ANNUAL MIGRATIONS OF CALIFORNIA STRIPED BASS [1]

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A well-defined annual migration of adult striped bass *(Roccus saxatilis),* initially suggested by the catch records for this fishery (Calhoun, 1949), has now been fully confirmed by a large number of tag returns.

Previous California tagging of striped bass (Clark, 1934, 1936) was limited almost entirely to small fish, mostly less than 12 inches in length and virtually all under 20 inches. The principal conclusion reached was that they made no definite migration, but simply diffused away from the tagging locality. Such behavior is apparently characteristic of immature striped bass everywhere (Vladykov and Wallace, 1938; Merriman, 1941) .

It is hoped that this report will clarify the California picture by outlining the migrations of the large striped bass within the Sacramento River system and adjacent waters. These were missed by Clark because he tagged so few large fish.

The tag which has been used in our work, commonly called a Petersen disc tag, consists of a pair of plastic discs, one at each end of a wire passing through the body of the fish. Initially they were placed high on the back, beneath the dorsal fin, but later they were put in the tail region,

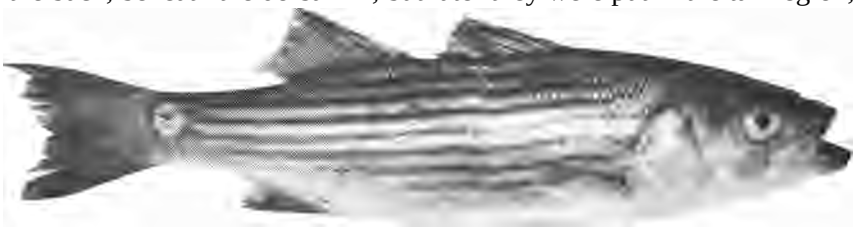

FIGURE 1. Petersen disc type of tag in place on the caudal peduncle of a striped bass

as shown in Figure 1. Many different metals and plastics have been tried since 1947, when tagging began, to discover the most satisfactory materials (Calhoun, Fry, and Hughes, 1951).

The striped bass used for this study were tagged principally during 1950 and 1951, in the spring of the year. At that season the adults are concentrated in the fresh-water Sacramento-San Joaquin Delta, and it is relatively easy to catch them in gill nets. Tagging localities were all within the hatched area shown in the first chart (Figure 5).

All fish were captured in gill nets. One method employed with great success in shallow, current-free areas like Franks Tract was to set the net in a circle, and then to create a disturbance by racing the boat around

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inside it. This caused any fish present to scatter wildly and to become entangled in the net, which was picked up immediately. The gear used for this type of operation was ordinarily about 1,200 feet long and 12 feet deep, and of large mesh size (about nine inches, stretched measurement).

Drift gill nets about 30 feet deep also proved highly effective. They were made up of four sections of different mesh sizes, from $4\frac{1}{2}$ inches to $8\frac{1}{2}$ inches (stretched measurement), in order to sample the various sizes of fish present. These drift nets were fished in the lower portions of the San Joaquin River, in the manner formerly employed by the commercial gill-netters, before the area was closed to them.

FIGURE 2. The Striper, 28-foot Fraser River type gill-netter used for striped bass tagging work

The research boat STRIPER, shown in the accompanying illustration, was invaluable in these tagging operations. She is a Fraser River type gill-netter, with a large, power-driven spool in the stern to handle the gill net, much as a fishing reel handles a line. Use of two tagging cradles simultaneously made it possible to handle fish as fast as the boatman could extract them from the net, with the result that several hundred could be tagged readily in a day when they were abundant. The actual tagging operation in progress is shown in Figure 3.

For the sake of convenient reference, the tagged fish have been divided into three different groups.

The first group, representing no more than pilot experiments, has been included principally because it contains the only two tags ever returned from fish caught in the Pacific Ocean proper. It consists of 336 large bass tagged at Franks Tract during January and November of 1947. Even though this represents tagging during two successive winter seasons, the returns have all been combined, since they revealed essentially similar movements, and the numbers involved were very small.

FIGURE 3. A striped bass being **tagged** aboard the *Striper*

Length frequencies of a representative sample of 87 of these fish are shown by the dotted line in Figure 4 (mean length 32.2 inches ; standard deviation 2.04; range 25 to 37). Measurements are from the tip of the lower jaw to the fork of the tail.

The second group, consisting of about 1,800 fish, was tagged mainly during the spring of 1950. Those caught the preceding fall and winter are also included, but they are relatively few. Most of this group was caught in the San Joaquin River, in drift nets, as described previously, although some were also taken in circle nets in Franks Tract and Sherman Island Lake.

There were many more medium-sized individuals in this second group than in the first one. Length frequencies of these fish are graphed in Figure 4 (mean length 25.0 inches, standard deviation 5.07, range 12 to 42).

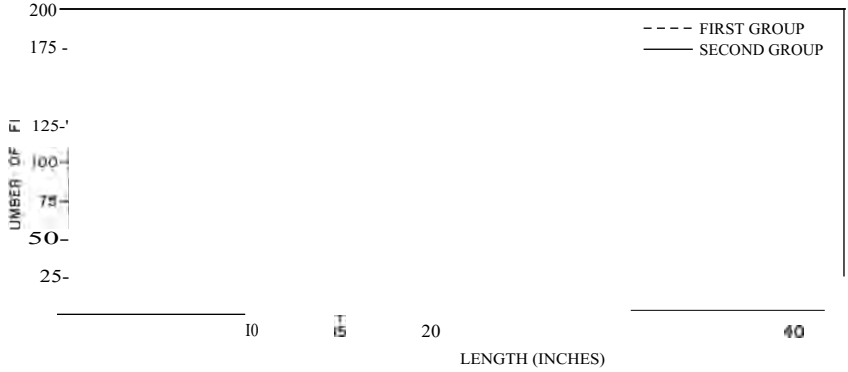

FIGURE 4. Length frequencies of tagged striped bass. The dotted line represents a sample of 87 individuals from the first group, tagged in November of 1947. The solid line represents 1,799 individuals from the second group, tagged during the 1949-1950 season.

The third and final group was generally similar to the second in all respects, except for being tagged the following season, 1950-1951. It contained about 2,000 fish.

Up to the present time (January, 1952) tag returns from these three groups for which date and place of capture are known total roughly 400. Each return is plotted as an individual mark on one of the accompanying series of six charts (Figures 5 to 10) showing where tagged fish were caught during successive calendar periods. The groups are represented by different symbols, as indicated in the legend in the first chart : group one by crosses, group two by circles, and group three by squares. The juveniles are shown by half-dark symbols in each case.

The arbitrary selection of 20 inches as a dividing line between juveniles and adults is actually an oversimplification because the males mature sexually at a much smaller size than this. However, it is entirely satisfactory for the purpose at hand.

The first chart in the series of six shows recaptures during the winter and early spring soon after tagging. Numbers are small because fishing is always relatively poor at this season ; the bass do not bite well when the water is cold. Also, fewer tagged fish were available to the fishermen than later, for large numbers were released subsequently during April and May. There is little indication of any movement away from the tagging locality during the winter, although a few individuals have traveled some distance down the river. (Figure 5.)

The second chart shows where tagged fish were recaptured during April, as spawning is approaching a peak. As yet few of the fish have had time to spawn and return to the ocean. This chart is of particular interest because it illustrates the spreading out of the striped bass into the remoter sections of the delta and its tributary rivers to spawn. (Figure 6.)

The third chart covers the brief period of six weeks in late spring and early summer when the main body of fish is moving back down to the bays after spawning. At this time they are caught simultaneously over a very wide area. (Figure 7.)

Next is the summer picture, from mid-June to the end of August. During this season virtually all recaptures of adult fish took place in the salt

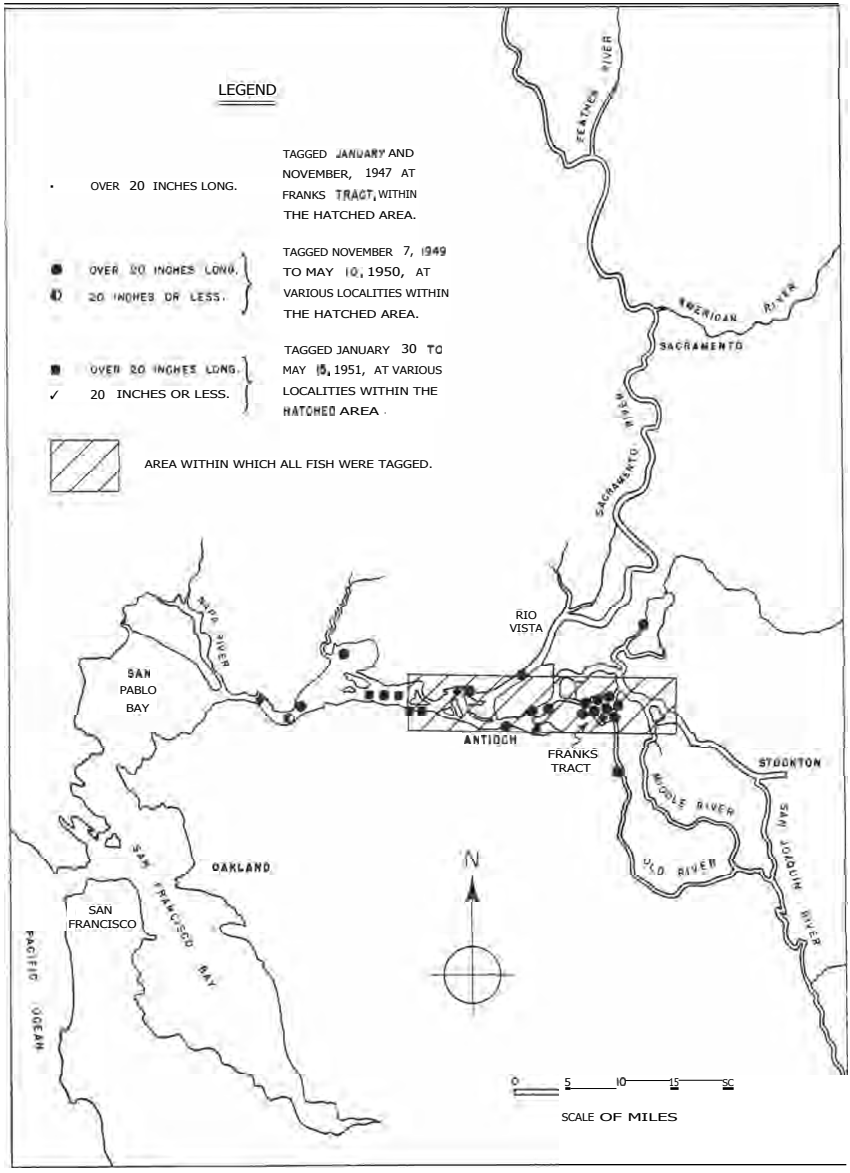

FIGURE 5. Tag recoveries from November 1st to March 31st, inclusive, immediately after tagging. During the winter the fish are concentrated in the Sacramento-San Joaquin Delta, and most recoveries were in or near the tagging area.

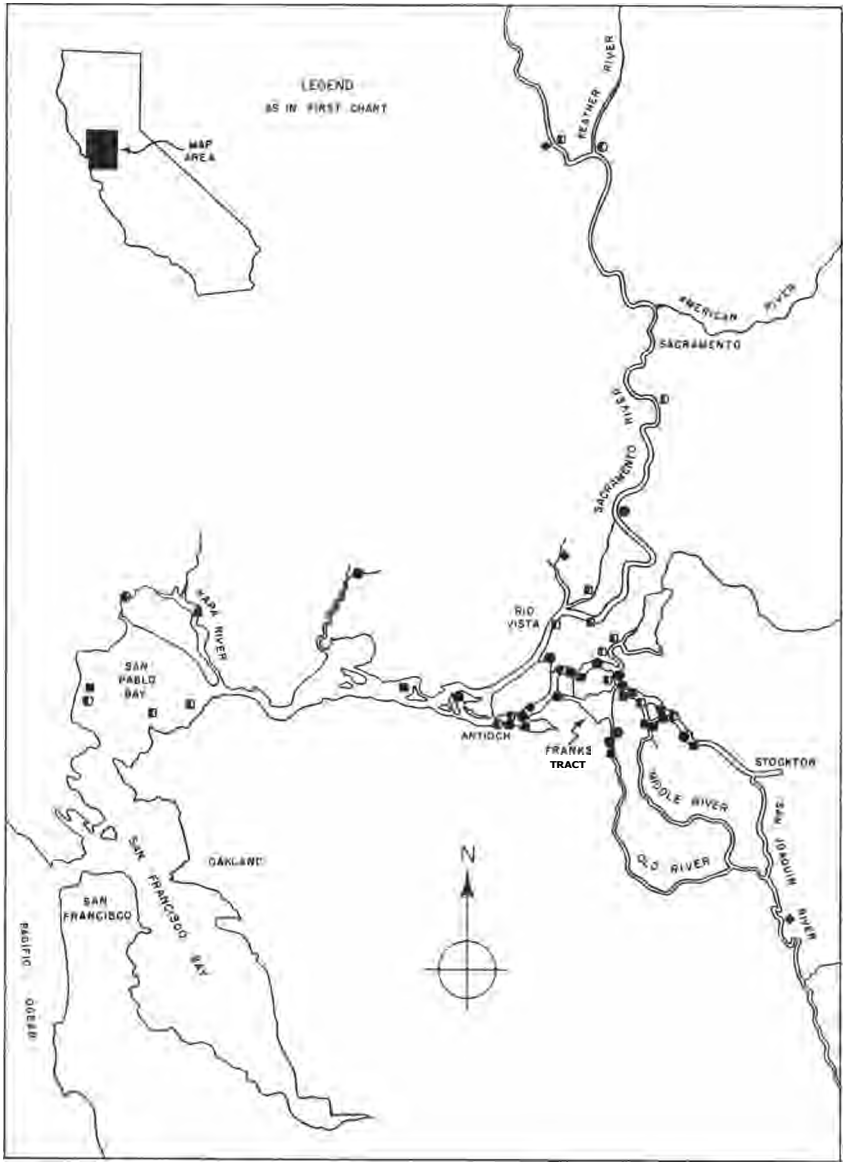

FIGURE 6. Recoveries during April. As the height of the spawning approaches, the fish spread out over the delta to spawn, and also ascend the tributary rivers.

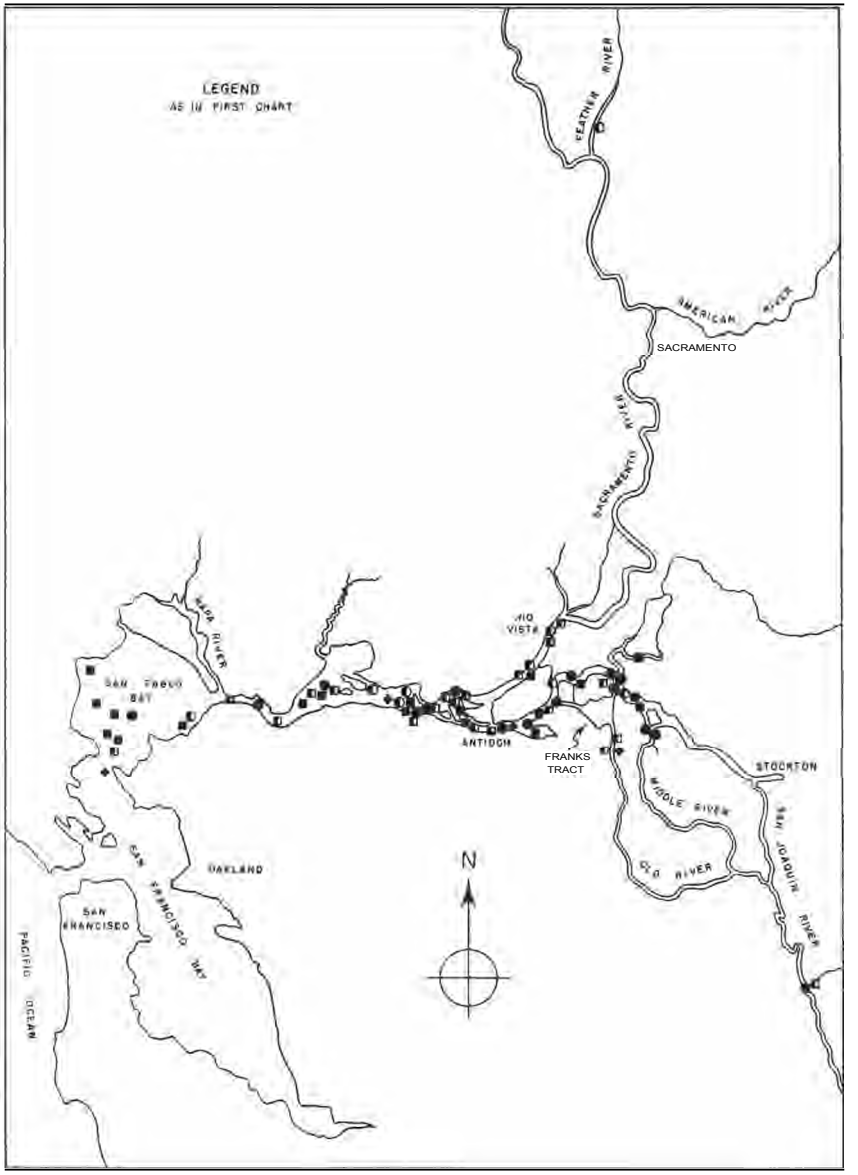

FIGURE 7. Recoveries from May 1st to June 15th.

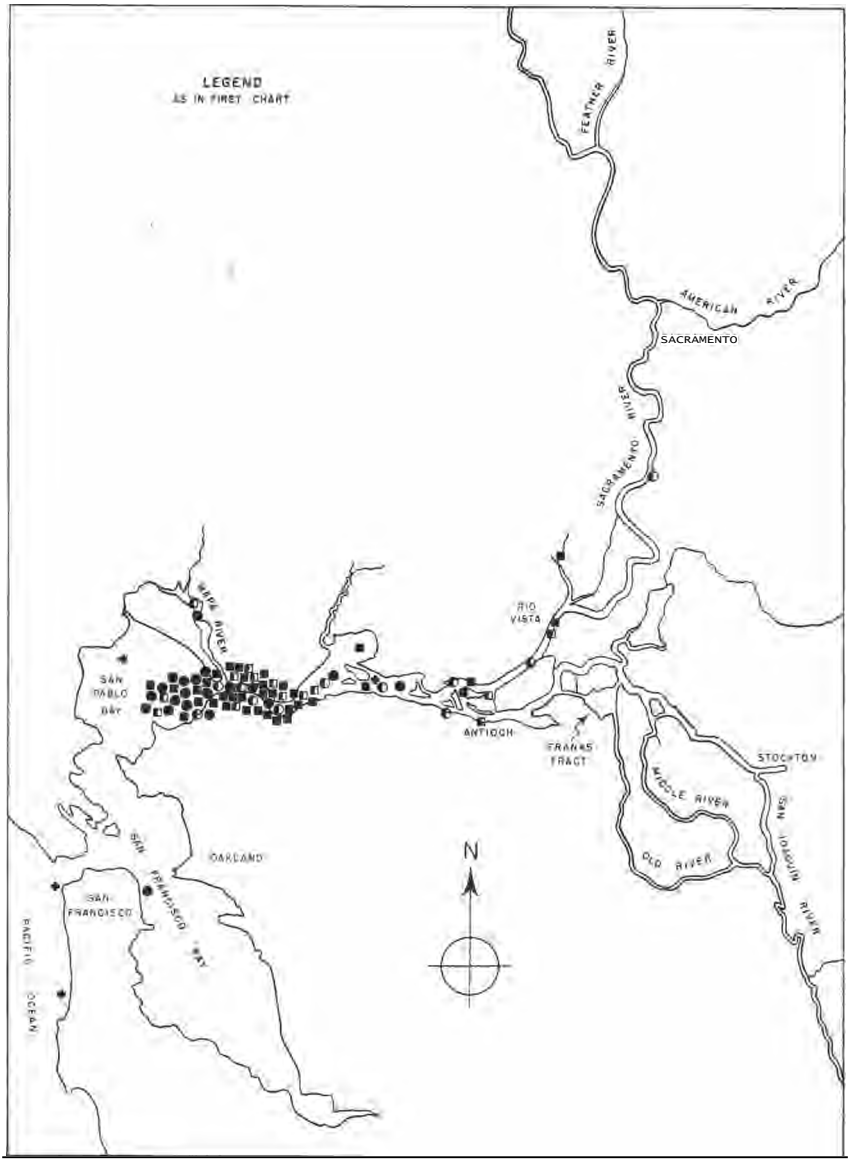

FIGURE 8. Recoveries from June 16th to the end of August. During the summer almost all the adults are in salt or brackish water.

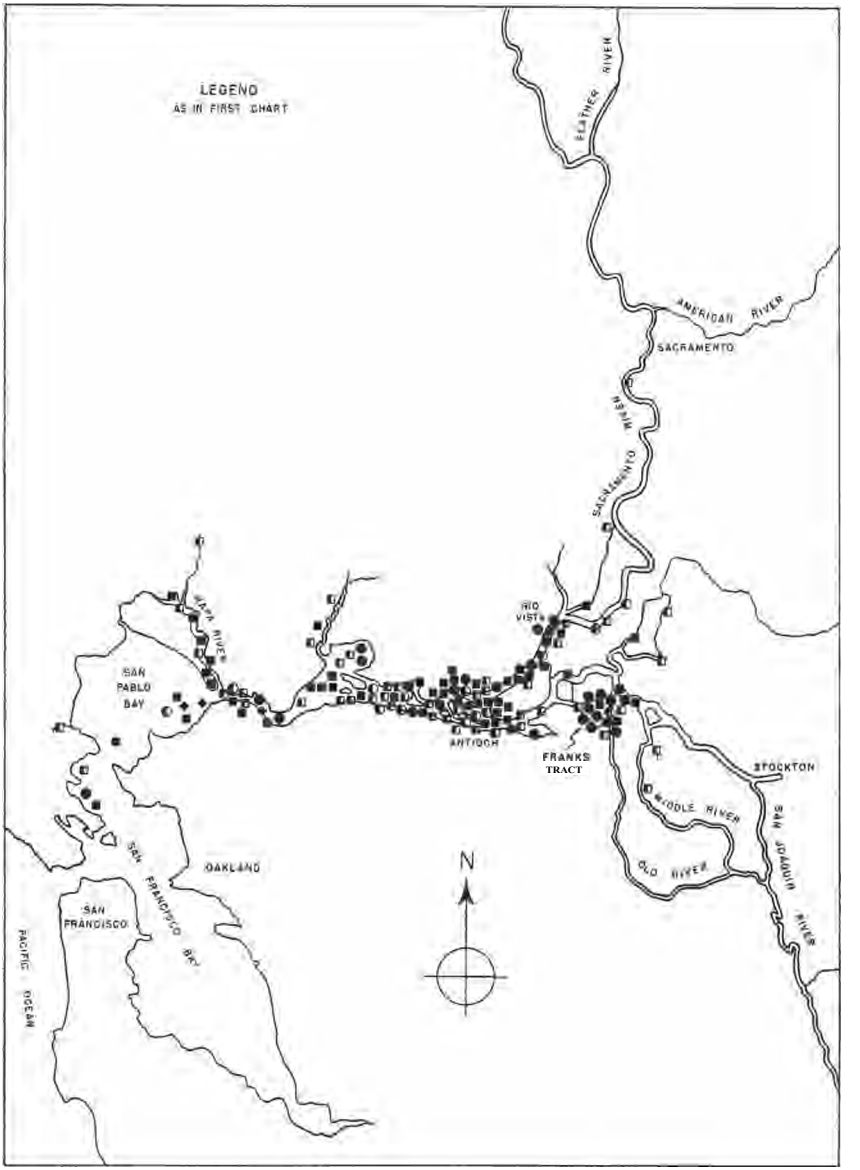

FIGURE 9. Recoveries during September and October. In the fall most of the fish pass back up into the delta again.

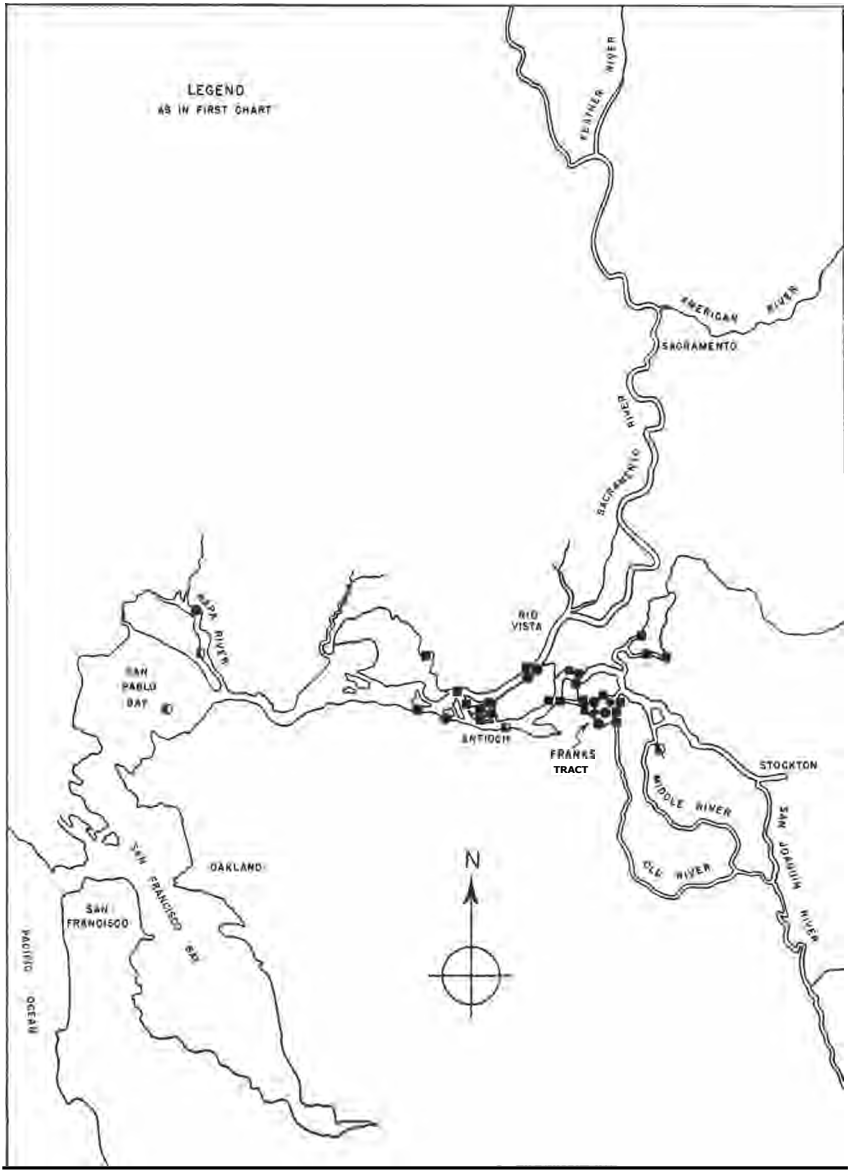

FIGURE 10. Recoveries between November 1st and March 31st, during the winter season roughly one year after tagging. This duplicates the first chart and completes the cycle.

and brackish areas inside the Golden Gate (Figure 8). Migration out into the Pacific Ocean is discussed later.

In the fall the fish again pass up into the delta, as shown in the fifth chart. These tag returns have a pattern essentially like the one in the third chart, when the bass were moving in the opposite direction, except that angling is much better in the fall and many more tagged fish were caught then. (Figure 9.)

The final chart shows recoveries during the winter season roughly a year after tagging (Figure 10). It duplicates the pattern in the first chart, and completes the cycle.

The general similarity of the distribution of the three different symbols on each of these charts attests to the regularity with which this same pattern is repeated in successive years. Four different seasons are represented simultaneously by these charts.

The few recaptures made the second year after tagging also fall into the same general pattern. They have not been shown because of the small numbers involved.

It is of interest to compare these California migrations with those which occur elsewhere. Recent striped bass tagging at Coos Bay, Oregon (Morgan and Gerlach, 1950), indicates that these northern fish behave much like those in California, having one spawning migration upstream in the spring and a second migration into the sloughs in the fall. The Oregon fish apparently migrate out of Coos Bay into the ocean in large numbers in early summer, returning again in the fall. However, as in California, they are not caught in the ocean to any extent.

In the Atlantic, the situation is apparently quite different ; but this is scarcely surprising, in view of the many basic dissimilarities between the two coast lines. In Chesapeake Bay bass are said to move from the upper to the lower bay in the fall months and back in the spring (Vladykov and Wallace, 1938). This appears to be the reverse of the California cycle. A different sort of behavior, resembling that in California, is reported for the rivers of New Jersey by Pearson (1938) . He also states that in Chesapeake Bay the bass spend the winter in the deeper channels of the bay and the mouths of its tributary rivers, while in southern Atlantic waters they remain more or less continually in fresh or brackish water.

A mass movement of the Atlantic striped bass north along the coast in the spring and back south in the fall over great distances has also been reported (Merriman, 1941). There is nothing to suggest that anything of this sort occurs along the Pacific Coast. Some California tags would probably have been returned from Oregon if it did. It is entirely possible, however, that more bass actually enter the Pacific Ocean through the Golden Gate each summer than either tag returns or catch records would indicate. Occasionally fishing is spectacular in the surf along the beaches south of the Golden Gate, for brief periods during the summer. This happened in 1948, the year in which the two ocean tag recoveries shown in Figure 8 occurred. However, in most years relatively few fish are taken in the ocean, probably well under 1 percent of the total. Even so, sizeable numbers could scatter along the many miles of inaccessible cliffs north and south of the Golden Gate each summer, with slight chance of being caught. It is certain that some individuals roam great distances.

The species spread from the Sacramento River north into Oregon within 20 years of the original introductions, in 1879 and 1882. The small number initially planted and the lack of intervening estuaries makes this a more remarkable feat than it might at first appear. Moreover, as early as 1906, bass were being caught in traps at the mouth of the Columbia River, some 600 miles north of the Golden Gate (Smith, 1910). Small numbers are still present there (Oreg. Fish Comm., 1948) although the species has never become abundant that far north on this coast. Occasional stragglers are also picked up hundreds of miles south of the Golden Gate, off Southern California. A 10-inch specimen was caught in a purse seine off Huntington Beach, south of Los Angeles, on May 10, 1948, and an eight-pound fish was taken from the Mission Bay Bridge near San Diego on May 27, 1947 (Fitch, 1949).

The failure of striped bass to become abundant on the Pacific Coast anywhere except around San Francisco and Coos Bay is readily understandable. These are the only two river systems south of the Columbia with extensive tidal estuaries of the sort the species seems to require for nursery areas and wintering grounds. Temperatures approaching 60 degrees F. are believed to be necessary for spawning (Calhoun, 1950), and this helps to explain why bass have not thrived north of Coos Bay. For example, in 1948 the Columbia River at Bonneville Dam did not reach this temperature until July 19 (U. S. Army Corps of Engineers, 1949), long after spawning is over in California. South of San Francisco, the limited rainfall precludes the possibility of spawning areas or nursery grounds of any consequence. Between San Francisco and Coos Bay the coast is precipitous, for the most part, and the rivers lack estuaries. Where borderline conditions exist, as in the Russian and Salinas rivers, small populations occur.

ACKNOWLEDGMENTS

This is a welcome opportunity to thank the San Francisco Striped Bass Club for its splendid publicity program in conjunction with these tagging experiments. Over a three-year period the club has awarded a great many impressive cash and merchandise prizes to anglers returning tags, at drawings held three times a year. A highly effective newspaper publicity campaign was also carried on by the club in conjunction with the drawings. Bernard Wilson, Ralph Krona, Marion Richards, George Savey, and Charles Burkhardt were particularly active in this program, and others too numerous to mention gave assistance along the way. So much interest and cooperation has been stirred up throughout Central California that it seems fairly certain that nearly all tags are being returned. This is, of course, particularly important in connection with the program's primary objective of evaluating fishing pressure.

The cooperation of the fishermen who returned tags is gratefully acknowledged. We are also indebted to Howard McCully, of the Bureau of Marine Fisheries, for suggesting and designing the plastic commendation cards sent to all individuals returning tags.

A number of California Department of Fish and Game employees assisted in this program. Vincent Catania, William Johnson, David Pelgen, and Richard Beland all helped with the capture and tagging of the fish. Jean Glass gave invaluable assistance with records and correspondence. The six migration charts were drawn by William Rowley.

SUMMARY

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