Cut.
18 (1948)	South Fork Mokelumne River, from North Fork to Terminus.
18 (1949)	South Fork Mokelumne River, from Terminus to Sycamore Slough.
19 (1948)	North Fork Mokelumne River, from mouth of South Fork, upstream two miles.
19 (1949)	North Fork Mokelumne River, from five miles above South Fork upstream two miles.
20	Mokelumne River, Georgiana Slough to Jackson's Harbor.
21	Georgiana Slough, Tyler Island Bridge to mouth of Slough.
22	Sacramento River, Pratt-Low Preserving Co. Cannery to Isleton Highway Bridge.
23	Sacramento River, from Isleton to Grand Island Sounding Board.
24	Sacramento River, west side of river, from Rio Vista to Three Mile Slough.
25	Sacramento River, east side of river, from Toland's Landing to Towers.
26	Sacramento River, Bell-buoy No. 10 to Stake Point.

A special field form was designed for recording the catch of each towing operation, including water temperature, direction of current, tide and turbidity.

During 1949 improved coverage of the Delta was made possible with an increase in the number of personnel, and the addition of a second launch. This permitted dividing the Delta into two areas: one included all stations located in the Sacramento Delta, Mokelumne River, and those stations situated in the San Joaquin Delta below the mouth of Old River; the other area included all stations located in the San Joaquin Delta above the mouth of Old River. Each area was assigned a launch and operating crew. A minimum of eight stations was sampled daily, with a cycle of all stations completed in a period of three days. Thirty-three weekly cycles were completed from January 25th to September 22nd, 1949.

The fishes, post-larval and juveniles, taken alive, were measured in the field and returned to the water. Specimens killed in towing operations were measured and then preserved in five percent formalin. Measurements were made to the nearest millimeter from the anterior tip of the head to the fork of the tail. Plankton-net catches were examined in the field for striped bass eggs and larval fishes when time allowed; otherwise, the samples were preserved in five percent formalin and sorted at headquarters. Identification of the larval striped bass and shad was checked with the aid of the following references: Pearson (1938), Merriman (1940), Leim (1924), and Leach (1925). Through the courtesy of Dr. A. J. Calhoun, of the California Division of Fish and Game, identified specimens of eggs and larvae were made available for aid in identification of our material.

In order to determine the distribution of the immature salmon, striped bass and shad in the Delta, it was necessary to calculate relative abundance of each species at each tow-net station. The calculation was based on the assumption that the horizontal and vertical distribution of the fish was uniform and that the thirty-minute tow-net sample was representative of conditions at the station. Since the tow net had a diameter of five feet and was towed immediately beneath the surface, the calculation was limited to the upper five feet of depth. The mean width of the station was determined from U. S. Corps of Engineers maps of the Delta channels (1933, 1934, and 1936). The average width of the channel in feet at the station was multiplied by five to obtain the cross-sectional area involved. The cross-sectional area was then divided by 20 square feet, the cross-sectional area of the tow net, and the dividend was multiplied by the number of young fish of each species taken in the station. In this manner, adjustments were made for the differences in width of channels at station sites. The relative numbers of salmon, striped bass and shad thus obtained were assumed to represent the abundance of young fish in the area sampled. The calculated results for the three species are illustrated graphically in independent series of maps, showing the cyclic distribution of each species in the Sacramento-San Joaquin Delta in 1948 and 1949 as determined from tow-net sampling. On the graphic illustrations, the area of each circle is proportional to the calculated number of specimens at each station. The mean length of the measured sample from each station is given with each circle. The hydrodynamics occurring during the cycle are included, showing mean Delta inflows in cubic feet per second, maximum and minimum temperature range in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand (California Division of Water Resources data 1948, 1949), and turbidity in inches, as determined with a four-inch Secchi disc.

Water temperature studies (Cope, 1949), considered an important part of this investigation, were carried on at critical locations in the Delta (See Fig. 1). Recording thermometers were used throughout the course of this work. The field installation of the instruments stressed maximum protection and stability. The thermographs were encased in steel housings firmly secured to structures such as concrete bulkheads, bridge dolphins or anchored barges. Servicing of the thermographs entailed weekly changes of the charts and the calibration of the instruments against a thermometer of known accuracy. Transcription of the daily maximum and minimum temperatures of water and air were completed on monthly temperature data forms. The temperature readings were read to the nearest degree, Fahrenheit. Additional temperature records were obtained by means of hand thermometers at established fyke-net and tow-net stations.

Studies of chemical features of the Delta waters included weekly analyses during 1948 for dissolved oxygen, alkalinity, pH, and turbidity in the San Joaquin River at Mossdale, Sacramento River at Isleton, and Old River at Clifton Court. Methods followed were obtained from American Public Health Association (1936). Hydrogen ion concentration was determined colorimetrically using a Hellige Pocket Comparator with Brom-thymol-blue, Phenol Red-D, and Chlor-phenol red against standard color discs. Turbidity of the water at the above locations was determined by means of a turbidity scale and tape (U. S. Geological Survey Model). Occasionally it was necessary to use a four-inch Secchi disc to determine turbidity at the water chemistry stations. The Secchi disc was regularly used in determining turbidity at the tow-net and fyke-net stations.

BIOLOGICAL INVESTIGATIONS

The field operations of this study were conducted with a view toward ascertaining the biology, composition, and abundance of the populations considered to be most vulnerable to the Tracy Pumping Plant and the Delta Cross-Channel. Emphasis was placed particularly upon immature king salmon, striped bass, and shad, the adults of which comprise among the most valuable fishery resources in the Delta. While these three anadromous species received the most attention, a great deal of information was purposely obtained relative to other species of fish utilizing Delta waters, in order that a complete understanding of the aquatic complex of the area would be gained. In addition to the collection of data pertaining to the fish themselves, the program included the gathering of such ecological information on the identity, presence, and numbers of invertebrate fish-food organisms, the importance of these organisms in the diet of juvenile fishes, the thermal patterns in the Delta, the chemical quality of Delta waters, and the hydrodynamics of important Delta channels.

It is recognized that any or all of the ecological factors mentioned may affect the well-being of fish in the Delta if the existing environmental balance is disrupted. It was the aim at the outset of the project to determine the importance of each of these factors with regard to the welfare of the fish populations. Although this section of the report will not treat ecological factors as units of the study, it should be stressed that, had the investigation been carried to completion, rather thorough inquiries into their influences would have been made. Before a real knowledge of the ecology of the Delta waters is gained, these studies will have to be pursued further.

It should be stated here that all the evidence obtained to date indicates that migrating juvenile fish studies in the Delta are distributed in proportion to the amount of water carrying them. Studies on the Sacramento River at Isleton and on Georgiana Slough demonstrated that migrating juvenile salmon were so distributed. It is assumed from this fact that the outflows from the Delta (Sacramento River and Delta-Mendota Canal) will contain fish in numbers proportional to their volume of flow. The same concept applies to inflowing streams, and to the portions of those inflows which would ultimately be pumped. The San Joaquin River, due to its proximity to the Tracy Pumping Plant, assumes unusual importance in this regard, because, at times, the entire flow of this stream and all of its fish will be drawn to the pumps.

The points taken up above will be considered in detail under later discussions on king salmon, striped bass, and shad. Other fishes will be mentioned here, but not in relation to population dynamics and project operation.

The anadromous fishes collected in this study were the king salmon (Oncorhynchus tschawytscha), steelhead trout (Salmo gairdnerii), striped bass (Roccus saxatalis), shad (Alosa sapidissima), two species of smelt (Hypomesus olidus and Spirinchus thaleichthys), and the Pacific lamprey (Entosphenus tridentatus). Other anadromous fishes known to utilize or migrate through the Delta, but not observed in this study are the white sturgeon (Acipenser transmontanus) and green sturgeon (Acipenser acutirostris).

The resident fresh-water fishes collected incidental to the study were catfish (Ictalurus catus and Ameiurus natalis), largemouth bass (Micropterus salmoides), black crappie (Pomoxis nigro-maculatus), bluegill (Lepomis macrochirus), and warmouth bass (Chaenobryttus coronarius). Cyprinidae noted in the Delta were carp (Cyprinus carpio), splittail (Pogonichthys macrolepidotus), squawfish (Ptycocheilus grandis), sucker (Catostomus occidentalis), hardhead (Mylopharodon conocephalus), Sacramento blackfish (Orthodon microlepidotus), and hitch (Lavinia exilicauda). The fresh-water viviparous perch (Hysterocarpus traski) was frequently taken. The three-spined stickleback

(Gasterostous aculeatus) was common. Two species of sculpin, Cottus asper and Leptocottus armatus were taken in the vicinity of Antioch. Juvenile starry flounder (Platichthys stellatus) were also taken in the nets. Station 26 in the lower Sacramento River yielded a considerable number of anchovy (Engraulis mordax nanus), bay smelt (Atherinops affinis affinis), and herring (Clupea pallasii). Two kinds of gobies were taken, one species, Clevelandia ios, was captured frequently at stations 15, 16, and 26; only a single specimen of the other, Lepidogobius lepidus, was taken in the fyke net off Toland's Landing.

In order to demonstrate to what degree the king salmon, striped bass, and shad will be endangered, it is essential that each species be discussed separately. The ensuing discussions, tables, and graphs summarize the data collected and provide evidence relative to the jeopardy into which these fish will be placed by the operation of the Tracy Pumping Plant and the transfer of Sacramento River water to the San Joaquin Valley via the Delta Cross-Channel.

The charts are designed to facilitate a clear understanding of the seasonal occurrence, distribution, and abundance of juvenile king salmon, striped bass, and shad in the Sacramento-San Joaquin Delta. By the use of these charts the reader is enabled to recognize the initial occurrence, with subsequent movements and fluctuations in abundance as the season progresses, and he can associate this information with certain measured physical factors represented by bar diagrams on each cycle. All data on which these charts are based are presented in tabular form in the appendix.

The amount of information collected on the life history of the smelt (Hypomesus olidus) warrants inclusion in this report. The data collected for each station during the two seasons (1948-1949) are given in Appendix Tables 17, 18, and 19, but the data are not discussed.

King Salmon (Oncorhynchus tschawytscha)

Spawning migration

The distribution of king salmon within the Sacramento-San Joaquin Delta reflects movement of adults to their upstream spawning grounds and young salmon migrating to the ocean.

Adult king salmon returning to spawn in the streams of the Central Valley pass through the Delta in every month of the year; however, the majority of them move during two distinct migration periods. These periods occur in the spring and fall of the year and are spread over several months. The spring migration appears in February, reaches peak proportions in May and diminishes in June. The fall run of salmon usually makes its appearance in August, increases to its peak of abundance in September and declines by the end of October.

The migration pattern of the adults through Delta waters has not been determined by direct investigation. However, returns from marked salmon recoveries made at Paladini Fish Company in Pittsburg, California, have contributed some knowledge of the migration pattern of the Sacramento run of fall spawning salmon. In the fall of 1948, 44 adult salmon previously marked at the Coleman Salmon Hatchery as seaward migrants were recovered from the commercial catch landed at the Paladini Fish Company. Nine of the marked salmon were taken in gill nets drifted in the San Joaquin River below the mouth of the Mokelumne River. These recoveries indicate the possibility that 20 percent of the Sacramento River salmon may return to their spawning grounds via San Joaquin River and then through Three Mile or Georgiana Sloughs. The principal upstream route is via Sacramento River.

In 1949 price disagreements between the packers and the fishermen's union prevented duplication of the previous years inspection of salmon landings at the Paladini Fish Company for marked fish and further study of adult salmon movements through the Delta.

No evidence of the migration pattern of the San Joaquin River king salmon has been obtained. It is assumed that the principal upstream migration is via Old River since approximately two-thirds of the San Joaquin River flow is carried by it during the fall runoff.

Seaward Migration

Two separate studies of the seaward migration of king salmon from the Sacramento River drainage have been made in the past. Rutter (1902) made the first systematic study at Walnut Grove and Balls Ferry, January 7 to May 8, 1899. Hatton (1940) and Hatton and Clark (1942) of the California Division of Fish and Game conducted a survey during the years 1939, 1940, and 1941 at Hood, California. The present investigation began by using methods similar to those of Hatton.

The pattern of the downstream migration of Sacramento River king salmon in 1947 is best illustrated by the following summary of fyke net results obtained at Toland's Landing:

	1946	1947				
Month	December	January	February	March	April	May
No. of Salmon	19	2	207	319	87	2
Percent of Total	1.0	.3	33.0	51.0	13.8	.3
Mean Monthly Runoff c.f.s.	17100	12740	23390	30170	24220	10790

Although the annual runoff of Sacramento River in 1947 was 54 percent of the fifty-year normal, the peak flows occurred in their historical runoff pattern, and the downstream movement of the juvenile salmon migrants from the Sacramento drainage conformed with this flow pattern.

Limited studies in the San Joaquin Delta during 1947 yielded incomplete information as to the movements of the seaward migrants from the San Joaquin River drainage. The total number of young salmon recovered was small. However, the results showed that the most significant downstream movement occurred in May.

In 1948 seaward migration of king salmon from the Sacramento drainage was influenced by drought conditions prevailing in the area from mid-January through the middle of March. An initial movement of downstream migrants to the delta in early January was noted from fyke net results. This influx diminished with the river runoff so that by January 23rd. no salmon were observable. Increasing water flows resulting from late March rains flushed the young salmon from the upper streams so that by the end of that month the seasonal peak of abundance was reached. The numbers and monthly percentages of king salmon migrants sampled by fyke net at Isleton during the 1948 downstream movement are summarized below:

	1948				
Month	January	February	March	April	May
No. of Salmon	29	0	721	262	4
Percent of Total	2.8		70.9	25.8	.4
Mean Monthly Runoff c.f.s.	23700	13000	19100	51780	52320

Studies by Rutter and Hatton of the seaward movement of young salmon were limited to the periphery of the Delta and up-river locations. Knowledge of the salmon dispersal in the Delta was fragmentary, although Hatton did observe salmon movements near Martinez. One of the objectives of the present investigation was to determine the migratory habits of the salmon within the Delta. To this end tow-netting operations at the twenty-five stations established in the Delta began on April 9, 1948.

Delay in the start of tow-netting prevented observation of the initial pattern of dispersion of the young salmon from the Sacramento River into the Delta. A total of 1,194 salmon migrants was captured in towing operations from April 9 to August 3, 1948, and all individuals were measured. Data collected for each station during the season are given in Appendix Table 5, and are further summarized in Appendix Table 1. The catch data for 1948 are shown graphically in Figure 3, which illustrates the distribution of king salmon migrants in the Sacramento-San Joaquin Delta as determined from tow-netting results.

Although a major segment of the young salmon moved down the Sacramento River toward the bay, a significant proportion was diverted via Georgiana Slough into the central San Joaquin Delta. There is evidence of further transfer of migrants by tidal action to the San Joaquin Delta through Three Mile Slough and Sherman Lake. The proportion of salmon migrants is assumed to be in direct relation to the amount of Sacramento water transferred to the Delta. Some of the diverted fish moved seaward down the San Joaquin River while others were dispersed further into the central Delta waters. Contrary previons to opinions, Sacramento River salmon remained in the San Joaquin Delta for a period of time. Young salmon of Sacramento River origin were taken on successive towing cycles at station 13 in the San Joaquin River, Station 6 in Old River and station 10 in Middle River (Fig. 2). This distribution of the Sacramento and possibly Mokelumne River salmon migrants within the Delta was due to circulation of Sacramento water into the San Joaquin Delta by flow and tidal action.

Salmon migrants from the San Joaquin River were noted in the first towing cycle, April 9-16, above and below the bifurcation of the San Joaquin and Middle Rivers (Fig. 3). Absence of young salmon in the Delta channels between station 8 in Middle River and station 6 in Old River separated the two groups. The mean lengths of station samples of Sacramento salmon (stations 6, 7, and 13-25,) ranged from 38-69mm (1.5 to 2.7 inches), and corresponding mean lengths of San Joaquin fish (stations 1, 2, 3, 5, 8, 11, and 12), ranged from 69-84mm (2.7 to 3.3 inches) during the first and second cycles and salmon from each source were separable by this difference (Appendix Table 5). Intermingling of the two groups of salmon was inevitable, and by the end of the third cycle it was impossible to differentiate the two groups of fish since a size group of Sacramento River salmon corresponding in size to the San Joaquin fish had also entered the Delta. Representative samples of young salmon were taken at all stations as the season advanced, with the largest catches continuing from the Sacramento Delta and the western and central San Joaquin Delta. The diversion of Sacramento salmon via Georgiana Slough, and their dispersal within the central San Joaquin Delta continued to be reflected in the tow-net catches from this area.

The seaward movement of young salmon migrants from the San Joaquin River system did not reach expected proportions during the year of 1948. Drought conditions in the San Joaquin Valley were severe, and practically prohibited the escapement of immature salmon from San Joaquin River and its tributaries, which are still considered good salmon spawning grounds. At no time during the migration period did the number of salmon migrants caught in the southern San Joaquin Delta equal or even approach the number caught in the Sacramento and the western and central parts of the Delta. The juvenile salmon entering the Delta from San Joaquin River were dispersed principally via Middle River to Salmon Slough, Grant Line Canal, and then down Old River. The progress of San Joaquin salmon through the Delta was slow. By the end of June the last salmon migrants from the two main river sources had apparently entered the Delta. The seaward movement of young salmon from the Delta extended through July, but negative catches in August indicated that they had left the Delta waters.

Figure 3 - Distribution of king salmon seaward migrants in the Sacramento-San Joaquin Delta, 1948. The area of each circle is proportional to the calculated number of specimens at each station. The hydrodynamics for each cycle are included, showing delta inflows in cubic feet per second, maximum and minimum temperatures in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand, and turbidity in inches with Secchi disc.

UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LEGEND
KING SALMON
TOWING CYCLE 1
SCALE 10,000 FISH =
TOWING CYCLE 2
TOWING CYCLE 3
TOWING CYCLE 4
TOWING CYCLE 5
TOWING CYCLE 6
TOWING CYCLE 7
TOWING CYCLE 8
TOWING CYCLE 10
TOWING CYCLE 11
TOWING CYCLE 12
WALNUT GROVE
ANTIOCH
STOCKTON
PUMPING PLANT
SCALE OF MILES

Operations in the Sacramento-San Joaquin Delta were accelerated in 1949 when tow-netting began on January 25th. During the period of downstream migration, February 22 to July 22, a total of 3,410 salmon were taken in tow-net catches and a random sample of 2,978 individuals were measured for length. Data collected for each station during the season are given in Appendix Table 6 and are further summarized in Appendix Table 2. Distribution of the king salmon migrants in the Delta as determined from the tow-net operations is illustrated graphically in Fig. 4.

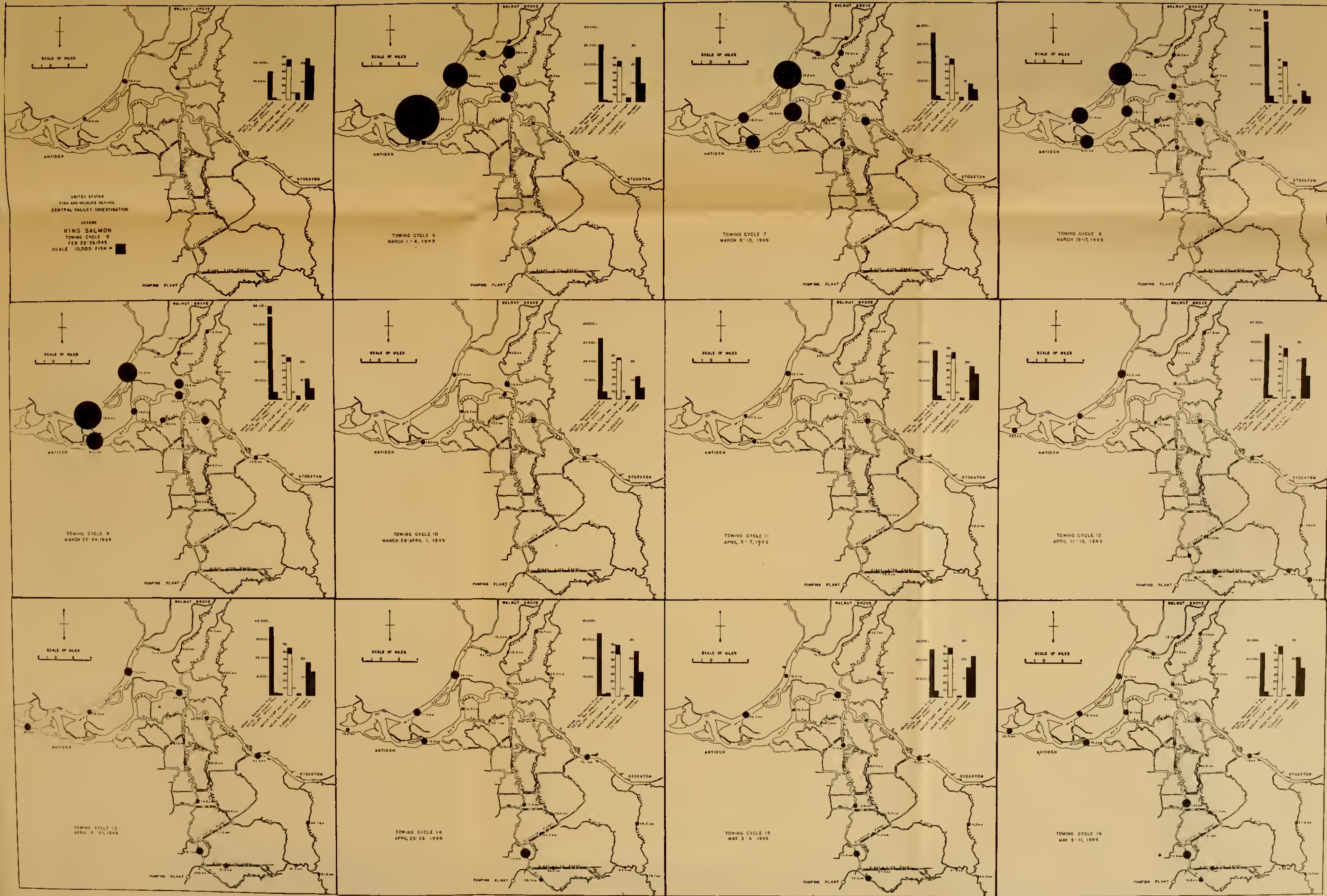
The first four weeks of tow-net sampling failed to show the presence of king salmon seaward migrants in the Delta. Initial appearance of Sacramento River salmon migrants was observed in the fifth towing cycle with specimens taken February 23rd. in the lower Mokelumne River, station 20, and Georgiana Slough, station 21. The following day, February 24th, several salmon migrants were taken in Sacramento River, stations 22, 24, and 25.

The appearance of young salmon in the Delta prompted several exploratory tows during the fifth cycle to observe the rate of downstream movement of the Sacramento migrants through the Delta. These exploratory tows revealed a steady but light migration of young salmon down Sacramento River and the transfer of some migrants to the San Joaquin River through Three Mile Slough. The first evidence of Sacramento River salmon entering San Joaquin River from Georgiana Slough was observed February 28th. at station 14.

The peak of seaward salmon migration from Sacramento River sources reached the Delta during the sixth towing cycle, March 1-4, 1949 (Fig. 4). This peak of abundance coincided with an increase in Sacramento River runoff which doubled over the previous week's mean flow of 15,600 second feet. The major portion of the seaward escapement was down Sacramento River with a proportionate diversion down Georgiana Slough. By the end of the sixth cycle some scattering of the young salmon was observed in central Delta waters.

Although the Sacramento River runoff was increasing, a decline in the number of salmon migrants entering the Delta occurred during the 7th. towing cycle, March 8-10, 1949. The Sacramento River salmon migrants were becoming well distributed throughout the central part of the Delta and some seaward movement of these fish was evident down the San Joaquin River. Dispersion of immature Sacramento River salmon toward the southern part of the Delta was noted, with recoveries of individuals from San Joaquin River at station 13, and Old River at station 6. Succeeding towing cycles (8 and 9) showed that the major segment of the Sacramento River salmon population had entered the Delta and escaped seaward by the end of March, principally down Sacramento River. A number of the juvenile salmon diverted via Georgiana Slough into the central Delta had penetrated up the San Joaquin Delta as far as the Borden Highway Bridge at Middle River, station 9, and the Santa Fe Railway Bridge at Old River, station 5.

Figure 4 - Distribution of king salmon seaward migrants in the Sacramento-San Joaquin Delta, 1949. The area of each circle is proportional to the calculated number of specimens at each station. The hydrodynamics for each cycle are included, showing delta inflows in cubic feet per second, maximum and minimum temperatures in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand, and turbidity in inches with Secchi disc.



UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LEGEND
KING SALMON
TOWING CYCLE 5
FEB 22-25,1949
SCALE 10,000 FISH =
WALNUT GROVE
ANTIOCH
STOCKTON
PUMPING PLANT
SCALE OF MILES
TOWING CYCLE 6
MARCH 1-4, 1949
TOWING CYCLE 7
MARCH 8-10, 1949
TOWING CYCLE 8
MARCH 15-17, 1949
TOWING CYCLE 9
MARCH 22-24, 1949
TOWING CYCLE 10
MARCH 28-APRIL 1, 1949
TOWING CYCLE 11
APRIL 5-7, 1949
TOWING CYCLE 12
APRIL 11-15, 1949
TOWING CYCLE 13
APRIL 18-21, 1949
TOWING CYCLE 14
APRIL 25-28 1949
TOWING CYCLE 15
MAY 3-6 1949
TOWING CYCLE 16
MAY 9-11, 1949

A rapid decline in the downstream escapement of Sacramento River salmon in cycles 10 and 11 accompanied a decrease in Sacramento flows. A sudden rise in Sacramento River flows in the 12th towing cycle was followed by an increase in the downstream movement of fish from that source. Juvenile salmon from the Sacramento River drainage continued to enter the Delta until June 9, 1949 (Cycle 20) with a proportionate number of individuals moving down Georgiana Slough. No further record of regular downstream movement was noted from the stations in the upper Sacramento River and Georgiana Slough, indicating completion of seaward migration from that source.

The average lengths of the station samples of Sacramento migrants from the beginning of towing through the peak period of abundance, ending with the 9th cycle, was 35-45 mm (1.4-1.7 inches). A gradual increase in growth continued until the 12th cycle, April 11, when migrants of a larger size-class began appearing in the samples. By the last week of April, 14th cycle, the majority of station samples of Sacramento salmon were 50-70 mm (2-2.7 inches). From the beginning of May to the end of the seaward migration, Sacramento migrants averaged 70-90 mm (2.7-3.5 inches).

Six weeks after the initial arrival of Sacramento River seaward migrants in the Delta, those from the San Joaquin River drainage began entering the southern Delta waters. Specimens were recovered at stations 2, 8, and 12 in the 11th cycle (Fig. 4). Their time of arrival was approximately the same as in the previous year and consisted of fingerlings ranging from 2.5 to 3.0 inches in mean length. The appearance of the San Joaquin River migrants reflected a spontaneous seaward movement, inasmuch as it was not influenced by increasing river runoff. Quite to the contrary, the San Joaquin River flow was receding and continued to do so for the succeeding three cycles. Significant numbers of salmon migrants were taken in the southern Delta stations in the ensuing nine cycles, to indicate a comparatively greater escapement than that of the previous year (Appendix Table 6). Throughout the season, stations in channels converging on the approach canal of the Tracy Pumping Plant yielded the largest catches (Fig. 4). One catch of 119 salmon fingerling averaging 71.4 mm (2.8 inches) was made in a standard tow from station 3 during the 14th cycle. Continuous migration from the San Joaquin River was evident through the 22nd cycle, June 20-23, 1949. Thereafter, only an occasional individual was recovered in the southern Delta channels. During the 25th and 26th cycles, water temperatures in the southern Delta reached a maximum of 80 degrees Fahrenheit.

One role of water temperatures in controlling the movements of immature salmon in the Delta is suggested by information presented in Fig. 9, which features a graphic summary of tow-net catches, together with a temperature curve based on five Delta stations. It is seen that after the mean daily water temperatures surpassed 75 degrees in 1948

(July 15), salmon soon disappeared from tow-net catches. In 1949, although 75 degrees was reached in the middle of June, the temperature dropped immediately, and July 10 is taken as the reference. Again salmon disappeared very shortly from the catches. This suggests that water temperatures are an important factor in regulating the exodus of salmon from the Delta; and that once an upper temperature limit is reached, movement seaward is rapid.

Discussion

The association of seaward migration of immature king salmon migrants with flood flows is historical in its annual recurrence and has been demonstrated in the past and present studies of the early life history of salmon in Sacramento and San Joaquin Rivers. During the course of this investigation the initial appearance of salmon fry from Sacramento River sources was observed at the time of the seasonal increase in runoff. Rutter (1902), Hatton (1940), and Hatton and Clark (1942) obtained similar results in their studies. This phenomenon was also observed by Hatton in the San Joaquin drainage during years of normal rainfall and prior to storage of runoff waters at Friant Reservior. Sub-normal water supplies in California's Central Valley during the period of this study affected downstream migration of juvenile salmon from the two principal sources, particularly in the San Joaquin drainage. The escapement from the Sacramento River drainage was least affected, since the runoff, although less in each of the three years than the fifty-year normal, still consisted of much uncontrolled water flowing in its historical pattern. Several factors altered the downstream escapement of salmon migrants from the San Joaquin drainage. The principal one was the storing of San Joaquin waters behind Friant Dam (Millerton Lake), thereby limiting runoff. Severe drought conditions in the San Joaquin Valley further affected the seaward migration and high water temperatures were undoubtedly effective in restricting downstream movement.

Upon reaching the peripheral limits of the Delta, the Sacramento migrants were apportioned with the runoff into its diverging channels. The migrants dispersed down the main stem of the river and the three sloughs off the river, Sutter, Steamboat, and Georgiana. Georgiana Slough is of particular importance because it is the chief connecting channel through which Sacramento water and migrants flow into the San Joaquin part of the Delta. The main body of the Sacramento River migration entering the Delta moves more or less directly seaward with a significant segment diverting into the San Joaquin Delta. This investigation has demonstrated that upon entering the San Joaquin Delta with its larger tidal basin the transferred migrants tend to remain within it for a period of time and a proportionate number disperse throughout the Delta with the Sacramento River water (see Figs. 3 and 4).

KING SALMON
TOWING CYCLE 17
SCALE 10,000 FISH =
TOWING CYCLE 18
MAY 24 - 26 1949
TOWING CYCLE 19
TOWING CYCLE 20
TOWING CYCLE 21
TOWING CYCLE 22
TOWING CYCLE 23
TOWING CYCLE 24
WALNUT GROVE
STOCKTON
ANTIOCH
PUMPING PLANT
SCALE OF MILES

This condition will be magnified when the water-use projects under construction, namely the Tracy Pumping Plant and the Delta Cross-Channel, are placed in operation and start drawing Sacramento water to the pumps. In addition to the Sacramento water schedule for Delta-Mendota demands, additional inflow will be required for consumption and salinity control. Based on the ultimate requirements with the Delta-Mendota pumping plant taking of 4,600 second feet, salinity control of 2,700 and San Joaquin Delta consumption of 2,700, a total of 10,000 second feet of Sacramento water will be transferred into the San Joaquin Delta. Three Mile Slough, connecting lower Sacramento River with San Joaquin River, delivers an additional net tidal flow of 950 second feet from the Sacramento to the San Joaquin Delta (California Division of Water Resources, Bulletin No. 27). This varies however, depending on the character of the tide. During the period of seaward migration of Sacramento River salmon, a proportionate number are transferred with the net flow through Three Mile Slough to the San Joaquin Delta. Samples of Sacramento migrants taken in Three Mile Slough and station 16, before migrants from Georgiana Slough had entered the central Delta, indicated the movement of salmon through this slough to the San Joaquin Delta.

The seasonal movement of juvenile Sacramento River salmon into the San Joaquin Delta and toward the Tracy Pumping Plant can be expected to be proportional to the amount of Sacramento River water transferred for project operation.

The position of the San Joaquin River salmon migrants with reference to the division of the river flows within the Delta and the Tracy Pumping Plant is extremely important. The initial division of the San Joaquin River into Delta channels occurs at the bifurcation from Middle River, with the major flow down Middle River. According to Bureau of Reclamation determinations of flow ratings of San Joaquin River at Brandt Bridge against the flow at Vernalis (USBR Delta District Hydrography Report, Volume No. II, 1947), the proportion of flow into Middle River is about two-thirds to three-fifths of recorded runoff of 2,500 to 5,000 second feet at Vernalis, Further division of flow occurs where Old River separates from Middle River, the major portion flowing down Old River channels, consisting of Salmon Slough, Grant Line and Fabian Bell Canals and Old River. Middle River, at its bifurcation from Old River, takes only a limited quantity of water (less than 100 second feet when the recorded flow at Vernalis is 3000 c.f.s.). The Old River channels converge within a half-mile of the approach canal of the Tracy Pumping Plant.

It has been demonstrated by the present investigation that the downstream migration of San Joaquin salmon through the Delta was principally via the channels coverging on the Tracy Pumping Plant (Tables 5 and 6, Figs 3 and 4). With the project in operation under the present conditions, it has been determined by the U. S. Bureau of Reclamation that the entire discharge of the San Joaquin River would flow into the pumping plant (USBR Hydraulic Laboratory Report No. 145). If the entire flow of the San Joaquin River can be expected to flow into the pumping plant, it is reasonable to state that all seaward migrating fish from the San Joaquin River will be endangered by the pumping plant operations.

Striped Bass (Roccus saxatalis)

In determining the status of striped bass in the Sacramento-San Joaquin Delta, the Fish and Wildlife Service has been concerned chiefly with the breeding distribution and early life stages of the juvenile bass in Delta waters in relation to the Tracy Pumping Plant and the Delta Cross-Channel. No direct sampling of the adult population was attempted in this study.

Observations of immature striped bass during the first year and a half, August 20, 1946 through December, 1947, were dependent on fyke net operations. The results showed trends in the abundance and rate of growth of the juvenile bass in the areas where the nets were fished. The San Joaquin River fyke net located below Antioch Bridge was fished continuously for three and a fraction years.

A late start in fyke-net sampling in 1946 obviated any analysis of trends for that year. In 1947 the fyke net was fished continuously through the year. The initial appearance of juvenile bass was in the last week of May. The period of peak abundance occurred during June 23-27, when 17 bass per hour were taken, averaging 32.8 mm (1.3 inches) in length. During 1948 and 1949 the fyke-net sampling continued as a supplement to the tow-net operations. The first significant fyke-net catch in 1948 was made June 16-30, followed by a period of peak abundance on July 25 to August 4, when 12.4 fish per hour were captured, averaging 31.4 mm in length (1.2 inches). In 1949 the initial fyke net catch of juveniles was made June 2-10, with the period of peak abundance occurring from June 29 to July 8 when 24.2 fish per hour were taken. These fish averaged 32.4 mm in length (1.3 inches). Thus 1949 was the best year of striped bass production in the Delta during the period 1947 to 1949.

The introduction in 1948 of tow-net sampling at selected stations located throughout the Delta provided a quantative method of determining abundance and dispersion of striped bass eggs, larvae and post-larval juveniles.

In 1948 sampling for striped bass eggs and larvae was limited to standard surface plankton net hauls of five and ten minutes duration. Tables 7 and 8 give a summary of the bass eggs and larvae taken in the plankton hauls. The spawning distribution of adult striped bass in the Sacramento-San Joaquin Delta is reflected indirectly by the plankton net catches of eggs at the twenty-five stations. The first collection of eggs, a small one, was made in San Joaquin River near Antioch on April 30th. Delta water temperatures ranged from 55 degrees to 65 degrees Fahrenheit at that time. Significant catches of bass eggs were first made May 5th (cycle 3) in San Joaquin River near Mossdale and below the bifurcation of San Joaquin River, and Middle River, stations 8, 11, and 12. Samples of eggs were taken from this area until May 28th (cycle 6), establishing the fact that San Joaquin River above the Delta is a breeding area of considerable importance. Spawning activity spread into the central portion of the Delta during cycles 4 and 5, with a considerable number of bass eggs taken in Middle River at station 10, and in Old River at stations 3 and 5. Stations 15, 16 and 17 in the central and western portions of the Delta were most productive in eggs yields from the 4th through the 8th towing cycle (May 4 to June 16). Spawning continued sporadically to the end of June. Evidence of striped bass breeding in Sacramento River was observed June 14th and 15th when several eggs were recovered in the river at Isleton and in Georgiana Slough. These eggs were probably flushed downstream from spawning areas in Sacramento River above the Delta (Calhoun, 1948). No further recoveries of eggs were made in Sacramento River, although stations were sampled regularly each towing cycle.

Plankton-net catches of larval specimens of striped bass were insignificant throughout the season and were limited to cycles 8 and 9 (Table 8). No deep hauls were made with the plankton net in 1948; thus, our information on striped bass larva distribution is incomplete for that year.

The initial catches of striped bass in the post-larval stages of development were made with the five-foot tow-net at eleven of the twenty-five stations in the 10th towing cycle, July 2-12, 1948. The appearance of young fry in the large net was abrupt, with significant numbers taken at several stations in the western and central portions of the Delta. Successive towing cycles yielded increasing numbers of juvenile bass at additional stations. During the season a total of 8,071 striped bass were captured with the large tow-net and a random sample of 5,306 individuals were measured. Data collected for each station are given in Appendix Table 9, and are further summarized in Appendix Table 2. Distribution of young striped bass in the Delta as determined from tow-net sampling is illustrated graphically in Figure 5.

The largest concentrations of juvenile bass were at stations in the western part of the Delta, which includes San Joaquin River from the mouth of Old River to Antioch, and Sacramento River below Rio-Vista. Juvenile bass were not taken in stations in Sacramento River between Rio Vista and Walnut Grove. The peak of abundance and the most extensive pattern of dispersion occurred in the 13th cycle,

Figure 5 - Distribution of striped bass (1948 year-class) in the Sacramento-San Joaquin Delta, 1948. The area of each circle is proportional to the calculated number of specimens at each station. The hydrodynamics for each cycle are included showing delta inflows in cubic feet per second, maximum and minimum temperatures in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand, and turbidity in inches with Secchi disc.


UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LEGEND
STRIPED BASS
TOWING CYCLE 10
JULY 2-12, 1948
SCALE 10,000 FISH =
TOWING CYCLE 11
JULY 12-20, 1948
TOWING CYCLE 12
JULY 20-AUG 3, 1948
TOWING CYCLE 13
AUGUST 4 - 17, 1948
TOWING CYCLE 14
AUGUST 18-25, 1948
TOWING CYCLE 15
SEPT 6 - 16, 1948
TOWING CYCLE 16
SEPT 21-29, 1948
WALNUT GROVE
ANTIOCH
STOCKTON
PUMPING PLANT
SCALE OF MILES

August 4-17, 1948. Stations in the southern Delta in the vicinity of the Tracy Pumping Plant yielded representative samples of striped bass through the 14th cycle. The diminishing catches of striped bass in the tows from the 14th cycle to the 17th cycle were probably due to the movement toward the lower bay, mortality, ability of the young to escape the tow-nets as they increased in size, and adaptation of adult characteristics of schooling and feeding nearer the bottom.

Weekly coverage of established stations in 1949 proved to be an improved means of sampling striped bass and gave a better relative measure of distribution of bass eggs, larvae, and juveniles in the Sacramento-San Joaquin Delta, than in 1948.

Results of sampling for striped bass eggs in 1949 are summarized in Appendix Table 11. This sampling generally consisted of three plankton-net hauls of five minutes duration at each station. Two surface tows were made, one at the beginning of the station and the second at the end of the station. The five-minute deep tow was usually made at the terminus of the station at a depth of 13-14 feet. Several stations in the southern Delta channels were too shallow to risk the loss of the net, so sampling was limited to the two surface hauls.

The first evidence of striped bass spawning was observed in San Joaquin River near Mossdale, station 11, in the 11th cycle (April 5-7, 1949), when two eggs were recovered. By the end of the next cycle (April 11-15, 1949) spawning activity was occurring in several scattered locations in the San Joaquin Delta. Significant catches of bass eggs were made in the southern part of the Delta through the major period of the spawning season. Increasing numbers of eggs were caught in successive towing cycles, with new stations added to the growing list. The peak period of spawning activity extended from the last week in April to the middle of May.

Observed water temperatures ranged from 57 degrees to 65 degrees Fahrenheit at the start of the spawning (April 5-7, 1949), and generally were above 60 degrees at the stations where eggs were taken. At the close of the spawning season (June 15-17, 1949) water temperatures in the Delta ranged from 69 degrees to 78 degrees Fahrenheit.

Assuming that the number of eggs recovered from week to week in the San Joaquin Delta is an index of spawning intensity, it is evident that the initial spawning was heaviest in the southern and central portion of the Delta, with a gradual shift to the western or lower San Joaquin River portion. Very few eggs were taken at stations located in Sacramento and Mokelumne Rivers. As in 1948, the most productive area was San Joaquin River from the mouth of Old River to Antioch. This concentration of eggs in the lower section of San Joaquin River was probably due to the eggs drifting with the net outflow of water, particularly with respect to the eggs recovered on station 17. Station 17 was apparently the lower limit of the outward drift of eggs. This was evident from the small number of eggs recovered from station 26, which was downstream from station 17.

The results of sampling in 1949 for striped bass larvae are given in Appendix Table 12. Sampling for larvae was carried on jointly with that of egg collecting. The first striped bass larvae were taken in plankton hauls during cycle 13 (April 18-21, 1949) at stations 4, 7, and 16. From then on the catches increased each week with a peak yield in cycle 20 (June 6-9, 1949) when larvae were taken at 11 of the 26 stations. A larger total catch was recovered in cycle 16 but was represented almost entirely from stations 16 and 17. The recovery of larval bass diminished in numbers as the season progressed, with the last larvae taken in the 23rd. cycle (June 27-30, 1949) at station 15.

Significant numbers of striped bass larvae were taken at stations located in Sacramento River from Isleton to Toland's Landing, in Georgiana Slough, and in Mokelumne River below the mouth of Georgiana Slough. The catches of larvae in Sacramento River were first made in the 18th towing cycle (May 23-26, 1949). This was a month later than the appearance of larvae in the San Joaquin Delta. The larvae captured in Sacramento River represented the production from spawning activity occuring in Sacramento River and tributaries north of the city of Sacramento (Calhoun, 1948).

Representative catches of striped bass larvae were recovered from station 26, located off Chipps Island, from May 9 through June 23, 1949. These larvae were of both Sacramento and San Joaquin River origin. Samples of striped bass larvae from the southern part of the Delta between Mossdale and the Tracy Pumping Plant were few in comparison to the eggs taken. Two factors may account for the small number of larvae recovered from this area: (1) the drift of the eggs and larvae from the area with the net outflow of water and (2) possible high rate of mortality.

The seasonal catch of striped bass larvae expressed in terms of a standard volume of water strained was derived for each station (see Appendix Table 14). A graphic composite illustrating the relative abundance and dispersion of striped bass larvae from April 18 to July 1, 1949, is shown in Fig. 6. A comparison of this chart with that of the egg chart shows the dispersion of the larvae in a pattern considerably different from that of the eggs, with the exception of San Joaquin River between the mouth of Old River and Antioch.

The lack of larvae in the southern part of the Delta is demonstrated very clearly and indicates that the net outflow of water in 1949 probably was one of the causes of the dispersion pattern exhibited by the larvae. The positive action of Sacramento River flows in flushing the larvae from the upriver spawning areas is obvious from the number of larvae present in Sacramento River below Walnut Grove.

Juvenile bass were sampled for fourteen consecutive weekly cycles, terminating with the 33rd cycle, September 20-22, 1949. A total of 20,242 juvenile striped bass were collected with a five-foot tow net and a random sample of 9,619 individuals was measured to observe the seasonal rate of growth. The data collected from the twenty-six stations are presented in Appendix Table 13, and are further summarized in Appendix Table 2. The weekly distribution of the young bass and their relative density as determined from tow-net hauls is illustrated graphically in Fig. 7.

Initial catches of post-larval striped bass were made in the 20th cycle (June 6-9, 1949) at several stations in the western part of the Delta. The average size of the young fry taken in this cycle was 13.1 mm (0.5 inch). An increasing number of stations yielded juvenile bass in the succeeding cycles. During cycles 20-24 (June 6-30, 1949) the principal catches were made in the lower Delta, particularly station 17, 25, and 26. The number of young bass captured in the central Delta area and San Joaquin River above Antioch began to increase in the succeeding cycles. Many of the stations produced 300 to 700 individuals in a standard tow, indicating the enormous population of juvenile striped bass present in the Delta during July. The peak period of abundance occurred during the 26th cycle (July 19-22, 1949). The length of individuals measured during this cycle averaged 37.7 mm (1.4 inch). Following the cycle of peak abundance, there was a rapid decline in the number of juveniles collected, particularly in the central and southern Delta. Coupled with diminishing returns in the central section of the Delta, was the apparent increase in catch in San Joaquin River at Antioch, and Sacramento River off Chipps Island. This increase in the lower river sections indicates a downstream movement toward the lower bay area. By the end of the season, tow-net samples of juvenile bass were limited to the lower Delta channels, with an occasional individual recovered in the southern and central Delta.

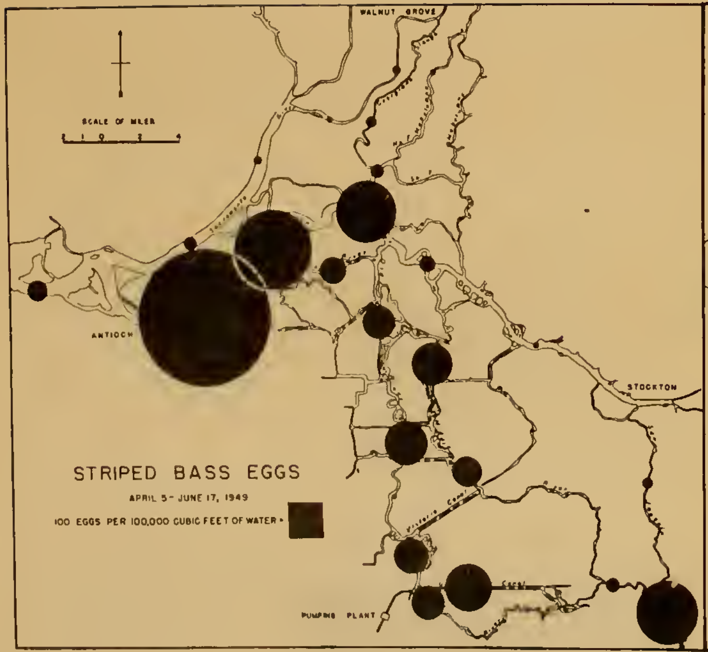
With the results available from two consecutive years of sampling striped bass eggs, larvae, and juveniles at the established stations in the Sacramento-San Joaquin Delta, certain facts concerning spawning, distribution, and movements become apparent.

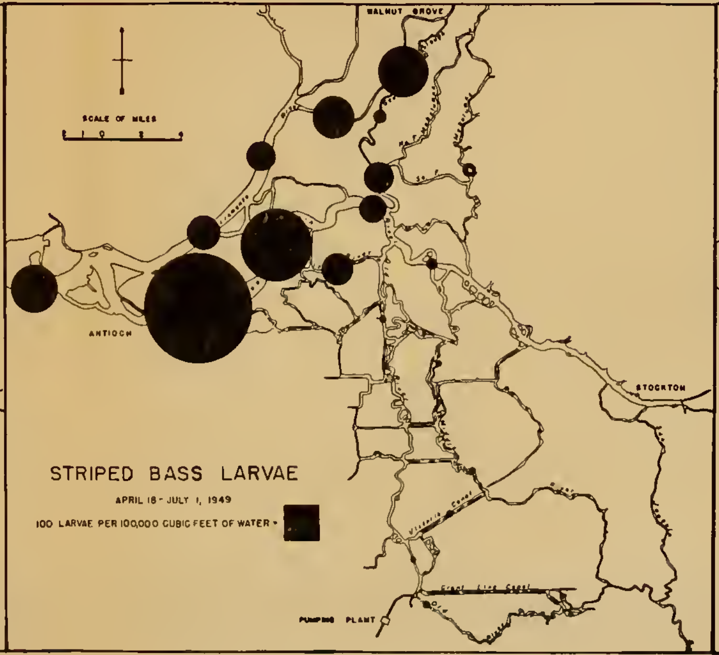
The relative importance of the areas within the Sacramento-San Joaquin Delta as striped bass spawning waters was determined during 1948 and 1949. Although in 1948, frequency in sampling did not approach that of 1949, the egg distribution was essentially the same. The time and extent of the spawning seasons varied and was dependent upon favorable water temperatures. Water temperatures of 60 degrees, Fahrenheit and higher were normally encountered where eggs were taken. The spawning season in 1948 extended from the first of May to the end of June, and in 1949 the spawning began the first of April and ended about the middle of June.

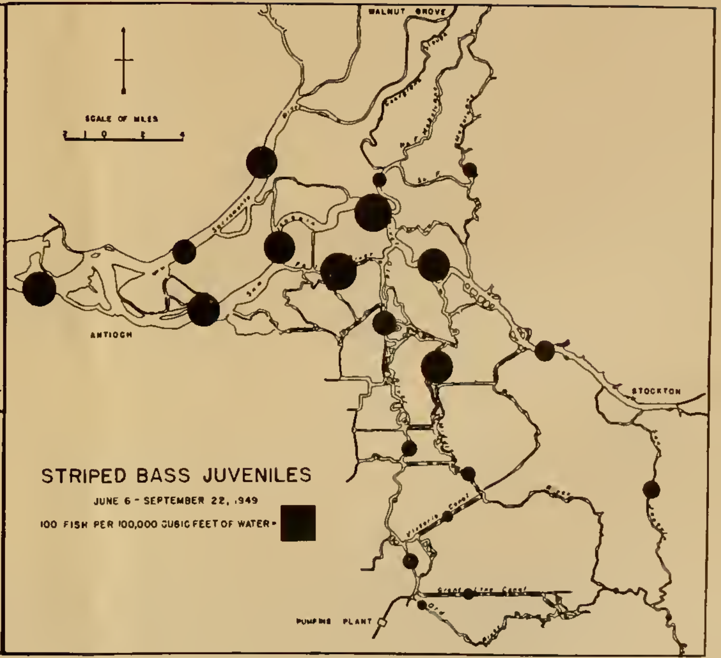
Figure 6 - Seasonal catch of striped bass eggs, larvae and juveniles expressed in terms of a standard volume of water strained (100 per 100,000 cubic feet of water), 1949.

UNITED STATES FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION

CATCH OF STRIPED BASS EGGS, LARVAE AND JUVENILES EXPRESSED IN TERMS OF A STANDARD VOLUME OF WATER STRAINED







The largest concentration of eggs occurred in San Joaquin River from Antioch to the mouth of Old River. Next in importance were Old River and Middle River, which will be the two principal channels carrying transferred Sacramento water to the Tracy Pumping Plant. San Joaquin River in the vicinity of Mossdale was also found to be a spawning area of significant importance. Very few eggs were taken during either year from the Mokelumne River area and Sacramento River downstream from Walnut Grove. In 1947 and 1948 Calhoun (1948) recovered considerable numbers of eggs in Sacramento and Feather Rivers and at their confluence, establishing them as spawning grounds of importance.

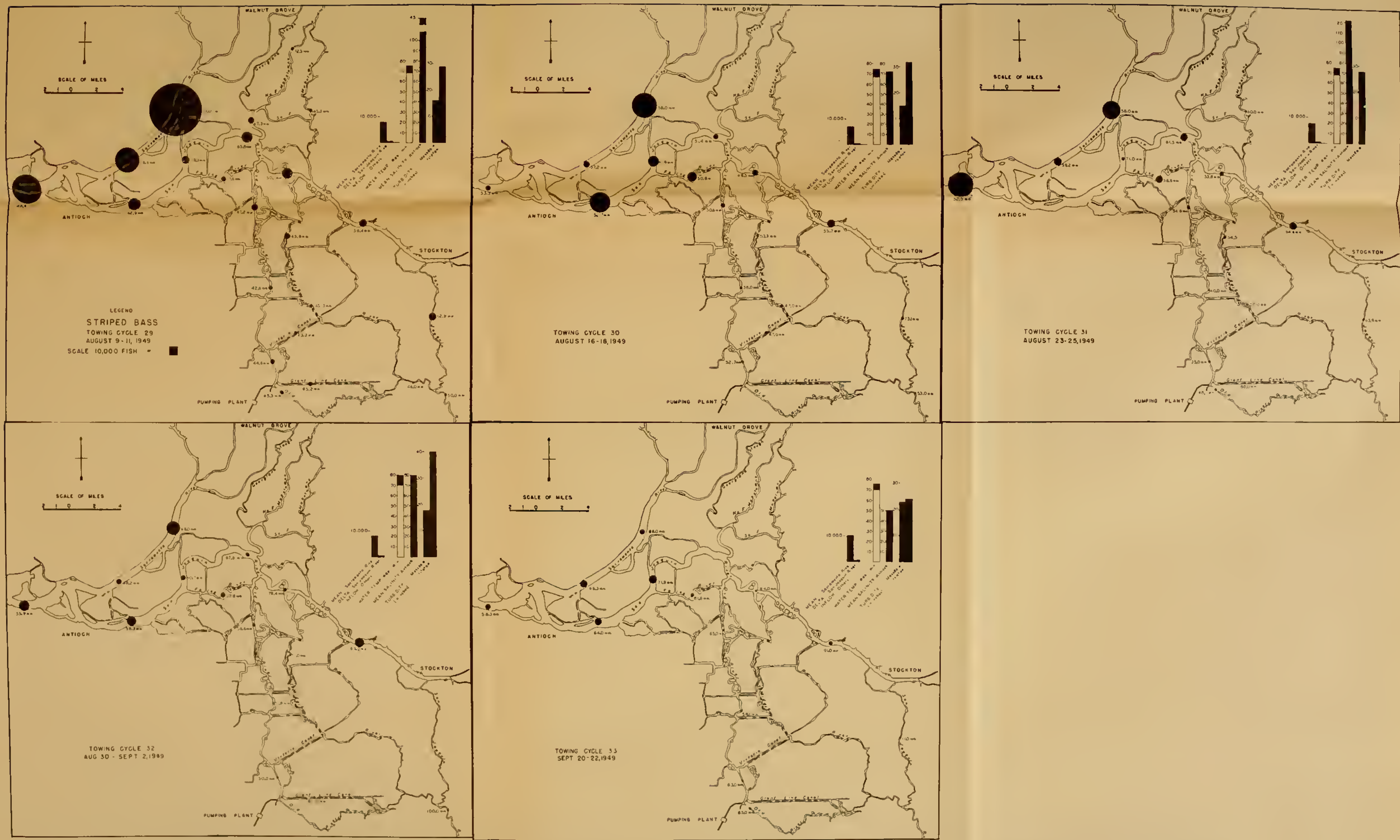
The area of densest larval bass concentration was in San Joaquin River between Three Mile Slough and Antioch. False River and San Joaquin River below the mouth of Mokelumne River yielded representative samples of larvae. Significant numbers of larval bass were taken from Sacramento River downstream from Walnut Grove, confirming the importance of the upper river spawning grounds. Comparatively small numbers of larvae were taken in the southern Delta regions.

Sufficient information has been collected to emphasize the importance of the several Delta areas as nursery grounds for juvenile striped bass. The distribution of young bass was general in the western and central sections of the Delta by the middle of July in 1949; the importance of these regions, including Old River and Middle River upstream to the Santa Fe Bridge, is revealed by the abundance of juvenile striped bass collected in those areas. The southern Delta region, which is a spawning ground of importance, did not approach the areas mentioned above in numbers of juveniles present; however, young bass were present in sufficient numbers to indicate that it was also a nursery ground of consequence.

Water temperature appears to have exerted a very important influence both in determining the time of spawning and the rate of development of larval and post-larval striped bass in the Delta. Spawning activity as reflected by collections of eggs was seen to have been related to water temperatures of 58 degrees and higher, with peak spawning occurring when temperatures ranged between 60 degrees and 67 degrees. The influence of warmer waters in speeding the growth of larval and juvenile bass can be seen by reference to Fig. 10, which brings out some differences between 1948 and 1949 populations. The spring water temperature changes of 1949 were about four weeks earlier than those of 1948. The date on which average Delta water temperatures attained 65 degrees in 1948 was June 19; in 1949 this occurred on May 23. The first appearance of juvenile bass in tow-net collections in 1948 was near July 2, approximately two weeks following the rise of water temperature above 65 degrees. In 1949, juveniles were taken on June 6, also two weeks after temperatures reached 65 degrees in that year. This suggests that water temperatures have determined to a great extent the time of spawning and the speed of development of immature bass in the Delta.

Figure 7 - Distribution of striped bass (1949 year-class) in the Sacramento-San Joaquin Delta, 1949. The area of each circle is proportional to the calculated number of specimens at each station. The hydrodynamics for each cycle is included, showing delta inflows in cubic feet per second, maximum and minimum temperatures in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand, and turbidity in inches with Secchi disc.

UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LEGEND
STRIPED BASS
TOWING CYCLE 20
JUNE 6 - 9, 1949
SCALE: 10,000 FISH =
SCALE OF MILES
WALNUT GROVE
ANTIOCH
STOCKTON
PUMPING PLANT
TOWING CYCLE 21
JUNE 15 - 17, 1949
TOWING CYCLE 22
JUNE 20 - 23, 1949
TOWING CYCLE 23
JUNE 27 - 30, 1949
TOWING CYCLE 24
JULY 5 - 8, 1949
TOWING CYCLE 25
JULY 11 - 14, 1949
TOWING CYCLE 26
JULY 19 - 22, 1949
TOWING CYCLE 27
JULY 26 - 29, 1949
TOWING CYCLE 28
AUGUST 2 - 4, 1949


WALNUT GROVE
SCALE OF MILES
ANTIOCH
STOCKTON
PUMPING PLANT
Grant Line Canal
LEGEND
STRIPED BASS
TOWING CYCLE 29
AUGUST 9-11, 1949
SCALE 10,000 FISH =
TOWING CYCLE 30
AUGUST 16-18,1949
TOWING CYCLE 31
AUGUST 23-25,1949
TOWING CYCLE 32
AUG 30 - SEPT 2,1949
TOWING CYCLE 33
SEPT 20-22,1949

Shad (*Alosa sapidissima*)

Observations of the migration of adult shad in the Delta were limited. The period of migration was established indirectly from the catch of the commercial fishery. From this source, it was determined that the fish entered the Delta on their spawning migration in early spring, usually in March, and reached the peak of abundance in May. Adults were observed in Sacramento River, Georgiana Slough, Mokelumne River, San Joaquin River and its distributaries below Mossdale during the spring months. During the month of June, 1949, large numbers of shad were seen in these waters in dead or dying condition.

Because of the nature of shad spawning activity and the character of the eggs, observations on spawning and recovery of eggs were not successfully accomplished with the collecting methods used. Considerable evidence substantiating the occurrence of spawning in the Delta was obtained from sampling larval shad at the established tow-net stations. The study of the early life stages of shad and their distribution in the Delta was carried on concurrently with that of salmon and striped bass.

The introduction in 1948 of the tow-net method of sampling selected stations in the Delta made it possible to determine certain facts about the spawning distribution of shad and the relative abundance and dispersion of larval and post-larval forms. During 1948 a total of 6,606 larval and juvenile shad were collected in standard tow-net hauls and a random sample of 3,908 individuals was measured for growth rate studies. Data for each station are given in Appendix Table 15, and are further summarized in Appendix Table 1. Distribution and abundance as determined from the sampling is illustrated graphically in Figure 8.

The first evidence to indicate that shad reproduction was well under way was collected during the 9th cycle, June 16-July 2, 1948. Larval shad were initially taken June 30th at towing stations located in Sacramento and Mokelumne Rivers. Young shad were taken in increasing numbers at these stations through July 20, the 11th towing cycle, with an extraordinary increase in catch occurring in the North and South Forks of the Mokelumne River. This large increment of young shad from the Mokelumne extended through four cycles (10-13), July 2 to August 17, and surpassed catch records from all other stations. The stations in the central and southern delta also yielded significant catches of post-larval shad. Tow-netting results from the stations in the Sacramento River and Georgiana Slough indicated that considerable spawning occurred in the Sacramento drainage above the Delta. Young shad entered the Delta from Sacramento River from the first of July to the end of October. Production of juvenile shad from the southern part of the Delta and San Joaquin River above the Delta extended from July 2 to October 23 with the peak yield from this area occurring in the 12th towing cycle. However, it did not approach the magnitude of the catches from Mokelumne and Sacramento Rivers. Mokelumne River was the major

Figure 8 - Distribution of shad (1948 year-class) in the Sacramento-San Joaquin Delta, 1948. The area of each circle is proportional to the calculated number of specimens at each station. The hydrodynamics for each cycle is included, showing delta inflows in cubic feet per second, maximum and minimum temperatures in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand, and turbidity in inches with Secchi disc.

WALNUT GROVE
SCALE OF MILES
ANTIOCH
STOCKTON
PUMPING PLANT
UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LEGEND
SHAD
TOWING CYCLE 9
JUNE 16 - JULY 2, 1948
SCALE 10,000 FISH =
TOWING CYCLE 10
JULY 2 - 12, 1948
TOWING CYCLE 11
JULY 12 - 20, 1948
TOWING CYCLE 12
JULY 20 - AUG 3, 1948
TOWING CYCLE 13
AUGUST 4 - 17, 1948
TOWING CYCLE 14
AUGUST 18 - 29, 1948
TOWING CYCLE 15
SEPT 6 - 15 1948
TOWING CYCLE 16
SEPT 21 - 29 1948
TOWING CYCLE 17
OCTOBER 22 - 29, 1948
TOWING CYCLE 18
NOVEMBER 9 - 12, 1948

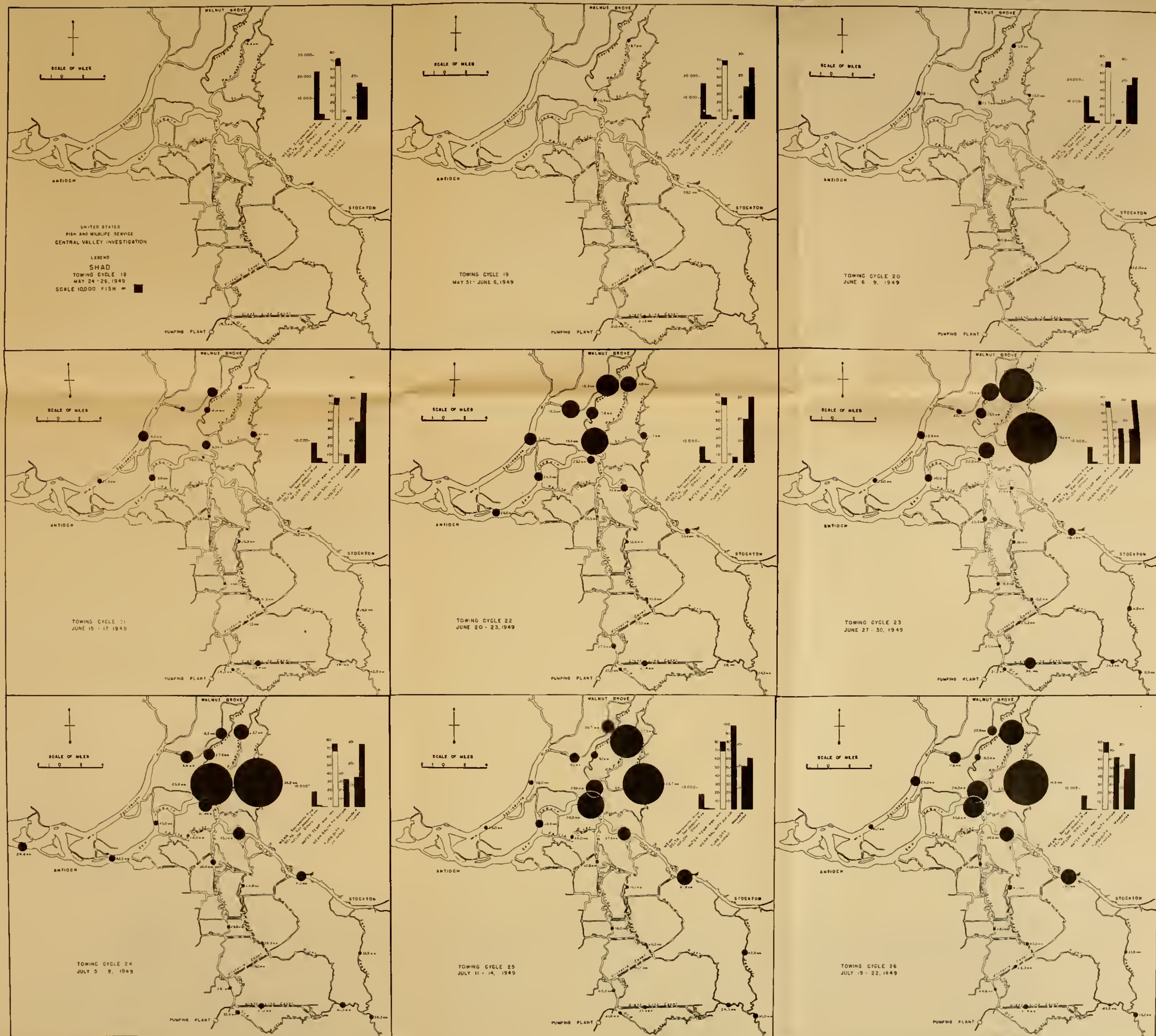
spawning area of shad within the confines of the Delta in 1948. Production of young shad from this source was continuous, with larval specimens taken as late as October.

The growth of larval shad was rapid. Those in the southern part of the Delta were of greater average length than those from Sacramento and Mokelumne River sources. However, the average length of the larvae from all stations for the 9th and 10th towing cycles, June 16 to July 12, was less than 20mm (0.8 inch). The peak of abundance occurred in the 11th towing cycle. Most larvae had completed transformation to the juvenile form by the end of the 12th towing cycle, July 20-August 3, and had attained a mean length of 33mm (1.3 inches). The growth of juvenile shad was also very rapid. Their mean length was 45mm by the middle of August, and 57mm by the end of August. By the end of September, in the 16th towing cycle, the young shad had attained a mean length of 70mm. A few averaging 75mm in length were taken in November, the 18th towing cycle.

Evidence of the seaward movement of young shad was noted from the results of the succeeding towing cycles (Figure 8). Larval shad were flushed from the upper Sacramento River spawning grounds by river run-off toward Suisun Bay, with significant numbers diverted into the central San Joaquin Delta via Georgiana Slough. The peak of the Sacramento migration occurred during the 11th cycle, July 12-20, followed by a secondary peak in the 13th cycle, August 4-17. Juvenile shad from San Joaquin River above the Delta and from the southern section were slower in their downstream movement, peaking in the 12th cycle. These fish spread out into the central Delta area. Large numbers of shad persisted in the lower Mokelumne River through the 12th cycle, July 20-August 3. However, a gradual movement from the Mokelumne into the central San Joaquin Delta was evident in the 11th and 12th cycles. Emigration from the Mokelumne was definite by the end of the 13th cycle, and was reflected in the larger catches from stations 15 and 17 in the lower San Joaquin River. Dispersal of the Mokelumne shad through the central Delta area was evident in cycles 13 and 14. The tendency of some of the shad to remain within Delta waters was indicated by catches of the larger size shad at a majority of the stations as late as the last week of October, with even a few taken in November.

The study of shad distribution in Delta waters in 1949 was conducted in the same manner as in the previous year. However, weekly sampling at the tow-net stations gave a more representative distribution pattern of the larval and juvenile shad in the Delta. Relocation of stations 18 and 19 (Figure 1) on the South and North Forks of Mokelumne River was helpful in evaluating the importance of these waters as shad producers. In 1949 the total catch of the early life stages of shad with the five-foot tow net was 22,461 specimens. Of this catch a random sample of 8,405 individuals was measured for studies in growth rate. Data for the tow-net stations are given in Appendix Table 16 and are further summarized in Appendix Table 2. The distribution of shad as determined from tow-net samples is presented graphically in Figure 9.

Figure 9 - Distribution of Shad (1949 year-class) in the Sacramento-San Joaquin Delta, 1949. The area of each circle is proportional to the calculated number of specimens at each station. The hydrodynamics for each cycle is included, showing delta inflows in cubic feet per second, maximum and minimum temperatures in degrees Fahrenheit, mean salinity at Antioch in parts per one hundred thousand, and turbidity in inches with Secchi disc.


UNITED STATES
FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION
LEGEND
SHAD
TOWING CYCLE 18
MAY 24 - 26, 1949
SCALE 10,000 FISH =
TOWING CYCLE 19
MAY 31 - JUNE 6, 1949
TOWING CYCLE 20
JUNE 6 - 9, 1949
TOWING CYCLE 21
JUNE 15 - 17 1949
TOWING CYCLE 22
JUNE 20 - 23, 1949
TOWING CYCLE 23
JUNE 27 - 30, 1949
TOWING CYCLE 24
JULY 5 - 8, 1949
TOWING CYCLE 25
JULY 11 - 14, 1949
TOWING CYCLE 26
JULY 19 - 22, 1949
WALNUT GROVE
ANTIOCH
STOCKTON
PUMPING PLANT
SCALE OF MILES


WALNUT GROVE
SCALE OF MILES
ANTIOCH
STOCKTON
PUMPING PLANT
LEGEND
SHAD
TOWING CYCLE 27
JULY 26 - 29, 1949
SCALE. 10,000 FISH
TOWING CYCLE 28
AUGUST 2 - 4, 1949
TOWING CYCLE 29
AUGUST 9 - 11, 1949
TOWING CYCLE 30
AUGUST 16 - 18, 1949
TOWING CYCLE 31
AUGUST 23 - 25, 1949
TOWING CYCLE 32
AUG. 30 - SEPT 2, 1949
TOWING CYCLE 33
SEPT 20 - 22, 1949

The first catches of shad larvae were made in plankton-net hauls in the 13th cycle (April 18-21, 1949) at station 8 in the San Joaquin River and at station 21 in the North Fork of Mokelumne River. Thereafter, shad larvae were taken occasionally in plankton-net hauls, but never in significant numbers. Catches of advanced forms of larval and juvenile shad with the standard five-foot tow net were first made in the 18th cycle (May 24-26, 1949) in the North Fork of Mokelumne River and in Old River near the approach canal of the Tracy Pumping Plant. By the 20th cycle (June 6-9, 1949) shad larvae were taken in Georgiana Slough, Sacramento River below Rio Vista, in the forks of Mokelumne River, and in several stations in the southern Delta. A wide dispersion of larval and juvenile shad was recorded in the 21st cycle when 21 of the 26 stations yielded large numbers of fish. From then on the total catch for each cycle increased rapidly until the peak of abundance occurred in the 23rd cycle (June 27-30, 1949). Although many of thestations continued to yield larval forms, particularly stations in Mokelumne River, the growth rate was rapid with the average length exceeding the 25-28mm measurement considered to be the length at which transformation occurs (Leim 1924). The distribution of immature shad in the succeeding cycles remained relatively constant to July 22. Mokelumne River continued to be the most important source of shad production, with the Sacramento River stations also yielding significant catches. The rapid growth continued so that by the 26th cycle the mean length of the measured catches was 34.9 (1.5 inches).

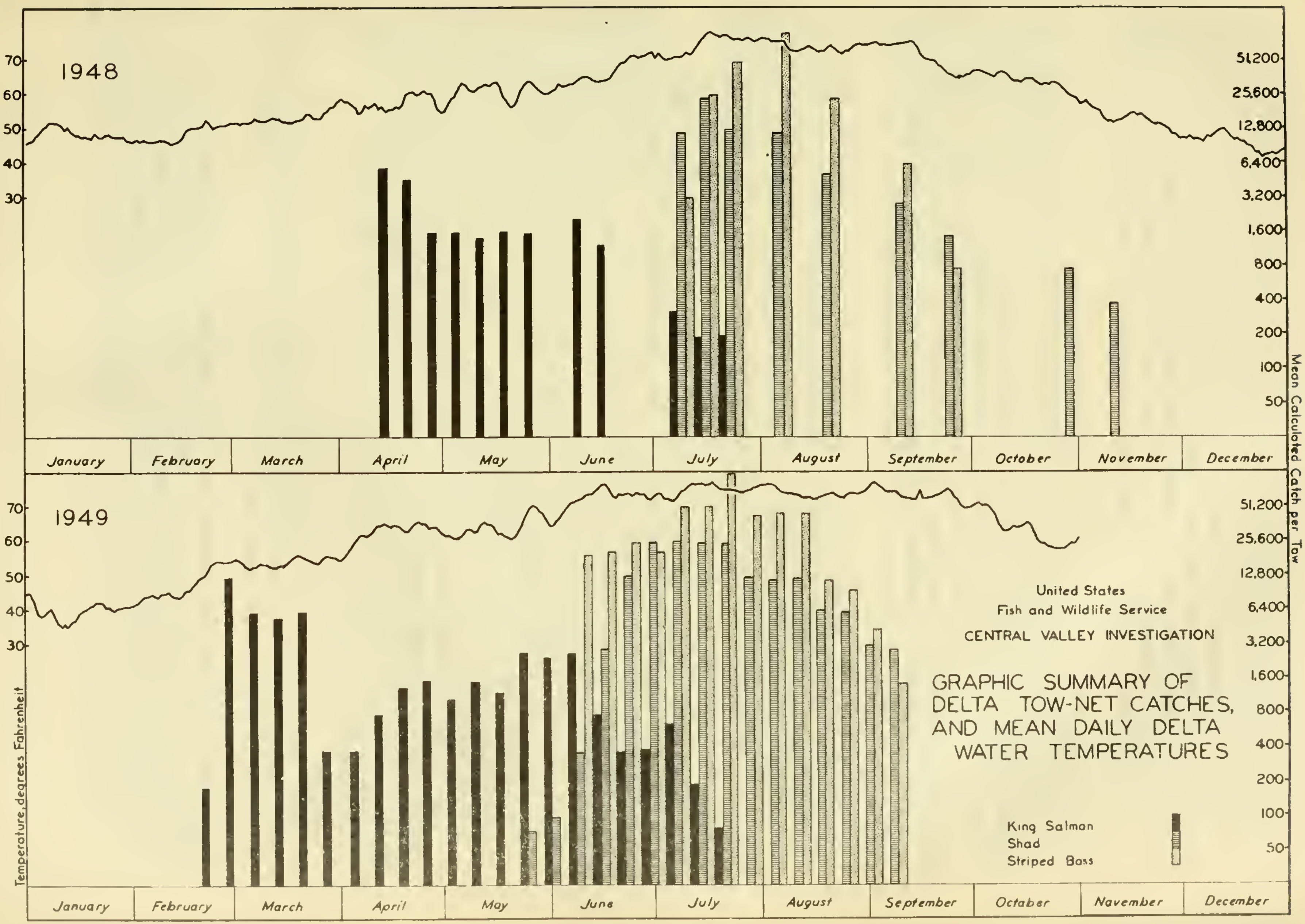
Catches of larvae and juveniles became progressively smaller after the 26th cycle, with the central portion of the Delta continuing to yield the principle catches. This tendency prevailed until the termination of field activities on September 22, at which time it was apparent that the results of further sampling would have paralleled those of 1948.

The charts clearly show that larval and juvenile shad were always concentrated in areas which will be within the influence of flows to the Tracy Pumping Plant.

WATER FLOW IN RELATION TO FISH POPULATIONS

The preceding sections have dealt separately with the distribution and occurrence of juvenile king salmon, striped bass, and shad in the Sacramento-San Joaquin River Delta. The charts illustrating this information for each species have shown their relative abundance and distribution in relation to the various channels that form the Delta. They have also portrayed abundance in relation to time and demonstrated an overlap of all species. Overlapping of species is more clearly seen in Figure 10, where the juveniles of all species are shown to be present in considerable numbers in the months of June and July. This figure also demonstrates that fingerling salmon are present in Delta waters as early as February and remain there until the latter part of July.

Figure 10 - Graphic summary of delta tow-net and mean daily delta water temperatures. Bars, representing numbers of fish, follow a geometric scale. The temperature line represents composite mean daily readings based on thermographs located on Sacramento River at Walnut Grove, San Joaquin River at Mossdale and Stockton, Old River at Clifton Court, and Middle River at Tracy Island Bridge.


1948
1949
70
60
50
40
30
51,200
25,600
12,800
6,400
3,200
1,600
800
400
200
100
50
January
February
March
April
May
June
July
August
September
October
November
December
Temperature, degrees Fahrenheit
Mean Calculated Catch per Tow
United States
Fish and Wildlife Service
CENTRAL VALLEY INVESTIGATION
GRAPHIC SUMMARY OF DELTA TOW-NET CATCHES, AND MEAN DAILY DELTA WATER TEMPERATURES
King Salmon
Shad
Striped Bass

Striped bass and shad spawn in Delta waters in the spring, and the resultant eggs and larvae are found throughout that area with notable concentrations in its central portion. The juveniles of these species remain in considerable numbers in Delta waters much longer than the salmon. Collections of juvenile striped bass and shad were regularly made through September, and shad were taken as late as November. Hook and line fishing and exploratory tows proved the presence of juvenile shad and striped bass in quantity in all other months of the year.

The egg, larval, and juvenile stages are particularly vulnerable to the actions of the various components of their complex environment, especially that of flow. The inability of eggs and larval fish to resist current is a matter of common knowledge, and is a pertinent consideration in this situation. Salmon juveniles and the juveniles of striped bass and shad, because of their larger size, have greater power to resist currents, and would not be affected to the same extent as larval forms of striped bass and shad. Since shad eggs are demersal, currents do not affect them to the same degree as they do the pelagic striped bass eggs.

The evidence obtained in this investigation seems conclusive that the Delta provides excellent spawning and nursery grounds for the species of fish emphasized in this discussion. It also demonstrates that the various fresh-water phases of their life histories occupy the entire twelve months of the year in Delta waters. This is particularly true with striped bass and shad.

Termination of the study at approximately the halfway mark prevented intensive investigation into the problem of the distribution of fish in relation to flow. However, sufficient evidence has been gathered on this problem to indicate strongly that flow is the most important controlling factor in the distribution of juvenile fishes in the channels of the Delta. Evidence of primary importance was obtained in 1948 as a result of fishing fyke nets in Georgiana Slough and in Sacramento River below Isleton during the peak of the spring seaward migration of juvenile salmon. Georgiana Slough diverts Sacramento River water at Walnut Grove, which lies approximately 8 miles above Isleton. Results of catches made in these nets were compared with the flows at their respective locations, and showed a phenomenal degree of correlation. During the period March 26 through 30, Georgiana Slough was carrying 22.28 percent of the total Sacramento River flow above its sources as calculated from U. S. Bureau of Reclamation rating curves. The flow in Sacramento River below the head of Georgiana Slough, was, of course, 77.72 percent of the flow of the main stream as described above. Of the total number of seaward migrants taken in the fyke nets, 22.56 per cent were taken in the Georgiana Slough net and 77.44 percent were taken in Sacramento River.

It is recognized, of course, that the numbers of juveniles occupying certain areas are limited by the volumes of water present in those areas. It seems characteristic, however, that numbers tend to pile up in large areas of open water that are susceptible to maximum tidal influence, as the channel of the main San Joaquin River between its confluences with Middle River and Seven Mile Slough.

From the foregoing it is evident that a clear understanding of the entire problem demands consideration of the sums of the juvenile populations of salmon, striped bass, and shad in relation to the flow patterns that will occur in the Delta when the Tracy Pumping Plant and Delta Cross-Channel are operating. It is also clear that a proper relationship can only be visualized by utilizing information obtained on the fishes in 1948 and 1949 in conjunction with project operation schedules calculated in accordance with Delta inflows for the years 1948 and 1949. These operation schedules were obtained from the U. S. Bureau of Reclamation and concern initial Central Valley Project operation and that project operation as modified by increased storage at Folsom Reservoir now under construction on the American River. They do not, however, show flow conditions that would have prevailed in the Delta in 1948 and 1949 with the project in full operation. Under full operation, the Tracy Pumping Plant would deliver a maximum flow of 4,600 cubic feet per second to the Delta-Mendota Canal. Data on this operation were not available at the time of preparation of this report and accordingly their inclusion was impossible. However, the relationship of Delta fish populations to flow patterns that would have existed in 1948 and 1949 with the project operating at its maximum level is a matter of primary importance. A critical study of Figure 11 should be conditioned by this fact.

The relationships between fish populations and flow are shown diagrammatically in Figure 11 for the various months during which juvenile fish were studied in 1948 and 1949. The data presented and used in the formulation of the various diagrams are presented in Appendix Tables 20, 21,23,25,26, and 27. The relative magnitude of the sums of juvenile populations of striped bass, salmon, and shad is illustrated by circles, and is proportional to the area of the circles in each case. The proportion of the total population represented by each species in each month is given in percentum. The percent of abundance of each species is shown by a segment of the circle as well as by a figure within the segment. Water flows into and out of the Delta are designated by single lines or pairs of parallel lines radiating from the circumference at each major point of entry and exit. These points are named, and arrows indicate the direction of flow. Mean monthly flows are given in each case and the distance between parallel lines is drawn to scale according to volume of flow to assist in their comparison. The outflow point at the bases of the circles is designated, Delta-Mendota Demand, and represents outflow to the Tracy Pumping Plant. In each figure, the total volume of water carried from the Delta via this route is shown and the sources and volumes making up this flow are given.

An examination of the monthly diagrams in Figure 11 clearly shows that juvenile fish are most abundant in Delta waters in the months of June, July, and August. They also show that the population is dominated by striped bass and shad in the months of July and August. Salmon constituted only a small fraction of the total in June of 1949 but were more abundant in that month in 1948. They show, too, that seaward migrant salmon made up the entire population of juvenile fish in the Delta in the spring months preceding June.

The variations in abundance and composition of juvenile populations are paralleled by a variety of flow patterns. The most significant of these are the patterns of inflow and outflow that prevail during the months of greatest population density. Inflow is reduced during these months and consequently outflow to the sea is similarly reduced. But the outflow pumped to the Delta-Mendota Canal reaches peak levels in June, July, and August. Outflow to the pumps sometimes exceeds the amount of water flowing from the Delta to the sea. This would have been the case in July of 1949 with project operation modified for increased storage at Folsom Reservoir. In that month, the outflow to the sea would have been 3,000 cubic feet per second while the pump demand would have been 3,040 cubic feet per second. Generally, pump demand for the months under consideration in 1948 and 1949 would have ranged from one-third to over one-half that of the volume of flow passing to the sea. The effect of flow on fish in these instances needs no further elaboration.

As previously stated, the population of juvenile fish in the Delta from February to June is composed entirely of seaward migrant king salmon. It has also been pointed out that these fish enter the Delta in peak numbers during periods of heavy run-off. Thus, inflow to the Delta is at peak levels during most of the period that these salmon are in the area. Similarly, outflow to the sea is at peak levels while pump demand is low. This situation appears to be favorable to the bulk of king salmon seaward migrants from Sacramento River.

Seaward migrant king salmon of San Joaquin River origin must face an entirely different set of circumstances, most of which are detrimental with the project in operation. They arrive in the Delta six weeks to two months later than the Sacramento River fish; their point of entry into the Delta is in close proximity to the Tracy Pumping Plant; their avenues of migration through the Delta converge on the intake to the pump channel; and up to 70 percent of the entire San Joaquin River flow is destined for the pumps during their period of migration.

It is evident, therefore, that king salmon migrants of Sacramento River origin are more secure than those of San Joaquin River origin. Nevertheless, migrants from both sources that are in the central Delta area in June and July will be influenced by the current patterns prevailing at that time. Striped bass and shad juveniles in the central delta will be subject to the same influences.

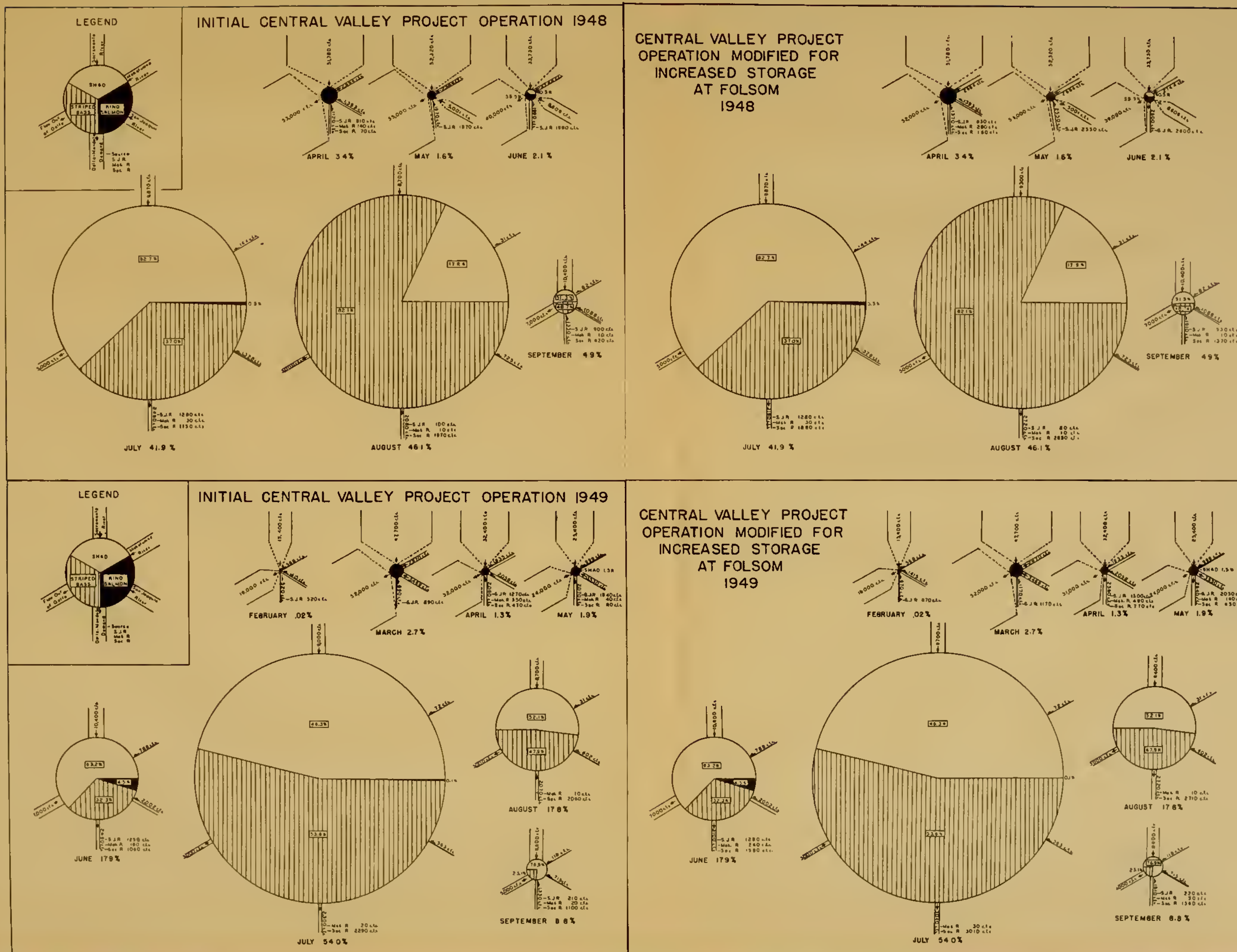
FISH PROTECTION

Preceding sections of this report have shown that important segments of the immature populations of king salmon, striped bass, and shad enroute through and within the Sacramento-San Joaquin Delta will be endangered by the conditions created by the Tracy Pumping Plant and the Delta Cross-Channel. The information gathered is sufficient to support recommendation

Figure 11 - Monthly occurrence and relative abundance of salmon, striped bass and shad juveniles as related to the 1948 and 1949 flow patterns in the Delta, adjusted to the Delta-Mendota demand. The area of the circles represents the monthly occurrence in per cent of the total seasonal catch, and each circle is divided proportionate to the monthly catch of the three species. The Delta inflow and outflow patterns for 1948 and 1949, modified for (1) the Initial Central Valley Project Operation and (2) Coordination with Folsom Operation of the Tracy Pumping Plant, are shown in their relative magnitude. The Delta upland use and Delta consumption are not illustrated.

UNITED STATES FISH AND WILDLIFE SERVICE
CENTRAL VALLEY INVESTIGATION

MONTHLY OCCURRENCE AND RELATIVE ABUNDANCE OF SALMON, STRIPED BASS AND SHAD JUVENILES AS RELATED TO THE FLOW PATTERNS IN THE DELTA ADJUSTED TO DELTA-MENDOTA DEMAND



of positive means of fish protection involving (1) a screen at the Tracy Pumping Plant intake channel, and (2) an adequate method of by-passing the screened fish to areas outside the influence of the pump draft.

Several plans for the protection of the fishery resources in the Delta relative to the water-use projects have been considered by State and Federal fishery agencies since construction of the Central Valley Project was undertaken by the U.S. Bureau of Reclamation. Modifications of this basic recommendation were mentioned briefly in the introduction. The original plan of the U. S. Bureau of Reclamation to transport Sacramento River water through a closed channel to the Tracy Pumping Plant was supported by fishery interests because it would have resulted in no changes in existing flow conditions in the Sacramento-San Joaquin Delta. Fish protection would have been limited to the intake structure at the point of diversion on Sacramento River, with very little required in the way of protective devices along the closed channel. However, this plan was abandoned in favor of the "State Plan", which proposed the transfer of Sacramento River water to the Tracy Pumping Plant via existing Delta channels.

The original "State Plan", modified by the U. S. Bureau of Reclamation, and called the Delta Cross-Channel, was thoroughly studied and found to be the most economical and feasible means of delivering water to the Tracy Pumping Plant. The Delta Cross-Channel will be a gravity diversion with the point of diversion in the vicinity of Walnut Grove. The natural diversion, Georgiana Slough, will also be used. As demands increase, additional water will be obtained by constructing a diversion near Isleton. The possibility of installing low-head pumps to supplement flow has also been considered. Initial operation is scheduled for July 1951.

This plan of operation imposes serious problems in the protection and maintenance of the fishery resources dependent on the Delta.

Time has not been available to carry through a screen-testing program in relation to this project. However, a self-cleaning, traveling water screen appears to be the most feasible because: it can operate under the tidal conditions present; it can handle the great loads of debris characteristic of Delta waters; and it offers a means of collecting screened fish for transfer to a by-pass canal.

The screen structure should be located in the approach canal at a point where the velocity of the current ranges between 1.5 and 2.5 feet per second. Screens towed in the Delta through this range of velocity demonstrated low mortality of screened fish. No trials were made with velocities exceeding 2.5 feet per second. However, it is known that excessive velocity does cause high mortality in the operation of stationary and rotary screens.

Size of the screen mesh used in the traveling water screens for fish protection is governed by the clearance between the stationary and moving parts of the unit and by the sizes of fish to be screened. One type of traveling water screen can hold its clearance to .159 inches, the theoretical opening of the 5x5 to-the-inch mesh of No. 19 wire. There would be no advantage in reducing the screen size to less than the limits of these clearances. Sufficient information has been gained from other projects where traveling water screens are used to prove that seaward migrating salmon are screenable with 5x5 to-the-inch mesh. It is recognized that the eggs and immature forms of striped bass and larval shad cannot be successfully screened by this size of mesh.

In order to determine the size at which juvenile striped bass could be screened, a weekly series of tows testing the effectiveness of 5x5, No. 19 hardware cloth in the screening of striped bass juveniles were completed between June 20 and July 22, 1949. The method used in determining the screenable size of the young bass was to secure a 12-1/2 square foot circular section of screen, four feet from the mouth and inside the cone of a five-foot standard tow net. This apparatus was towed through the water at 2.5 feet per second, which is approximately the calculated velocity of the current in the approach canal to the Tracy Pumping Plant. The results revealed that the maximum length of striped bass passing through the screen was 26mm (1 inch); however, only one individual of this size was found in the net behind the screen. Bass 20mm (0.8 inch) and less in length passed through the screen consistently, while many individuals 20-25mm (0.8 to 1 inch) were stopped by the screen. The following table shows the calculated screening efficiency of 5x5, No. 19 hardware cloth as derived from a regression of mean length of striped bass upon percentage screened:

MEAN LENGTH	PER CENT SCREENABLE
10 mm (0.4 inch)	0
15 mm (0.6 inch)	7.5
20 mm (0.8 inch)	30.0
25 mm (1 inch)	53.0
30 mm (1.2 inch)	75.0
35 mm (1.4 inch)	98.0

The same tests were planned for learning the screenable size of shad, but lack of sufficient time prevented fulfillment of plans. However, preserved specimens of shad juveniles 32mm and over could not be forced through the 5x5 No. 19 screen meshes.

Figure 12 presents growth curves of mean and minimum lengths of salmon, shad, and striped bass, plotted in relation to mean size screenable determined as described above. Examination of this figure shows that with few exceptions, king salmon juveniles are screenable at all times during their period of residence in the Delta. It also demonstrates the particular vulnerability of shad, and to a lesser degree, striped bass.

It is evident that large portions of the populations of larval shad and striped bass may fall within the influence of the pumps and pass through 5x5 mesh screen. This suggests that intensive study be made to determine if there are means of affording them protection. Additional studies along these lines should include investigations into the matter of operating speed of screens, approach velocity to the screens, and the welfare and disposition of adult fishes within the influence of the pumps.

To complete its function, the screen must be provided with a by-pass of sufficient capacity, and of certain dimensions to carry the fish to a point of safety within the shortest time possible. An integral part of the screen structure should include means of collecting fish from the screen and transferring them to the intake of the by-pass canal. These are details that must be worked out by engineers in collaboration with fishery biologists.

Several alternate plans for transporting juvenile fish collected by the screen have been proposed. The initial plan proposed that the by-pass originate in the vicinity of Mossdale on the San Joaquin River. From this point it would follow Paradise Cut, a short stretch of Tom Paine Slough, thence through about 12 miles of new canal constructed along the southwest side of the Delta to the screen structure. From this point it would be necessary to construct another 15 miles of new canal to the lower section of Dutch Slough, which empties into the San Joaquin River upstream from Antioch, California, and is considered to be sufficiently removed from pump influence to assure safety of the fish.

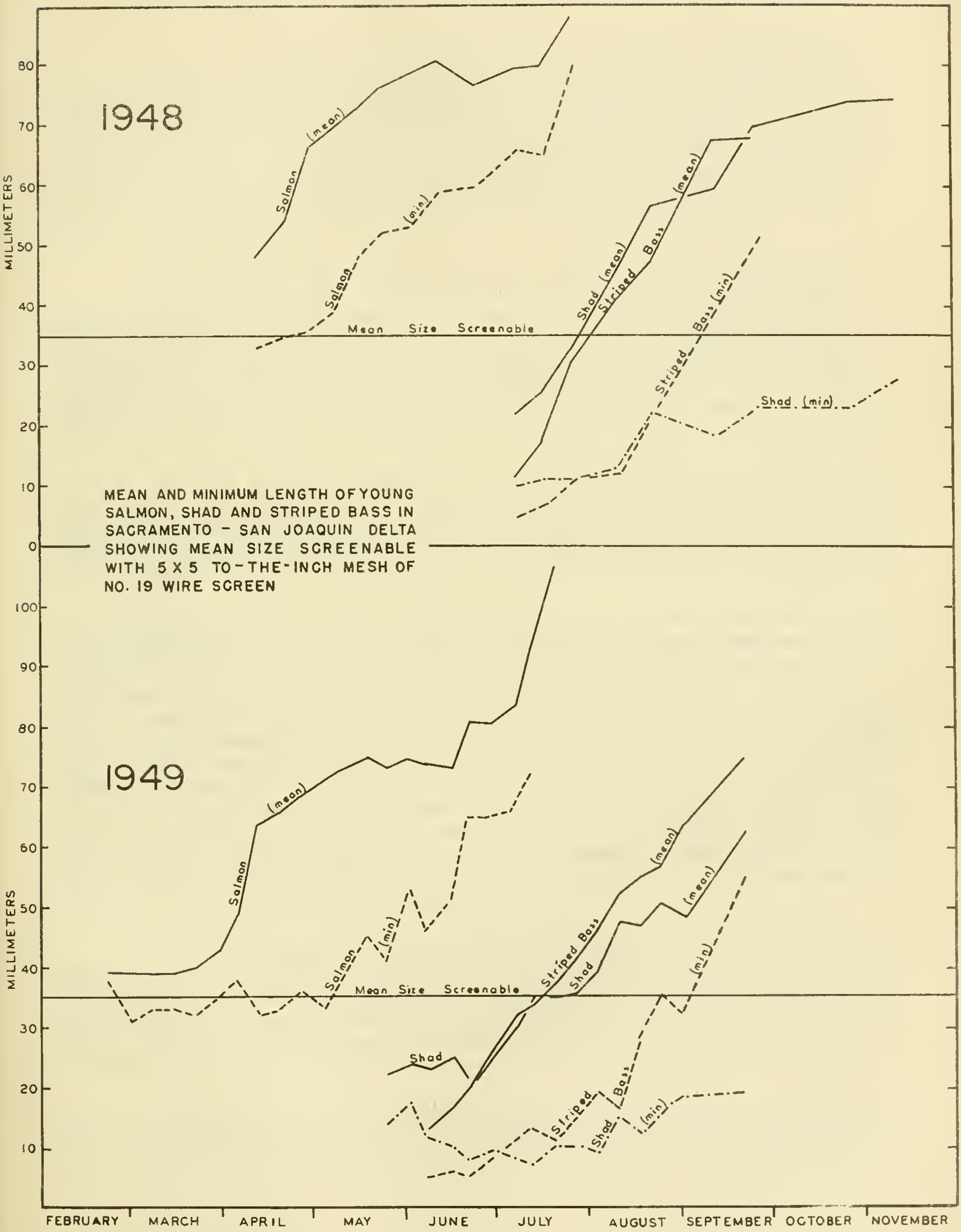
This by-pass canal, approximately 33 miles in length, would have a capacity of 500 cubic feet per second, and would derive its entire flow from the San Joaquin River by means of a 12 foot concrete diversion dam. This structure would provide a 10 foot head at the point of diversion. This canal would be continuous and would pick up fish collected at the screens.

This plan, as well as one which proposed a by-pass flow of 500 cubic feet per second originating at the screen structure, was abandoned because of complexity and prohibitive costs.

The plan currently in favor proposes a by-pass canal of 200 cubic feet per second capacity originating at the screen structure and terminating in Dutch Slough. It would be supplied by means of water pumped from the approach canal. The channel would have a total length of approximately 15 miles, all of which would have to be constructed, since there are no natural channels which could be used along its route. To assure the maintenance of water temperatures as low as possible and to attain maximum safety from predators, this canal should be made as deep as possible consistent with its capacity.

The adequacy of the channel and its volume of flow can only be determined under actual maximum operation of the project. If changes are warranted at that time, they should be made.

Figure 12 - The mean and minimum length of young salmon, shad and striped bass in the Sacramento-San Joaquin Delta showing mean size screenable with 5x5 to the inch mesh of No. 19 wire screen.


1948
1949
MEAN AND MINIMUM LENGTH OF YOUNG SALMON, SHAD AND STRIPED BASS IN SACRAMENTO – SAN JOAQUIN DELTA SHOWING MEAN SIZE SCREENABLE WITH 5 X 5 TO-THE-INCH MESH OF NO. 19 WIRE SCREEN
MILLIMETERS
Salmon (mean)
Salmon (min)
Mean Size Screenable
Shad (mean)
Striped Bass (mean)
Striped Bass (min)
Shad (min)
Shad
Striped Bass
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER

GPO SF FSO

SUMMARY

1. The U. S. Fish and Wildlife Service carried on investigations in the Sacramento-San Joaquin Delta from 1946 to 1949 in order to determine: (1) the magnitude, composition and occurrence of populations of king salmon, striped bass, and shad that occur in or utilize Delta waters; (2) the effects of changes in Delta hydrodynamics on these populations that would result from project operation; (3) the effects of various other environmental factors; and (4) ways and means of protecting and maintaining these populations if damage to them was indicated.

2. Young stages of anadromous fishes were found in Delta waters in all months of the year. King salmon were dominant from February through May, with peak numbers occurring in March. Large numbers of salmon remained in the Delta to the middle of July. The juveniles of striped bass and shad were dominant during the period June through September, with peaks of abundance occurring in July and August. The juveniles of all three species were present in quantity during the months of June and July.

3. In 1948 and 1949 striped bass and shad spawned in the Delta from early April to the end of June, with peak activity occurring in the month of May, and with some shad spawning as late as the end of August. Occurrence and abundance of the larval forms of these species paralleled that of spawning activity.

4. Eggs, larvae, and juveniles of striped bass and shad were distributed throughout the Delta, with heavy concentrations occurring in the central area, particularly in the channels of the lower Mokelumne River, San Joaquin River between its confluences with Middle River and Seven Mile Slough, and Old and Middle Rivers. King salmon juveniles entered the Delta from Sacramento River through Georgiana Slough, Three Mile Slough, and, by tidal action, up the mouth of San Joaquin River. They distributed themselves throughout the Delta in a manner similar to that noted above for striped bass and shad. Juvenile king salmon entered the Delta from San Joaquin River principally through the channels of Middle River, Old River, and Grant Line Canal, all of which converge on the southwest corner of the Delta. Their dispersal from this point was quite uniform and seemed to follow a definite seaward movement.

5. It was observed that the early life stages of salmon, striped bass, and shad occurred in abundance in relation to water volume, and it was further observed that populations of fish tended to pile up in large open-water areas most susceptible to tidal action. As a corollary to this principle, evidence was obtained to show that distribution was in proportion to flow.

6. When the project is in operation, drastic changes in existing Delta flow patterns will occur, particularly during the months of June, July, August, and September, when project demand will be high. Water

demand for the Delta-Mendota Canal will be at its peak in June and July, and outflow at this point will sometimes exceed outflow to the sea. During the other months of this period outflow through the pumps will be equivalent to one-third to one-half of the outflow to the sea.

7. The evidence is conclusive that in order to protect and maintain populations of king salmon, striped bass, and shad, positive means for preventing their passage through the pumps must be adopted.

RECOMMENDATIONS

1. It is recommended as a result of these studies that a screen be installed in the approach canal, complete with a fish-collecting system and a by-pass canal that will carry screened fish to an area beyond the influence of the Tracy Pumping Plant. The screen should be of the travelling water type. The by-pass should originate at the screen and terminate at Dutch Slough, and should have a capacity of 200 cubic feet per second, the water to be pumped into the by-pass from the approach canal.

2. It is recommended that additional studies be made to determine: (1) means of affording protection to eggs and larval fish; (2) further effects of environmental factors in controlling fish populations in the Delta; (3) the behavior of adult king salmon, striped bass, and shad; (4) the degree of success of the fish protective devices during all stages of development and operation, and (5) the effects of altered Delta environment on fish populations.

3. It is recommended that the operation of the fish protection devices be under the supervision of a competent fishery biologist.

REFERENCES

American Public Health Association

1936 Standard Methods of Water Analysis, Eighth Edition.

Calhoun A. J.

1949 California Striped Bass Catch Records from the Party Boat Fishery: 1938-1948; California Fish and Game, Vol. 35, No. 4, p. 211.

Calhoun, A. J. & Woodhull, C. A.

1948 Progress Report on Studies of Striped Bass Reproduction in Relation to Central Valley Project; California Fish & Game, Vol. 34, No. 4, pp. 171-188.

California Division of Fish and Game

1913 General Report on the Chinook Salmon Investigations carried on during Spring and Summer of 1911; California Fish & Game, Fish Bulletin No. 1.

Towing Salmon & Steelhead Fry from Sacramento to the Sea in a Live Car; California Fish & Game, Fish Bulletin No. 1.

1949 The Commercial Fish Catch of California for the Year 1947 with an Historical Review 1916-1947; California Fish & Game, Fish Bulletin No. 74.

California Division of Water Resources

1931 Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay, 1931, Bulletin No. 27.

Water Supervision Reports, 1931-1948.

Clark, G.H.

1929 Sacramento-San Joaquin Salmon (Oncorhynchus tschawytscha) Fishery of California; California Fish & Game, Fish Bulletin No. 17.

Cope, O. B.

1949 Water temperature records from California's Central Valley, 1939-1948; U.S. Fish & Wildlife Service Special Scientific Report: Fisheries No. 2, pp. 1-77, September, 1949.

Hatton, S. Ross

1940 Progress Report of Central Valley Fishery Investigations, 1939; California Fish and Game, Vol. 26, No. 4, pp. 334-373.

1942 Striped Bass Spawning Areas in California; California Fish & Game, Vol. 28, No. 1, p.65.

Hatton, S. Ross & Clark, G. H.

1942 A Second Progress Report on the Central Valley Fisheries Investigation; California Fish & Game, Vol. No. 28, No. 2, pp. 116-123.

Leach, G. C.
1924 Artificial Propagation of Shad; Report of the Comm. of Fisheries, Appendix VIII, Doc. No. 981, pp. 459-486.

Leim, A. H.
1924 The Life History of the Shad with special reference to factors limiting its abundance. Contributions to Canadian Biology, Vol. 2, No. 11, pp. 161-284.

Moffett, James W.
1949 The First Four Years of King Salmon Maintenance below Shasta Dam, Sacramento River, California; California Fish & Game, Vol 35, No. 2, pp. 77-102.

Murphy, Garth
1941 A Key to the Fishes of the Sacramento-San Joaquin Basin; California Fish & Game, Vol. 27, No. 3, pp. 165-171.

Rich, Willis H.
1920 Early History of Seaward Migration of Chinook Salmon in the Columbia & Sacramento River; U.S. Bureau of Fisheries Bulletin, Vol. 37, Doc. 887.

Rutter, Cloudsley
1902 Natural History of the Quinnat Salmon Investigation on Sacramento River, U. S. Bureau of Fisheries Bulletin No. 22.

Schultz, Leonard P.
1936 Keys to the Fishes of Washington, Oregon and closely adjoining regions. University of Washington, Publications in Biology, Vol. 2, No. 4, pp. 103-228.

Scofield, E. C.
1928 Striped Bass Studies; California Fish & Game, Vol. 14, No. 1, pp. 29-37.

1931 The Striped Bass of California; California Fish & Game Bulletin 29, pp. 82.

Scofield, N. B.
1900 Notes on movements and rate of growth of Quinnat Salmon Fry in Sacramento River. Biennial Report of California Fish & Game Comm. 1897-1898.

1910 Notes on Striped Bass in California, 21st Biennial Report, 1909-1910.

Scofield, N. B. & Bryant, H. C.
1926 The Striped Bass in California; California Fish & Game, Vol. 12, No. 2, pp. 55-74.

Scofield, N. B. & Coleman, G. A.
1910 Notes on spawning and hatching striped bass eggs at Boulder Isl.; 21st Biennial Report, California Fish & Game, 1909-10, pp. 109-117.

Snyder, J. O.
1928 Salmon Investigations; California Fish & Game, Vol. 14, No. 1, Jan., pp. 25-29.

Truitt, R. V. & Valdykov, V. D.
1936 Striped Bass Investigations in the Chesapeake Bay; Transactions of American Fisheries Society, Vol. 66, pp. 225-226.

U. S. Bureau of Reclamation
1944 Hydraulic Laboratory Report No. 145
Hydraulic Laboratory Report No. 155

1945 Comprehensive Plan for Water Resources Development Central Valley Basin, Project Planning Report No. 2-4.0-3, November, 1945.

1947 Region II, Delta District Hydrography Report.

U. S. Corps of Engineers
1933 Sacramento River, Sacramento to Collinsville Maps.

1934 San Joaquin River & Suisun Bay Maps.

1936 Old River Maps.

U. S. Geological Survey
1931 Water Supply Paper

1939 Water Supply Paper

1942 Water Supply Paper

1945 Stream Gaging Procedure, Water Supply Paper 888.

Van Cleve, Richard
1945 A Preliminary Report on the Fishery Resources of California in Relation to Central Valley Project; Calif. Fish & Game, Vol. 31, No.2.

Vladykov, V. D. & Wallace, D. H.
1937 Remarks on populations of the Shad (Alosa sapidissima) along the Atlantic Coast Region; Trans. of American Fisheries Society, Vol. 67, pp. 52-66.

Wallace, David H., & Truitt, R V
1938 Progress of the Rock and Shad Research Work at the Chesapeake Biological Laboratory; Trans. of American Fisheries Society, Vol. 68, pp. 364-368.

Woodhull, Chester
1947 Spawning Habits of the Striped Bass (Roccus saxatalis) in California Waters; California Fish & Game, Vol. 33, No. 2, pp. 97-102.

APPENDIX TABLES

1. Summary of tow-net catches of salmon, striped bass and shad, with computed results, 1948.
2. Summary of tow-net catches of salmon, striped bass and shad, with computed results, 1949.
3. Hydrodynamics of the Sacramento-San Joaquin Delta, 1948.
4. Hydrodynamics of the Sacramento-San Joaquin Delta, 1949.
5. King salmon seaward migrants taken in towing cycles, Sacramento-San Joaquin Delta, 1948.
6. King salmon seaward migrants taken in towing cycles, Sacramento-San Joaquin Delta, 1949.
7. Striped bass eggs taken in plankton-tows, 1948.
8. Striped bass larvae taken in plankton-tows, 1948.
9. Striped bass (1948 year-class) taken in towing cycles, Sacramento-San Joaquin Delta, 1948.
10. Striped bass (1948 year-class) taken in towing cycles, Sacramento-San Joaquin Delta, 1949.
11. Striped bass eggs taken in plankton-tows, 1949.
12. Striped bass larvae taken in plankton-tows, 1949.
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14. Catch of striped bass eggs, larvae, and juveniles expressed in terms of a standard volume of water strained, 1949.
15. Shad (1948 year-class) taken in towing cycles, Sacramento-San Joaquin Delta, 1948.
16. Shad (1949 year-class) taken in towing cycles, Sacramento-San Joaquin Delta, 1949.
17. Smelt, *Hypomesus olidus*, taken in towing cycles, Sacramento-San Joaquin Delta, 1948.
18. Adult smelt, *Hypomesus olidus*, taken in towing cycles, Sacramento-San Joaquin Delta, 1949.
19. Smelt, *Hypomesus olidus* (1949 year-class) taken in towing cycles, Sacramento-San Joaquin Delta, 1949.
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21. Delta-Mendota Demand, showing source of water, 1948 and 1949.
22. Delta-Mendota Demand, showing source of water, 1931, 1938 and 1940.
23. Mean monthly flow of Sacramento River at Sacramento, California.
24. Estimated flow of Sacramento River at Sacramento, plus flood-flow in Yolo By-Pass.
25. Mean monthly flow of San Joaquin River at Vernalis, California.
26. Mokelumne River flows entering the Delta.
27. Flow out of Delta.

Table 1. - Summary of tow net catches of Salmon, Striped Bass and Shad with calculated results, 1948

Cycle Date	1 4/9-16	2 4/16-26	3 4/26-5/6	4 5/4-12	5 5/11-21	6 5/19-28	7 5/27-6/6	8 6/7-16	9 6/16-7/2
Salmon									
Total Catch	284	220	131	106	86	100	94	103	45
Percent in each cycle	23.78	18.42	10.97	8.87	7.2	8.37	7.87	8.62	3.76
Total calculated catch per cycle	100564	82328	33580	34423	27590	39651	31843	35328	20409
Mean calculated catch per tow	4022	3293	1342	1377	1104	1586	1274	1616	850
Number Measured	284	220	131	106	86	100	94	103	45
Mean Length	48.1	54.4	66.1	69.5	72.9	77.1	78.1	80.8	78.9
Standard Deviation	14.13	18.03	14.73	12.45	10.56	7.68	8.19	8.0	9.96
Striped Bass									
Total Catch									
Percent in each cycle									
Total calculated catch per cycle									
Mean calculated catch per tow	- - - - - -	- - - -	- - - -	- - - -	- - No Juveniles Taken - -	- - - -	- - - -	- - - -	- - - -
Number Measured									
Mean Length									
Standard Deviation									
Shad									
Total Catch									165
Percent in each cycle									2.49
Total calculated catch per cycle									44322
Mean calculated catch per tow	- - - - - -	- - - -	- - - -	- - - -	- - No Juveniles Taken - -	- - - -	- - - -	- - - -	1772
Number Measured									0
Mean Length									Larvae*
Standard Deviation									

Cycle Date	10 7/2-12	11 7/12-20	12 7/20-8/3	13 8/4-17	14 8/18-25	15 9/6-16	16 9/21-29	17 10/22-25	18 11/9-12	TOTAL
Salmon										
Total Catch	12	10	3							1194
Percent in each cycle	1.00	.83	.25							
Total calculated catch per cycle	5398	3571	3800							
Mean calculated catch per tow	216	149	158							
Number Measured	12	10	3							1194
Mean Length	79.5	79.9	86.0							
Standard Deviation	9.63	10.06	11.22							
Striped Bass										
Total Catch	139	874	1939	3588	1146	282	23			8071
Percent in each cycle	1.72	10.82	24.02	46.42	14.22	8.42	.28			
Total calculated catch per cycle	72763	479154	976501	1446406	436486	122069	12847			
Mean calculated catch per tow	2910	19965	40688	60266	18187	5087	584			
Number Measured	123	868	1486	1634	694	269	23			6306
Mean Length	11.5	17.2	30.7	40.9	47.1	67.1	67.7			
Standard Deviation	3.81	5.01	6.16	7.77	7.83	10.53	3.33			
Shad										
Total Catch	1294	1974	1748	736	312	199	122	50	12	6606
Percent in each cycle	19.58	29.88	26.39	11.13	4.72	3.01	1.86	.76	.18	
Total calculated catch per cycle	214056	414794	281983	203762	83563	49225	24735	13949	4302	
Mean calculated catch per tow	8562	17263	11749	8490	3488	2051	1124	634	307	
Number Measured	533	939	1157	663	231	199	122	50	12	3908
Mean Length	21.8	25.1	32.6	46.0	66.5	68.2	69.5	73.7	74.0	
Standard Deviation	8.55	8.84	9.42	10.23	11.28	14.25	13.88	21.12	23.91	

* Less than 20mm.

Table 2. - Summary of tow net catches of Salmon, Striped Bass and Shad with calculated results, 1949

Cycle Date	5 2/22-24	6 3/1-4	7 3/8-10	8 3/15-17	9 3/22-24	10 3/29-4/1	11 4/5-7	12 4/11-15	13 4/18-21	14 4/25-28	15 5/3-6	16 5/9-11	17 5/18-20	18 5/24-28
Salmon														
Total Catch	10	710	303	188	263	34	29	142	172	249	184	265	113	272
Percent each cycle	0.29	20.82	8.88	5.51	7.71	0.99	0.85	4.16	5.04	7.30	5.39	7.77	3.31	7.97
Total calculated catch per cycle	3437	245343	127426	98314	134173	10517	8501	18323	24924	31701	21074	34878	23515	46862
Mean calculated catch per tow	137	9814	5097	3853	5367	422	340	705	959	1218	811	1341	904	1784
Number measured	10	368	284	184	223	34	29	141	172	249	184	265	113	272
Mean Length	39.1	39.0	38.6	39.0	39.9	42.7	48.6	63.8	65.7	68.6	71.2	72.7	74.7	73.2
Standard Deviation	1.32	2.48	2.28	2.73	3.69	5.85	10.06	14.46	11.88	10.2	8.57	8.07	9.46	8.26
Striped Bass														
Total Catch														
Percent each cycle														
Total calculated catch per cycle														
Mean calculated catch per tow	- - - -	- - - -	- - - -	- - - -	- - - -	- - No Juveniles Taken - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Number measured														
Mean Length														
Standard Deviation														
Shad														
Total Catch														13
Percent each cycle														0.05
Total calculated catch per cycle														1332
Mean calculated catch per tow	- - - -	- - - -	- - - -	- - - -	- - - -	- - No Juveniles Taken - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	53
Number measured														8
Mean Length														22.0
Standard Deviation														4.24

Cycle Date	19 5/31-6/3	20 6/6-9	21 6/15-17	22 6/20-23	23 6/27-30	24 7/5-8	25 7/11-14	26 7/19-22	27 7/26-29	28 8/2-4	29 8/9-11	30 8/16-18	31 8/23-25	32 8/30-9/2	33 9/20-22	TOTAL
Salmon																
Total Catch	173	195	42	22	17	16	10	2								3410
Percent each cycle	5.07	5.71	1.23	0.64	0.49	0.43	0.29	0.06								
Total calculated catch per cycle	45843	47791	18860	7464	10369	11776	4670	1414								
Mean calculated catch per tow	1766	1838	729	289	398	453	180	54								
Number measured	172	193	35	20	10	6	8	2								2978
Mean Length	74.7	73.8	73.3	81.0	80.5	83.5	92.9	106.5								
Standard Deviation	8.49	6.46	9.81	7.06	10.14	9.88	12.72	1.5								
Striped Bass																
Total Catch		506	534	1144	1064	3099	3140	4610	2200	1391	1507	396	334	168	89	20242
Percent each cycle		2.49	2.63	5.65	5.21	15.31	15.51	22.28	10.86	7.86	7.44	1.85	1.66	0.82	0.29	
Total calculated catch per cycle		360877	380121	561926	372497	1262830	1272278	2070025	777986	854034	835034	216628	181251	84982	29448	
Mean calculated catch per tow	- -	13880	14620	22382	14328	48185	48983	79618	29923	32847	32146	8340	6972	8258	1133	
Number measured		261	218	648	719	1427	1073	1548	1174	948	722	324	332	168	68	9619
Mean Length		13.1	16.6	20.3	26.4	32.0	33.5	37.7	41.4	48.1	52.0	64.9	66.7	63.8	74.7	
Standard Deviation		3.78	4.80	8.87	8.10	9.05	8.94	8.43	9.27	9.09	10.98	8.48	9.09	11.54	14.11	
Shad																
Total Catch	21	82	430	1923	3898	3600	3163	2773	1670	1207	1308	968	678	361	398	22461
Percent each cycle	0.09	0.27	1.91	8.56	17.36	16.03	14.04	12.35	7.43	5.37	5.82	4.31	3.02	1.60	1.77	
Total calculated catch per cycle	2695	7659	58347	274234	551271	828818	632072	498285	278125	237116	246973	144967	126494	73134	58812	
Mean calculated catch per tow	100	296	2283	10546	21203	24165	20464	19154	10620	9120	9498	5578	4942	2813	2262	
Number measured	16	28	176	538	766	1025	1083	1049	734	786	690	449	406	256	289	8406
Mean Length	23.7	23.0	26.0	20.4	24.2	29.6	34.6	34.9	35.6	39.3	47.4	46.7	50.5	48.3	62.4	
Standard Deviation	4.80	7.28	11.07	8.62	6.79	10.11	10.41	13.29	14.16	17.13	17.52	20.76	20.12	22.29	22.30	

TABLE NO. 3

Hydro-dynamics of the Sacramento-San Joaquin Delta, 1948

Date	Towing Cycle No.	Mean Delta In-flow in c.f.s. Sacramento River	San Joaquin River	Others*	TOTAL	Temperature °F. Max	Min	Mean Salinity at Antioch (p.p.100,000)	Turbidity in inches (Secchi Disc) Mossdale	Isleton
1/1-1/15		30,486	1,444	367	32,297	50.5	48.0	26	30	-
1/16-1/31		14,693	1,322	255	16,270	49.0	46.0	10	45	14
2/1-2/15		12,420	1,149	233	13,802	48.0	45.0	15	36	14
2/16-2/29		11,964	767	202	12,933	52.0	50.0	15	30	16
3/1-3/15		10,076	511	228	10,815	53.5	51.0	14	26	19
3/16-3/31		25,518	787	1,833	28,138	55.0	53.0	11	21	7
4/9-16	1	44,612	873	3,030	48,515	59.5	52.0	3	12	6
4/16-28	2	63,153	1,729	3,277	68,159	65.0	55.0	3	18	7
4/26-5/5	3	62,800	3,162	3,267	69,229	63.5	54.0	2	17	11
5/4-12	4	62,444	3,794	2,681	68,919	66.0	58.0	3	19	15
5/11-21	5	51,472	4,813	2,668	58,953	66.0	57.5	3	15	12
5/19-28	6	42,100	5,824	3,061	50,985	66.0	57.0	2	13	13
5/27-6/8	7	42,153	9,290	3,391	54,834	69.0	59.0	2	17	13
6/7-16	8	40,650	10,350	3,807	54,807	68.0	63.0	2	16	13
6/16-7/2	9	23,094	6,634	1,936	31,664	73.0	65.5	2	18	13
7/2-12	10	12,045	1,856	360	14,261	74.5	67.5	4	26	24
7/12-20	11	8,972	902	89	9,963	78.5	70.5	10	33	23
7/20-8/3	12	8,330	762	49	9,141	79.5	69.0	28	33	20
8/4-17	13	8,846	945	26	9,817	77.5	68.0	78	31	20
8/18-25	14	8,662	1,065	22	9,749	76.5	68.0	64	29	20
9/6-15	15	9,650	807	**	10,457	79.0	69.0	35	30	18
9/21-29	16	11,355	997	**	12,352	71.5	64.0	30	23	28
10/22-29	17	9,975	1,145	**	11,120	67.0	58.0	15	28	28
11/9-12	18	11,850	1,267	**	13,117	57.0	54.0	11	20	24
12/1-16	19	12,275	1,367	**	13,642	50.0	47.0	12	19	19

* Includes the Consumnes, Mokelumne and Calveras Rivers and Dry Creek.

** Daily average flow not available.

TABLE NO. 4

Hydro-dynamics of the Sacramento-San Joaquin Delta, 1949

Date	Towing Cycle No.	Mean Delta In-flow in c.f.s Sacramento River	San Joaquin River	Others*	TOTAL	Temperature °F. Max	Min	Mean Salinity at Antioch (p.p. 100,000)	Turbidity in Inches (Secchi Disc) Mossdale	Isleton
1/25-27	1	11,233	1,953	189	13,375	43.0	32.5	16	33	20
2/1-4	2	9,937	1,462	173	11,572	48.0	39.5	10	-	28
2/8-12	3	16,060	1,654	135	17,849	47.0	42.5	9	-	19
2/15-17	4	14,500	1,433	88	16,021	50.5	43.0	8	12	16
2/22-24	5	15,666	1,183	202	17,051	56.5	47.0	10	23	18
3/1-4	6	31,000	1,340	596	32,936	56.0	49.0	6	24	10
3/8-10	7	36,733	2,320	502	39,555	57.5	49.5	4	9	6
3/15-17	8	61,333	3,956	696	65,985	48.0	51.0	5	7	4
3/22-24	9	58,133	4,103	617	62,853	58.0	52.0	5	11	6
3/29-4/1	10	32,700	4,270	652	37,622	56.5	53.5	4	12	6
4/5-7	11	26,400	2,393	328	29,121	65.0	57.0	3	18	14
4/11-15	12	34,600	1,746	317	36,663	69.0	57.0	3	22	12
4/18-21	13	37,175	1,645	1,000	39,820	65.5	58.0	3	18	13
4/25-28	14	33,750	1,367	1,812	36,929	69.5	57.0	2	24	13
5/3-6	15	25,725	3,550	229	29,504	68.0	58.5	2	16	22
5/9-11	16	23,633	2,686	240	26,559	69.0	58.0	2	21	15
5/18-20	17	27,800	4,533	762	33,095	67.0	60.0	2	19	14
5/24-26	18	22,466	2,270	257	24,993	73.0	64.0	3	17	15
5/31-6/3	19	16,800	3,810	1,002	21,612	69.0	64.0	3	15	24
6/6-9	20	12,700	2,552	1,182	16,434	74.0	67.0	4	18	22
6/15-17	21	9,266	1,983	671	11,920	78.0	69.0	10	19	33
6/20-23	22	7,512	1,178	164	8,854	77.0	68.0	7	20	30
6/27-30	23	7,665	821	87	8,573	75.0	68.0	42	16	30
7/5-8	24	7,060	696	62	7,818	75.0	66.0	33	14	29
7/11-14	25	7,360	589	166	8,115	80.0	69.0	99	20	24
7/19-22	26	6,447	498	23	6,968	80.0	68.0	62	18	26
7/26-29	27	7,582	446	24	8,052	78.0	68.0	157	16	28
8/2-4	28	7,353	458	24	7,835	78.0	68.0	83	20	30
8/9-11	29	7,830	528	23	8,381	75.0	68.0	145	16	28
8/16-18	30	6,940	619	21	7,580	75.0	67.0	72	15	32
8/23-25	31	7,686	713	22	8,421	75.0	68.0	122	26	-
8/30-9/2	32	7,917	639	24	8,580	80.0	70.0	80	18	40
9/20-9/22	33	8,933	746	132	9,811	76.0	70.0	50	23	24

* Includes only Mokelumne River

TABLE NO. 5

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1948

		Cycle #1 4/9-16/48				Cycle #2 4/16-28/48				Cycle #3 4/26-5/5/48			
Stn	Average Width of Station	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn
1	200	0				7	84.3	70-90	350	1	76.0		50
2	400	0				3	76.7	69-81	300	1	74.0		100
3	250	0				16	77.6	71-87	992	9	76.8	68-85	558
4	350	0				0				2	67.5	67-68	174
5	400	0				9	83.4	77-100	900	12	83.5	72-117	1200
6	670	8	54.4	45-68	1336	14	69.6	40-97	2338	9	62.4	41-92	1503
7	750	1	69.0		187	8	59.3	41-88	1496	10	49.4	36-66	1870
8	150	14	75.4	68-85	518	1	68.0		37	5	76.4	71-85	185
9	350	0				0				1	64.0		87
10	250	1	65.0		62	3	65.3	51-82	186	2	81.5	76-87	124
11	250	4	69.8	64-81	249	6	69.8	62-76	372	3	72.0	62-76	186
12	200	2	78.5	72-85	100	1	71.0		50	5	75.8	65-82	250
13	1000	12	59.3	44-98	3000	24	53.0	40-92	6000	14	67.1	54-85	3500
14	1500	45	45.4	38-68	16875	10	48.6	37-59	3750	6	57.2	46-70	2250
15	2390	9	47.3	37-60	5373	8	45.3	37-89	4776	12	48.8	37-61	7164
16	2230	12	45.8	37-60	6684	11	44.5	37-71	6127	3	52.3	48-55	1671
17	3890	9	53.6	39-72	8748	3	49.7	39-69	2916	4	47.3	40-51	3888
18	750	7	41.9	33-54	1309	2	58.0	38-78	374	0			
19	450	5	45.0	39-64	560	5	54.2	39-70	560	0			
20	900	10	39.5	33-46	2250	11	41.5	35-86	2475	2	61.5	43-80	450
21	160	54	43.0	34-122	2160	7	43.9	35-84	280	9	64.6	38-88	360
22	500	20	47.3	34-88	2500	1	64.0		125	9	66.7	41-83	1125
23	600	3	53.7	37-85	450	4	39.5	35-48	600	3	78.3	74-86	450
24	2880	9	37.9	35-39	6480	51	43.2	35-89	36720	4	78.3	70-87	2880
25	2830	59	44.4	34-86	41713	15	44.2	36-76	10605	5	75.6	60-87	3535
		234	48.1			220	54.4			131	66.1		

TABLE NO. 5 (CONTINUED)

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1948

		Cycle #4 5/4-12/48				Cycle #5 5/11-21/48				Cycle #6 5/19-28/48			
Stn	Average Width of Station	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn
1	200	3	78.7	75-84	150	4	80.5	72-85	200	0			
2	400	2	75.5	72-79	200	3	80.5	73-88	300	3	77.0	76-79	300
3	250	4	76.8	68-82	248	6	76.5	74-80	372	4	85.5	79-90	248
4	350	3	84.7	74-91	261	0				1	78.0		87
5	400	5	75.6	65-80	500	8	81.0	75-88	800	1	84.0		100
6	670	22	77.1	55-90	3674	8	73.6	52-96	1336	4	75.0	56-87	668
7	750	2	53.0	48-58	374	6	65.5	54-84	1122	1	74.0		187
8	150	0				0				3	79.3	72-82	111
9	350	1	61.0		87	2	56.0	52-60	174	1	77.0		87
10	250	2	73.0	63-79	124	3	65.0	62-70	186	1	80.0		62
11	250	2	76.0	68-84	124	1	81.0		62	2	83.5	82-85	124
12	200	5	77.2	74-82	250	0				4	81.5	74-90	200
13	1000	7	59.4	52-67	1750	8	66.8	48-75	2000	2	86.0	81-91	500
14	1500	11	53.0	45-70	4125	9	65.6	48-77	3375	7	75.1	67-83	2625
15	2390	5	63.6	51-85	2985	2	57.0		1194	6	79.2	72-91	3582
16	2230	6	69.8	61-83	3342	2	72.0	67-77	1114	3	78.0	75-80	1671
17	3890	4	76.5	63-83	3888	8	72.3	54-86	7776	11	79.0	70-88	10692
18	750	0				2	77.0	76-78	374	1	69.0		187
19	450	0				0				0			
20	900	1	77.0		225	2	85.0	84-86	450	5	75.0	71-79	1125
21	160	0				1	82.0		40	6	69.3	62-87	240
22	500	2	75.5	70-81	250	0				6	72.8	63-85	750
23	600	3	80.3	76-87	450	2	72.5	69-76	300	7	75.6	65-84	1050
24	2880	8	74.6	39-85	5760	4	79.0	68-84	2880	16	74.4	52-87	11520
25	2830	8	79.1	63-88	5656	5	76.0	62-81	3535	5	80.8	69-90	3535
		106	69.5			86	72.9			100	77.1		

TABLE NO. 5 (CONTINUED)
King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1948

Station	Cycle #7 5/27-6/8/48 Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Cycle #8 6/7-16/48 Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Cycle #9 6/16-7/2/48 Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn
1	2	90.0	88-92	100	3	91.0	75-109	150	0			
2	1	77.0		100	4	85.5	81-95	400	0			
3	4	85.5	76-96	240	5	90.4	85-95	310	1	88.0		62
4	2	83.5	82-85	174	2	83.0	82-84	174	2	93.5	89-98	174
5	2	85.0	81-89	200	10	90.4	83-96	1000	3	88.7	87-92	300
6	6	86.7	81-90	1002	3	88.0	85-91	501	Not Towed			
7	5	73.2	54-85	935	10	83.4	65-91	1870	2	70.5	64-77	374
8	0				Not Towed				0			
9	3	83.7	81-87	261	3	84.7	75-97	261	2	92.0	89-95	174
10	1	81.0		62	1	81.0		62	0			
11	5	87.5	81-93	310	Not Towed				0			
12	1	87.0		50	Not Towed				1	89.0		50
13	0				6	82.0	70-90	1500	4	86.3	76-92	1000
14	3	76.0	69-89	1125	1	82.0		375	0			
15	0				10	77.0	71-82	5970	9	75.2	68-84	5373
16	2	79.0	76-82	1114	10	71.3	65-81	5570	2	74.0	71-77	1114
17	4	77.3	74-82	3888	9	81.8	70-93	8748	4	80.5	79-82	3888
18	0				1	69.0		187	0			
19	0				1	72.0		112	0			
20	1	64.0		225	7	73.0	70-77	1575	2	67.0	65-69	450
21	7	75.4	53-85	280	2	67.5	60-75	80	1	66.0		40
22	6	75.3	69-82	750	3	79.3	76-82	375	1	60.0		125
23	12	75.0	68-88	1800	4	74.2	59-88	600	1	65.0		150
24	10	71.8	63-82	7200	4	69.5	65-75	2880	5	63.6	60-67	3600
25	17	76.8	61-88	12019	4	73.5	68-79	2828	5	75.2	69-87	3535
	94	78.1			103	80.8			45	76.9		

TABLE NO. 5 (CONCLUDED)

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1948

	Cycle #10 7/2-12/48				Cycle #11 7/12-20/48				Cycle #12 7/20/8/3/48			
Station	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn
1	1	97.0		50	1	81.0		50	0			
2	1	79.0		100	0				0			
3	1	85.0		62	1	94.0		62	0			
4	0				0				0			
5	1	90.0		100	0				0			
6	0				0				0			
7	1	79.0		187	2	73.5	72-75	374	0			
8	0				0				0			
9	0				0				0			
10	0				0				0			
11	0				0				0			
12	0				Not Towed				Not Towed			
13	0				0				0			
14	0				0				0			
15	0				0				0			
16	0				4	76.5	65-88	2228	0			
17	2	74.5	72-77	1944	0				1	103.0		972
18	0				0				0			
19	0				0				0			
20	0				0				0			
21	0				0				0			
22	1	72.0		125	0				0			
23	0				1	98.0		150	0			
24	0				0				0			
25	4	74.8	66-94	2828	1	73.0		707	2	80.5	76-85	2828
	12	79.5			10	79.9			3	88.0		

TABLE NO. 6

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1949

		Cycle #5 2/22-24/49				Cycle #6 3/1-4/49				Cycle #7 3/8-10/49			
Stn	Average Width of Station	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Length mm	Size Range mm	Salmon in Station
1	200	0				0				0			
2	400	0				0				0			
3	250	0				0				0			
4	350	0				0				0			
5	400	0				0				0			
6	670	0				0				12	39.7	38-41	2004
7	750	0				0				1	38.0	38.0	187
8	150	0				0				0			
9	350	0				0				0			
10	250	0				0				0			
11	150	0				0				0			
12	200	0				0				0			
13	1000	0				0				2	41.5	41-42	500
14	1500	0				1	37.0	37.0	375	14	40.9	38-43	5250
15	2390	0				12	40.0	36-43	7164	9	38.7	34-41	5373
16	2230	0				0				43	38.6	33-42	23951
17	3890	0				1	39.0	39.0	972	12	39.4	36-46	11664
18	750	0				1	39.0	39.0	187	2	39.0	37-41	574
19	450	0				7	39.4	37-41	784	0			
20	900	5	39.6	38-41	1125	99	39.2	37-43	22275	37	38.1	35-41	8325
21	160	1	38.0	38.0	40	280	39.4	35-57	11200	61	39.5	35-46	2440
22	500	1	35.0	35.0	125	9	38.9	37-44	1125	10	39.0	36-43	1250
23	600	0				21	36.2	31-41	3150	10	39.0	35-42	1500
24	2880	2	39.5	39-40	1440	66	38.2	34-44	47520	79	38.2	35-46	56880
		(1 - 154mm)*											
25	2830	1	42.0	42.0	707	213	39.6	33-45	150591	11	38.8	36-45	7777
		10	39.1			710	39.0			303	38.8		

*Yearling not included in Mean Length or Salmon in tow.

TABLE NO. 6 (CONTINUED)
King Salmon Seaward Migrants taken in towing cycles
- Sacramento and San Joaquin Delta, 1949

	Cycle #8 3/15-17/49				Cycle #9 3/22-24/49				Cycle #10 3/29-4/1/49				Cycle #11			
Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn
1	0				0				0				0			
2	0				0				0				1	78.0	78.0	100
3	0				0				0				0			
4	0				0				0				0			
5	0				1	40.0	40.0	100	0				0			
6	6	40.8	38-46	1002	3	44.7	42-46	501	2	42.0	38-46	334	3	42.7	40-44	501
7	9	38.8	35-41	1683	10	39.5	36-46	1870	2	37.0	35-39	374	0			
8	0				0				0				1	61.0	61.0	37
9	0				1	50.0	50.0	87	1	50.0	50.0	87	2	50.5	48-53	174
10	2	44.0	44.0	124	1	45.0	45.0	62	0				0			
11	0				0				0				0			
12	0				0				0				2	62.0	50-74	100
13	0				3	43.0	39-46	750	4	51.5	46-59	1000	2	49.5	40-59	500
14	14	40.9	36-47	5250	16	41.6	37-50	6000	6	42.3	37-51	2250	6	50.3	42-63	2250
15	5	40.8	34-46	2985	8	43.3	38-54	4776	1	39.0	39.0	597	1	51.0	51.0	597
16	15	39.5	34 -43	8365	6	39.2	35-41	3342	1	36.0	36.0	557	0			
17	14	40.1	37-46	13608	23	40.0	36-46	22356	1	38.0	38.0	972	1	43.0	43.0	972
18	3	38.0	36-42	561	2	40.5	40-41	374	0				1	42.0	42.0	187
19	0				8	43.0	39-55	896	3	47.0	39-53	336	3	43.7	38-50	336
20	8	39.1	36-43	1800	26	38.6	33-42	5850	8	39.6	38-41	1800	2	39.5	39-40	450
21	25	38.3	33 -44	1000	30	38.6	35-48	1200	2**	44.5	38-51	80	0			
22	2	39.0	37-41	250	3	38.7	37-41	375	0				0			
23	2	39.0	39.0	300	2	37.0	36-38	300	0				1	35.0	35.0	150
24	55	38.3	34-47	39600	38	39.2	32-47	27360	3	37.0	37-49	2160	2*	45.5	42-49	1440
25	28	37.4	33-40	19796	82	39.3	34-54	57974	0				1	47.0	47.0	707
	188	39.0			263	39.9			34	42.7			29	48.6		

* Includes one yearling 154mm; not included in mean length.
** Includes one yearling 115mm; not included in mean length.

TABLE NO. 6 (CONTINUED)

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #12 4/11-15/49				Cycle #13 4/18-21/49				Cycle #14 4/25-28/49				Cycle #15 5/3-6/49			
Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn
1	4	77.8	70-83	200	2	56.0	40-72	100	23	70.7	58-88	1150	51	72.0	48-90	2550
2	19	76.7	64-88	1900	16	67.8	50-83	1600	7	66.2	39-80	700	5	67.4	60-76	500
3	11	79.9	74-88	682	63	68.7	37-92	3906	119	71.4	67-96	7378	43	73.6	54-93	2666
4	2	64.0	43-85	174	1	73.0	73.0	87	6	66.2	62-71	522	5	72.2	64-79	435
5	1	88.0	88.0	100	6	74.8	68-90	600	9	71.0	62-86	900	14	73.4	57-81	1400
6	1	58.0	58.0	167	2	87.5	85-90	334	1	52.0	52.0	167	7	79.1	72-91	1169
7	2	50.0	48-52	374	0				3	82.7	70-78	561	1	64.0	64.0	187
8	37	64.5	40-80	1369	17	61.2	40-91	629	6	69.5	65-75	222	6	67.8	60-74	222
9	0				1	66.0	66.0	87	1	68.0	68.0	87	1	78.0	78.0	87
10	0				1	81.0	81.0	62	0				2	79.5	74-85	124
11	29	49.8	35-70	1798	6	61.8	46-69	372	3	69.7	64-76	186	4	69.3	64-82	248
12	9	73.9	68-83	450	20	64.7	50-80	1000	20	66.2	43-80	1000	17	71.3	54-85	850
13	4	52.5	44-59	1000	10	62.2	54-85	2500	9	70.7	58-80	2250	7	76.0	72-81	1750
14	3	46.3	43-48	1125	2	68.0	60-76	750	1	80.0	80.0	375	1	75.0	75.0	375
15	0				5	62.0	44-82	2985	1	73.0	73.0	597	5	65.2	60-72	2985
16	0				0				1	72.0	72.0	557	1	72.0	72.0	557
17	0				0				3	79.0	74-85	2916	0			
18	0				2	49.0	43-55	374	2	52.0	42-62	374	5	41.2	33-67	935
19	4	57.8	47-64	448	2	61.5	60-63	224	7	50.7	40-80	784	3	52.7	42-65	336
20	1	32.0	32.0	225	0				2	45.0	44-46	450	0			
21	3	51.0	49-53	120	2	53.0	39-67	80	5	52.2	37-83	200	0			
22	0				0				4	79.3	73-83	500	0			
23	1	77.0	77.0	150	2	73.5	66-81	300	3	48.7	36-73	450	1	78.0	78.0	150
24	6	65.5	42-76	4320	6	53.3	33-73	4320	7	55.1	38-73	5040	1	78.0	78.0	720
25	3	51.3	32-77	2121	2	36.0	35-37	1414	5	71.0	65-78	3535	4	63.5	38-80	2828
26*	2	58.5	46-71	1600	4	78.0	70-87	3200	1	74.0	74.0	800	0			
	142	63.6			172	65.7			249	68.5			184	71.2		

*Station 26 established on April 11, 1949

TABLE NO. 6 (CONTINUED)

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #16 5/9-11/49				Cycle #17 5/18-20/49				Cycle #18 5/24-26/49				Cycle #19 5/31-6/3/49			
Stn	Salmon in tow	Mean Lgt mm	Size Range mm.	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn
1	26	74.8	65-87	1300	11	77.5	68-98	550	17	72.0	65-80	850	13	78.5	70-100	650
2	10	71.0	63-74	1000	5	73.8	68-82	500	37	71.8	60-104	3700	12	72.3	62-90	1200
3	73	72.6	58-96	4526	10	78.7	72-90	620	31	75.7	66-98	1922	28	75.2	66-107	1736
4	7	70.1	58-90	609	3	77.3	71-88	261	6	75.0	70-78	522	14	73.8	66-85	1218
5	55	73.6	63-92	5500	10	76.5	71-84	1000	18	76.3	65-95	1800	10	80.9	73-104	1000
6	4	70.0	66-72	668	2	73.5	73-74	334	18	78.2	68-96	3006	14	75.1	69-87	2338
7	0				2	87.0	87.0	374	1	59.0	59.0	187	3	74.3	65-89	561
8	12	69.8	64-77	444	2	67.5	63-72	74	23	74.3	61-87	851	2	79.5	75-84	74
9	8	70.5	65-76	696	7	71.0	60-78	609	3	75.0	70-81	261	1	80.0	80.0	87
10	1	66.0	66.0	62	2	77.0	74-80	124	Sample Lost				2	73.5	73-74	124
11	4	68.0	59-73	248	0				9	72.2	60-86	558	5	69.0	57-76	310
12	13	67.8	60-80	650	0				6	70.7	64-80	300	2	74.0	73-75	100
13	6	77.8	68-92	1500	8	77.1	74-81	2000	7	76.9	68-85	1750	5	78.6	71-84	1250
14	5	73.6	62-91	1875	3	77.3	74-82	1125	3	78.0	72-82	1125	4	75.3	65-83	1500
15	2	83.5	72-95	1194	1	88.0	88.0	597	2	70.0	68-72	1194	2	89.0	88-90	1194
16	3	81.7	77-91	1671	1	73.0	73.0	557	0				0			
17	3	79.3	78-80	2916	4	75.3	74-77	3888	3	78.7	74-84	2916	6	74.8	67-87	5832
18	1	78.0	78.0	187	0				0				3	67.3	61-75	561
19	7	57.6	45-75	784	2	87.5	85-90	224	6	61.2	49-77	672	0			
20	3	68.3	37-98	675	2	61.5	63-70	450	2	72.5	72-73	450	2	64.0	54-74	450
21	1	71.0	71.0	40	11	60.0	45-84	440	14	66.4	41-78	560	4	72.5	59-90	160
22	6	72.2	66-75	750	6	72.8	60-92	750	32	69.1	53-81	4000	0			
23	6	77.2	68-98	900	11	75.8	61-101	1650	10	68.9	60-78	1500	9	74.9	63-90	1350
24	3	74.7	70-80	2160	3	72.0	70-76	2160	2	75.0	70-80	1440	16	67.0	53-81	11520
25	3	76.3	72-81	2121	4	79.3	70-92	2838	14	77.8	70-90	9898	4	76.8	68-85	2828
26	3	90.0	83-98	2400	3	80.7	74-85	2400	8	81.9	66-99	6400	12	77.4	68-100	9600
	265	72.7			113	74.7			272	73.2			173	74.7		

TABLE NO. 6 (CONTINUEL)

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #20 6/6-9/1949				Cycle #21 6/15-17/49				Cycle #22 6/20-23/49				Cycle #23 6/27-30/49			
Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn
1	6	72.2	67-77	300	2	79.0	77-81	100	1	83.0	83.0	50	0			
2	8	70.9	61-80	800	2	85.0	85.0	200	2	87.0	80-94	200	2	79.5	78-81	200
3	36	74.3	65-83	2232	6	77.2	67-86	372	4	85.5	81-89	248	0			
4	5	72.8	70-76	435	0				0				0			
5	26	73.9	67-84	2600	1	74.0	74.0	100	2	82.0	79-85	200	0			
6	4	63.5	54-70	668	3	68.0	51-82	501	0				0			
7	3	74.3	65-79	561	0				0				2	74.0	74.0	374
8	0				0				2	87.0	82-92	74	0			
9	4	70.8	60-81	348	0				0				0			
10	3	71.7	68-75	186	0				1	83.0	83.0	62	0			
11	4	74.0	69-79	248	0				1	74.0	74.0	62	0			
12	2	73.5	71-76	100	1	69.0	69.0	50	*				0			
13	1	88.0	88.0	250	0				0				0			
14	4	76.5	65-85	1500	0				0				0			
15	12	78.1	68-85	7164	5	67.0	60-71	2985	1	87.0	87.0	597	0			
16	7	75.1	68-81	3899	0				1	72.0	72.0	557	1	78.0	78.0	557
17	1	72.0	72.0	972	2	80.0	80.0	1944	4	74.0	73-75	3888	0			
18	3	71.3	69-75	561	1	61.0	61.0	187	0				0			
19	1	46.0	46.0	112	1	60.0	60.0	112	1	65.0	65.0	112	0			
20	7	79.9	64-93	1575	3	70.3	68-73	675	0				0			
21	11	68.5	60-75	440	0				0				0			
22	13	71.9	59-79	1625	0				0				0			
23	8	71.0	55-80	1200	0				0				0			
24	4	71.3	66-75	2880	1	65.0	65.0	720	0				0			
25	5	73.8	68-80	3535	2	81.5	74-89	1414	2	77.5	76-79	1414	4	88.0	87-89	2828
26	17	78.9	72-93	13600	12	76.3	67-103	9600	0				8	79.5	65-104	6400
	195	73.8			42	73.3			22	81.0			17	80.5		

*Sample lost when not caught on bottom

TABLE NO. 6 (CONCLUDED)

King Salmon Seaward Migrants taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #24 7/5-8/49				Cycle #25 7/11-14/49				Cycle #26 7/19-22/49				Cycle #27 7/26-29/49			
Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in Stn	Salmon in tow	Mean Lgt mm	Size Range mm	Salmon in tow
1	0				0				0				0			
2	0				0				0				0			
3	0				0				0				0			
4	0				1	73.0	73.0	87	0				0			
5	0				0				0				0			
6	0				0				0				0			
7	0				0				0				0			
8	0				0				0				0			
9	0				0				0				0			
10	0				0				0				0			
11	0				0				0				0			
12	0				0				0				0			
13	0				0				0				0			
14	0				0				0				0			
15	0				2	103.0	103.0	1194	0				0			
16	2	66.0	66.0	1114	0				0				0			
17	2	86.0	86.0	1944	0				0				0			
18	0				0				0				0			
19	0				0				0				0			
20	0				0				0				0			
21	0				0				0				0			
22	0				3	102.3	98-109	375	0				0			
23	0				0				0				0			
24	1	82.0	82.0	720	0				0				0			
25	0				2	83.5	72-95	1414	2	106.5	105-108	1414	0			
26	10	86.4	76-104	8000	2	90.0	90.0	1600	0				0			
	15	83.5			10	92.9			2	106.5			0			

TABLE NO. 7

Striped Bass Eggs taken in Plankton Tows, 1948

Cycle	Date	Type of tow	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
3	4/26-5/5	Surf	0	0	0	0	0	0	0	26	0	0	81	38	0	0	0	0	2	0	0	0	0	0	0	0	0	147
4	5/4-12	"	0	0	24	0	20	0	0	0	0	1120	15	1	0	0	0	26	0	0	0	0	0	0	0	0	0	1206
5	5/11-21	"	0	0	0	0	10	0	0	0	0	0	0	0	0	2	0	108	12	0	0	0	1	0	0	0	2	135
6	5/19-28	"	0	0	0	0	0	0	2	10	4	0	2	18	0	0	2	0	16	0	0	0	0	0	0	0	0	54
7	5/27-6/8	"	0	2	0	0	0	0	4	0	0	0	2	0	0	0	6	8	8	0	0	0	0	0	0	0	0	30
8	6/7-16	"	0	0	0	0	-	0	2	0	12	48	-	-	0	0	2	2	2	0	0	0	4	6	6	0	0	84
9	6/16-7/2	"	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	2	2	0	0	0	0	0	0	0	0	7

TABLE NO. 8

Striped Bass Larvae taken in Plankton Tows, 1948

Cycle	Date	Type of tow	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
8	6/7-16	Surf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
9	6/16-7/2	"	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2	0	0	0	0	0	0	0	0	6

Tows were ten-minute hauls

TABLE NO. 9

Striped Bass Juveniles (1948 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta 1948

		Cycle #10 7/2-12/48				Cycle #11 7/12-20/48				Cycle #12 7/20-8/3/48			
Stn	Average Width of Station	Bass in tow	Mean Length mm	Size Range mm	Bass in Station	Bass in tow	Mean Length mm	Size Range mm	Bass in Station	Bass in tow	Mean Length mm	Size Range mm	Bass in Station
1	200	0				0				0			
2	400	0				0				1	40.0		100
3	250	0				1	20.0		62	2	25.0	22-28	124
4	350	0				2	19.5	12-31	174	21	19.3	12-31	1827
5	400	0				6	13.2	9-22	100	14	20.6	11-31	1400
6	670	7	9.9	6-15	1169	66	16.9	8-30	11022	107	21.1	12-36	17869
7	750	3	11.0	11.0	561	144	16.6	9-28	26928	220	30.0	12-46	41140
8	150	0				0				0			
9	350	4	9.6	8-11	348	4	14.8	12-17	348	75	22.2	12-36	6525
10	250	4	10.0	8-12	248	58	17.8	9-25	3596	38	27.5	15-37	2356
11	250	0				0				0			
12	200	0				Discontinued							
13	1000	6	11.3	8-13	1500	24	21.4	13-38	6000	91	29.7	17-47	22750
14	1500	22	13.3	7-25	8250	75	19.3	8-38	28125	205	29.1	15-47	76875
15	2390	4	16.5	16-17	2398	62	20.8	12-42	37014	463	33.6	14-58	276411
16	2230	3	16.0	12-24	1671	88	16.4	7-41	49016	217	34.1	11-45	120869
17	3890	6	16.5	15-18	5832	294	16.3	10-30	285768	264	30.5	16-44	256608
18	750	0				2	22.5	13-32	374	10	52.2	41-70	1870
19	450	0				0				0			
20	900	12	11.5	6-19	2700	7	19.4	8-34	1575	0			
21	160	0				0				0			
22	500	0				0				0			
23	600	0				0				1	46.0		150
24	2880	0				5	15.2	12-19	3600	89	38.3	26-49	64080
25	2830	68	11.0	5-19	48076	36	14.9	11-26	25452	121	32.7	13-55	85547
		139	11.6			874	17.2			1939	30.7		

TABLE NO. 9 (CONCLUDED)

Striped Bass Juveniles (1948 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1948

Stn	Cycle #13 8/4-17/48 Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Cycle #14 8/18-25/48 Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Cycle #15 9/6-16/48 Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Cycle #16 9/21-29/48 Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn
1	17	42.4	29-51	850	8	47.1	33-60	400	2	66.0	52-80	100	0			
2	30	39.3	23-50	3000	19	47.1	25-70	1900	0				0			
3	48	35.6	12-55	2976	24	42.5	33-55	1488	1	57.0		62	0			
4	68	36.0	14-56	5916	46	40.1	26-54	4002	0				1	77.0		87
5	63	29.6	20-48	6300	31	40.7	29-56	3100	6	52.5	40-64	600	0			
6	247	37.2	23-53	41219	93	43.7	29-63	15531	27	56.5	46-95	4500	0			
7	588	44.0	31-70	109956	116	50.3	37-73	21692	7	64.1	58-76	1309	0			
8	0				0				0				Discontinued			
9	178	36.0	20-51	15486	61	40.8	22-55	5307	0				0			
10	338	40.4	24-60	20956	75	45.4	27-57	4650	26	55.2	45-65	1612	1	55.0		62
11	0				0				0				Discontinued			
12	Discontinued															
13	204	38.3	20-60	51000	120	47.9	34-59	30000	24	60.9	49-83	6000	1	64.0		250
14	462	41.6	13-63	173250	142	46.1	36-66	53250	16	64.7	52-90	6000	7	66.3	55-82	2625
15	184	42.4	31-69	109848	44	47.1	38-65	26268	0				3	61.3	59-65	1791
16	192	43.9	32-64	106944	87	55.6	35-77	48459	159	73.4	50-102	88563	1	51.0		557
17	427	42.5	30-79	415044	79	47.1	28-70	76788	13	67.7	58-76	12636	4	77.5	59-93	3888
18	28	57.3	44-67	5236	1	43.0		187	0				0			
19	0				0				0				0			
20	92	56.2	42-67	20700	0				0				0			
21	0				0				0				0			
22	0				0				0				0			
23	0				0				0				0			
24	325	42.4	31-59	234000	50	55.9	42-65	36000	0				4	71.0	61-75	2880
25	175	42.2	27-61	123725	152	50.5	35-67	107464	1	64.0		707	1	67.0		707
	3666	40.9			1148	47.1			282	67.1			23	67.7		

TABLE NO. 10

Striped Bass (1948 Year-Class as based on length frequencies) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

Cycle #4 2/15-17				Cycle #6 3/1-4				Cycle #7 3/8-10				Cycle #8 3/15-17			
Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm
18	1	98.0	98.0	1	1	103.0	103.0	7	1	72.0	72.0	6	1	88.0	88.0
				2	1	86.0	86.0	9	1	86.0	86.0				
				6	3	93.7	78-107								
				14	2	87.5	83-92								
				15	2	82.0	80-84								
				17	1	80.0	80.0								
	1	98.0	98.0		10	88.9	78-107		2	79.0	72-86		1	88.0	88.0

Cycle #9 3/22-24				Cycle #10 3/29-4/1				Cycle #11 4/5-7				Cycle #12 4/11-15			
Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm
6	1	79.0	79.0	9	1	83.0	83.0	5	1	121.0	121.0	10	1	100.0	100.0
7	2	81.0	77-85					6	3	136.0	85-219	12	1	116.0	116.0
								13	1	92.0	92.0				
								14	1	83.0	83.0				
								16	1	69.0	69.0				
								17	1	75.0	75.0				
	3	80.3	77-85		1	83.0	83.0		8	106.0	83-219		2	108.0	100-116

TABLE NO. 10 (CONTINUED)

Striped Bass (1948 Year-Class as based on length frequencies) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

Cycle #13 4/18-21				Cycle #14 4/25-28				Cycle #16 5/3-6				Cycle #17 5/9-11			
Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm
10	1	85.0	85.0	1	1	105.0	105.0	4	1	89.0	89.0	9	1	118.0	118.0
				14	1	114.0	114.0	15	1	72.0	72.0	10	1	91.0	91.0
								19	1	110.0	110.0				
	1	85.0	85.0		2	109.5	105-114		3	90.3	72-110		2	104.5	91-118

Cycle #18 5/24-26				Cycle #19 5/31-6/3				Cycle #20 6/6-9				Cycle #21 6/15-17			
Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm
11	4	115.0	105-124	1	1	155.0	155.0	2	1	102.0	102.0	1	1	140.0	140.0
13	2	91.0	78-104	13	4	140.8	126-149	12	1	154.0	154.0	11	1	142.0	142.0
22	1	115.0	115.0					13	3	134.3	130-140				
								14	1	145.0	145.0				
	7	108.1	78-124		5	143.6	126-155		6	133.9	102-154		2	141.0	140-142

TABLE NO. 10 (CONCLUDED)

Striped Bass (1948 Year-Class as based on length frequencies) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

Cycle #22 6/20-23				Cycle #23 6/27-30				Cycle #24 7/5-8				Cycle #25 7/11-14			
Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm
3	1	149.0	149.0	3	1	136.0	136.0	5	1	245.0	245.0	1	1	175.0	175.0
4	2	132.5	125-140	13	4	138.0	115-155					5	1	152.0	152.0
9	1	128.0	128.0									11	1	150.0	150.0
13	5	142.0	125-160												
	9	139.1	125-160		5	137.6	115-155		1	245.0	245.0*		3	159.0	150-175

* Two Year Old

Cycle #26 7/19-22				Cycle #27 7/26-29			
Stn	Bass in tow	Mean Length mm	Size Range mm	Stn	Bass in tow	Mean Length mm	Size Range mm
11	1	140.0	140.0	8	1	160.0	160.0
13	1	185.0	185.0	13	1	158.0	158.0
	2	162.5	140-185		2	159.0	158-160

TABLE NO. 11

Striped Bass Eggs taken in Plankton Tows, 1949

Cycle	Date	Type of tow	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
11	4/5-7	Surf	-	0	-	-	0	0	0	0	-	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
12	4/12-14	Surf	11	9	22	0	0	0	4	0	8	0	1	0	0	1	43	21	0	0	0	0	2	0	0	0	0	0	122
13	4/18-21	Surf	0	7	2	0	0	0	3	0	0	54	10	0	0	1	2	2	5	0	0	0	0	0	1	0	0	0	87
		Deep							0								0	0	4		0	1					0	0	5
14	4/25-28	Surf	17	53	15	0	60	17	0	0	5	14	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	185
		Deep															0		0	0	0	0	0	0			0	0	0
15	5/3-6	Surf	0	0	0	0	1	12	4	3	2	2	30	0	1	2	57	34	3	0	0	0	0	0	0	0	0	0	151
		Deep		0	0		0	1				6			0	1	33	88	2	0	0	0	0	0	0	0	2	0	133
16	5/9-12	Surf	0	1	4	0	9	10	2	2	0	0	25	3	0	1	0	1	3	0	1	0	0	0	0	0	0	0	62
		Deep			2		9	3				1			0	0	0	8	0	0	0	0	1	0	0	0	0	2	26
17	5/18-20	Surf	0	0	0	0	2	0	4	0	6	0	0	0	0	0	5	23	522	0	0	0	0	0	0	0	0	2	564
		Deep		0	0		0	0				0			0	0	1	13	239	0	0	0	0	0	0	0	0	0	253
18	5/23-26	Surf	2	0	1	0	1	2	3	0	0	0	45	0	0	0	1	1	8	0	0	0	0	1	0	0	1	0	66
		Deep		0	4		2	0				0			0	1	0	2	8	0	0	0	0	0	0	1	0	0	18
19	5/31-6/3	Surf	0	0	0	0	0	0	1	0	1	0	8	0	0	0	20	18	1	0	0	1	0	0	0	0	1	7	58
		Deep	0	0	0	0	0	0	0		0	0			0	0	4	2	0	0		0	0	0	0	0	0	0	6
20	6/6-9	Surf	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	4
		Deep		0	0		0	0				0			0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
21	6/15-17	Surf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	3
		Deep			0		0					0			0		0	3	0	0					0	0	0	0	3

Surface tows combine two five-minute hauls
Deep tows were five minute hauls

TABLE NO. 12

Striped Bass Larvae taken in Plankton Tows, 1949

Cycle	Date	Type of tow	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
			Stations																										
13	4/18-21	Surf	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
		Deep							0								0	1	0		0	0					0	0	1
14	4/25-28	Surf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	5	0	0	0	0	0	0	0	1	0	15
		Deep															0	0	1	0	0	0	0	0			0	0	1
15	5/3-6	Surf	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	0	0	0	0	0	0	0	1	1	7
		Deep		0	0		0	0				0			0	0	0	0		0	0	0	0	0	0	0	1	0	1
16	5/9-12	Surf	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	17	30	0	0	1	0	0	0	0	0	7	62
		Deep			0		0	0				0			0	0	2	91	267	0	0	0	0	0	0	0	0	2	362
17	5/18-20	Surf	0	0	0	0	0	1	10	0	0	0	0	0	0	0	1	7	37	0	0	0	0	0	0	0	2	14	72
		Deep		0	0		0	0				0			0	0	0	0	11	3	0	0	0	0	0	0	1	1	16
18	5/23-26	Surf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	34	21	0	3	0	61
		Deep		0	0		0	0	0			0			0	0	0	0	3	0	0	0	2	1	32	0	8	7	53
19	5/31-6/3	Surf	0	0	0	0	0	0	4	0	0	0	0	0	0	0	5	6	17	0	0	3	0	3	0	4	1	8	51
		Deep	0	0	0	0	0	0	0	0	0	0			0	0	2	3	4	0		0	0	5	1	1	0	6	22
20	6/6-9	Surf	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	8	25	0	0	0	0	4	1	2	5	28	81
		Deep		0	0		0	0				0			0	0	4	15	5	0	0	23	1	43	3	17	2	13	126
21	6/15-17	Surf	1	0	0	0	0	1	8	0	0	0	0	0	0	2	5	7	8	0	0	4	0	1	0	0	16	4	57
		Deep			1		0					0			0		0	5	0						0	1	4	1	12
22	6/20-23	Surf	0	0	0	0	0	0	5	0	1	0	0	0	0	0	8	0	1	0	0	0	0	0	0	0	2	0	17
		Deep			0		0					0				1	1	7	3	0	0	0	0	0	0	1	1	6	20
23	6/27-30	Surf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Deep			0		0	0							0	0	1	0	0	0	0	0	0	0	0	0	0	0	1

Surface tows combine two five-minute hauls
Deep tows were five minute hauls

TABLE NO. 13

Striped Bass Juveniles (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

		Cycle #20 6/6-9/49				Cycle #21 6/15-17/49				Cycle #22 6/20-23/49			
Stn	Average Width of Station	Bass in tow	Mean Length mm	Size Range mm	Bass in Stn	Bass in tow	Mean Length mm	Size Range mm	Bass in Stn	Bass in tow	Mean Length mm	Size Range mm	Bass in Station
1	200	0				0				6	17.0	12-20	300
2	400	0				0				3	25.3	10-38	150
3	250	0				5	22.8	19-29	310	4	18.3	8-25	248
4	350	0				0				11	26.8	18-35	957
5	400	1	26.0	26.0	100	1	14.0	14.0	100	11	22.0	15-30	1100
6	670	0				3	18.7	16-22	501	57	20.0	11-37	9519
7	750	72	16.1	9-30	13464	65	17.9	6-30	12155	202	21.8	10-40	37774
8	150	0				0				0			
9	350	0				0				7	28.1	15-41	609
10	250	15	14.1	9-23	930	14	23.2	10-25	868	121	24.4	12-47	7502
11	250	0				0				0			
12	200	0				0				*			
13	1000	0				1	22.0	22.0	250	23	24.7	12-40	5750
14	1500	8	15.4	8-28	3000	3	20.3	17-22	1125	78	21.9	13-39	29250
15	2390	0				23	17.4	12-31	13731	41	17.4	5-37	24477
16	2230	0				12	13.5	7-25	6684	16	18.0	14-27	8912
17	3390	109	12.3	5-22	105948	170	15.2	8-37	165240	146	17.3	10-30	141912
18	750	0				0				1	51.0	51.0	187
19	450	0				0				0			
20	900	0				18	19.0	15-21	4050	0			
21	160	0				0				0			
22	500	0				0				0			
23	600	0				0				0			
24	2880	3	14.0	14.0	2160	0				18	9.5	6-13	12960
25	2830	25	12.1	7-20	17675	1	15.0	15.0	707	203	17.3	8-40	143521
26	3200	272	11.7	5-21	217600	218	15.8	13-22	174400	196	16.5	8-32	156800
		505	13.1			534	16.6			114.	20.3		

*Sample lost - not hit bottom.

TABLE NO. 13 (CONTINUED)

Striped Bass Juveniles (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #23 6/27-30/49				Cycle #24 7/5-8/49				Cycle #25 7/11-14/49				Cycle #26 7/19-22/49			
Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn
1	13	36.5	32-45	650	12	32.3	22-43	600	5	45.8	40-49	250	11	38.0	30-53	550
2	20	30.2	16-42	2000	11	35.4	17-45	1100	16	29.7	15-49	1600	40	43.1	20-61	400
3	52	27.9	12-47	3224	29	32.7	18-42	1798	40	27.4	18-43	2480	70	33.9	18-51	4340
4	10	23.6	17-32	870	27	30.7	17-47	2349	11	25.5	18-31	957	27	33.9	22-55	2349
5	44	22.0	11-36	4400	35	26.2	17-38	3500	48	27.5	13-56	4800	148	29.9	17-55	14800
6	84	23.1	13-36	14028	195	26.0	11-44	32565	183	33.9	18-60	30561	173	33.1	16-84	28891
7	148	17.7	10-40	27676	386	27.2	13-58	72182	426	32.9	16-52	79662	522	39.2	26-56	97614
8	2	35.0	32-38	74	2	43.5	42-45	74	7	38.9	33-51	259	4	45.8	11-59	148
9	26	26.3	11-44	2262	47	27.9	15-45	4089	51	25.3	15-44	4437	98	35.0	21-49	8526
10	108	27.4	8-47	6696	481	28.3	13-50	29822	277	31.3	20-46	17174	373	32.9	18-49	23126
11	2	36.0	34-38	124	10	39.5	29-49	620	1	51.0	51.0	62	7	47.0	17-59	434
12	4	35.8	30-40	200	1	41.0	41.0	50	65	38.4	18-60	2750	64	49.8	28-73	3200
13	19	33.5	25-43	4750	129	33.1	11-54	32250	49	35.6	20-65	12230	110	37.1	26-70	27500
14	124	27.9	14-47	46500	394	27.5	12-43	147750	322	33.2	15-61	120750	474	36.3	20-62	177750
15	63	21.6	10-39	37611	204	26.9	14-44	121788	762	33.3	18-47	454914	792	37.3	24-66	472824
16	69	28.1	12-48	38433	142	34.9	13-59	79094	670	42.6	23-62	373190	568	39.9	22-60	316376
17	20	18.2	12-23	19440	370	35.5	15-54	359640	124	33.7	13-55	120528	574	38.8	23-59	557928
18	45	32.1	22-62	8415	149	37.9	20-60	27863	38	43.0	22-75	7106	9	48.6	32-69	1683
19	2	37.0	37.0	224	0				0				0			
20	2	11.0	10-12	450	24	37.3	20-54	5400	4	21.5	18-25	900	0			
21	0				0				0				0			
22	0				0				0				0			
23	1	13.0	13.0	150	0				0				0			
24	0				93	37.6	14-54	66960	8	37.1	20-52	5760	178	45.4	34-61	128160
25	28	27.4	12-44	19796	248	36.9	12-62	175336	27	29.8	20-52	19039	118	42.5	22-69	83426
26	168	20.4	12-36	134400	110	35.1	27-44	83000	16	32.4	18-47	12800	150	41.1	29-58	120000
	1056	25.4			3099	32.0			3140	33.9			4510	37.7		

TABLE NO. 13 (CONTINUED)

Striped Bass Juveniles (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #27 7/26-29/49				Cycle #28 8/2-4/49				Cycle #29 8/9-11/49				Cycle #30 8/16-18/49			
Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn	Bass in tow	Mean Lgt mm	Size Range mm	Bass in Stn
1	26	43.6	28-65	1300	5	48.8	35-88	250	8	45.3	30-58	400	0			
2	20	38.3	27-53	2000	10	43.1	34-60	1000	16	45.2	25-66	1600	0			
3	60	35.9	15-66	3720	28	40.4	23-63	1736	32	44.6	16-62	1984	3	52.7	38-70	186
4	18	33.3	25-48	1566	15	44.3	36-50	1305	6	43.3	38-48	522	7	47.0	44-50	609
5	63	36.5	25-73	6300	28	43.3	34-57	2800	16	42.6	30-58	1600	2	38.0	33-43	200
6	86	37.4	27-79	14362	51	40.0	19-52	8517	33	47.2	38-60	5511	11	50.6	35-70	1837
7	226	37.7	15-66	42262	171	42.9	28-77	31977	10	47.6	35-60	1870	62	50.8	28-82	11594
8	2	61.5	61-62	74	6	68.2	58-77	222	2	46.0	45-47	74	0			
9	17	36.6	31-45	1479	20	42.5	21-52	1740	4	45.3	42-49	348	1	47.0	47.0	87
10	170	41.2	28-86	10540	91	42.9	32 -53	5642	45	45.9	33-55	2790	3	53.3	49-62	186
11	3	41.0	33-50	186	3	45.0	44-46	186	1	50.0	50.0	62	2	53.0	52-54	124
12	88	48.9	35-66	4400	40	64.4	43-88	2000	166	62.9	46-101	8300	12	73.1	61-94	600
13	108	41.0	32-63	27000	88	48.1	35-81	22000	33	56.4	40-90	8250	36	55.7	37-86	9000
14	242	38.9	27-55	90750	106	40.7	31-64	39750	40	50.1	35-95	15000	11	49.5	41-60	4125
15	554	40.3	28-64	330738	48	46.2	34-79	28656	26	65.8	21-110	15522	5	51.4	48-59	2985
16	154	38.9	25-60	85778	12	43.2	35-57	6684	12	49.3	30-69	6684	28	61.9	50-81	15596
17	36	44.3	35-60	34992	168	44.9	33-71	163296	20	42.9	37-48	19440	67	52.7	38-75	65124
18	13	45.8	31-62	2431	0				3	45.3	44-47	561	0			
19	0				0				4	72.5	61-84	448	0			
20	224	51.8	28-84	50400	0				16	67.3	44-82	3600	0			
21	0				1	47.0	47.0	40	0				0			
22	0				0				0				0			
23	0				0				0				0			
24	14	51.7	48-56	10080	275	51.5	28-69	198000	728	51.0	33-68	524160	137	58.0	44-77	98640
25	34	51.7	42-63	24038	19	47.3	30-72	13433	126	56.9	40-75	89082	5	57.2	50-66	3535
26	42	45.2	35-56	33600	406	48.2	36-65	324800	160	48.8	37-63	128000	3	53.3	50-58	2400
	2200	41.4			1591	46.1			1507	52.0			395	54.9		

TABLE NO. 13 (CONCLUDED)

Striped Bass Juveniles (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #31 8/23-25/49				Cycle #32 8/30-9/2/49				Cycle #33 9/20-22/49			
Station	Bass in tow	Mean Length mm	Size Range mm	Bass in Stn	Bass in tow	Mean Length mm	Size Range mm	Bass in Stn	Bass in tow	Mean Length mm	Size Range mm	Bass in Station
1	1	68.0	68.0	50	0				4	85.0	75-100	200
2	1	80.0	80.0	100	1	80.0	80.0	100	0			
3	1	35.0	35.0	62	1	50.0	50.0	62	1	83.0	83.0	62
4	0				0				0			
5	1	40.0	40.0	100	4	51.8	32-65	400	1	58.0	58.0	100
6	12	54.9	35-78	2004	5	56.6	45-66	835	1	65.0	65.0	167
7	34	56.6	38-77	6358	16	57.3	40-70	2992	5	81.6	73-110	935
8	0				0				0			
9	1	50.0	50.0	87	0				0			
10	17	54.5	38-64	1054	3	51.0	38-63	186	0			
11	0				1	100.0	100.0	62	0			
12	14	63.9	46-80	350	0				2	111.0	111.0	100
13	32	64.4	47-93	8000	43	63.5	50-75	10750	7	91.0	84-105	1750
14	6	53.8	45-60	2250	5	78.4	56-101	1875	1	84.0	84.0	375
15	12	61.5	46-87	7164	4	87.8	77-115	2388	0			
16	3	71.0	51-86	1671	6	60.7	48-75	3342	16	71.9	60-91	8912
17	0				14	58.3	47-75	13608	6	64.0	60-68	5832
18	1	60.0	60.0	187	0				0			
19	0				0				0			
20	0				0				0			
21	0				0				0			
22	0				0				0			
23	0				0				0			
24	68	58.0	43-73	48960	39	69.0	52-98	28080	3	68.0	68-70	2160
25	12	59.2	45-71	8484	6	68.2	53-80	4242	8	66.3	61-75	5656
26	118	52.5	41-65	94400	20	55.9	46-79	16000	4	58.3	55-61	3200
	334	56.7			168	63.5			59	74.7		

TABLE NO. 14

Catch of Striped Bass Eggs, Larvae and Juveniles expressed in terms of a standard volume of water strained
1949

Station	EGGS 4/5-6/17, 1949		LARVAE 4/18-7/1, 1949		JUVENILES 6/6-9/22, 1949	
	No. of Samples	Catch per 100,000 Cubic Feet	No. of Samples	Catch per 100,000 Cubic Feet	No. of Samples	Catch per 100,000 Cubic Feet
1	20	68.3	22	2.1	14	3.2
2	27	99.5	28	0	"	4.8
3	27	75.0	31	1.1	"	11.4
4	20	0	22	2.1	"	4.6
5	28	127.2	31	0	"	14.1
6	27	65.6	29	2.5	"	31.2
7	23	41.7	24	65.0	"	81.8
8	21	10.3	22	0	"	.9
9	20	50.1	22	2.1	"	9.5
10	27	106.2	30	1.2	"	59.9
11	21	250.3	22	0	"	1.1
12	21	6.2	22	0	"	15.6
13	28	1.3	30	0	"	23.7
14	27	12.1	30	4.8	"	63.3
15	31	240.1	34	44.5	"	88.4
16	30	404.8	33	326.1	"	59.6
17	31	1193.4	33	772.5	"	63.6
18	28	0	31	6.8	"	9.1
19	28	1.3	31	0	"	.2
20	30	7.2	33	58.5	"	10.0
21	28	6.5	31	6.8	"	.03
22	28	2.5	31	159.3	"	0
23	27	1.3	30	106.9	"	.03
24	28	2.4	31	49.8	"	54.6
25	30	6.8	33	67.2	"	30.0
26	31	21.6	34	138.6	"	65.7

TABLE NO. 15

Shad (1948 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1948

		Cycle #9 6/16-7/2/48				Cycle #10 7/2-12/48				Cycle #11 7/12-20/48			
Stn	Average Width of Station	Shad in tow	Mean Length mm	Size Range mm	Shad in Stn	Shad in tow	Mean Length mm	Size Range mm	Shad in Stn	Shad in tow	Mean Length mm	Size Range mm	Shad in Station
1	200	0				8	31.1	26-38	400	13	28.0	18-51	650
2	400	0				3	35.7	34-38	300	45	30.9	21-54	4500
3	250	0				31	22.8	21-25	1922	15	34.3	25-50	930
							(27 larval)						
4	350	0				10	34.5	22-46	870	32	30.9	17-51	2784
5	400	0				8	28.3	15-30	800	13	39.5	15-55	1300
6	670	0				11	31.0	27-38	1837	10	34.0	26-49	1670
7	750	0				0				0			
8	150	0				0				20	22.3	11-48	740
9	350	0				1	31.0		87	21	28.6	19-55	1827
10	250	0				6	38.3	29-45	372	20	30.9	22-46	1240
11	250	0				0				1	22.0		62
12	200	Discontinued											
13	1000	0				6	47.0	25-61	1500	38	41.2	22-75	9500
14	1500	0				6	48.7	35-66	2250	23	37.3	21-75	8625
15	2390	0				0				56	30.8	19-75	33432
16	2230	0				1	39.0		557	4	23.5	23-25	2228
17	3890	0				0				0			
18	750	33	Larval*		6171	437	18.6	10-43	81719	706	24.2	11-41	132022
19	450	20	Larval*		2240	485	17.4	10-42	54320	483	19.9	12-31	54096
20	900	41	Larval*		9225	212	24.8	11-61	47700	78	27.5	14-44	17550
21	160	0				36	Larval*		1440	130	17.6	8-26	5200
22	500	41	Larval*		5125	3	Larval*		375	68	19.0	11-23	7250
23	600	0				7	Larval*		1050	36	18.7	12-24	5400
24	2880	27	Larval*		19440	23	19.1	10-26	16560	168	21.2	12-32	120960
25	2830	3	Larval*		2121	0				4	23.8	22-25	2828
		185				1294	21.8			1974	25.1		

* Larval = under 20 mm in length

TABLE NO. 15 (CONTINUED)

Shad (1948 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta 1948

	Cycle #12 7/20-8/3/48				Cycle #13 8/4-17/48				Cycle #14 8/18-25/48				Cycle #15 9/6-15/48			
Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Length mm	Size Range mm	Shad in Stn
1	48	37.4	23-60	2400	40	49.1	32-63	2000	4	63.0	49-89	200	0			
2	209	29.1	19-48	20900	9	49.7	37-79	900	4	63.0	53-69	400	0			
3	26	38.7	24-59	1612	31	43.9	29-64	1922	2	59.0	43-75	124	3	68.3	41-85	186
4	64	31.6	19-49	5568	21	47.1	38-59	1827	37	52.0	31-77	3219	2	74.5	73-76	174
5	28	34.2	24-44	2800	11	43.5	30-52	1100	0				0			
6	28	38.0	27-48	4676	1	40.0		167	1	55.0		167	3	76.3	72-85	501
7	7	43.1	38-49	1309	45	52.2	48-83	8415	4	63.5	56-75	748	14	67.9	55-82	2618
8	26	20.8	16-28	962	2	61.0	39-83	74	23	54.5	47-70	851	0			
9	36	37.0	23-52	3132	15	48.5	42-55	1305	6	56.2	36-67	522	4	73.0	66-79	348
10	13	35.8	22-48	2106	12	55.7	50-67	744	1	61.0		62	6	74.0	71-77	372
11	15	29.4	19-45	930	15	44.5	30-73	930	21	57.8	33-74	1302	0			
12	Discontinued															
13	201	43.9	25-70	50250	35	51.4	41-64	8750	72	58.3	49-71	18000	17	69.9	47-85	4250
14	16	37.8	22-50	6000	24	54.5	43-70	9000	52	61.7	47-84	14300	3	68.3	62-73	1125
15	28	43.8	24-60	16716	54	50.6	34-70	32238	22	55.0	48-67	13134	2	57.0	54-60	1194
16	8	35.0	20-64	4456	6	47.7	44-54	3342	23	66.2	53-76	12811	6	75.5	71-82	3342
17	1	40.0		972	28	60.4	43-104	27216	4	64.0	54-73	3888	14	76.6	67-84	13608
18	442	33.9	22-63	82654	100	42.1	18-58	18700	13	35.6	22-52	2431	33	47.0	26-67	6171
19	295	26.5	16-38	33040	141	38.3	13-59	15792	0				72	52.8	18-68	8064
20	68	27.5	16-48	15300	18	37.1	27-41	4050	6	36.8	29-52	1350	6	47.7	32-58	1350
21	141	28.0	16-44	5640	34	36.5	21-51	1360	2	41.5	38-45	80	6	51.3	39-60	240
22	3	19.0	11-32	375	2	40.5	39-42	250	0				0			
23	15	32.7	20-45	2250	3	32.3	29-35	450	1	22.0		150	0			
24	20	44.7	22-79	14400	78	46.2	29-56	56160	2	60.0	60.0	1440	2	59.0	55-63	1440
25	5	33.4	23-65	3535	10	59.5	51-70	7070	12	62.0	55-71	8484	6	66.8	62-73	4242
	1743	32.6			735	46.0			312	56.5			199	59.2		

TABLE NO. 15 (CONCLUDED)

Shad (1948 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta 1948

	Cycle #16 9/21-29/48				Cycle #17 10/22-29/48				Cycle #18 11/9-12/48				Cycle #19 12/1-16/48			
Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn
1	8	84.5	75-91	400	1	95.0		40	0				0			
2	12	82.5	75-92	1200	4	92.0	85-99	400	0				0			
3	2	72.5	72-73	124	3	94.0	88-99	750	0				0			
4	10	76.1	70-81	870	0				0				0			
5	1	79.0		100	3	90.3	89-93	300	2	98.5	94-103	200	0			
6	4	69.0	51-78	668	1	85.0		167	0				0			
7	8	75.9	68-82	1496	2	82.0	82.0	374	3	68.3	28-89	561	0			
8	Station Discontinued															
9	3	77.0	74-84	261	0				0				0			
10	1	81.0		62	1	85.0		62	0				0			
11	Station Discontinued															
12	Station Discontinued															
13	10	65.9	26-87	2500	3	97.3	95-99	750	1	121.0		250	0			
14	11	71.6	54-86	4125	3	72.0	64-79	1125	3	57.0	33-70	1125	0			
15	5	66.8	60-81	2985	6	71.8	47-103	3582	2	68.5	55-82	1194	0			
16	5	65.8	57-77	2785	1	78.0		557	0				0			
17	1	68.0		972	2	96.0	89-103	1944	1	72.0		972	1	60.0		972
18	7	53.3	24-70	1309	5	58.4	33-79	935	Station not towed				0			
19	8	42.8	23-76	896	8	42.8	23-76	896	Station not towed				0			
20	1	65.0		225	0				Station not towed				0			
21	0				1	69.0		40	Station not towed				0			
22	22	66.7	52-84	2750	0				Station not towed				0			
23	2	64.0	63-65	300	4	65.5	58-72	600	Station not towed				0			
24	0				1	71.0		720	Station not towed				0			
25	1	89.0		707	1	93.0		707	Station not towed				0			
	122	69.6			50	73.7			12	74.0			1	60.0		

TABLE NO. 16

Shad (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #18 5/24-26/49				Cycle #19 5/31-6/3/49				Cycle #20 6/6-9/49				Cycle #21 6/15-17/49			
Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn
1	2	28.5	27-30	100	3	31.0	30-32	150	0				11	26.3	20-36	550
2	0				4	27.5	23-32	400	0				41	28.4	10-58	4100
3	0				0				0				0			
4	0				0				0				3	37.5	27-48	261
5	0				0				1	22.0	22.0	100	8	27.1	17-50	800
6	0				0				0				3	30.7	24-39	501
7	0				0				0				0			
8	0				0				0				7	48.7	42-54	259
9	0				0				0				4	16.3	12-20	348
10	0*				0				3	30.3	27-35	186	10	29.3	24-38	620
11	0				0				0				1	42.0	42.0	62
12	0				0				6	32.0	22-42	300	8	38.6	27-57	400
13	0				1	59.0	59.0	250	0				1	26.0	26.0	250
14	0				0				0				0			
15	0				0				0				1	18.0	18.0	597
16	0				0				0				8	19.8	17-26	4456
17	0				0				0				0			
18	0				0				4	22.0	18-25	748	26	19.1	12-29	4862
19	11	19.3	14-22	1232	10	19.7	18-23	1120	20	15.9	12-20	2240	11	19.6	13-27	1232
20	0				3	20.7	20-21	675	5	22.7	21-25	1125	34	19.3	10-30	7650
21	0				0				20	-		800	121	16.4	11-46	4840
22	0				0				0				99	-		12375
23	0				0				0				15	-		2250
24	0				0				3	18.7	15-21	2160	16	19.3	16-23	11520
25	0				0				0				2	21.5	21-22	1414
26	0				0				0				0			
	13	22.0			21	23.7			62	23.0			430	25.0		

*Gas Line Plugged Up.

TABLE NO. 16 (CONTINUED)

Shad (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #22 6/20-23/49				Cycle #23 6/27-30/49				Cycle #24 7/5-8/49				Cycle #25 7/11-14/49			
Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Length mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn
1	13	35.0	17-47	650	18	31.2	23-40	900	36	32.9	19-51	1800	12	41.4	30-62	600
2	36	27.4	20-48	3600	142	36.1	23-56	14200	30	37.2	20-75	3000	18	35.9	23-50	1800
3	35	27.5	16-50	2170	7	27.4	21-40	434	16	34.1	25-46	992	10	40.2	29-60	620
4	3	27.0	25-28	261	4	25.3	23-28	348	3	29.0	21-34	261	3	41.7	36-50	261
5	0				11	28.9	20-38	1100	6	29.8	26-37	600	8	36.0	30-45	800
6	2	20.5	18-23	334	13	35.9	20-42	2171	20	32.4	21-50	3340	4	42.8	37-46	668
7	0				0				2	34.0	34.0	374	4	44.0	35-53	748
8	11	38.1	20-60	407	56	24.9	15-62	2072	111	40.5	20-69	4107	60	34.5	21-84	2220
9	6	30.8	22-40	522	6	30.2	21-43	522	4	39.3	30-47	348	6	44.3	40-55	522
10	8	33.4	22-52	496	15	36.1	22-55	930	14	34.8	26-44	868	15	36.1	29-47	930
11	2	24.5	24-25	124	16	28.9	22-43	992	34	38.3	17-54	2108	42	30.0	15-60	2604
12	*				43	31.8	21-63	2150	22	33.5	21-55	1100	90	42.6	23-80	4500
13	8	53.4	35-80	2000	28	48.3	38-61	7000	42	41.1	24-72	10500	110	47.8	30-69	27500
14	13	34.6	22-74	4875	2	31.0	27-35	750	46	35.1	22-48	17250	53	37.6	22-60	19875
15	10	23.2	19-30	5970	1	22.0	22.0	597	32	30.4	23-40	19104	136	38.9	24-55	81192
16	13	24.6	19-39	7241	10	30.0	23-54	5570	4	45.0	43-47	2228	14	58.9	42-68	7798
17	6	26.0	23-30	5832	0				4	62.5	55-70	3888	0			
18	25	21.7	17-34	4675	1533	26.1	15-41	286671	1474	36.2	15-40	275638	997	33.7	20-46	186439
19	271	14.9	10-22	30352	1170	19.5	10-28	131040	240	23.7	15-37	26880	1084	27.5	17-46	121408
20	361	19.4	12-30	81225	122	21.1	11-44	27450	906	25.9	16-37	203850	174	28.6	16-42	30150
21	375	17.8	10-43	15000	334	20.0	10-31	13360	332	27.5	11-40	13280	116	19.2	7-38	4640
22	466	18.3	8-22	58250	336	17.5	9-22	42000	100	18.3	10-40	12500	138	36.7	18-53	17250
23	239	16.5	10-25	35850	16	22.1	18-24	2400	112	16.4	10-23	16800	56	18.0	11-26	8400
24	20	15.4	11-20	14400	10	22.9	17-26	7200	0				2	38.0	26-50	1440
25	0				2	23.0	23.0	1414	0				1	56.0	56.0	707
26	0				0				10	24.6	8-51	8000	0			
	1923	20.4			3695	24.2			3600	29.8			3153	34.6		

*Sample Lost

TABLE NO. 16 (CONTINUED)

Shad (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #26 7/19-22/49				Cycle #27 7/26-29/49				Cycle #28 8/2-4/49				Cycle #29 8/9-11/49			
Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn
1	0				2	52.5	51-54	100	1	54.0	54.0	50	1	40.0	40.0	50
2	26	41.8	24-61	2600	0				0				1	45.0	45.0	100
3	8	44.8	27-60	496	2	50.5	34-67	124	1	31.0	31.0	62	2	60.5	57-64	124
4	15	44.3	33-53	1305	7	50.6	45-60	609	6	54.0	43-61	522	1	60.0	60.0	87
5	4	48.0	35-57	400	4	55.3	53-58	400	2	73.0	70-76	200	2	70.5	70-71	200
6	5	45.8	40-54	835	3	49.3	47-54	501	6	58.5	52-65	1002	1	41.0	41.0	167
7	0				0				4	53.3	27-68	748	6	62.3	59-68	1122
8	33	45.8	30-80	1221	10	52.8	24-63	370	23	58.0	44-75	851	27	62.8	34-80	999
9	10	40.6	24-55	870	3	51.3	48-56	261	8	59.8	54-65	696	4	62.0	56-72	348
10	29	41.1	29-55	1798	10	45.2	28-51	620	10	56.8	47-65	620	5	57.0	49-64	310
11	35	36.2	25-59	2170	25	43.0	35-60	1550	11	56.9	40-70	682	8	60.8	51-70	496
12	19	35.8	21-59	950	28	50.4	35-66	1400	3	53.3	50-55	150	25	70.6	39-82	1250
13	116	54.5	23-84	29000	37	55.1	31-75	9250	86	57.9	21-74	21500	152	66.2	40-83	38000
14	63	39.6	22-52	23625	32	44.3	27-52	12000	55	51.2	30-73	20625	15	54.5	40-65	5625
15	78	45.6	19-61	46566	22	52.0	46-57	13134	28	57.9	45-76	16716	46	51.4	29-65	27462
16	0				2	62.0	62.0	1114	4	61.0	60-62	2228	8	66.4	58-78	4456
17	0				6	59.3	52-65	5832	4	66.5	64-69	3888	6	71.0	66-77	5832
18	1254	36.9	16-61	234498	677	36.4	16-60	126599	453	37.5	15-60	84711	273	38.4	16-63	51051
19	620	26.0	15-46	69440	424	21.7	12-41	47488	214	21.5	12-48	23968	546	31.8	15-60	61152
20	206	24.5	13-44	46350	82	45.0	21-71	18450	76	26.6	12-50	17100	32	44.1	16-61	7200
21	77	26.5	13-41	3080	115	24.7	10-53	4600	89	21.5	9-48	3560	35	31.5	15-55	1400
22	68	22.6	12-47	8500	117	35.8	16-71	14625	32	32.2	15-57	4000	50	42.1	17-62	6250
23	92	17.6	10-26	13800	48	18.5	11-24	7200	58	22.5	14-34	8700	23	33.3	22-80	3450
24	12	25.3	21-28	8640	0				14	52.6	21-72	10080	20	55.9	39-70	14400
25	3	61.7	59-66	2121	14	66.0	62-70	9898	8	72.4	59-85	5656	6	70.0	67-75	4242
26	0				0				11	79.8	72-98	8800	14	78.1	65-85	11200
	2773	34.9			1670	35.6			1207	39.3			1309	47.4		

TABLE NO. 16 (CONCLUDED)

Shad (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #30 8/16-18/49				Cycle #31 8/23-25/49				Cycle #32 8/30-9/2/49				Cycle #33 9/20-22/49			
Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn	Shad in tow	Mean Lgt mm	Size Range mm	Shad in Stn
1	1	65.0	65.0	50	4	67.0	40-81	200	2	79.5	73-86	100	1	105.0	105.0	50
2	2	60.0	59-61	200	1	75.0	75.0	100	2	80.0	80.0	200	0			
3	0				3	103.3	94-120	186	1	84.0	84.0	62	0			
4	3	62.7	60-66	261	1	62.0	62.0	87	2	70.0	70.0	348	0			
5	0				1	82.0	82.0	100	1	91.0	91.0	100	0			
6	0				2	61.5	58-65	334	1	84.0	84.0	167	0			
7	5	71.8	58-85	935	5	75.4	69-82	935	2	56.0	55-57	374	1	50.0	50.0	187
8	28	66.9	53-92	1036	0*				3	82.5	70-83	111	0			
9	1	59.0	59.0	87	1	75.0	75.0	87	5	67.8	60-74	435	0			
10	3	63.3	50-70	186	6	54.7	35-77	372	0				0			
11	46	70.7	56-85	2852	0*				4	82.5	80-88	248	0			
12	1	55.0	55.0	50	7	85.3	68-98	350	1	78.0	78.0	50	0			
13	41	70.8	61-86	10250	15	81.7	66-95	3750	5	72.4	54-84	1250	1	90.0	90.0	250
14	4	51.0	40-64	1500	9	68.0	56-76	3375	8	63.1	59-68	3000	0			
15	21	56.8	39-73	12537	17	59.1	44-73	10149	2	48.5	44-53	1194	2	82.5	79-86	1194
16	8	69.8	56-80	4456	5	75.2	74-76	2785	12	79.3	71-85	6684	0			
17	6	79.5	71-87	5832	2	71.0	53-89	1944	7	85.9	81-100	6304	2	84.5	82-87	1944
18	132	34.8	15-60	24684	115	36.5	20-66	21505	54	29.6	19-55	10098	17	43.4	25-68	3179
19	628	29.7	12-58	70336	374	41.2	18-64	41888	212	39.6	18-70	23744	87	34.8	19-66	9744
20	3	24.7	23-26	675	11	32.2	16-51	2475	13	36.4	27-57	2925	0			
21	18	35.6	20-58	720	18	31.4	18-57	720	5	28.4	19-39	200	8	51.0	32-70	320
22	0				35	60.4	27-73	4375	0				198	77.3	66-103	12250
23	8	23.9	20-30	1200	1	21.0	21.0	150	0				50	75.1	33-95	7500
24	1	82.0	82.0	720	41	76.0	61-85	29520	2	60.5	51-70	1440	7	78.4	67-85	5040
25	0				1	89.0	89.0	707	0				22	82.1	68-92	15554
26	8	80.8	77-87	6400	3	78.3	55-89	2400	17	88.2	75-115	13600	2	100.0	90-110	1600
	968	46.7			678	50.5			361	48.3			398	62.4		

* Pollution

TABLE NO. 17

Smelt, Hypomesus olidus taken in towing cycles
Saoramento and San Joaquin Delta, 1948

		Cycle #9 6/16-7/2				Cycle #10 7/2-12				Cycle #11 7/12-20			
Station	Average Width of Station	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Station
1	200	0				1	41.0	41.0	50	1	41.0	41.0	50
2	400	0				0				1	52.0	52.0	100
3	250	0				2	34.0	22-46	124	5	46.0	40-50	310
4	350	0				1	49.0	49.0	87	4	41.0	38-45	348
5	400	0				0				0			
6	670	0				0				1	37.0	37.0	167
7	750	1	44.0	44.0	187	5	37.2	28-49	935	42	39.6	22-56	7854
8	150	0				0				0			
9	350	0				0				1	35.0	35.0	87
10	250	0				0				1	38.0	38.0	62
11	250	0				0				0			
12	200	0				Station Discontinued							
13	1000	0				45	32.3	22-45	11250	20	34.8	27-45	5000
14	1500	4	31.0	22-40	1500	76	30.7	17-46	28500	47	33.1	22-48	17625
15	2390	0				14	35.1	21-45	8358	38	33.8	21-49	22686
16	2230	0				6	35.8	30-46	3342	114	38.4	18-52	63498
17	3890	0				3	31.3	24-40	2916	28	30.3	19-42	27216
18	750	0				0				6	41.2	28-50	1122
19	450	1	32.0	32.0	112	1	36.0	36.0	112	0			
20	900	0				9	35.5	26-47	2025	4	40.5	28-49	900
21	160	0				0				0			
22	500	0				0				0			
23	600	0				0				0			
24	2880	0				3	40.3	40-45	2160	0			
25	2830	0				66	40.4	21-53	46662	171	42.6	22-57	120897
		6	33.3			232	34.8			484	38.7		

TABLE NO. 17 (CONTINUED)

Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1948

	Cycle #12 7/20-8/3				Cycle #13 8/4-17				Cycle #14 8/18-25				Cycle #15 9/6-16			
Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in. Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	2	41.0	36-46	200	0				0				0			
3	1	40.0	40.0	62	0				0				0			
4	0				0				0				0			
5	0				0				0				0			
6	0				0				0				0			
7	9	38.8	30-54	1683	10	59.8	30-59	1870	0				2	57.5	55-60	374
8	0				0				0				0			
9	1	58.0	58.0	87	0				0				0			
10	0				0				0				0			
11	0				0				0				Station Discontinued			
12	Station Discontinued															
13	3	39.3	35-43	750	2	38.5	38-39	500	0				2	57.0	56-58	500
14	4	39.5	36-45	1500	1	50.0	50.0	375	0				0			
15	15	35.6	26-51	8955	7	46.4	38-55	4179	0				3	49.3	45-54	1791
16	29	40.5	25-53	16153	3	41.3	30-53	1671	0				6	52.4	42-66	3342
17	32	41.8	22-50	31104	9	36.0	15-51	8748	7	49.4	44-61	6804	0			
18	0				0				0				1	55.0	55.0	187
19	0				0				0				1	52.0	52.0	112
20	0				0				0				0			
21	0				0				0				0			
22	0				0				0				0			
23	1	27.0	27.0	150	0				0				0			
24	3	40.7	28-52	2160	27	41.0	26-59	19440	6	59.2	53-66	4320	0			
25	134	41.2	22-59	94738	492	54.1	15-65	347844	678	56.6	42-65	479346	29	54.5	44-81	20503
	234	40.7			551	52.7			691	56.5			44	54.1		

TABLE NO. 17 (CONCLUDED)

Smelt, Hypomesus olidus taken in towing cycles
Sacramonto and San Joaquin Dolta, 1948

Stn	Cycle #16 9/21-29 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Cycle #17 10/22-29 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Cycle #18 11/9-12 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Cycle #19 12/1-16 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	0				0				0				0			
3	0				0				0				0			
4	0				0				0				0			
5	0				1	44.0	44.0	100	0				0			
6	0				0				1	83.0	83.0	167	0			
7	1	49.0	49.0	187	1	48.0	48.0	187	4	58.3	54-68	748	11	66.2	60-73	2057
8	Station Discontinued															
9	0				0				0				0			
10	0				0				1	78.0	78.0	62	6	63.0	68-75	372
11	Station Discontinued															
12	Station Discontinued															
13	2	62.5	62-63	500	2	62.5	62-63	500	0				0			
14	2	61.0	58-64	750	8	55.1	47-63	3000	21	66.7	57-74	7875	11	73.4	68-83	4125
15	5	53.0	50-55	2985	23	61.9	51-71	13731	12	65.6	57-77	7164	7	67.3	63-73	4179
16	5	55.6	44-85	2785	1	63.0	63.0	557	0				21	66.1	59-74	11697
17	3	53.3	49-57	2916	7	66.6	55-79	6804	4	63.5	50-74	3888	2	64.0	61-67	1944
18	0				0				Not Towed				0			
19	0				0				Not Towed				0			
20	0				0				Not Towed				0			
21	0				0				Not Towed				0			
22	0				0				Not Towed				0			
23	0				0				Not Towed				0			
24	0				19	65.5	55-71	13680	Not Towed				0			
25	27	56.3	48-65	19089	9	54.2	45-62	6363	Not Towed				1	65.0	65.0	707
	45	56.0			71	61.2			43	66.0			59	67.2		

TABLE NO. 18

Adult Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

		Cycle #1 1/25-27				Cycle #2 2/1-4				Cycle #3 2/15-19			
Stn	Average Width of Station	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Station
1	200	2	76.0	75-77	100	2	73.0	72-75	100	9	76.0	70-82	450
2	400	0				3	77.3	76-80	300	4	77.5	76-78	400
3	250	7	74.3	71-83	434	2	73.0	73.0	124	6	75.0	69-83	372
4	350	7	69.9	52-80	609	9	73.2	64-81	783	20	74.4	68-84	1740
5	400	3	77.3	75-79	300	13	74.3	64-81	1300	14	73.2	61-78	1400
6	670	9	73.0	69-85	1503	0				6	68.8	53-78	1002
7	750	1	73.0	73.0	187	0				0			
8	150	0				0				Not towed*			
9	350	2	81.0	81.0	174	5	74.8	69-82	435	6	71.6	61-79	522
10	250	12	73.3	70-78	744	15	72.7	68-80	930	13	76.3	69-95	806
11	250	0				0				Not towed*			
12	200	0				1	75.0	75.0	50	Not towed*			
13	1000	1	77.0	77.0	250	0				0			
14	1500	2	73.0	71-75	750	0				3	71.7	71-72	1125
15	2390	1	73.0	73.0	597	1	79.0	79.0	597	0			
16	2230	4	72.0	67-77	2228	2	63.5	57-70	1114	2	65.5	63-68	1114
17	3890	8	69.0	58-76	7776	4	72.3	69-75	3888	0			
18	750	4	76.0	69-89	748	4	73.5	73-74	748	4	78.2	68-96	748
19	450	2	63.5	59-68	224	8	73.1	65-76	896	1	73.0	73.0	112
20	900	0				0				6	75.0	64-82	1350
21	160	0				0				0			
22	500	0				0				0			
23	600	0				0				0			
24	2880	0				1	59.0	59.0	720	22	67.2	57-77	15840
25	2830	1	77.0	77.0	707	0				4	61.2	55-69	2828
		66	72.9			70	73.2			120	72.5		

*Copepod broke down

TABLE NO. 18 (CONTINUED)

Adult Smolt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #4 2/15-17				Cycle #5 2/22-24				Cycle #6 3/1-4				Cycle #7 3/8-10			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	2	73.0	73.0	100	1	70.0	70.0	50	0				0			
2	6	73.8	65-78	600	6	71.3	64-76	600	5	78.2	74-82	500	1	74.0	74.0	100
3	16	74.9	69-82	992	8	74.3	65-80	496	11	71.9	65-80	682	3	76.3	76-83	186
4	14	71.6	64-78	1218	26	73.7	61-84	2262	17	72.2	63-80	1479	12	74.8	69-81	1044
5	6	76.2	72-81	600	17	73.4	67-81	1700	2	78.0	76-80	200	10	73.2	63-80	1000
6	5	68.0	61-73	835	11	68.9	55-78	1837	6	75.7	71-82	1002	5	72.4	67-76	835
7	5	71.2	62-80	935	32	67.9	57-92	5984	1	76.0	76.0	187	4	77.3	70-85	748
8	1	78.0	78.0	37	0				0				1	79.0	79.0	37
9	4	75.3	73-80	348	5	76.6	72-84	435	7	75.6	73-78	609	8	76.4	71-82	696
10	1	74.0	74.0	62	10	75.4	63-92	620	6	70.3	63-76	372	4	68.8	68-75	248
11	0				0				0				1	82.0	82.0	62
12	0				1	67.0	67.0	50	0				7	76.3	74-82	350
13	9	75.2	70-80	2250	3	71.3	70-72	750	8	77.5	72-82	2000	14	73.5	60-84	3500
14	7	72.6	67-79	2625	15	70.7	65-76	5625	14	71.2	61-81	5250	23	72.1	66-84	8625
15	3	64.7	60-71	1791	9	66.3	56-77	5373	5	66.2	60-75	2985	0			
16	0				5	65.8	59-76	2785	1	55.0	55.0	557	5	67.6	63-75	2785
17	4	69.5	63-74	3888	58	66.2	57-78	56376	10	67.6	60-78	9720	86	66.0	53-78	83592
18	4	70.3	68-72	748	9	73.8	63-88	1683	2	77.0	74-80	374	4	81.0	65-94	748
19	4	71.3	65-80	448	19	72.8	67-85	2128	6	77.2	71-83	672	0			
20	2	73.5	73-74	450	3	73.7	67-77	675	2	75.0	74-76	450	1	80.0	80.0	225
21	0				0				0				0			
22	0				0				0				0			
23	0				2	74.0	69-79	300	0				0			
24	23	68.5	55-87	16560	6	68.5	57-81	4320	4	74.5	74-76	2880	3	71.7	70-73	2160
25	29	67.3	59-81	20503	14	64.6	54-71	9898	3	72.0	70-74	2121	1	70.0	70.0	707
	145	71.0			260	69.9			110	72.8			193	70.3		

TABLE NO. 18 (CONTINUED)

Adult Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #8 3/15-17				Cycle #9 3/22-24				Cycle #10 3/29-4/1				Cycle #11 4/5-7			
Stn	Smolt in tow	Mean Lgt mm	Size Range mm	Smolt in Stn	Smolt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	3	74.7	74-76	150	4	71.8	69-76	200	0				1	72.0	72.0	50
2	1	79.0	79.0	100	2	75.5	71-80	200	0				1	72.0	72.0	100
3	1	81.0	81.0	62	4	70.2	60-76	248	0				2	70.0	65-75	124
4	10	73.3	67-82	870	3	73.4	70-77	261	3	69.3	65-73	261	0			
5	2	71.5	70-73	200	5	74.8	72-77	500	6	73.8	69-83	600	3	72.3	70-76	300
6	11	71.8	64-79	1837	1	69.0	69.0	167	3	71.0	67-74	501	9	73.8	63-82	1503
7	1	65.0	65.0	187	3	71.0	70-72	561	10	70.0	62-81	1870	3	71.3	71-72	561
8	1	76.0	76.0	37	0				0				0			
9	3	74.3	72-76	261	1	80.0	80.0	87	0				1	73.0	73.0	87
10	3	71.7	68-74	186	0				2	72.0	69-75	124	0			
11	4	77.5	75-80	248	2	73.5	74-77	124	0				0			
12	4	74.5	72-78	200	6	77.3	75-80	300	1	71.0	71.0	50	1	68.0	68.0	50
13	14	71.8	61-81	3500	10	74.0	68-79	2500	27	74.8	69-86	6750	19	73.1	66-84	4750
14	21	72.4	58-94	7875	5	73.4	70-76	1875	11	71.2	62-81	4125	8	74.9	68-80	3000
15	0				1	73.0	73.0	597	2	69.0	65-73	1194	0			
16	2	72.5	67-78	1114	15	72.7	64-85	8355	3	76.3	73-79	1671	4	66.8	60-69	2228
17	21	68.7	60-77	20412	57	67.1	55-90	55404	16	66.6	61-72	15552	6	69.0	66-72	5832
18	1	82.0	82.0	187	3	77.0	74-81	561	3	72.7	71-74	561	2	72.5	72-73	374
19	1	75.0	75.0	112	5	75.0	68-82	560	3	72.0	71-73	336	2	74.5	74-75	224
20	1	69.0	69.0	225	3	73.7	71-75	675	1	75.0	75.0	225	0			
21	0				0				5	76.8	72-81	200	0			
22	0				0				0				0			
23	0				0				0				0			
24	2	67.0	64-70	1440	2	72.5	72-73	1440	2	69.0	61-87	1440	21	68.3	60-90	15120
25	3	63.3	49-74	2121	6	71.7	65-75	4242	0				6	67.8	61-73	4242
	110	71.8			138	70.9			98	71.9			89	71.1		

TABLE NO. 18 (CONTINUED)

Adult Smelt, *Hypomesus olidus* taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #12 4/11-15				Cycle #13 4/18-21				Cycle #14 4/25-28				Cycle #15 5/3-6			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	4	75.0	70-80	200	0				1	86.0	86.0	50	1	90.0	90.0	50
2	0				1	86.0	86.0	100	0				0			
3	2	78.5	72-85	124	1	82.0	82.0	62	3	79.0	77-82	186	0			
4	0				0				1	72.0	72.0	87	0			
5	1	63.0	63.0	100	1	88.0	88.0	100	3	77.0	73-81	300	1	78.0	78.0	100
6	5	72.0	68-77	835	1	73.0	73.0	167	1	74.0	74.0	167	1	84.0	84.0	167
7	9	68.3	60-74	1683	2	67.0	65-69	374	1	75.0	75.0	187	1	73.0	73.0	187
8	0				0				0				0			
9	2	74.5	72-77	174	0				0				0			
10	2	73.0	72-74	124	0				0				0			
11	1	86.0	86.0	62	1	82.0	82.0	62	0				0			
12	0				3	73.0	70-75	150	1	75.0	75.0	50	1	73.0	73.0	50
13	18	68.9	74-87	4500	1	70.0	70.0	250	7	76.9	67-84	1750	2	86.5	83-90	500
14	10	72.4	55-98	3750	2	85.0	74-96	750	11	72.0	59-82	4125	7	76.9	68-85	2625
15	1	70.0	70.0	597	2	71.5	70-73	1194	0				0			
16	5	80.0	71-94	2785	3	66.7	63-69	1671	1	79.0	79.0	557	11	71.1	66-86	6127
17	10	66.8	61-73	9720	1	64.0	64.0	972	2	73.0	72-74	1944	4	74.8	72-78	3888
18	2	71.0	70-72	374	1	75.0	75.0	187	0				1	73.0	73.0	187
19	2	72.0	70-74	224	2	71.5	69-74	224	1	68.0	68.0	112	1	80.0	80.0	112
20	1	67.0	67.0	225	1	70.0	70.0	225	1	80.0	80.0	225	1	75.0	75.0	225
21	0				0				0				0			
22	0				0				0				0			
23	0				1	73.0	73.0	150	0				0			
24	13	69.8	62-77	9360	1	58.0	58.0	720	3	78.3	76-80	2160	0			
25	6	67.2	62-72	4242	1	65.0	65.0	707	6	73.0	64-84	4242	1	69.0	69.0	707
26*	6	72.2	69-75	4800	5	68.0	64-69	4000	2	67.5	67-68	1600	0			
	100	70.7			31	72.1			45	74.7			33	75.4		

* Station 26 established April 11, 1949.

TABLE NO. 18 (CONTINUED)

Adult Smelt, *Hypomesus olidus* taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #16 5/9-11				Cycle #17 5/18-20				Cycle #18 5/24-26				Cycle #19 5/21-6/3			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	1	73.0	73.0	100	0				0				0			
3	0				0				0				0			
4	1	92.0	92.0	87	0				0				0			
5	1	77.0	77.0	100	0				0				0			
6	1	78.0	78.0	167	0				0				1	76.0	76.0	167
7	7	72.3	55-80	1309	0				1	73.0	73.0	187	1	75.0	75.0	187
8	0				0				0				0			
9	0				0				0				0			
10	2	78.5	74-83	124	0				0*				0			
11	0				0				0				0			
12	0				1	78.0	78.0	50	1	83.0	83.0	50	0			
13	5	75.4	65-86	1250	0				1	72.0	72.0	250	0			
14	8	78.6	71-86	3000	5	77.0	71-85	1875	15	83.5	77-98	5625	3	81.0	80-82	1125
15	1	74.0	74.0	597	0				1	70.0	70.0	597	0			
16	1	71.0	71.0	557	0				0				0			
17	6	72.5	65-78	5832	0				1	71.0	71.0	972	0			
18	0				0				0				0			
19	1	70.0	70.0	112	4	78.0	72-82	448	1	75.0	75.0	112	0			
20	0				0				0				0			
21	1	75.0	75.0	40	0				3	75.0	70-80	120	0			
22	0				0				1	73.0	73.0	125	0			
23	0				0				0				0			
24	0				0				0				0			
25	1	74.0	74.0	707	0				2	73.5	72-75	1414	0			
26	1	71.0	71.0	800	0				0				8	74.8	71-80	6400
	38	75.2			10	77.5			27	79.3			13	76.3		

*Gas line plugged up

TABLE NO. 18 (CONTINUED)

Adult Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #20 6/6-9				Cycle #21 6/15-17				Cycle #22 6/20-23				Cycle #23 6/27-30			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	0				0				0				0			
3	0				0				0				0			
4	0				0				0				0			
5	0				0				0				0			
6	0				0				0				0			
7	1	78.0	78.0	187	0				0				0			
8	1	77.0	77.0	37	0				0				0			
9	0				0				0				0			
10	0				0				0				0			
11	0				0				0				0			
12	0				0				*				0			
13	2	75.0	73-77	500	0				0				0			
14	3	80.3	73-85	1125	1	80.0	80.0	375	1	89.0	89.0	375	0			
15	0				1	83.0	83.0	597	0				1	72.0	72.0	597
16	0				1	72.0	72.0	557	0				1	80.0	80.0	557
17	5	74.8	72-79	4860	2	72.0	72.0	1944	0				0			
18	0				0				1	72.0	72.0	187	0			
19	0				0				0				0			
20	0				1	83.0	83.0	225	0				0			
21	0				0				0				0			
22	1	83.0	83.0	125	0				0				0			
23	0				0				0				0			
24	0				0				1	81.0	81.0	720	0			
25	1	78.0	78.0	707	0				8	75.5	73-79	5656	10	78.6	73-84	7070
26	15	80.9	73-91	12000	4	85.0	83-87	3200	4	80.0	79-81	3200	4	81.5	79-84	3200
	29	79.1			10	80.2			15	77.7			16	79.0		

* Sample lost when net hit bottom

TABLE NO. 18 (CONTINUED)

Adult Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

Stn	Cycle #24 7/5-8 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Cycle #25 7/11-14 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Cycle #26 7/19-22 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Cycle #27 7/26-29 Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	0				0				0				0			
3	0				0				0				0			
4	0				0				0				0			
5	0				0				0				0			
6	0				0				0				0			
7	6	86.0	79-92	1122	0				0				0			
8	0				0				0				0			
9	0				0				0				0			
10	0				0				0				0			
11	0				0				0				0			
12	0				0				0				0			
13	0				0				0				0			
14	0				0				0				0			
15	0				0				0				0			
16	0				0				0				0			
17	0				0				0				2	74.0	74.0	1944
18	0				0				0				0			
19	0				0				0				0			
20	0				0				0				0			
21	0				0				0				0			
22	0				0				0				0			
23	0				0				0				0			
24	0				0				0				0			
25	0				0				7	81.3	76-89	4949	2	87.0	87.0	1414
26	0				2	85.0	85.0	1600	6	88.3	87-90	4800	8	78.5	73-81	6400
	6	86.0			2	85.0			13	84.5			12	79.2		

TABLE NO. 18 (CONTINUED)

Adult Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #28 8/2-4				Cycle #29 8/9-11				Cycle #30 8/16-18				Cycle #31 8/23-25			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	0				0				0				0			
3	0				0				0				0			
4	0				0				0				0			
5	0				0				0				0			
6	0				0				0				0			
7	0				0				0				0			
8	0				0				0				0			
9	0				0				0				0			
10	0				0				0				0			
11	0				0				0				0			
12	0				0				0				0			
13	0				0				0				0			
14	0				0				0				0			
15	0				0				0				0			
16	0				0				1	81.0	81.0	557	0			
17	0				0				0				0			
18	0				0				0				0			
19	0				0				0				0			
20	0				0				0				0			
21	0				0				0				0			
22	0				0				0				0			
23	0				0				0				0			
24	0				0				0				0			
25	11	84.8	78-94	7777	8	80.3	73-89	5656	3	84.0	70-92	2121	8	87.0	82-96	5656
26	12	83.5	72-91	9600	14	83.3	78-91	11200	1	80.0	80.0	800	1	97.0	97.0	800
	23	84.1			22	82.2			5	82.6			9	88.1		

TABLE NO. 18 (CONCLUDED)

Adult Smelt, Hypomesus olidus taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #32 8/30-9/2				Cycle #33 9/20-22			
Station	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Station	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Station
1	0				0			
2	0				0			
3	0				0			
4	0				0			
5	0				0			
6	0				0			
7	0				0			
8	0				0			
9	0				0			
10	0				0			
11	0				0			
12	0				0			
13	0				0			
14	1	82.0	82.0	375	0			
15	0				0			
16	0				0			
17	0				0			
18	0				0			
19	0				0			
20	0				0			
21	0				0			
22	0				0			
23	0				0			
24	1	84.0	84.0	720	0			
25	2	92.0	74-110	1414	0			
26	10	84.3	77-94	8000	0			
	14	85.2			0			

TABLE NO. 19

Smelt, Hypomosus olidus (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

		Cycle #17 5/18-20				Cycle #18 5/24-26				Cycle #19 5/31-6/3				Cycle #20 6/6-9			
Stn	Average Width of Station	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	200	0				0				0				0			
2	400	0				0				0				0			
3	250	0				0				0				0			
4	350	0				0				0				0			
5	400	0				0				0				0			
6	670	0				0				0				0			
7	750	0				0				0				6	24.8	21-27	1122
8	150	0				0				0				0			
9	350	0				0				0				0			
10	250	0				0				0				12	29.2	22-37	744
11	250	0				0				0				0			
12	200	0				0				0				0			
13	1000	0				0				0				7	-	-	1750
14	1500	1	21.0	21.0	375	0				13	26.5	22-37	4875	43	29.1	22-34	16125
15	2390	0				0				0				1	31.0	31.0	597
16	2230	0				0				0				0			
17	3890	0				0				0				7	26.3	22-32	6804
18	750	0				0				0				0			
19	450	0				0				0				0			
20	900	0				0				0				1	28.0	28.0	225
21	160	0				0				0				0			
22	500	0				0				0				0			
23	600	0				0				0				0			
24	2880	0				0				0				0			
25	2830	0				0				0				10	28.1	16-40	7070
26	3200	0				0				0				0			
		1	21.0			0				13	26.5			87	28.4		

TABLE NO. 19 (CONTINUED)

Smelt, *Hypomesus olidus* (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #21 6/15-17				Cycle #22 6/20-23				Cycle #23 6/27-30				Cycle #24 7/5-8			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	2	27.5	22-33	100	2	28.0	27-29	74	0				1	45.0	45.0	50
2	0				2	23.0	18-28	200	0				1	42.0	42.0	100
3	0				0				0				0			
4	0				5	28.5	23-32	261	0				0			
5	0				7	24.5	19-34	700	0				0			
6	1	32.0	32.0	167	0				0				1	41.0	41.0	167
7	13	33.0	25-39	2431	16	33.3	22-42	2992	24	34.9	22-48	4488	74	35.8	24-44	13838
8	0				0				0				0			
9	0				0				0				0			
10	4	32.8	29-36	248	6	27.0	23-34	372	0				0			
11	0				0				0				0			
12	0				*				1	36.0	36.0	50	0			
13	3	31.0	29-35	750	12	29.0	20-38	3000	6	28.5	19-36	1500	1	40.0	40.0	250
14	94	33.7	25-42	35250	82	33.7	21-43	30750	38	33.4	23-45	14250	11	34.1	25-46	4125
15	107	32.6	23-42	63879	12	37.4	25-42	7164	67	35.3	22-45	39999	94	34.5	25-45	56118
16	10	33.3	30-38	5570	11	40.6	37-46	6127	116	32.5	19-48	64612	128	32.8	16-49	71296
17	14	36.0	31-39	13608	40	35.4	24-41	38880	64	29.1	20-43	62208	12	42.2	38-46	11664
18	7	39.9	35-43	1309	0				36	37.9	25-49	6732	18	42.9	30-49	3366
19	2	28.5	22-35	224	0				4	41.5	40-43	448	0			
20	1	48.0	48.0	225	0				1	37.0	37.0	225	2	32.0	32.0	450
21	0				0				0				0			
22	0				0				0				0			
23	0				0				0				0			
24	0				0				0				12	27.2	19-47	8640
25	4	27.5	23-36	2828	42	34.9	20-46	29694	310	40.5	20-52	219170	54	47.9	30-54	38178
26	16	37.0	37.0	12800	0				6	41.0	40-42	4800	0			
	278	33.5			235	33.8			673	36.7			409	36.4		

* Sample lost when net hit bottom.

TABLE NO. 19 (CONTINUED)

Smelt, Hypomesus olidus (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #25 7/11-14				Cycle #26 7/19-22				Cycle #27 7/26-29				Cycle #28 8/2-4			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	1	37.0	37.0	50	0				0				0			
2	2	36.0	32-40	200	0				1	44.0	44.0	100	1	47.0	47.0	100
3	4	38.5	34-42	248	2	34.5	31-38	124	2	44.0	40-48	124	0			
4	0				0				1	31.0	31.0	87	0			
5	0				1	40.0	40.0	100	0				0			
6	0				1	28.0	28.0	167	2	37.0	33-41	334	0			
7	70	32.7	21-46	13090	72	37.3	28-53	13464	16	37.4	25-46	2992	20	42.3	32-57	3740
8	0				0				0				0			
9	0				0				0				0			
10	1	31.0	31.0	62	0				0				0			
11	0				0				0				0			
12	0				0				0				0			
13	7	42.3	34-49	1750	8	36.1	32-41	2000	14	41.0	35-50	3500	1	45.0	45.0	250
14	4	39.3	32-44	1500	8	42.8	32-51	3000	0				15	41.8	35-47	5625
15	80	33.4	22-50	47760	10	41.0	30-48	5970	122	38.2	25-51	72834	38	41.1	30-52	22686
16	730	38.1	25-54	406610	58	43.1	33-52	32306	66	39.9	29-57	36762	2	35.0	35.0	1114
17	82	37.6	25-50	79704	34	42.6	30-57	33048	52	42.5	33-54	50544	8	43.5	41-46	7776
18	52	36.9	25-52	9724	8	39.8	26-48	1496	7	38.3	27-50	1309	2	37.5	37-38	374
19	0				0				0				0			
20	6	35.3	27-46	1350	0				2	34.0	34.0	450	0			
21	0				0				0				0			
22	0				0				0				0			
23	0				0				0				0			
24	33	23.8	15-33	23760	2	60.0	60.0	1440	0				5	45.4	38-51	3600
25	250	37.5	25-57	176750	709	41.9	30-59	501263	94	37.7	28-49	66458	799	44.9	31-61	664893
26	14	46.1	38-60	11200	8	48.3	43-55	6400	12	50.7	43-59	9600	20	55.6	41-66	16000
	1336	37.1			921	41.6			391	39.4			911	45.9		

TABLE NO. 19 (CONTINUED)

Smelt, *Hypomesus olidus* (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

	Cycle #29 8/9-11				Cycle #30 8/16-18				Cycle #31 8/23-25				Cycle #32 8/30-9/2			
Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn	Smelt in tow	Mean Lgt mm	Size Range mm	Smelt in Stn
1	0				0				0				0			
2	0				0				0				0			
3	0				0				0				0			
4	1	30.0	30.0	87	0				0				0			
5	0				0				0				0			
6	0				0				0				0			
7	18	45.7	33-58	3366	15	40.6	35-52	2805	1	58.0	58.0	187	11	52.0	43-70	2057
8	0				0				0				0			
9	0				0				0				0			
10	0				0				0				0			
11	0				0				0				0			
12	0				0				0				0			
13	5	43.8	37-53	1250	2	51.0	50-52	500	1	57.0	57.0	250	2	46.0	42-50	500
14	19	46.2	30-87	7125	3	52.7	43-60	1125	14	55.6	35-84	5250	10	53.6	45-60	3750
15	36	45.4	31-58	21492	29	45.2	28-56	17313	22	46.7	37-53	13134	18	52.3	48-58	10746
16	60	46.1	32-58	33420	122	48.3	34-58	67954	124	47.8	40-62	69068	80	51.0	40-67	10026
17	18	41.7	30-57	17496	6	47.5	36-55	5832	12	49.3	35-61	11164	6	49.3	46-55	5832
18	3	42.7	53-65	561	0				1	34.0	34.0	187	2	46.5	43-50	374
19	2	38.0	38.0	224	0				0				1	48.0	48.0	112
20	2	52.0	52.0	450	0				0				0			
21	0				0				0				0			
22	0				0				0				0			
23	0				0				0				0			
24	4	45.0	41-49	2880	7	55.9	41-77	5040	52	54.6	43-73	37440	75	52.5	38-65	54720
25	140	47.8	39-64	98980	217	50.0	37-63	153419	402	53.2	43-76	284214	206	52.1	38-62	147056
26	20	58.6	53-65	16000	1	61.0	61.0	1600	0				119	57.2	39-70	95200
	328	47.1			403	48.9			629	52.0			531	53.1		

TABLE NO. 19 (CONCLUDED)

Smelt, *Hypomesus olidus* (1949 Year-Class) taken in towing cycles
Sacramento and San Joaquin Delta, 1949

Cycle #33
9/20-22

Stn	Smelt in tow	Mean Length mm	Size Range mm	Smelt in Station
1	1	45.0	45.0	50
2	0			
3	2	49.0	34-64	124
4	0			
5	0			
6	0			
7	9	54.7	45-65	1683
8	0			
9	0			
10	0			
11	0			
12	0			
13	0			
14	11	58.8	48-81	4125
15	0			
16	13	55.1	48-64	7241
17	7	55.1	49-60	6804
18	0			
19	0			
20	0			
21	0			
22	0			
23	0			
24	0			
25	1223	53.3	40-65	864661
26	0			
	1266	53.4		

TABLE NO. 26

Monthly Occurrence and Relative Abundance of Salmon, Striped Bass and Shad Juveniles as shown from tow net catches in the Sacramento-San Joaquin Delta

1948

Month	No. of Cycles	Total Catch Salmon	% of Monthly Catch	Total Catch Bass	% of Monthly Catch	Total Catch Shad	% of Monthly Catch	% of Seasonal Catch
April	3	635	100.0					3.4
May	3	292	100.0					1.6
June	3	242	59.5			165	40.5	2.1
July	3	25	.3	2952	37.0	5011	62.7	41.9
August	2	0		4814	82.1	1047	17.9	46.1
September	2	0		305	48.7	321	51.3	4.9
Totals	16	1194		8071		6544		100.0

1949

Month	No. of Cycles	Total Catch Salmon	% of Monthly Catch	Total Catch Bass	% of Monthly Catch	Total Catch Shad	% of Monthly Catch	% of Seasonal Catch
February	4	10	100.0					.02
March	5	1498	100.0					2.7
April	4	592	100.0					1.3
May	4	834	98.5			13	1.5	1.9
June	5	449	4.5	3239	32.3	6331	63.2	17.9
July	4	27	.1	12949	53.6	11196	46.3	54.0
August	4			3827	47.9	4162	52.1	17.8
September	2			227	23.1	759	76.9	4.4
Totals	32	3410		20242		22461		100.0

TABLE NO. 21

DELTA MENDOTA DEMAND SHOWING SOURCE OF WATER 1/

Cubic Feet per Second

	J	F	M	A	M	J	J	A	S	O	N	D
Modified for Initial Central Valley Project												
1948												
From San Joaquin	370	530	230	910	1970	1990	1280	100	900	800	510	400
From Sacramento	0	0	380	70	0	0	1150	1970	420	0	0	0
From Mokelumne	0	0	110	140	0	0	30	10	10	0	0	0
Total	370	530	720	1120	1970	1990	2460	2080	1330	800	510	400
1949												
From San Joaquin	160	520	890	1270	1940	1250	0	0	210			
From Sacramento	0	0	0	470	90	1060	2280	2060	1100			
From Mokelumne	0	0	0	350	40	180	20	10	20			
Total	160	520	890	2090	2070	2490	2300	2070	1330			
Central Valley Project Modified for Increased Storage at Folsom												
1948												
From San Joaquin	490	630	630	930	2550	2600	1280	80	530	1030	740	400
From Sacramento	0	30	220	160	0	0	1880	2630	1370	230	0	0
From Mokelumne	0	0	70	280	0	0	30	10	10	10	0	0
Total	490	660	920	1370	2550	2600	3190	2720	1910	1270	740	400
1949												
From San Joaquin	280	670	1170	1300	2050	1280	0	0	220			
From Sacramento	0	0	0	770	450	1580	3010	2710	1560			
From Mokelumne	0	0	0	490	140	240	30	10	30			
Total	280	670	1170	2560	2640	3100	3040	2720	1810			

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

TABLE NO. 22

DELTA MENDOTA DEMAND SHOWING SOURCE OF WATER 1/

Cubic Feet per Second

	J	F	M	A	M	J	J	A	S	O	N	D
Modified for Initial Central Valley Project												
1931												
From San Joaquin	163	180	750	0	0	0	0	0	100	335	570	0
From Sacramento	0	0	180	1800	2200	2120	2280	1980	1190	270	0	0
From Mokelumne	0	0	0	0	0	0	20	70	0	0	0	0
Total	163	180	930	1800	2200	2120	2300	2050	1290	605	570	0
1938												
From San Joaquin	163	180	895	1950	2490	2550	2790	1690	900	760	690	0
From Sacramento	0	0	0	0	0	0	0	920	720	0	0	0
From Mokelumne	0	0	0	0	0	0	0	30	40	0	0	0
Total	163	180	895	1950	2490	2550	2790	2640	1660	780	690	0
1940												
From San Joaquin	163	174	930	2000	2490	980	470	490	630	735	670	0
From Sacramento	0	0	0	0	0	1320	1970	1520	840	0	0	0
From Mokelumne	0	0	0	0	0	250	40	40	40	0	0	0
Total	163	174	930	2000	2490	2550	2480	2050	1510	735	670	0
Modified for Increased Storage at Folsom												
1931												
From San Joaquin	277	342	750	0	0	0	0	0	100	335	580	0
From Sacramento	0	0	450	2270	2760	2730	2990	2590	1660	495	140	0
From Mokelumne	0	0	0	0	0	10	20	90	0	0	0	0
Total	277	342	1200	2270	2760	2740	3010	2680	1760	830	720	0
1938												
From San Joaquin	277	342	1170	2420	3060	3180	3500	1690	900	1010	840	0
From Sacramento	0	0	0	0	0	0	0	1530	1180	0	0	0
From Mokelumne	0	0	0	0	0	0	0	50	50	0	0	0
Total	277	342	1170	2420	3060	3180	3500	3270	2130	1010	840	0
1940												
From San Joaquin	277	330	1200	2470	2780	980	470	490	630	960	820	0
From Sacramento	0	0	0	0	140	1880	2680	2140	1300	0	0	0
From Mokelumne	0	0	0	0	120	320	50	50	50	0	0	0
Total	277	330	1200	2470	3040	3180	3200	2680	1980	960	820	0

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

TABLE NO. 22 (CONCLUDED)

DELTA MENDOTA DEMAND SHOWING SOURCE OF WATER 1/
Cubic Feet per Second

	J	F	M	A	M	J	J	A	S	O	N	D
	Modified for Group 2A plus Iron Canyon and New Bullards Bar Reservoir											
					1931							
From San Joaquin	960	1120	760	0	590	130	0	0	280	410	0	1510
From Sacramento	2415	2320	3330	4550	4000	4130	4210	3750	3704	1870	0	2160
From Mokelumne	40	40	20	10	10	10	50	180	0	0	0	190
Total	3415	3480	4110	4560	4600	4270	4260	3930	3984	2280	0	3860
					1938							
From San Joaquin	3415	3480	4160	4600	4600	4600	4590	2900	1670	1530	0	2900
From Sacramento	0	0	0	0	0	0	0	1540	2590	2280	0	1070
From Mokelumne	0	0	0	0	0	0	0	50	90	10	0	10
Total	3415	3480	4160	4600	4600	4600	4590	4490	4350	3820	0	3980
					1940							
From San Joaquin	2060	3500	4600	4600	3290	2670	1800	1440	780	1090	0	2460
From Sacramento	955	0	0	0	820	1640	2740	3100	3420	1680	0	1250
From Mokelumne	400	0	0	0	490	290	60	60	100	60	0	250
Total	3415	3500	4600	4600	4600	4600	4600	4600	4300	2830	0	3960

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

TABLE NO. 23

Mean Monthly Flow of Sacramento River at Sacramento 1/

Cubic Feet per Second

Year	J	F	M	A	M	J	J	A	S	O	N	D
						Historical						
1931	13560	13860	16000	8200	4520	2080	160	480	2990	4330	6070	15818
1938	31415	66491	67830	64220	62960	40910	10880	5350	6270	8940	10226	13759
1940	47200	58400	56600	56600	30400	11800	3760	2710	5400	6640	10500	28200
1948	23700	13000	19100	51780	52320	33730	9870	8500	10400	10400	11570	14030
1949	13620	15390	47670	32390	25370	10440	7048	7500	8632			
						Modified for Initial Central Valley Project						
1931	11700	11700	13000	9500	9500	9900	10300	9200	6700	5600	7000	10900
1938	31400	60500	59200	55700	62700	40600	12900	9000	8600	8900	16700	15600
1940	37800	57000	44700	48100	30200	15500	9700	9900	8540	8000	11700	44800
1948	23700	13000	19100	51780	52320	33730	9870	8700	10400	10400	11570	14030
1949	13600	15400	47700	32400	25400	10400	9000	8700	8600			
						Modified for Increased Storage at Folsom						
1931	11700	11700	13000	9500	9500	9900	10300	9600	8260	6000	7000	10900
1938	31400	60500	59200	55700	62700	40600	12900	9000	8600	8900	16700	15600
1940	37800	57000	44700	48100	30200	15500	9700	9900	8540	8000	11700	44800
1948	23700	13000	19100	51780	52320	33730	9870	9300	10400	10400	11570	14030
1949	13600	15400	47700	32400	25400	10400	9700	9400	8600			

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

TABLE NO. 24

Estimated Flow of Sacramento River at Sacramento plus Flood Flow in Yolo By-Pass 1/

Cubic Feet per Second

Year	J	F	M	A	M	J	J	A	S	O	N	D
Historical Conditions												
1931	14000	14000	16000	8200	4500	2100	160	490	3000	4300	6300	21000
1938	33000	103000	118000	84000	78000	42000	11000	5400	6300	8500	10000	13000
1940	58000	86000	119000	102000	31000	12000	3700	2800	5400	6700	11000	55000
Modified for Initial Central Valley Project (Shasta Reservoir and Millerton Lake Only)												
1931	-12000	12000	13000	9500	8900	9000	10000	9800	8100	6300	7300	17000
1938	32000	98000	110000	75000	77000	41000	11000	7800	7900	8200	18000	15000
1940	48000	85000	107000	93000	30000	12000	8600	9100	7900	7800	10000	56000
Modified for Initial Central Valley Project and Folsom Reservoir												
1931	12000	11000	11000	8800	9700	9200	11000	10000	8500	6400	7900	16000
1938	32000	98000	109000	72000	73000	39000	10000	8100	7800	8200	17000	15000
1940	41000	85000	107000	89000	26000	11000	9000	9300	8000	8200	10000	57000
Modified for Group 2A plus Iron Canyon and New Bullards Bar Reservoir												
1931	9400	9200	8600	7400	7400	8200	10000	9300	8900	7300	7000	9600
1938	31000	90000	100000	52000	63000	36000	10000	10000	9500	9600	16000	14000
1940	32000	67000	107000	71000	19000	10000	11000	11000	9100	10000	11000	45000

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

TABLE NO. 25

Mean Monthly Flow of San Joaquin River at Vernalis 1/

Cubic Feet per Second

Year	J	F	M	A	M	J	J	A	S	O	N	D
						Historical						
1931	1550	1600	881	389	444	392	233	228	320	478	643	1250
1938	6200	23400	34200	22400	28400	36700	14600	3360	2220	2670	3800	3700
1940	4130	8570	14700	16200	14300	10900	2000	1190	1690	1600	1720	3012
1948	1384	827	599	1393	5001	8606	1328	725	1088	1549	1492	1487
1949	1741	1415	3469	2058	3530	2002	563	602	715			
						Modified for Initial Central Valley Project						
1931*	1320	1580	1120	118	146	185	0	304	437	537	756	2540
1938*	7220	22830	33100	18300	21600	22100	9640	3010	1580	2470	3180	5220
1940*	4650	9060	14900	8410	5090	1820	1140	1140	1140	1590	2030	4340
1948	1384	827	599	1393	5001	8606	1328	725	1088	1549	1492	1487
1949	1741	1415	3469	2058	3530	2002	563	602	715			
						Modified for Increased Storage at Folsom						
1931*	1320	1580	1120	118	146	185	0	304	437	537	756	2540
1938*	7220	22830	33100	18300	21600	22100	9640	3010	1580	2470	3180	5220
1940*	4650	9060	14900	8410	5090	1820	1140	1140	1140	1590	2030	4340
1948	1384	827	599	1393	5001	8606	1328	725	1088	1549	1492	1487
1949	1741	1415	3469	2058	3530	2002	563	602	715			
						Modified for Group 2A plus Iron Canyon and New Bullards Bar Reservoir						
1931*	1320	1580	1140	138	1240	555	32	406	656	618	773	2080
1938*	6470	24040	33000	13400	19600	21900	11500	5350	2920	2390	2940	4730
1940*	3200	6370	14300	10700	5890	4860	3410	2750	1230	1640	2080	3930

1/ Data supplied by the U. S. Bureau of Reclamation, Sacramento, California.
* Increased diversions included.

TABLE NO. 26

Mokelumne River Flows Entering the Delta 1/
Cubic Feet per Second
Historical

Year	J	F	M	A	M	J	J	A	S	O	N	D
1931	105	108	56	13	16	18	74	309	10	6	40	593
1938	979	5023	6296	5372	5314	3035	686	263	332	617	846	722
1940	1663	2975	3806	4416	2922	1238	187	193	296	361	599	1038
1948	320	207	801	2664	2664	2744	144	31	82	204	354	479
1949	369	568	2970	1935	999	788	72	31	119			

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

TABLE NO. 27

FLOW OUT OF DELTA 1/
c.f.s.

Year	J	F	M	A	M	J	J	A	S	O	N	D
						Historical						
1931	16000	16000	17000	6400	2500	0	0	0	500	3200	6700	23000
1938	40000	134000	161000	111000	110000	79000	22000	5000	6100	10000	14000	18000
1940	65000	99000	139000	121000	46000	21000	2000	2000	4700	7000	12000	59000
1948	25000	14000	19000	54000	57000	42000	7000	5000	8000	10000	13000	15000
1949	15000	17000	53000	34000	26000	10000	3000	4000	6000			
						Modified for Initial Central Valley Project						
1931	13000	13000	13000	5900	4600	4500	4500	4500	4700	4500	7000	20000
1938	40000	121000	142000	90000	94000	57000	15000	4500	5100	8200	19000	20000
1940	52000	94000	121000	104000	34000	13000	4500	4500	4800	7000	11000	59000
1948	25000	13000	19000	53000	55000	40000	5000	3000	7000	10000	12000	15000
1949	15000	16000	52000	32000	24000	7000	3000	3000	5000			
						Modified for Increased Storage at Folsom						
1931	13000	12000	11000	5000	4500	4500	4500	4500	4700	4500	7500	17000
1938	39000	115000	138000	85000	89000	55000	13000	4500	5000	8000	19000	19000
1940	43000	88000	119000	98000	29000	11000	4500	4500	4700	7000	10000	58000
1948	24000	13000	19000	52000	54000	39000	5000	5000	7000	9000	12000	15000
1949	15000	16000	52000	31000	24000	7000	3000	3000	4000			
						Modified for Group 2A plus Iron Canyon and New Bullards Bar Reservoir						
1931	12000	11000	8100	4500	4500	4500	4500	4500	4500	4500	4500	15000
1938	35000	111000	131000	62000	79000	53000	13000	8000	5000	11000	14000	19000
1940	32000	70000	117000	77000	20000	8900	4500	4500	4500	6500	8900	48000

1/ Data supplied by U. S. Bureau of Reclamation, Sacramento, California.

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