State of California
The Resources Agency
Department of Fish and Game

DISTRIBUTION AND FOOD HABITS OF FISHES IN RELATION TO THE THERMAL PLUME AT PACIFIC GAS AND ELECTRIC COMPANY'S PITTSBURG POWER PLANT IN THE SACRAMENTO-SAN JOAQUIN DELTA 1/2/

by

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SUMMARY

Fish distribution was studied with gill nets set in the thermal plume at the Pittsburg power plant and at control stations at the ambient river temperature. Striped bass, splittail and carp were significantly more abundant in the plume than they were out of it. An analysis of the striped bass stomach contents suggested that young king salmon were more vulnerable to predation in the plume than at the control stations, but we do not know if the greater vulnerability is due to salmon suffering a physiological reaction to heat or simply because they are exposed to a high concentration of predators.

INTRODUCTION

The Pacific Gas and Electric Company operates a fossil fuel power plant at Pittsburg immediately below the confluence of the Sacramento and San Joaquin rivers. This plant uses river water to cool its steam condensers. The cooling water is discharged back to the river at an elevated temperature. This discharge forms a heated plume, the location of which is a function of tide and the size of which is determined primarily by the amount of power being generated. It is described in detail by Adams (1969).

1/ Anadromous Fisheries Branch Administrative Report No. 71-14.

2/ This work was conducted under contract with the Pacific Gas and Electric Company.

Other studies (Allen, Boydstun and Garcia, 1970; Gritz and Stevens, 1971) have shown that heat affects fish distribution. This report describes a study with a primary objective of determining the effects of the plume at Pittsburg on the distribution of juvenile and adult fishes in this area. A secondary objective was to learn, through an analysis of the stomach contents of the piscivorous species, if the plume affected the vulnerability of young king salmon, Oncorhynchus tshawytscha, to predation. Coutant (1969) has shown that young salmon are particularly susceptible to predation after exposure to heat.

The distribution analysis is based on catches made with gill nets between April 28 and July 12, 1971. Stomach contents were analyzed for the gill net-caught fish and also for fish caught in a concurrent trawl survey of young salmon distribution (Gritz and Stevens, 1971).

METHODS

We sampled at Pittsburg with two variable mesh gill nets one day per week during the study period. One net was 250 feet long and 12 feet deep with 50-foot sections of 2-1/2, 3, 3-1/2, 4 and 4-1/2 inch stretched mesh. The other net was 200 feet long and 12 feet deep with panels of 5, 5-1/2, 6 and 7 inch mesh. The larger mesh net was the only one used for the first (April 28) and second (May 6) weeks of sampling. From May 13 on, both large and small mesh nets were used.

The nets were set with anchors at both ends. One station was the warm water plume. Five control stations at ambient river temperature were used at various times. Two control stations were on the south shore. One was about 1.5 miles upstream from the outfall and the other was about the same distance downstream from the outfall. One station was on the north shore directly opposite the station downstream from the plume. One station was in Broad Slough. The other station was about 5 miles upstream on the south side of West Island (Figure 1).

Temperatures in the plume ranged from 4 to 15F above the ambient river temperature. The highest temperature during a set in the plume was 79F on July 12. The lowest plume temperature was 63F on April 28. Ambient river temperatures varied from 57F to 71F.

Fishing time varied between sets. Mean set time in the thermal plume was 24 minutes; it was 50 minutes at the control stations. Sets were shorter in the plume because the nets usually caught large numbers of fish there.

All catches were standardized to a 1-hour basis. To do this we divided each catch of each species by the total minutes of fishing time and multiplied by 60. In order to test differences between warm and ambient catches statistically, the catches +1 were transformed to logarithms and the assumption was made that the adjusted catches represented what would have been caught in one hour.

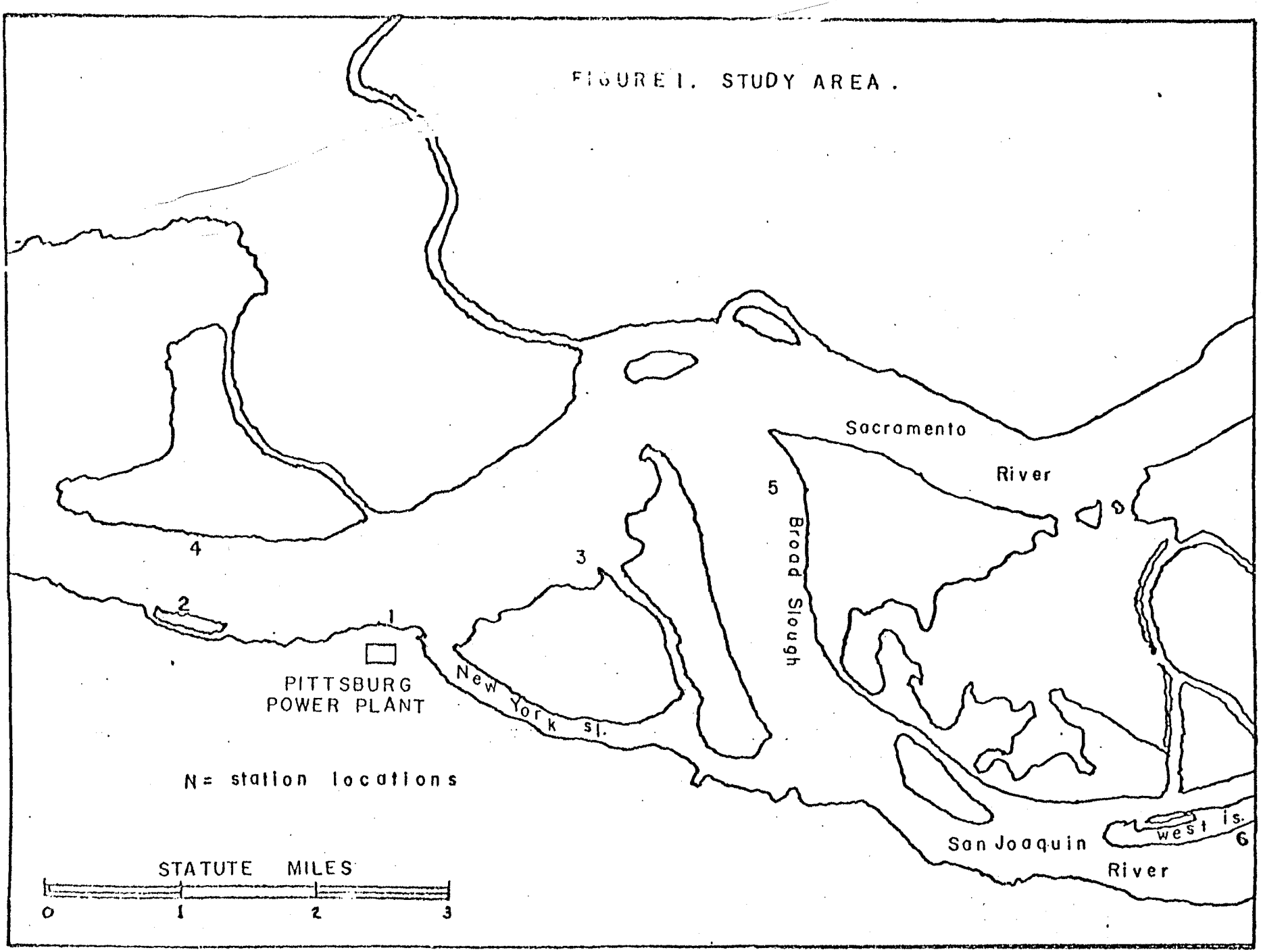

FIGURE 1. STUDY AREA.

Stomach contents were analyzed for the white catfish, squawfish and striped bass caught in the gill nets. In addition we also analyzed stomach contents of striped bass 8 inches and over, which were taken during a concurrent trawl survey of young salmon distribution (Gritz and Stevens, 1971).

The frequency of occurrence of food items was determined on the boat. Stomach contents were then preserved in 10% formalin. Contents were stratified by species and area. In addition striped bass contents were stratified by fish length. Length groups were 8-12 inches, 12-16 inches, and >16 inches.

Relative volumes of the food items were determined in the laboratory. Fishes in the stomachs were in various stages of digestion, but young salmon could be readily identified because the appearance of their vertebrae is distinctly different than that of other small fishes in the area.

RESULTS

Fish Abundance and Distribution

Striped Bass (Morone saxatilis)

Striped bass were the most numerous species in the catch. A total of 480 bass were caught in 12.75 hours of fishing in the plume for an average of 37.6 bass per hour. Their mean size was 15.3 inches. They ranged from 7 to 26.5 inches.

In water at the ambient river temperature we caught 38 bass in 29.4 hours of fishing, for a mean catch per hour of 1.3 bass, significantly smaller than in the plume, but still greater than for any other species. The highest catch at any control station was 3.4 bass per hour at West Island shoal. Bass at the control stations were about the same size as those in the plume. Their mean length was 16.7 inches, and they ranged from 8 to 33 inches. The difference between the catch inside the plume and out of it was significant at the 1% level ($t = 6.65$, 65 df).

Splittail (Pogonichthys macrolepidotus)

Splittail were the next most abundant species in the catch. The occurrence of splittail in the plume was sporadic. Thirty-four were caught in 6 of 32 sets in the plume. None were caught in the other 26 sets. The mean catch was 2.7 splittail per hour in the plume. These fish had a mean length of 10.7 inches. They ranged from 8 to 13 inches.

Only 4 splittail were caught at the control sites. This was 0.14 fish per hour. These fish ranged from 12 to 14 inches in length. The difference between these catches and those in the plume was statistically significant at the 5% level ($t = 2.09$, 65 df).

Carp (Cyprinus carpio)

Carp were the third most abundant species in our catch. We caught 25 carp in the plume; this was an average of 2 carp per hour. Their mean length was 14.6 inches. They ranged from 11 to 19 inches.

At the control stations we caught 11 carp, 0.4 per hour. The mean length of these fish was 14.9 inches, and they ranged from 10 to 18 inches. The difference in the catch for fish caught in and out of the plume was significant at the 1% level ($t = 3.03$, 65 df).

White Catfish (Ictalurus catus)

We caught 22 catfish in the plume with a mean length of 8.6 inches, and a range of 7 to 10 inches. At the control stations we caught only 6 catfish. They were from 8 to 10 inches in length. These catches were not significantly different.

Other Species

Other species caught were Sacramento squawfish, Ptychocheilus grandis (5 in plume, 10-17 inches; 9 at control sites, 11-21 inches); American shad, Alosa sapidissima (6 in plume, 12-19 inches; 5 at control sites, 11-21 inches); Sacramento western sucker, Catostomus occidentalis occidentalis (2 in plume, 1 at control sites); white sturgeon, Acipenser transmontanus (3 at control sites); and Sacramento blackfish, Orthodon microlepidotus (1 in plume).

Fish Food Habits

Striped Bass (8-12 inches)

Stomach contents of 137 bass in this size group were analyzed from the plume. Seventy-one of these stomachs contained food (Table 1). The opossum shrimp, Neomysis awatschensis, was the most important item in the diet of these bass. They occurred in 90% of the stomachs containing food, and formed 68% of the diet by volume. Fishes were the next most important food with a total of 10 fish occurring in 13% of the stomachs. They made up 25% of the total diet volume. Eight of these fish were salmon. One was found

Table 1

Stomach Contents of Striped Bass

Food Item	Thermal Plume 8-12 % Freq. Occ.	Thermal Plume 8-12 % by Vol.	Thermal Plume 12-16 % Freq. Occ.	Thermal Plume 12-16 % by Vol.	Thermal Plume >16 % Freq. Occ.	Thermal Plume >16 % by Vol.	Control (Ambient) 8-12 % Freq. Occ.	Control (Ambient) 8-12 % by Vol.	Control (Ambient) 12-16 % Freq. Occ.	Control (Ambient) 12-16 % by Vol.	Control (Ambient) >16 % Freq. Occ.	Control (Ambient) >16 % V
Crustaceans												
Opossum shrimp (Neomysis awatschensis)	90	68	83	27	73	5	89	73	100	98	71	
Isopods	--	--	--	--	5	Tr	--	--	--	--	--	
Amphipods (Corophium stimpsoni and/or C. spinicorne)	7	Tr	--	--	5	Tr	11	1	20	2	14	
Shrimp (Crago spp.)	--	--	6	2	5	Tr	--	--	--	--	--	
Insects												
Grasshopper (Orthoptera)	--	--	--	--	--	--	6	3	--	--	--	
Fishes												
King salmon (Oncorhynchus tshawytscha)	10	--	17	--	4	--	11	--	--	--	29	
Striped bass (Morone saxatilis)	--	--	--	--	23	--	--	--	--	--	14	
Unidentified fish	3	--	9	--	9	--	6	--	--	--	29	
Total fishes	13	25	26	71	36	94	17	23	--	--	71	
Bait	1.4	7	3	Tr	4	Tr	--	--	--	--	--	
Stomachs examined	137		231		256		46		20		26	
Number containing food	71		35		22		18		5		7	

in each of six stomachs, and another stomach contained 2 salmon. Amphipods, Corophium stimpsoni and/or C. spinicorne, occurred in 7% of the stomachs with food, but they made up only trace amounts (below 1%) of the diet by volume. Bait composed 7% of the total volume.

Only 46 stomachs were examined at the control stations. N. awatschensis occurred in 89% of these stomachs, accounting for 73% of the diet bulk. Corophium occurred in 11% of the stomachs; yet, accounted for only 1% of the diet by volume. One stomach contained a grasshopper (Orthoptera) and this formed 3% of the total diet. Three salmon were found in two stomachs. These salmon constituted 23% of the total food.

Striped Bass (12-16 inches)

Stomachs of 231 bass in this group were examined from the plume. Thirty-five stomachs contained food. Fishes occurred in 9 stomachs and comprised 71% of the diet by volume. Six of these stomachs contained a total of 15 salmon; one in each of three stomachs, 2 in each of two stomachs, and 8 in one stomach. N. awatschensis were a significant food also. They were found in 83% of the stomachs and formed 27% of the diet volume. Bait was found in trace amounts.

Twenty stomachs were examined from the control stations. No fishes were found in these stomachs. Only five stomachs contained food. N. awatschensis was found in all five and formed 98% of the diet. Corophium were in two stomachs and comprised the remaining 2% of the diet.

Striped Bass (>16 inches)

Stomachs from 256 bass from the plume were examined but only 22 had food. Fishes were in 8 stomachs and comprised 94% of the diet volume. Two salmon were found in one of these stomachs. N. awatschensis were in 16 stomachs, but the quantities were relatively small and they comprised only 5% of the diet bulk. Trace amounts of bait were found in one stomach.

At the control stations 26 stomachs were examined. Seven contained food. Fishes were in five stomachs and represented 95% of the diet volume. Two of these stomachs each held one salmon. Five of these bass ate small amounts of N. awatschensis but these shrimp comprised only 5% of the diet by volume. Traces of Corophium were found in the diet.

White Catfish

Stomachs of 22 catfish were examined from the plume. Fourteen of these contained food, but none held salmon. N. awatschensis occurred in 12 stomachs. They made up 41% of the diet by volume. A fish occurred in one of these stomachs and because it was large it formed 54.6% of the total food. Corophium occurred in one stomach, but were an insignificant part of the diet volume. All six catfish caught at the ambient river temperature had empty stomachs.

Sacramento Squawfish

All three squawfish stomachs with food contained yearling striped bass. Five squawfish were examined from the plume. Four were empty and one 17 inches long contained a bass about 5 inches in length. Ten stomachs were examined from fish caught at the control stations. Eight were empty. A 16-inch squawfish had eaten a bass about 5 inches long, and the stomach of a 21-inch squawfish contained a bass about 6 inches in length.

DISCUSSION

Fish distribution was studied with gill nets set in the thermal plume at the Pittsburg power plant and at control stations at ambient river temperature. Striped bass, splittail, carp, white catfish, American shad, Sacramento western sucker, and Sacramento blackfish were more abundant in the plume than they were out of it. The difference between catches in the plume and catches at the ambient river temperature were significant statistically for striped bass, carp and splittail, demonstrating a definite preference by these species for the warm water. Catches of Sacramento squawfish and white sturgeon were lower in the plume than at the control sites, although catches were low at all sites and the differences were not significant.

Temperatures measured in the plume during this study ranged up to 79F; however, temperatures at the cooling water discharge are sometimes higher than 90F (Kelly, 1971). We do not know how the fish were distributed in relation to temperature within the plume or whether they are attracted when the plume is hotter. Some or all species may be repelled or endangered by the maximum temperatures.

Stomach contents of those bass and catfish in our samples were generally similar to others examined in the Delta (Stevens, 1966; Thomas, 1967; Turner, 1966). The opossum shrimp, Neomysis awatschensis, was the primary food of 8-12 inch bass, although small fishes were also of value. The importance of N. awatschensis diminished and the importance of fishes increased with bass size. N. awatschensis was the predominant item in the white catfish stomachs. Three squawfish stomachs with food were analyzed; all contained a yearling striped bass.

The primary reason for the food habits portion of this study was to learn if young king salmon were more vulnerable to predators in the plume than to predators at normal temperatures, since Coutant (1969) has shown that young salmon are particularly susceptible to predation after a heat exposure. Young salmon are much less abundant in the plume than at ambient temperatures (Gritz and Stevens, 1971); therefore, even though salmon were slightly less frequent in stomachs of bass from the plume (11%) than in stomachs of bass from the control stations (13%),

the closeness of these percentages suggests that salmon were more vulnerable in the plume. Of course, the reason salmon are scarce in the plume could be due purely to the large number of predators there. Hence, while salmon appear to be more vulnerable in the plume, we do not know if it is because they suffer from a physiological reaction to heat or simply because they are exposed to a high concentration of predators.

There were no salmon in stomachs of white catfish and squawfish, but few of these stomachs were examined so this does not preclude the possibility that these species prey upon salmon.

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