JOB PERFORMANCE REPORT

State: California

Project F-51-R-2: Inland and Anadromous Sport Fish Management and Research

Subproject VIII: Sacramento-San Joaquin Delta Sport Fish Management

Study 2: Sturgeon Population Dynamics and Life History Studies

Job 4: Spawning Habitat Preferences of Sturgeon in California's Sacramento River

Period Covered: July 1, 1989 to June 30, 1990

I. SUMMARY: We tagged 30 white sturgeon with radio transmitters in the lower Sacramento River during the late winter spawning migration. Most of these fish were caught during two minor flow peaks in late February and early March. We were able to follow four females and eight males to the spawning area. Female behavior was more suggestive of spawning than that of males. Increases in flow may stimulate females to spawn. We suspect that tagging stress may have caused some fish to abandon their spawning migration.

II. BACKGROUND: Earlier studies that sampled sturgeon larvae with small mesh townets identified the Sacramento River upstream of Knights Landing (river km 145) as a spawning area for sturgeon (Kohlhorst 1976) (Figure 1). Since the Red Bluff diversion dam

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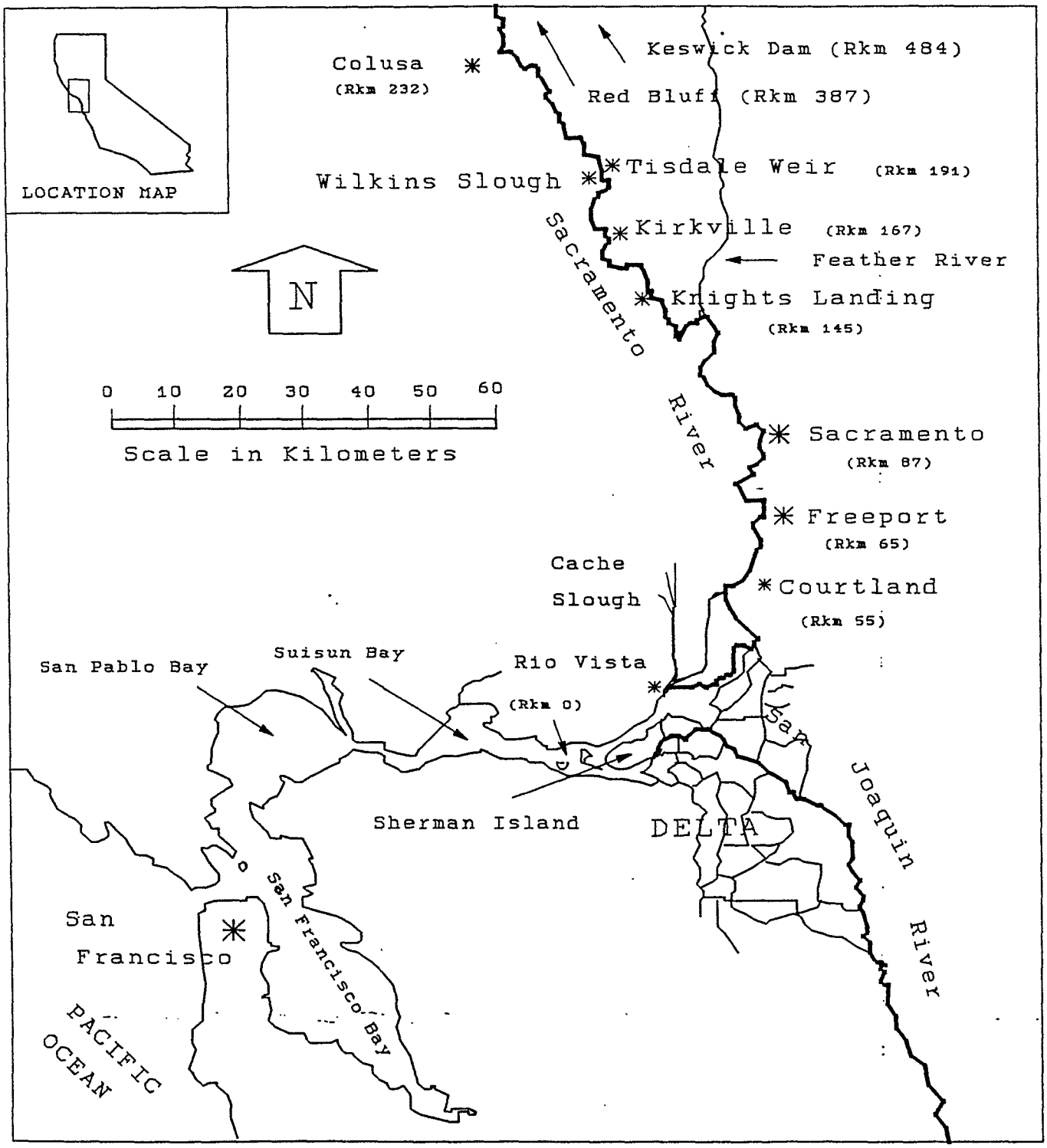

Figure 1. The primary area inhabited by white sturgeon in California. Distances are in river kilometers (Rkm) from the confluence of the Sacramento and San Joaquin rivers.

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gates have been open in winter to aid the migration of winter run salmon, juvenile sturgeon have been caught in set nets in the Tehama-Colusa canal (USFWS-unpublished), indicating the upstream limit of spawning is now above of Red Bluff (rkm 387). Within this long reach from Knight's Landing to the vicinity of Red Bluff, the Sacramento River provides a variety of habitats as it changes from a low gradient, slow moving, deep channel maintained by armored levees to a medium gradient, braided, pool-riffle river. We do not know which habitat(s) is critical for sturgeon spawning.

III. OBJECTIVES: To identify sturgeon spawning areas in the Sacramento River and to define the environmental characteristics of those areas.

IV. PROCEDURES: Sturgeon were tracked using transmitters manufactured by Advanced Telemetry Systems, Inc. Two types of tags were used: full power tags emitting 75 pulses per minute over a 2-year life span and reduced power tags broadcasting 55 pulses per minute for 3 years. Frequencies ranged from 48.01 to 49.42 Mhz. Tags were based on a "C" size dry cell lithium battery and were cylindrical with a diameter of 30 mm and an overall length of 90 mm. The attachment harness was two 2-mm diameter teflon coated stainless steel cables spaced 75 mm apart cast into the body of the tag. The tags were supplied with a drilled matching backing plate cut from a quarter- round section

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of PVC pipe. Each tag had a 40 cm long trailing antenna of stainless cable.

The scanning receivers could monitor all frequencies between 48.000 and 49.999 Mhz at scan rates of 2 seconds to 16 minutes per frequency. Frequencies to be scanned could be programmed individually. The receivers were equipped with both radio and audio frequency gain controls and a meter which measured audio output.

Sturgeon to be radiotagged were captured with setlines in the Sacramento River between Courtland and Freeport (Figure 1). We fished in this area, about 65 km upstream from the mouth of the Sacramento River, because it was reasonable to expect that sturgeon this far upstream were mature fish moving to spawning areas. We used approximately 400 hooks spread over four setlines (550 m/line) of 6.4-mm diameter soft-lay nylon rope. Originally, all hooks were 11/0, 12/0, 14/0, and 16/0 tuna circle hooks attached to the groundline clips with 1-m woven dacron leaders, but over the season 300 of these hooks were replaced with 10/0 and 12/0 straight shank "O'Shaugnessy" type hooks. We used squid (*Loligo opalescens*), mackerel (*Scomber sp.*), northern anchovy (*Engraulis mordax*), Pacific lamprey (*Lampetra tridentatus*), and ghost shrimp (*Callianassa sp.*) as bait.

The setlines were fished overnight and then retrieved with the aid of a hydraulically powered gill net reel. Captured sturgeon were lifted onto the deck of the boat with the aid of a rope noose slipped over the pectoral fins. The radiotag was

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attached by drilling 3-mm diameter holes through the 5th and 6th dorsal scutes. The plastic coated cables cast into the radiotag were threaded through the scutes and through the drilled backing plate, then made fast with crimp fittings. Tagged sturgeon were measured, sexed by external appearance, and released. The external characteristic used to sex tagged sturgeon was abdomen distension; we assumed that fish with noticeably distended abdomens were females. The reliability of this method has not been tested, but it was used in lieu of the additional stress associated with surgical examination of gonads.

We tracked radiotagged sturgeon by automobile, boat and airplane. Tracking by auto involved driving along levee roads at 45 to 60 km/h. Boat tracking was done from a 5-m outboard skiff operated between Sacramento and Colusa. We tracked fish by air during seven flights scheduled by this study and 10 angler survey flights by the Department of Fish and Game's Sacramento River Fishery Information Study. During our flights, the Cessna 185 was flown at 165 km/h at an altitude of 200-300 m above ground level (AGL); angler survey flights were flown at 220 km/h at an altitude of 100-200 m AGL. Our flights covered the Sacramento River and its north Delta tributary channels from Sherman Island to our most upstream known fish. Angler survey flights covered the Sacramento River upstream to Keswick Dam and major tributaries available to anadromous fishes, but, in the north Delta, these flights were generally restricted to the main channel.

In all tracking vehicles we scanned eight to 10 frequencies per receiver. Most tracking involved using a single receiver, but when a second observer was available, we used two receivers, doubling the number of frequencies scanned. The scanning antenna was a 1/4 wavelength omni-directional whip mounted on the roof of a car, the control console of the boat, or the wing strut of the airplane. When a tag was heard, its location was recorded by river kilometer according to USGS 1:24000 topographic maps. For more precise positioning during auto and boat searching, a hand-held, capacitor tuned, 0.5 m diamond loop was used to get two or more bearings for triangulation.

River stage and flow data used in our analyses were obtained from the California Data Exchange Center (CDEC) maintained by the California Department of Water Resources.

V. FINDINGS: We captured 37 white sturgeon during 17 fishing days between January 29 and March 7, 1990. These fish included 16 males, 16 females, and 5 unsexed fish (≤106 cm TL) that were considered immature. The mean length of males was 144.7 cm TL and females averaged 170.4 cm TL (Figure 2). Of these fish, we radiotagged 15 males, 14 females, and 1 one apparently immature fish.

Sturgeon showed a strong preference for hooks baited with Pacific lamprey. Although only about 20% of the hooks were baited with lamprey, they caught 30 sturgeon. Straight shank hooks were much more effective than circle hooks. We caught 34

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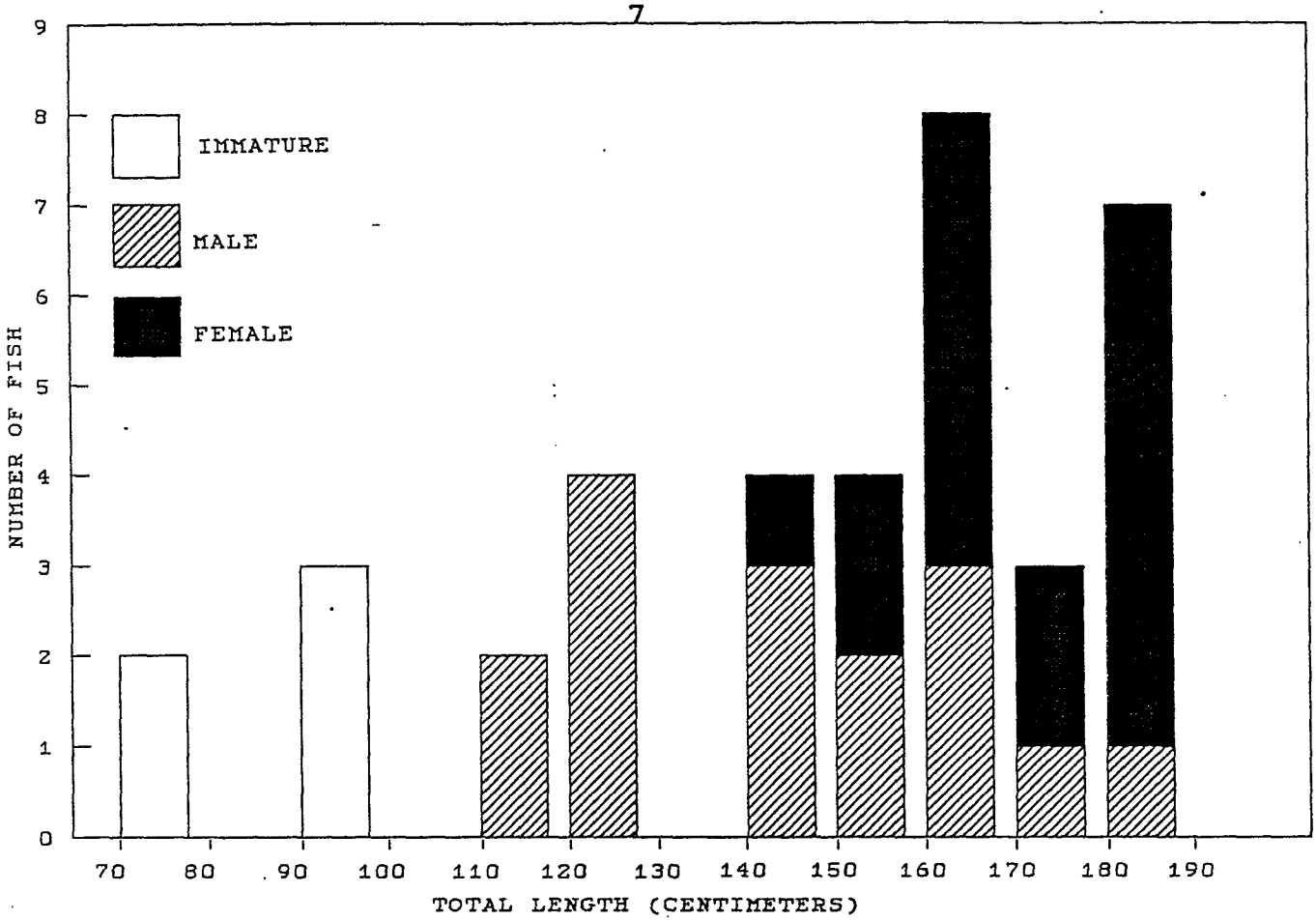

Figure 2. Sex stratified length frequency of sturgeon captured in the lower Sacramento River in late winter 1990.

of the 37 sturgeon on straight shank hooks.

Temporally, the sturgeon we tagged represented only a portion of the spawners. According to records available from a bait shop in Freeport (rkm 65), the first angler-caught sturgeon of the 1989-1990 run was brought in for weighing on October 29, 1989 and the last on April 29, 1990 (Figure 3). More than one-half of the sturgeon recorded by the bait shop were taken before we started fishing on January 29.

Short term flow events may have stimulated upstream movement of sturgeon during this low outflow water year. We captured most of our fish during two periods when flows were approximately 500

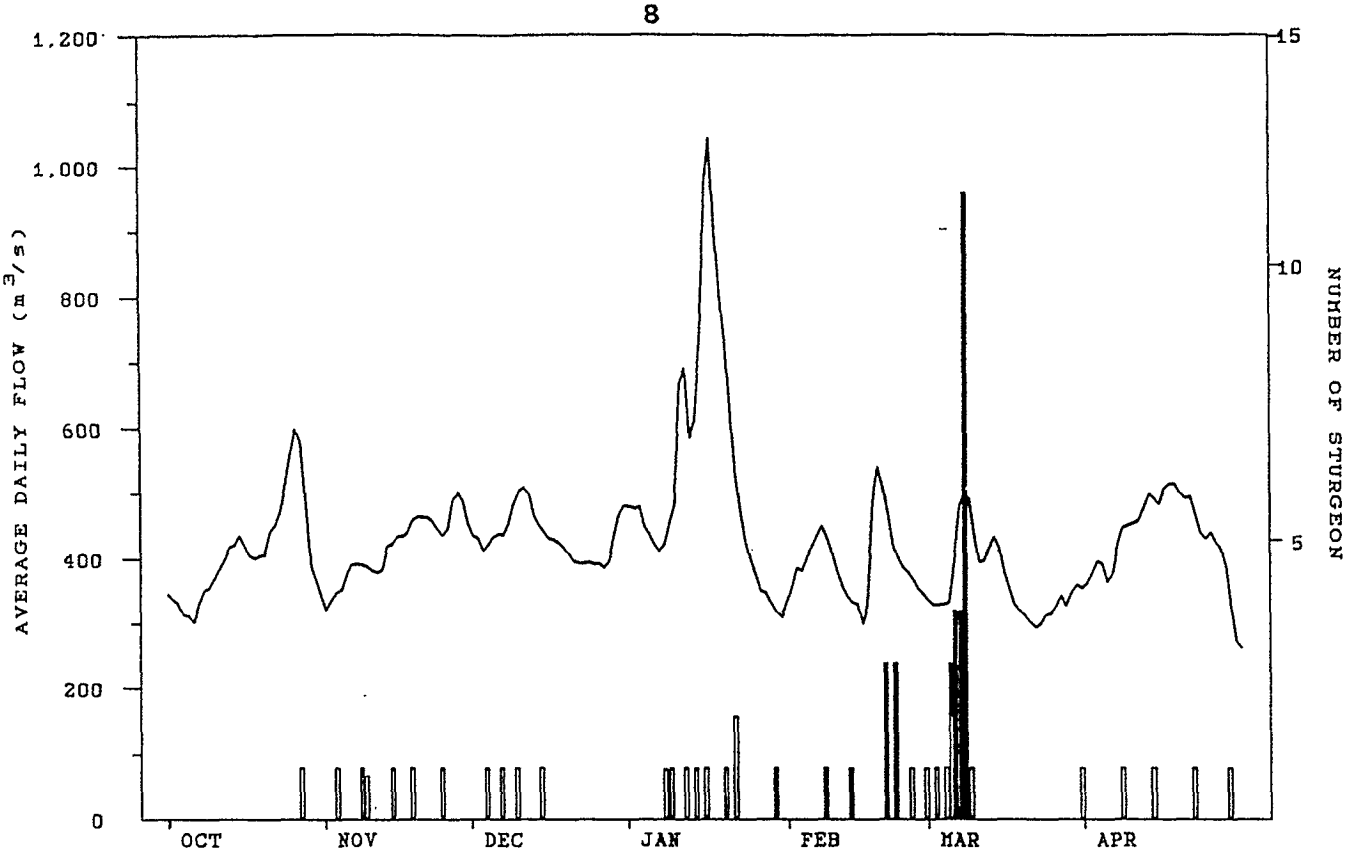

Figure 3. Temporal distribution of sturgeon catch by setlines (solid bars) and anglers (open bars) in the lower Sacramento River. Average daily Sacramento River flow at Freeport is shown for comparison.

m^3/sec and there was some clustering of angler catches during other high flow periods (Figure 3).

The electronic equipment worked well. During ground searches, we could usually detect a tag within a range of 300-500 m. Once detected, a fish could be located with an accuracy of about 100-200 m along the river axis by signal strength. While not routinely used, the handheld loop antenna could locate a tag within 5-10 degrees of arc. This degree of accuracy locates a fish within a error polygon of about 15 m per side when the antenna is used from the banks of the Sacramento River.

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We had no evidence of tag failure. One tag was either shed by a fish or returned to the water after being removed by an angler. One tag from a small male (117cm TL) was returned by the angler who caught the fish.

Fish behavior after tagging fell into three general classes: 1) resumption of upstream movement after remaining near or slightly downstream of the tagging location for several days, 2) downstream movement to the Rio Vista area followed by movement upstream, or 3) a cessation of the spawning migration and return to the estuary.

A 175-cm female (Figure 4) and a 144-cm male (Figure 5) demonstrate the extremes of the first behavior. The female, tagged on February 14, drifted about 8 km downstream in the first 4 days after tagging, then began a sluggish upstream movement of about 25 km in 7 days. This fish remained within a few kilometers of this location for another week before strongly resuming upstream migration 18 days after tagging. The other extreme is the 144-cm male which, probably hesitating less than a day after tagging, moved upstream 33 km in the 2 days following tagging. More typical delays of 3 and 5 days are demonstrated by the 182-cm female and the 129-cm male in Figures 4 and 5. Two females and eight males exhibited this type of movement.

The second behavior class is exemplified by a 185-cm female tagged on February 23 which drifted steadily downstream, reaching Rio Vista 11 days after tagging. It then resumed upstream movement, passing the original release site 20 days after

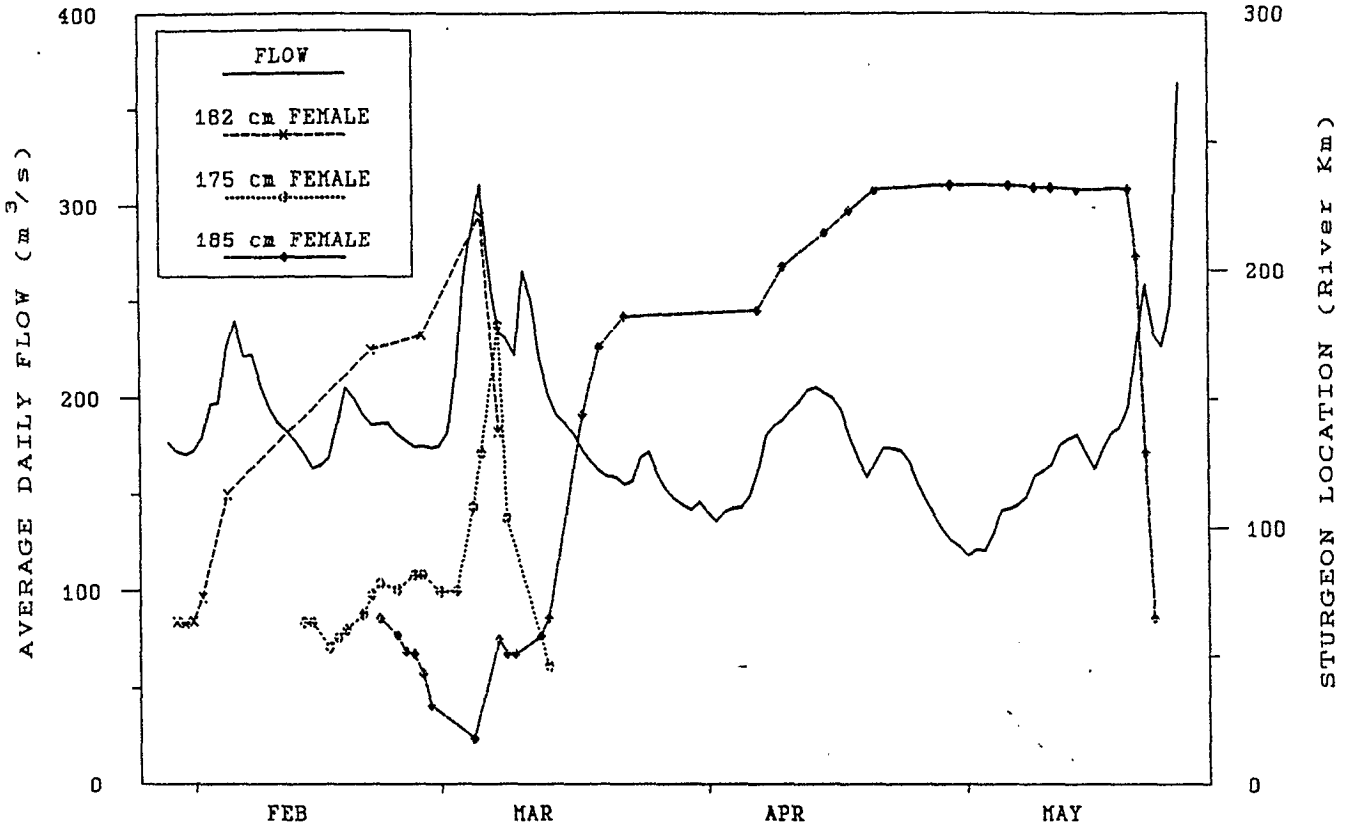

Figure 4. Comparison of movements in the Sacramento River of three female white sturgeon with average river daily flow at Wilkins Slough (river km 190).

tagging. From this point on, its upstream movement was swift, moving 80 km in 4 days. One other female also moved downstream to Rio Vista before resuming upstream migration.

Seventeen fish (11 females, 6 males) moved downstream after tagging with no subsequent reentry back into the tagging area. Of these fish, five left the lower river so rapidly that after 2 days they were never located again. The most likely cause of this apparent termination of spawning migration is tagging stress.

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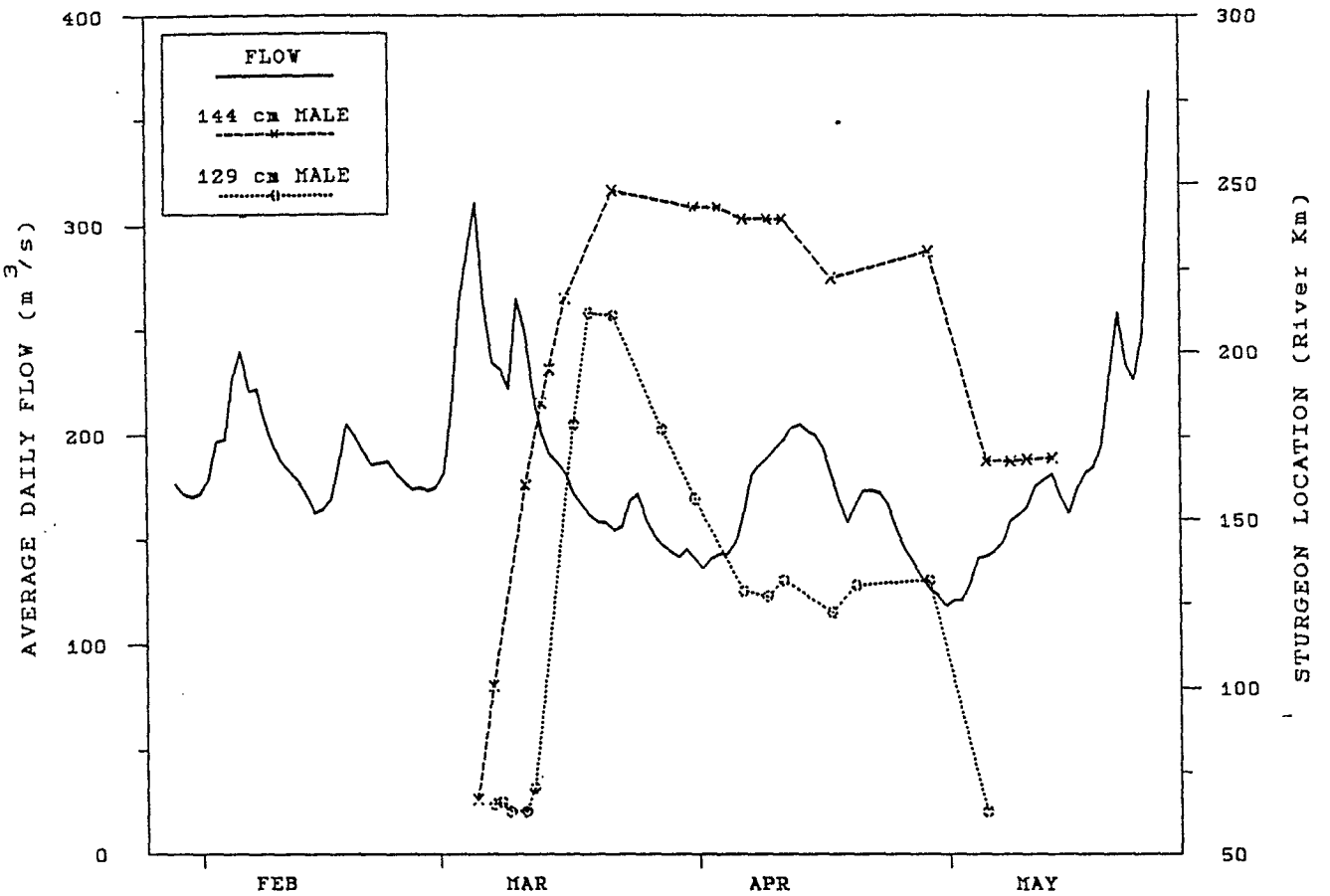

Figure 5. Comparison of movements in the Sacramento River of two male white sturgeon with average daily river flow at Wilkins Slough (river km 190).

The 95-cm immature fish also showed no evidence of pursuing a spawning migration. It remained within 10 km of the tagging site for 6 weeks and was found near Rio Vista during the last aerial survey on June 11.

Four females exhibited behavior suggestive of spawning. Two of these fish, after moving steadily upstream, apparently spawned, one near Colusa (rkm 235) about March 8 and one near Tisdale Weir (rkm 190) about March 9. They subsequently moved rapidly downstream. Another female moved deliberately upstream, then paused for about 15 days in late March when flows slowly

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decreased (185 cm TL female, Figure 4). It resumed moving upstream on slightly increased flows in early April and reached Colusa (rkm 233) on April 23. It remained in that area until probably spawning on May 23 or 24 before beginning a rapid downstream movement which brought it past Courtland (rkm 55) on the morning of May 26.

A fourth female (157 cm TL), lost for several weeks, was discovered near Tisdale Weir on May 2. This fish was found leaving the system on May 9 and presumably spawned on May 7 or 8 somewhere above Tisdale Weir. Based on these limited observations, it appears that female white sturgeon respond to flow on their spawning migration. The most active upstream migrations and spawning seemed to occur on rising or peak flows.

Male white sturgeon moved steadily upstream, but tended to drift more slowly downstream than females. Two fish, 124 cm and 144 cm, exemplify this behavior (Figure 5). The smaller of these fish moved upstream 142 km between March 14 and 21 and then gradually drifted downstream to the vicinity of Verona (rkm 130). From April 9 through May 2, this fish remained within 6 km of Verona and on two occasions was found in the Feather River 3-5 km upstream of its confluence with the Sacramento River. A week later, this fish moved below Sacramento and was downstream of Rio Vista by May 12.

The second male (144 cm TL) likewise moved strongly upstream after tagging, traveling 156 km in 12 days. It remained within 10 km of Colusa for about 5 weeks before descending about 65 km

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downstream to near Kirksville (rkm 167,) where it remained for at least 1 week. Between May 17 and 24, the tag stopped moving, suggesting that it was probably shed.

Spawning times of male sturgeon are not as easily inferred from their movements as for females. It is possible that they spawned at the apex of their upstream movement, like females, but moved more leisurely downstream. They also may have spawned repeatedly during the time they were in the river.

VI. RECOMMENDATIONS: Although we did not observe any fish actually spawning, we have demonstrated the value of radiotagging for determining sturgeon movements and general spawning location. Radiotagging should be continued for 2 more years to better define spawning areas and to observe sturgeon movements under higher flow conditions. Lamprey is the most successful bait and setlining and radiotagging should only be attempted when there is an adequate supply of lamprey for bait. If adequate bait is not available, we recommend deployment of artificial substrate modules to attempt to collect sturgeon eggs in areas tentatively identified as spawning areas. Evaluation of environmental conditions where eggs are collected may allow definition of preferred spawning habitat.

We should monitor radio frequencies of fish tagged this year again during the spring of 1991 for evidence of repeat spawning or to detect fish which apparently moved out of the river without spawning during 1990 and which may try again during 1991. Such

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monitoring could provide additional information on sturgeon movements and spawning locations.

VII. PREPARED BY: Raymond G. Schaffter, Fishery Biologist

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REFERENCES

Kohlhorst, D.W. 1976. Sturgeon spawning in the Sacramento River in 1973, as determined by distribution of larvae. California Fish and Game 62:32-40.