

SONIC TAGGING OF SALMON ON THE SAN JOAQUIN RIVER, 1965

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Abstract: Sonic tags were used by the California Department of Fish and Game to study San Joaquin River salmon migrations through the Sacramento-San Joaquin Delta, to find out if the effects of adverse stream conditions are a significant cause of salmon run decline.

It was concluded from the 1965 sonic tagging that (1) the fall-run migrated through the Delta and lower San Joaquin River with ease, reaching the spawning areas two weeks earlier than in recent years, (2) once the San Joaquin River quality and quantity reached suitable levels for salmon, the rate of migration was not affected by gradual changes which occurred in these factors thereafter and (3) pumping water from Tracy into the San Joaquin River above Stockton, to increase the flow past Stockton, increased the numbers of Sacramento River salmon in the lower San Joaquin River.

INTRODUCTION

San Joaquin River system fall-run king salmon, Oncorhynchus tshawytscha, runs have decreased markedly in recent years. One theory advanced to account for at least a portion of this decline is that it is due to problems faced by adult salmon in the lower San Joaquin River, caused by low flows, flow reversal and pollution.

In the fall of 1963 a study was initiated to insure safe passage of the 1963 San Joaquin River salmon run, and to find out if the effects of adverse stream conditions in the lower

San Joaquin River on adult salmon are a significant cause of the population decline and if so, how to correct these conditions. Stream flows in the San Joaquin River past Stockton were increased by installation of a partial barrier (barge) across the head of Old River and then pumping water from Tracy and releasing it into the San Joaquin River. Water quality measurements were made, and the salmon were sampled by gill netting. At the conclusion of this preliminary work a study plan was developed, and in 1964 the investigation was continued in a more comprehensive manner. A major objective in 1964 was to determine the migration pattern of adult salmon in the main San Joaquin River and in Old River, and to relate this pattern to stream flow variation and other measurable factors. Several Federal, State, and local agencies cooperated in the study, both in 1963 and 1964.

In 1964 we used sonic tagging equipment for the first time. In addition, the several cooperating agencies collected information on dissolved oxygen, water temperature and other water quality data, as well as stream flows. A rockfill partial barrier was also placed temporarily across the head of Old River, and flows in the San Joaquin River past Stockton were increased by a combination of the effects of the barrier and releases of water from the Delta-Mendota Canal into the Upper San Joaquin River.

It was concluded from results of the 1964 study that neither increased water flow nor decreased dissolved oxygen had any measurable effect on the 1964 adult salmon migration, but that rainfall and decreased water temperature had a favorable effect, or increased the migration rate. It was further concluded that perhaps the most significant factor contributing to the San Joaquin River salmon decline might not be adverse conditions faced by adults in the Delta, but instead losses occurring among fingerlings on their way to the sea.

In 1965, sonic tagging was tried again but with no barrier across Old River and no supplementary water releases from the Delta-Mendota Canal into the San Joaquin River. The purpose of the 1965 sonic tag study was to determine, under "normal" flow conditions, the 1965 migration pattern of adult king salmon in the San Joaquin River and in Old River, and to relate the effect of stream flow, dissolved oxygen and water temperature on this migration.

METHODS

To study the adult salmon migration, a trammel net was fished in the San Joaquin River at Prisoner's Point to capture fish for tagging. Prisoner's Point is one mile above the mouth of Old River. Tagging was conducted during the principal period of adult salmon migration, September through November, with a goal of ten fish a week to be tagged and released. The same type sonic tag (same frequency and pulse rate) was used during the entire period. Had the tagged fish delayed their migration, and then moved upstream rapidly at some period in the season as they did in 1964, the tag type (pulse rate only) would have been changed in an attempt to evaluate the effect of tagging on fish.

Three times a week, two mobile tag tracking crews recorded the daytime distribution of tagged fish in the San Joaquin River between Antioch and Todd's River Club, located about four miles downstream from Mossdale. One crew also recorded mid-water depth dissolved oxygen and water temperature at five locations between Stockton and the mouth of the Mokelumne River, as they tracked tags. Tag tracking in other portions of the Delta, including the Mokelumne and Old River was done as time permitted.

Two shore monitors were located on the San Joaquin River above Stockton, about two miles apart. It was felt that two monitors placed in close proximity would give a better indication of timing and direction of fish movement than a single monitor. A single monitor was located on Old River near Tracy (opposite the end of Grant Line Canal), and an additional one was placed on the Sacramento River near Courtland.

Theoretically all tagged fish migrating upstream out of the Delta, except those which spawned in the Mokelumne River system, had to pass a shore monitor. When locating the shore monitors in 1965, it was assumed (from results of the 1964 study) that salmon would not migrate into the Upper San Joaquin River system via Middle River. This assumption, apparently true during the low flows experienced in 1964 may or may not have been true for the much larger flows that prevailed in 1965.

SONIC TAG EQUIPMENT

The Department of Fish and Game purchased sonic tag equipment for the 1965 study from Smith-Root Electronics of Seattle, Washington. This equipment consisted of sonic tags, portable receivers and stationary receivers, each with hydrophones.

Sonic Transmitter Fish Tags

Sonic tags use a crystal to change electrical oscillatory signals into mechanical motion (vibrations). A battery supplies power to an electrical circuit which oscillates, and causes the crystal to vibrate at a designated frequency. The tags then send these high frequency sounds which fall in a range of 127 to 130 kilocycles per second, into the water. The sound waves are sent out in bursts (pulses) to conserve battery life and to permit the identity of more than one tag group. Four tag groups, each with a different pulse rate, were purchased in 1965, although only one group was used.

The tags are housed in water-proof, polystyrene, cylindrical cases measuring $3\frac{1}{2}$ inches long by $\frac{3}{4}$ inch in diameter. They are bullet shaped on either end. Each tag is activated by means of a magnetic reed switch mounted next to the inner wall of the capsule. Before placing the tag on a fish a small magnet is glued to the capsule's outer wall directly over the switch. Life expectancy of the tags, based on the life of the enclosed batteries, was approximately 2,000 hours.

Portable Receiver and Hydrophone

Sonic tag sound waves were picked up in the water by a crystal transducer in the probe or portable hydrophone and amplified by a battery-powered, fixed-tuned receiver. Tag signals are heard in the form of "beeps".

Stationary Receiver and Recorders (Shore Monitors)

Fish tag signals (sound waves), are picked up by stationary underwater microphone, or hydrophone, and amplified approximately three million times by a fixed-tuned receiver. When a tag signal is received, a second signal is sent, within the shore monitor, to a control circuit which activates a magnetic tape recorder.

The control circuit is designed to hold the recorder on 5 seconds and then shut it off. However, if another signal is received within 5 seconds, the recorder will reset and continue to function another 5 seconds. Therefore, if no restraining device were included, when a fish tag signal was received, with each signal being spaced less than 5 seconds apart (pulses), the recorder would continue to run as long as the tagged fish remained in the vicinity of the monitor and tag signals were being received. However, to conserve recorder tape, a "lockout" circuit has been built into the monitor. When a tag signal is being received, the recorder will continue to run only 30 seconds, and then it is shut off by the lockout circuit even though the receiver may still be getting a tag signal. The lockout circuit will remain in this "locked out" condition, and the recorder will not function until the lockout is reset. The manner in which the lockout circuit is reset to permit recording of additional tag signals, is governed by the position in which the "lockout" switch is placed by the operator. There are two choices. If the lockout switch is in the "Auto" position, the lockout circuit will be reset automatically when the fish tag signal is lost for a period of 5 seconds or longer. However, if the "lockout" switch is in the "5 min. lockout" position the lockout circuit will be reset by a clock timer which makes a switch closure every 5 minutes. If a tag signal is still being received at the end of any 5 minute lockout period, the recorder will operate another 30 seconds. The tape recorder has two channels. One for recording tag signals and another for recording time.

Installation of Shore Monitors

To protect the four shore monitors from the weather they were placed in waterproof boxes having length, width and height dimensions of about 30 inches. Each box was completely lined on the inside with a 4-inch layer of styrofoam. A 3/4-inch hole was drilled through the box for the hydrophone cable.

The hydrophone, or transducer, was mounted on a weighted, iron stand so it would be about one foot off the river bottom when in place, and so it would monitor the entire stream width. To be sure the hydrophone would detect all tagged fish passing by, an activated sonic tag was submerged in the river and manipulated with the aid of a boat at different distances, angles and depths from the installation.

TAGGING

Salmon tagging, in the San Joaquin River started on September 14 and was concluded on November 15, 1965. During this period, 69 "effectively" tagged fish were released including 67 at Prisoner's Point and 2 at the mouth of Seven Mile Slough. An attempt was made to tag ten fish each week, but not more than five during any one day. However, the salmon were generally so scarce that it was difficult to tag the weekly quota, even with five days of tagging effort. No attempt was made to capture salmon for tagging other than during daylight hours.

Salmon for tagging were caught in a trammel net, 3-fathoms deep and 230 fathoms in length. The net consisted of a gill net in the center with a wall of trammel netting hung on each side. Catching and tagging salmon was done by a three-man crew on the Department of Fish and Game's 26-foot research vessel, M. V. Striper. Fish becoming entangled in the net were removed immediately upon being detected. To do this, the section of net containing the fish was pulled on board. As the tag was being attached to a salmon, the tagging vessel was driven rapidly away from the net several hundred yards to minimize the chances of a tagged fish being immediately recaptured. Before being released, they were held in the water beside the boat until they appeared to be fully recovered. A fish was out of the water about 2 minutes.

All tags were attached to a salmon just in front of the dorsal fin with the tag lengthwise on the fish's back. Two nylon plastic straps encircled the tag and lay along either side of the fish pointing downward. A short piece of 0.09-inch diameter nylon rod, or pin, ran through the straps as well as the back of the fish. Tag straps, cut from 0.010-inch material, were each 6 inches long and 0.654-inches wide. To attach the straps to a tag so they would encircle it, the straps were trisected lengthwise near the center by two slits 1-1/8-inches long and 0.218-inches apart. The tag was then slipped through the slits. Slits in the front strap were 0.062-inches longer so the alnico #5 magnet, which was cemented to the tag to activate it, could also be encircled by the strap. The magnets were 0.500-inches long and 0.125-inches wide and 0.062-inches thick.

SALMON MIGRATION

Tagged Fish Detected By Tracking

Tracking Procedure

Two tracking crews recorded the daytime movement and distribution of tagged fish, three times a week, in the San Joaquin River between Antioch and Mossdale (Todd's River Resort).

The general tracking technique was to operate the boat near mid-channel and stop about every half mile or less to listen for tag signals. Tags could be picked up by the portable receivers at least 3/4 of a mile. The receivers were directional. When a tag was detected, its direction was determined and the boat was usually moved almost directly over it, or at least close enough to obtain a count of the beeps (pulse rate).

Fish Movement

Tracking or searching for tagged fish started on September 14, the day the first salmon was tagged. Except for one fish, located in the lower Mokolunne River on September 22, all tagged salmon detected by tracking during the first two weeks of the study were found in the San Joaquin River between the tagging area and Antioch. This tendency for tagged salmon to move downstream immediately after being tagged was also noted during the 1964 sonic tagging study, and it has also been observed elsewhere in the Central Valley through the years during other tagging programs. Although there was generally a concentration of tagged fish in the San Joaquin River below or near the tagging area, as the season progressed they did not move downstream as far.

Fish Movement

A total of 47 of the 69 salmon tagged was detected by shore monitors as they left the Delta. The last tagged fish passed a shore monitor on November 16. In addition, on that date four live and four dead tagged salmon (or lost tags) were also located by tracking in the San Joaquin River. Only five tagged fish were recovered on the spawning beds; four on the Stanislaus River and one on the American River at Nimbus Hatchery.

On September 27 the first tagged salmon to be detected above the tagging area was located opposite Medford Island. By early October a gradual but steady upstream migration was underway past Stockton. The tagged fish had moved out of the lower San Joaquin River by November 19.

The determination that 47 tagged fish passed the three shore monitors as they left the Delta is an estimate based upon an analysis of the tape recordings, and is not the total tag transmissions recorded. Since the monitors did not record the direction a tagged fish was swimming, it was impossible to determine their exact numbers migrating past a monitor. It is quite possible that a tagged fish may have been recorded more than once.

Most of the tagged salmon were either San Joaquin or Mokelumne River fish as only seven, or 10 percent, of the total tagged were detected in the Sacramento River as they migrated past the Courtland monitor. This is in contrast to the 1964 sonic tag results which revealed that 40 percent of the fish released at Prisoner's Point, which were later detected, migrated up the Sacramento River. In 1965 five tagged fish left the Delta via Old River, passing the Tracy monitor between October 7 and 27, while 35 migrated up the main stem of the San Joaquin River.

Tagged salmon passing the San Joaquin River monitors at Bowman Road and Todd's River Resort showed a steady migration out of the upper Delta, starting near the middle of October and continuing through the middle of November. Tagged salmon leaving the Delta via the Sacramento River did so earlier than San Joaquin fish, as six of the seven recorded, passed the Courtland monitor in September and October.

Stanislaus River Trapping

Salmon trapping by region 4 personnel in the Stanislaus River was started on October 12 and concluded on November 8, due to excessively high flow releases. The first salmon was trapped on October 14. From that date on, the numbers captured gradually increased until November 7. In all, 130 salmon were captured. The Stanislaus River trapping records indicate the run reached Orange Blossom by mid-October and gradually increased through the first week in November. Since the

trapping was stopped on November 8, when salmon were still being captured in comparatively good numbers, it is not known whether the peak of the run had been reached when the trap was removed. The Stanislaus River salmon migration closely paralleled the migration pattern of tagged salmon migrating out of the Delta past the Bowman Road and Todd's River Resort monitors. The 1965 run entered the Stanislaus River about two weeks earlier than runs during recent dry years. Four sonic tagged fish were recovered or observed in the Stanislaus River, three by Department of Fish and Game personnel and one by a sportsman.

Mokelumne River Counts

Mokelumne River salmon were counted from October 4 through November 12 as they passed through a fishway at Woodbridge Dam. Fish were counted by one man during a 7-hour daylight period each day. The fishway was open 24 hours a day, but no counts were made during the hours of darkness. Since no trap was installed in the fishway it was impossible to recover a sonic tag had one been observed. A total of 267 salmon was observed (none tagged) passing Woodbridge Dam.

CONCLUSIONS

In 1965, adult fall-run salmon migrated through the Delta and into the San Joaquin River tributaries with very little apparent difficulty. In fact, they reached the spawning beds in some areas two weeks earlier than they have in recent years.

Once the San Joaquin River water quality (D. O. and temp.) and quantity reached suitable levels for salmon in 1965 the rate of migration out of the Delta was not affected by the gradual changes which occurred in these factors afterward, but more by the inherent characteristics of the fish and some other factor not measured. Apparently the three factors measured reached satisfactory levels by mid-October at which time temperatures were about 64° F or less, dissolved oxygen about 6 ppm or more and stream flows past Stockton (of San Joaquin River system origin) of approximately 1,000 cfs.

In 1964, pumping water in the fall from Tracy via the Delta Mendota Canal into the San Joaquin River above Vernalis (with a partial barrier installed across Old River) increased the number of Sacramento River salmon attracted into the lower San Joaquin River, since the water being pumped was probably primarily of Sacramento River origin. In 1964, when supplemental water from Tracy was released in the San Joaquin River (with the Old River barrier in place), 40 percent of the salmon tagged at Prisoner's Point later migrated up the Sacramento River. In 1965, with no supplemental water from Tracy, but with substantial flows in the San Joaquin River from its own tributaries, only 10 percent of the salmon tagged at Prisoner's Point were Sacramento River fish.

SUMMARY

San Joaquin River system fall-run king salmon runs have decreased markedly in recent years. The decline may have been caused by low flows, flow reversal and pollution. In 1963, a study was initiated to find out if the effects of adverse stream conditions in the lower San Joaquin River on adult salmon are a significant cause of the population decline and if so, how to correct these conditions. The study was continued in 1964 and 1965, during which sonic tags were used on adult salmon.

This is a report on the 1965 sonic tag study. The purpose of this study (Sept.-Nov.) was to determine the 1965 adult salmon migration pattern in the San Joaquin River and in Old River under "normal" flow conditions, and to relate the effect of stream flow, dissolved oxygen, and water temperature on the migration.

To study the salmon migration, adult salmon were tagged in the San Joaquin River at Prisoner's Point. Shore monitors were placed where they would detect any tagged salmon migrating upstream out of the Delta, except those entering the Mokelumne River or those which might use Middle River. Two mobile tag tracking crews recorded the daytime distribution of tagged fish, and one of the crews also recorded mid-water depth dissolved oxygen and water temperatures.

Sonic tagging equipment was purchased for the 1965 study. A description of this equipment and its use are included.

A total of 69 salmon was caught in a gill net and "effectively" tagged, between September 14 and November 15, 1965.

Sonic tag tracking indicated that tagged fish moved downstream immediately after being tagged, as they did the previous fall. By early October a gradual but steady upstream migration was underway past Stockton, and continued until mid-November.

Migration patterns of adult salmon in the Stanislaus and Mokelumne Rivers coincided with the migration past Stockton.

Three conclusions were made: (1) In 1965, adult fall-run salmon migrated through the Delta and lower San Joaquin River with apparent ease, reaching some spawning areas two weeks earlier than in recent years, (2) once the San Joaquin River water quality and quantity reached suitable levels for salmon in the fall of 1965, the rate of migration out of the Delta was not affected by the gradual changes which occurred in these factors afterward, (3) pumping water from Tracy via the Delta Mendota Canal into the San Joaquin River above Vernalis (with a barrier installed across the head of Old River) increased the number of Sacramento River salmon attracted into the lower San Joaquin River.

REFERENCES

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