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High Concentrations of Total Dissolved Solids Block Spawning Migration of Striped Bass, *Roccus saxatilis*, in the San Joaquin River, California[1]

INTRODUCTION

To predict the effects of water development projects on the fisheries resources in the Sacramento–San Joaquin Delta, fishery biologists need a better understanding of the environmental factors affecting the spawning migration of anadromous fishes. Previous studies (Radtke, 1966) have suggested that in some years relatively high concentrations of total dissolved solids block spawning migrations of striped bass in the San Joaquin River. The purpose of this study was to test the hypothesis of such blockage and, if true, to determine more accurately the levels of dissolved solids involved.

STUDY AREA

The study area was a ten-mile section of the San Joaquin River just below Stockton, California, where flows from the Sacramento and San Joaquin rivers meet and are mixed by tidal action during dry years (Figure 1). The quality of water in the two rivers is quite different. In dry years, such as 1966, the flow in the San Joaquin River is greatly reduced and consists largely of irrigation return water having relatively high concentrations of total dissolved solids. In contrast, the Sacramento River is characteristically low in dissolved solids. A dissolved solids gradient is created in the study area by the mixture of water from the two rivers as they are drawn across the central Delta by the U. S. Bureau of Reclamation pumping plant at Tracy, California. The net effect is that water in the San Joaquin River from the study area to its junction with the Sacramento River about 25 miles downstream is primarily Sacramento River water. It is fresher than either the water farther downstream, which is mixed with ocean water, or the San Joaquin River water upstream. Thus, striped bass moving upstream and having made the normal adjustment to fresh water must readjust to more saline water if they continue upstream.

Except for this salinity gradient, habitat in this section of the river is very uniform from about 5 miles below the study area to about 2 miles above it. It is a dredged navigation channel varying in width from 300 to 400 feet and has a depth of at least 30 feet.

METHODS

Our procedure was to sample striped bass throughout the dissolved solids gradient during the time of spawning migration. Samples were taken twice a week from 21 March to 31 May 1966, using a drift gill net 200 feet long, 24 feet deep, and made up of four 50-foot sections of webbing with stretch mesh sizes of 5, 5½, 6, and 7 inches. From 3 to 8 one-hour drifts were made each day. During each gill net drift, we usually towed a plankton net for striped bass eggs and larvae to determine if spawning had occurred. The net was constructed of nylon marquisette with 20 openings to the inch; the mouth was 10 inches in diameter. Tows were 20 minutes long. Sampling stations were located in relation to the dissolved solids gradient by checking the specific conductance of the water with a portable conductivity meter (Industrial Instruments RB2 Solu Bridge). Specific conductance of the water was assumed to be directly related to the dissolved solids content. In addition, water samples were taken at the beginning and end of each gill net drift and analyzed for specific conductance in the laboratory with a Wheatstone Bridge. These conductivity values were then converted to total dissolved solids in parts per million (Richards, 1954). The average of each pair of sample values was compared with the corresponding fish catches.

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FIGURE 1.—Location of study area in the San Joaquin River, California.

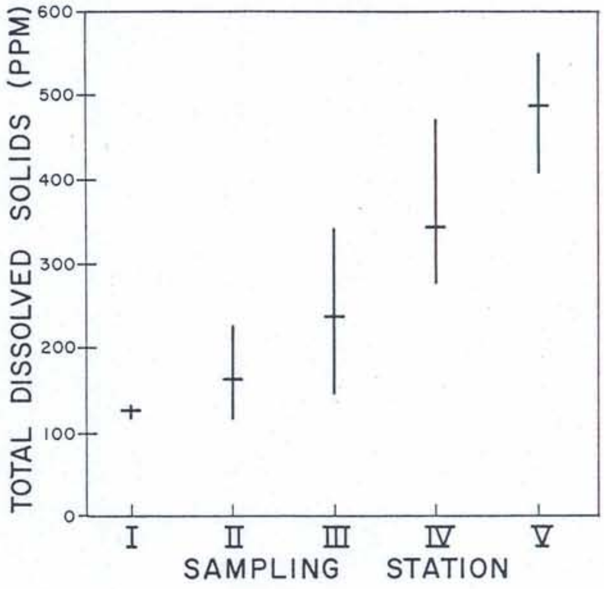

FIGURE 2.—Concentration of total dissolved solids at sampling stations in the San Joaquin River.

RESULTS

The concentration of dissolved solids varied at each station due to tidal movement with an increase in mean values from station I through V (Figure 2). Our catch of striped bass at any one station was greatly affected by the concentration of dissolved solids at the time of sampling. For example, on 10 May at station IV, we caught 52 striped bass per hour at high tide compared to 2 striped bass per hour at low tide. The concentration of dissolved solids was 275 ppm and 475 ppm respectively. Hence, catches were compared with the corresponding values of dissolved solids.

A total of 586 striped bass were caught in 59 gill net drifts. These fish ranged in fork length from 32 to 105 cm. Although sampling began in March, few bass were taken until the middle of April. The highest average catch of striped bass, 24.6 bass per hour's fishing, was made at concentrations of dissolved solids ranging from 251 to 300 ppm (Figure 3). Catches were somewhat lower in concentrations below 250 ppm, and always low at levels above 350 ppm.

The results of this study, and the greater upstream migration which occurs in years when total dissolved solids in the study area are low (Farley, 1966), support the hypothesis that relatively high concentrations of dissolved solids block the striped bass spawning migration up the San Joaquin River. This study demonstrates that 350 ppm is the critical concentration and helps explain the erratic spawning migrations that have occurred in the past in the San Joaquin River above Stockton.

Even though striped bass were numerous in the study area, only 68 bass eggs were taken in 44 plankton tows. Fifty-one of these were taken in concentrations of dissolved solids less than 150 ppm. Thus, striped bass apparently require a lower concentration of dissolved solids for spawning than that which limits their upstream movement. Farley (1966) compared the catches of striped bass eggs over several years in the Sacramento–San Joaquin Delta and concluded that no significant spawning occurred in water with a dissolved solids content greater than 180 ppm. In the past, very little spawning has

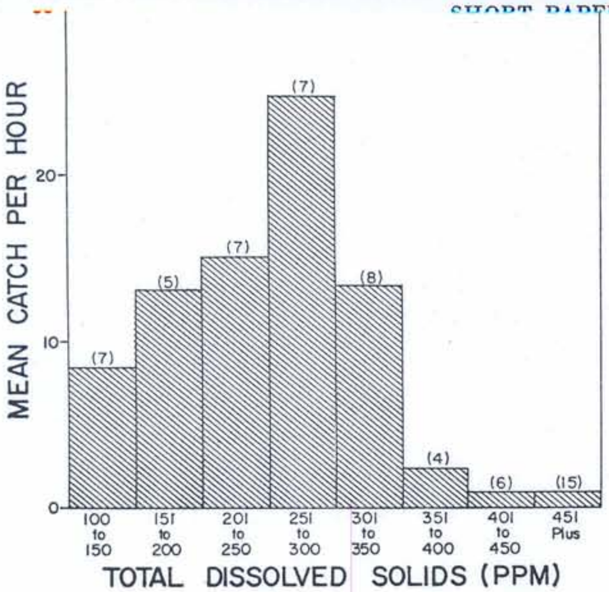

FIGURE 3.—Mean catch per hour of striped bass in relation to total dissolved solids in the San Joaquin River at Stockton, California, in 1966. Numbers of gill net drifts are in parentheses.

occurred in our study area (Chadwick, 1958; Farley, 1966; Donald E. Stevens, pers. comm.); most of it takes place downstream where the concentrations of dissolved solids are lower. Most bass migrating up into relatively high concentrations of dissolved solids must therefore drop back downstream to spawn. Under present conditions this is not a serious problem, as the run of striped bass in the San Joaquin River above Stockton is small even under ideal water conditions. However, with some proposed water development plans the entire spawning migration in the San Joaquin River could be threatened.

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