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Ecological Studies of The Sacramento-San Joaquin Delta
Part II: Fishes of The Delta

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FOREWORD

In July 1961 the Delta Fish and Wildlife Protection Study began an investigation of the ecology of the Sacramento-San Joaquin estuary in California. Our investigations were designed to answer specific questions raised by water development plans proposed for the estuary, and to provide a background of information that could be used to evaluate these plans.

We have annually prepared a progress report, and more recently published the first volume of our ecological studies; a series of eight papers on fishes of San Pablo and Suisun bays, and of zooplankton and zoobenthos of the Delta and San Pablo and Suisun bays.

This is the second volume of our ecological studies. It consists of 12 individual papers about the distribution, relative abundance, food and spawning habits of fishes in the Sacramento-San Joaquin Delta.

All investigations of the Delta Fish and Wildlife Protection Study have been financed with funds made available through the California Department of Water Resources by the California Water Bond Act. The practical result is that those who will profit by water development have paid for investigations needed to protect fish and wildlife resources dependent upon that water.

In 1965, after evaluation of four alternative Delta water transfer concepts, the peripheral canal plan was selected as the only plan with the opportunity to both protect and enhance these resources. Our present studies are being directed toward learning how to operate the peripheral canal to use these opportunities.

Acknowledgments

The success of any undertaking of this size is dependent on the cooperation, advice, and participation of many people.

The Delta Studies Section of the California Department of Water Resources provided us with much of the information regarding physical conditions in the Delta. Special thanks are expressed to Cyril McRae, Glenn Twitchell, Roy Nelson, and August Mueller.

Clarkson E. Blunt, Jr., helped to organize the fish study and directed the first year of the investigation.

David Ganssle organized and conducted the 1963 survey of striped bass eggs and larvae distribution.

Vincent Catania made many helpful suggestions concerning our operations and captained the trawl-netting boat at all times. Elvn Gunderson kept our gill-net boat in operation and spent many unrewarded hours in the field. Ratzi Mercurio made and repaired most of our nets.

John Pierce assisted in our field program and did the laboratory analysis of food habits of threadfin shad. Numerous others assisted in

Conditions for carp spawning may be poor in the Delta. Wales (1941) and Sigler (1958) reported that carp choose shallow waters of 6 inches to 3 feet deep to spawn. Carp eggs are slightly adhesive and usually stick to debris or plants or sink to the bottom. Any exposure to air will kill the eggs. There is little shallow water less than 3 feet in depth in the Delta, and tidal fluctuations would alternately flood and expose any eggs that were deposited in extremely shallow water. The water level of reservoirs has been dropped to kill carp eggs and reduce their populations in South Dakota (Shields, 1957).

The length frequency of catch with both gill net and otter trawl indicates the population is dominated by a certain size of fish (over 70 percent of the catch by all gears was 30–39 cm in length). This is not uncommon with carp populations, as a uniform size group or perhaps a single year-class has been known to dominate a carp population over a period of time (Mraz and Cooper, 1957).

Carp, Sacramento blackfish, and Sacramento hitch were all extremely abundant at Mossdale, more than at any other station in the Delta. During low flow months, flows in this reach of the San Joaquin River are made up almost entirely of irrigation return waters having high concentrations of dissolved solids (see Radtke, p. 25). These conditions appear to favor the carp, blackfish, and hitch. These same conditions may exclude the Sacramento squawfish which was never taken at Mossdale on the San Joaquin River or in the adjacent sampling stations with high total dissolved solids.

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13. DISTRIBUTION OF THREADFIN SHAD, DOROSOMA PETENENSE; TULE PERCH, HYSTEROCARPUS TRASKII; SCULPIN SPP. AND CRAYFISH SPP. IN THE SACRAMENTO-SAN JOAQUIN DELTA

JERRY L. TURNER

13.1. THREADFIN SHAD

The threadfin shad, Dorosoma petenense, was introduced into southern California from Tennessee by the California Department of Fish and Game in November 1953 (Parsons and Kimsey, 1954). They were later introduced into several reservoirs in the Central Valley of California and have since found their way into the Sacramento-San Joaquin Delta. This paper is a description of their distribution in the Delta from September 1963 to August 1964 and their food habits from September 1963 to May 1964.

Threadfin shad were most abundant in September and were least abundant in January. We found evidence that low water temperatures during the winter caused a heavy mortality of threadfins. Animal matter, particularly crustacean plankton, was the most frequent item in the diet of the threadfin shad, but it and plant material were equally important on a volume basis. Threadfin shad concentrated in areas of high crustacean plankton abundance. It is doubtful that severe competition for food exists between young-of-the-year striped bass and threadfin shad because relatively few young bass inhabit the areas where threadfin shad are most abundant.

13.1.1. Distribution

More than 64,000 threadfin shad were captured during our sampling. Most of these fish were caught with the midwater trawl (Table 1). Very few were captured with the otter trawl except at some of our shallow water stations. Only two threadfin shad were taken with the gill nets. Most were small enough to pass through the meshes.

TABLE 1

Total Number of Threadfin Shad, Tule Perch, and Sculpins Collected in the Gill Net, Otter Trawl, and Midwater Trawl

Species	Gill Net	Otter Trawl	Midwater Trawl	Total Number
Threadfin shad	2	2,268	62,136	64,406
Tule perch	52	820	23	895
Sculpins	—	97	—	97

TABLE 1

Total Number of Threadfin Shad, Tule Perch, and Sculpins Collected in the Gill Net, Otter Trawl, and Midwater Trawl

Threadfin shad were caught at every sampling station in the Delta (Figure 1). The greatest numbers were caught in late summer and fall in Hog and Sycamore Slough (both dead-end sloughs) and in the San Joaquin River at Fourteen Mile Slough. A total of 1,625, 4,385, and 4,279 threadfish shad was taken in three successive 10-minute tows at Fourteen Mile Slough in September 1963. Few threadfin shad were caught at our stations in the western Delta.

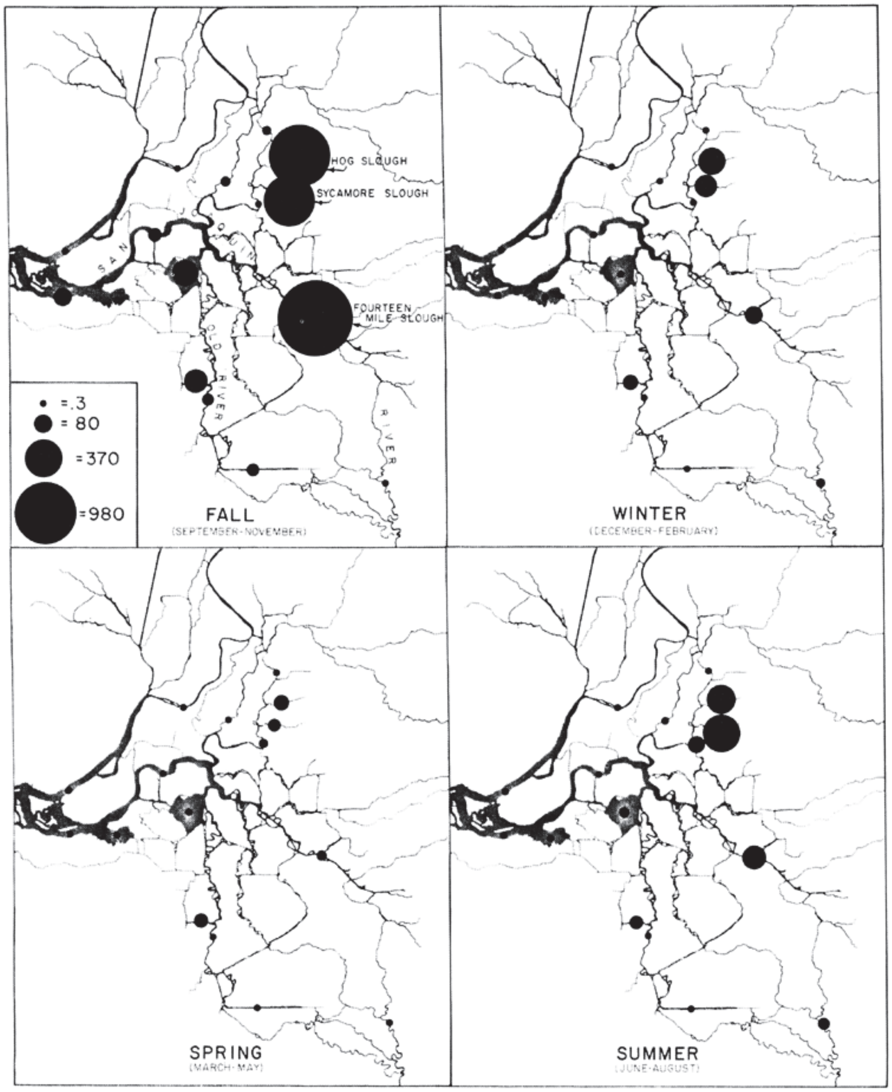

FIGURE 1. Distribution of threadfin shad in the Sacramento-San Joaquin Delta from September 1963 to August 1964. The area of each circle is proportional to the mean number caught in the midwater trawl at each station.

FIGURE 1. Distribution of threadfin shad in the Sacramento-San Joaquin Delta from September 1963 to August 1964. The area of each circle is proportional to the mean number caught in the midwater trawl at each station

Most of the threadfin shad caught in the fall and winter ranged in length from 5 to 12 cm FL (Figure 2). These were of the 1963 year-class. Their numbers declined rapidly during late fall and winter and increased only slightly the following June. A second and smaller size group (the 1964 year-class) appeared in our catches in July 1964 and completely dominated our August sample.

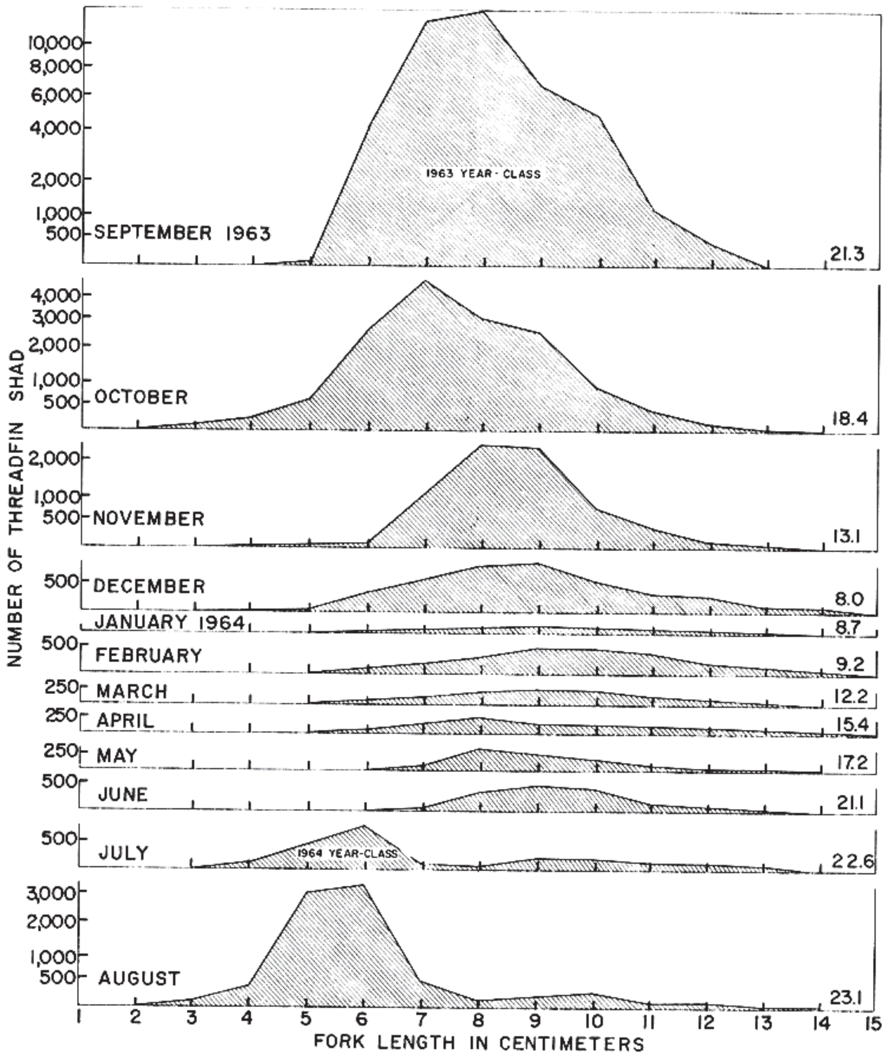

FIGURE 2. Length frequency of catch of all threadfin shad taken by midwater trawl from September 1963 to August 1964. Average monthly temperature in degrees centigrade is noted in the right-hand margin.

FIGURE 2. Length frequency of catch of all threadfin shad taken by midwater trawl from September 1963 to August 1964. Average monthly temperature in degrees centigrade is noted in the right-hand margin

13.1.2. Food Habits

Food habits of threadfin shad were determined by analyzing 518 stomachs collected from September 1963 to May 1964. These stomachs came from fish that were preserved in 10 percent formalin soon after they were collected. In the laboratory, the contents of each stomach and esophagus were washed into individual petri dishes and stained with rose bengal dye to facilitate identification and enumeration of food organisms. Cladocerans and copepods were found in most stomachs (Table 2). Desmids, diatoms, and filamentous algae were found in many. A large portion of the contents of many stomachs was so ground up that it could not be recognized. We estimated that 53 percent of the total volume of the stomach contents was plant material. A number of stomachs contained sand. Kimsey, Hagy, and McCammon (1957) and Haskell (1959) also found quantities of sand in threadfin stomachs.

TABLE 2

Stomach Contents of Threadfin Shad in the Sacramento-San Joaquin Delta, 1963–1964

Food Item	Percent Frequency of Occurrence (Average of all Stations)
Animal Matter	
Rotifers	26.5
Annelids	6.1
Cladocerans and Copepods	82.4
Amphipod (*Corophium*)	1.6
Amphipod (*Gammarus*)	0.2
Insect larvae	6.4
Asiatic clam (*Corbicula fluminea*)	4.2
Unidentified animal matter	80.9
Plant Matter	
Algae	46.1
Unidentified plant matter	66.1
Inorganic Matter	
Sand	54.8

TABLE 2

Stomach Contents of Threadfin Shad in the Sacramento-San Joaquin Delta, 1963–1964

Young Asiatic clams, Corbicula fluminea, averaging 1 mm greatest shell diameter, were common in the stomachs in the spring. One threadfin shad collected in Old River had eaten 26 clams. Young clams are regularly collected in plankton nets in the spring in the Delta (Hazel and Kelley, 1966).

The numbers of crustacean plankton ingested by individual threadfin shad at each station in the fall were directly related to the concentration of crustacean plankton in the environment (Figure 3). The concentration of crustacean plankton at each station was measured during a plankton survey conducted during the same months the shad were collected (Turner, 1966). Ivlev (1961) observed that the ration of a predator experiencing favorable feeding conditions cannot increase above a certain size. Because the curve in Figure 3 is not asymptotic, it indicates that optimum feeding conditions for threadfin shad may not have existed in the Delta at the time of our comparison.

The concentrations of threadfin shad in the Delta were directly related to the concentrations of crustacean plankton in the Delta (Figure 4). The areas of high plankton concentrations had low net velocities and high concentrations of dissolved solids (Turner, 1966).

13.2. DISCUSSION

Few threadfin shad were taken in the western Delta. Ganssle (1966) reported a decreasing catch of threadfin shad with increasing distance into the salinity gradient downstream from our study area. Kimsey (1958) found that threadfin shad live and show excellent growth in the Salton Sea but he did not believe that they spawned there. He

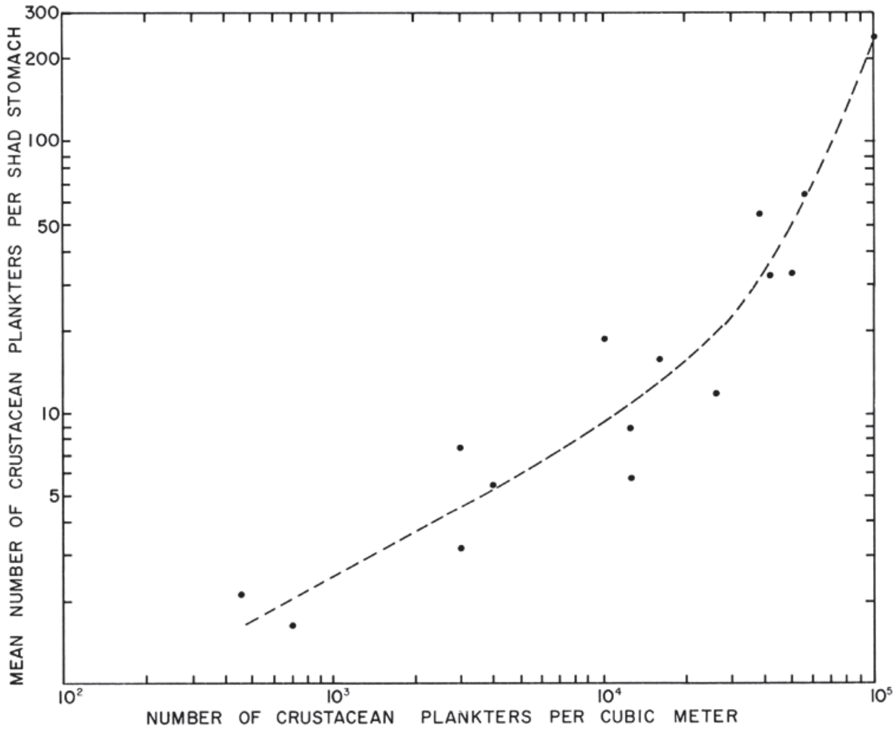

FIGURE 3. Mean number of crustacean plankters per threadfin shad stomach compared with the concentration of crustacean plankters in the environment, September to November 1963. Comparisons were made only if five or more stomachs were examined.

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thought they were swept into the sea from adjacent waterways. Shad milt expressed into Salton Sea water, which approaches salt content of sea water, congealed into strings and was incapable of fertilization. Hendricks (1961) found that threadfin shad were most abundant in the Salton Sea near freshwater outlets.

A heavy mortality of threadfin shad must have occurred in the Delta during the winter months. Our catches of the 1963 year-class declined rapidly after September and increased only slightly the following summer. Dryer and Benson (1957) reported that heavy winter mortalities of threadfin shad are common in TVA waters. Parsons and Kimsey (1954) found that the mortality of threadfin shad was high when water temperatures were experimentally decreased from 10°C and 15.6°C to below 7.7°C, and they observed that very few fish survived when water temperatures were below 4.4°C. Water temperatures in the Delta averaged 8.0°C in December. The minimum temperature was 6.7°C.

Before the threadfin shad was introduced into the Central Valley of California, Kimsey (1958) expressed concern over the possibility that threadfin shad and small striped bass would compete for food in the Delta. I do not believe that competition between the two species is severe. Copepods and cladocerans are important foods of threadfin shad throughout their life but are important to striped bass only in their first 3 months of life (Heubach, et al., 1963). Relatively few young bass of this age inhabit the areas in the Delta where threadfin

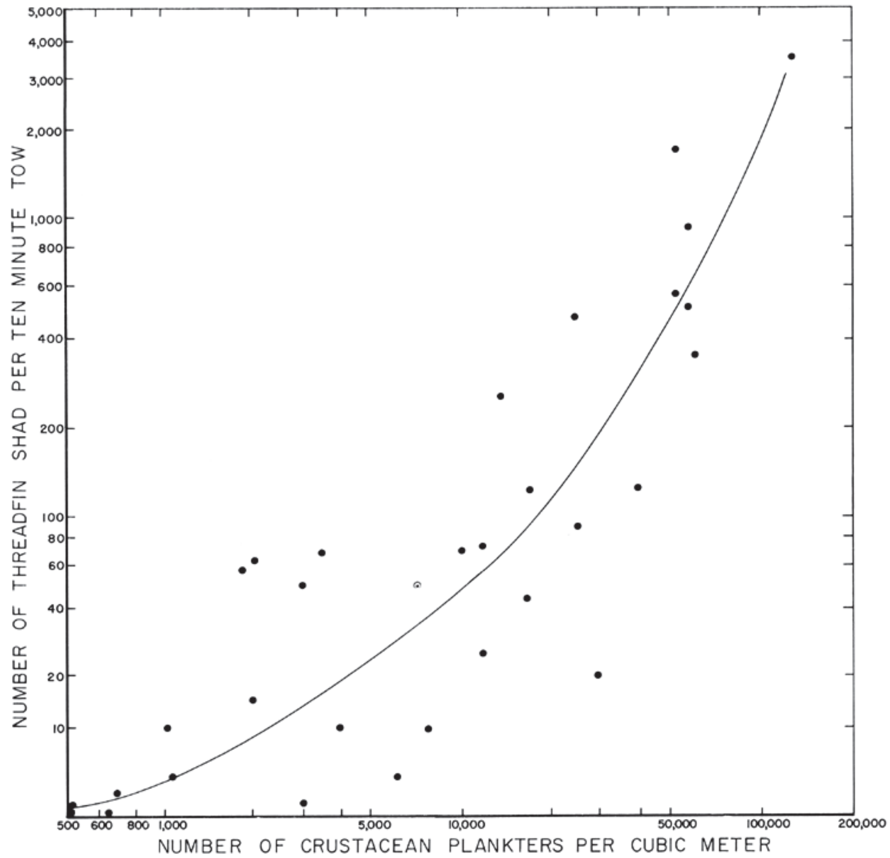

FIGURE 4. Number of threadfin shad taken per 10-minute tow by the midwater trawl compared to number of crustacean plankters per cubic meter of water in the environment, September to November 1963.

FIGURE 4. Number of threadfin shad taken per 10-minute tow by the midwater trawl compared to number of crustacean plankters per cubic meter of water in the environment, September to November 1963

shad have become abundant. Chadwick (1964) demonstrated from extensive tow net surveys that in the summer most of the population of young bass (1 inch long) are within a few miles of the confluence of the Sacramento and San Joaquin rivers. Sasaki (see p. 49) found that young bass (2 inches and longer) were concentrated in the fall in the western Delta and were not abundant in other areas of the Delta. Stevens (see p. 72) reported that these young bass were not feeding on copepods or cladocerans but were feeding on larger organisms such as the mysid shrimp, Neomysis awatschensis, and the amphipod, Corophium. These larger organisms did not occur in the diet of the threadfin shad.

The small size of the threadfin shad makes it a very desirable food source for piscivorous fishes, but its importance as a forage fish in the Delta may be limited because it is abundant only in restricted areas of quiet water.

13.3. TULE PERCH

Eight hundred and seventy-five tule perch, Hysterocarpus, traskii, were collected with the otter and midwater trawls and with set gill nets (Table 1). Analysis of the tule perch distribution is based on the mean numbers caught in the otter trawl at each station over the entire sampling period.

The tule perch in our catches ranged from 4 to 20 cm FL; the mean was 10.9 cm.

Tule perch were relatively scarce in the Delta. The greatest concentrations were in stations upstream from the central Delta. Highest catches were made in the North and South Fork of the Mokelumne River. No tule perch were taken in the San Joaquin River below Stockton, the Sacramento River below Isleton, and in Old River below Fabian Canal (Figure 5). Limited numbers were taken in Franks Tract and Big Break.

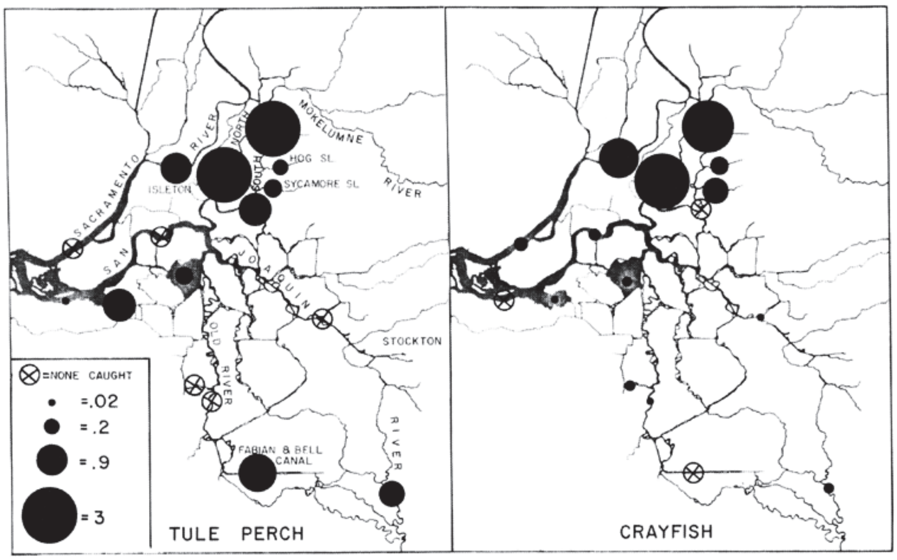

FIGURE 5. Distribution of (A) tule perch and (B) crayfish, both *Pacifastacus leniusculus* (common) and *Procambarus clarkii* (uncommon), in the Delta from September 1963 to August 1964. The area of each circle is proportional to the mean number caught in the otter trawl at each station.

FIGURE 5. Distribution of (A) tule perch and (B) crayfish, both Pacifastacus leniusculus (common) and Procambarus clarkii (uncommon), in the Delta from September 1963 to August 1964. The area of each circle is proportional to the mean number caught in the otter trawl at each station

The tule perch was the only viviparous fish that we collected. A total of 14 females containing unborn young were collected in April and May in Sycamore and Hog Slough (dead-end sloughs), Franks Tract and Big Break (flooded island), and in the Mokelumne River. In June and July a total of 16 out of 21 females examined were spent.

The stomachs of 206 tule perch were examined to determine their food habits. They are primarily benthic feeders (Table 3). Corophium occurred in the stomachs more frequently than any other organism. These amphipods made up over 91 percent of the diet bulk. Tendipedid larvae were also an important food source, especially for young-of-the-year tule perch. Tendipedids were consumed by 9 of 10 young-of-the-year collected during the summer in the Mokelumne River. Seventy-seven small Asiatic clams, Corbicula fluminea, were the only food in the stomachs of five tule perch captured during the spring in the Sacramento River at Isleton.

TABLE 3

Stomach Contents of Tule Perch in the Sacramento-San Joaquin Delta, 1963–1964

Food Item	Percent Frequency of Occurrence					Percent of Total Volume
	Fall	Winter	Spring	Summer	Average	
Mysid shrimp (*Neomysis awatschensis*)	—	9.1	—	—	2.4	0.2
Isopod (*Exosphaeroma oregonensis*)	—	3.0	—	—	0.8	0.5
Amphipod (*Corophium*)	100.0	90.0	87.2	77.5	86.3	91.8
Tendipedids	16.7	9.1	12.8	40.0	21.0	3.9
Asiatic clam (*Corbicula fluminea*)	—	—	12.8	—	4.0	3.6
Stomachs examined	22	58	58	68	206	
Stomachs containing food	12	33	39	40	124	

TABLE 3

Stomach Contents of Tule Perch in the Sacramento-San Joaquin Delta, 1963–1964

13.4. SCULPINS

Very low numbers of Pacific staghorn sculpin, Leptocottus armatus, and prickly sculpin, Cottus asper, were taken with the otter trawl (Table 1). The staghorn sculpin is a saltwater form that ranges into brackish and fresh water. The prickly sculpin is found in the fresh water of coastal streams. Regrettably, the two forms were not separated and their distribution cannot be described other than that one or the other was caught at every sampling station in the Delta. Large numbers of sculpin larvae, believed to the Cottus asper, were taken in plankton nets towed during the spring. Chadwick (1958) reported that large numbers of larvae of Cottus asper were taken in the Delta about the first of April.

13.5. CRAYFISH

Two species of crayfish, Pacifastacus leniusculus and Procambarus clarkii, were caught with otter trawls. Pacifastacus were much more numerous than Procambarus in our catches. The greatest concentrations of crayfish occurred in the northern Delta, particularly at Isleton on the Sacramento River and in the North and South Fork of the Mokelumne River (Figure 5). Very few crayfish were taken in other areas.

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