# Effects of Mitigative Measures on Productivity of White Sturgeon Populations in the Columbia River Downstream from McNary Dam, and Status and Habitat Requirements of White Sturgeon Populations in the Columbia and Snake Rivers Upstream from McNary Dam

## Annual Report April 1993 – March 1994


U.S. Department of Energy
Bonneville Power Administration
Division of Fish & Wildlife

Oregon Department of Fish and Wildlife

Washington Department of Fish and Wildlife

National Biological Service

National Marine Fisheries Service

U.S. Fish and Wildlife Service

Columbia River Inter-Tribal Fish Commission


May 1995

# EFFECTS OF MITIGATIVE MEASURES ON PRODUCTIVITY OF WHITE STURGEON POPULATIONS IN THE COLUMBIA RIVER DOWNSTREAM FROM MCNARY DAM, AND STATUS AND HABITAT REQUIREMENTS OF WHITE STURGEON POPULATIONS IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM MCNARY DAM

ANNUAL PROGRESS REPORT

APRIL 1993-MARCH 1994

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## CONTENTS

## EXECUTIVE SUMMARY

We report on progress from April 1993 through March 1994 of research on white sturgeon in the lower Columbia River.

The study began in July 1986 and is a cooperative effort of federal, state, and tribal fisheries entities to determine (1) the status and habitat requirements, and (2) effects of mitigative measures on productivity, of white sturgeon populations in the lower Columbia River.

Work conducted through 1992 (Phase I) examined the status and habitat requirements of white sturgeon populations downstream from McNary Dam. Phase II began in 1993 to examine the effects of mitigative measures recommended in Phase I. The status and habitat requirements of white sturgeon populations upstream from McNary Dam (between McNary and Priest Rapids dams on the mainstem Columbia River and in the lower Snake River) are also being examined in Phase II.

This report describes activities conducted during the second year of Phase II. Information was collected, analyzed, and evaluated on subadult and adult life histories, population dynamics, quantity and quality of habitat, and production enhancement strategies. An abstract is provided at the beginning of Sections A through F that summarizes the results of work performed by each of the cooperators.

REPORT A

1. Description of the life history and population dynamics of subadult and adult white sturgeon in the Columbia River between McNary, Priest Rapids, and Ice Harbor dams.

2. Assessment of quantity and quality of habitat available for use by subadult and adult white sturgeon downstream from McNary Dam.

3. Evaluation of growth, mortality, and contributions to fisheries of juvenile white sturgeon transplanted from areas between the estuary and The Dalles Dam to areas in The Dalles and John Day reservoirs.

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## CONTENTS

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## ABSTRACT

We report on work performed from April 1993 to March 1994 to determine the life history and population dynamics of white sturgeon *Acipenser transmontanus* in the Columbia and Snake rivers between McNary, Priest Rapids, and Ice Harbor dams. We set 192 set lines and caught 169 white sturgeon. We applied tags to 156 of these fish. Catch rates among reservoir sections were similar but may not accurately represent white sturgeon distribution because our gear appeared to retain white sturgeon less effectively in high water velocities encountered in free-flowing areas. Recapture rates of white sturgeon were low because each section of the reach was sampled for only three consecutive days. Mean relative weight was higher than values reported for white sturgeon populations in reservoirs downstream from McNary Dam. We did not observe dimorphism in snout/head length ratio previously reported by other researchers.

## INTRODUCTION

In 1986, the Bonneville Power Administration (BPA) funded a 6-year study of white sturgeon *Acipenser transmontanus* in the Columbia River below McNary Dam. The study addressed objectives of a research program implementation plan developed in response to measure 903(e)(1) of the Columbia River Basin Fish and Wildlife Program (Northwest Power Planning Council 1987). Phase I of this research was completed in 1992. In 1993, BPA extended funding for continued white sturgeon research in this study area and above McNary Dam. In this report we describe our activities and results from April 1993 through March 1994, summarizing progress toward study objectives and intermediate results that we will use to estimate the productivity of white sturgeon between McNary, Ice Harbor, and Priest Rapids dams (we refer to this area as the McNary Reach). Sampling in 1993 was designed to reconnoiter the McNary Reach, tag fish for future estimates of exploitation, and begin to collect individual growth data.

## METHODS

We sampled white sturgeon in the McNary Reach in June and July 1993 to estimate population statistics. We divided the reach into eight, approximately 22.5-km sections (Figure 1). We did not sample within boat-restricted zones (BRZ's) immediately below Ice Harbor Dam on the Snake River and Priest Rapids Dam on the Columbia River due to high water velocities and shallow depths.

Setlines were used exclusively for sampling because they provide the greatest catch rate and are less size selective than other gears (Elliott and Beamesderfer 1990). We set 192 setlines and fished them overnight for 14.0 to 28.8 hours (average 22.1 hours, Table 1). We used 12/0, 14/0, and 16/0 hooks baited with pieces of Pacific lamprey *Lampetra tridentata*. Each line had 40 hooks.

We measured fork length (cm) and weight (0.1 kg) of each white sturgeon captured and we looked for tags, tag scars, fin marks, and scute marks. All white sturgeon longer than 64 cm were tagged with one spaghetti tag placed at the base of the anterior end of the dorsal fin. Those longer than 79 cm were tagged with two additional tags: a Carlin tag and a molded nylon tipped dart tag. The Carlin tag was placed at the base of the posterior end of the dorsal fin. The dart tag was similar to the tag described in Gutherz et al. (1990) and was placed near the anterior origin of the dorsal fin and about 2.5 cm beneath the fin insertion. We removed the fifth right lateral scute as a secondary mark to identify year of capture if all tags were shed or lost. A pectoral fin-ray section was collected from each white sturgeon to determine age.

We injected 57 white sturgeon ($<$80 cm or $>$155 cm) with oxytetracycline (OTC) to validate our age interpretations from fin-ray sections using fish we recapture in future years. We injected 100 mg/ml OTC into the red muscle under the dorsal scutes immediately posterior to the head. Each fish received about 25 mg OTC/kg of body weight (McFarlane and Beamish 1987; Rien and Beamesderfer 1994). We removed the second right lateral scute from OTC injected fish to identify injected white sturgeon at recapture. We did not collect fin-ray samples from any fish previously injected with OTC.

We surgically examined the gonads of every white sturgeon longer than 155 cm to determine sex and stage of maturity following procedures outlined in Beamesderfer

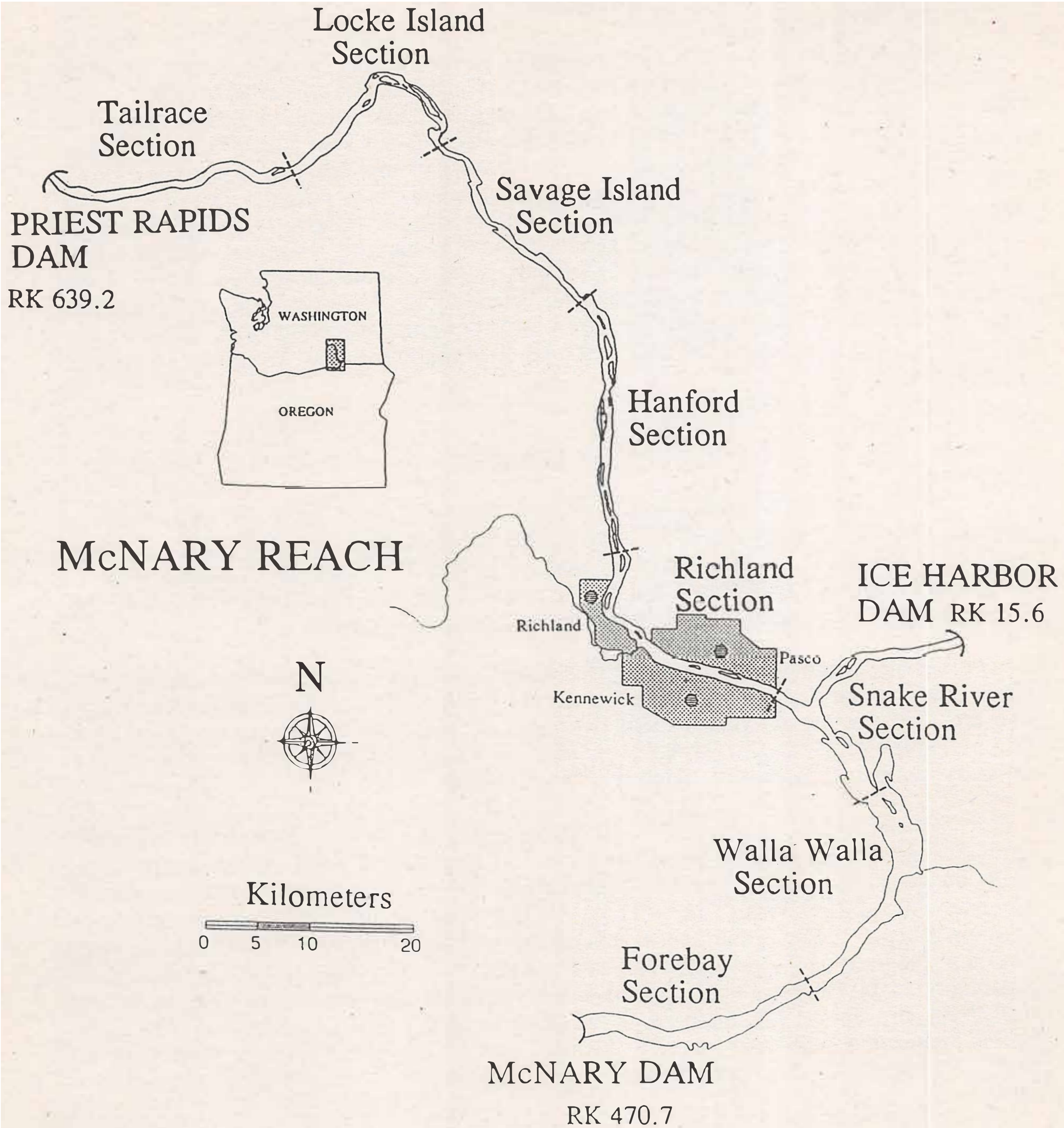


Figure 1. Columbia and Snake rivers between McNary, Priest Rapids and Ice Harbor dams (McNary Reach). Sampling area boundaries are indicated by dashed lines

et al. (1989). We made a 1-2 cm incision through the ventral body wall near the midline and anterior to the vent. We utilized an arthroscope and a modified 300-watt halogen light source to locate the gonad and facilitate sex determination. A small sample ($<1$ g) of the gonad was removed from females using biopsy forceps. We preserved the samples in formalin. Incisions were closed with sutures and sealed with a surgical adhesive.

Distribution of white sturgeon was examined by comparing setline catch rates among sampling sections. Catch rates of setlines were compared among 5 m depth intervals to identify preferences. Statistical differences ($P<0.05$) in catch rates were evaluated on transformed catch per set data [$\log_e$(catch+1)] with programs of the Statistical Analysis System (SAS 1988a). Comparisons between sample means were made using analysis of variance (ANOVA) and Tukey's studentized range test.

Ages of white sturgeon were estimated from thin cross sections of pectoral fin rays following procedures outlined in Beamesderfer et al. (1989). Each fin-ray section was aged twice each by two experienced readers, and up to 20 fish for each 20 cm interval were aged. An age-length frequency distribution was developed from these readings.

Paired samples of fork length and weight were used to calculate a regression. Relative weights ($W_r$) were used to estimate the condition of white sturgeon captured (Beamesderfer 1993), and we compared $W_r$ between impounded and free-flowing areas using ANOVA.

We examined snout dimorphism by calculating the ratio of head to snout length from white sturgeon. Crass and Gray (1982) speculated that snout shape dimorphism in the McNary Reach may be evidence of divergence since white sturgeon were isolated by impoundment. Head length was measured with calipers as the linear distance from the dorsal insertion of the opercle to the anterior tip of the snout. Snout length was measured with calipers as the linear distance from the anterior orbit of the eye to the anterior tip of the snout (Scott and Crossman 1973). All measurements were recorded to the nearest mm. Linear regressions were calculated for paired samples of head and snout lengths, and fork length and head/snout length ratios. We assessed the normality of head/snout length ratio distribution with a Shapiro-Wilk statistic (W). A W value near 1 indicates samples from a normal distribution, while multi-modal distributions expected for polymorphic characteristics would have W values near 0 (Zar 1984; SAS 1988a). We compared head/snout ratios between impounded and free-flowing areas using ANOVA.

## RESULTS

### Catch

We caught 169 white sturgeon (49-232 cm) in the McNary Reach (0.88 fish per setline set, Table 1, Figure 2A). The catch consisted of 62% sublegal ($<110$ cm), 19% legal (110-151 cm), and 19% over-sized ($>151$ cm) white sturgeon. Mean fork length of white sturgeon caught in the Forebay was significantly greater than in any other reservoir section (Figure 3).

TABLE 1. Summary of sampling dates, number of setline sets, effort (hours), catch, catch per set, and tagging of white sturgeon in the McNary Reach, June through July 1993.

| Location | Section | Dates | Sets | Hours | Catch | Catch/Set | Fish Tagged |
|---|---|---|---|---|---|---|---|
| Forebay | 1 | 06/07-06/10 | 24 | 506.4 | 15 | 0.63 | 15 |
| Walla Walla | 2 | 06/10-06/13 | 24 | 528.0 | 24 | 1.00 | 23 |
| Snake River | 3 | 07/10-07/13 | 24 | 525.6 | 27 | 1.12 | 27 |
| Richland | 4 | 07/07-07/10 | 24 | 566.4 | 30 | 1.25 | 25 |
| Hanford | 5 | 06/21-06/24 | 25 | 520.0 | 22 | 0.88 | 22 |
| Savage Isl. | 6 | 06/24-06/27 | 25 | 547.5 | 20 | 0.80 | 19 |
| Locke Isl. | 7 | 07/21-07/24 | 19 | 448.4 | 12 | 0.63 | 12 |
| Tailrace | 8 | 07/24-07/27 | 27 | 591.3 | 19 | 0.70 | 13 |
| Total | | | 192 | 4,233.6 | 169 | 0.88 | 156 |

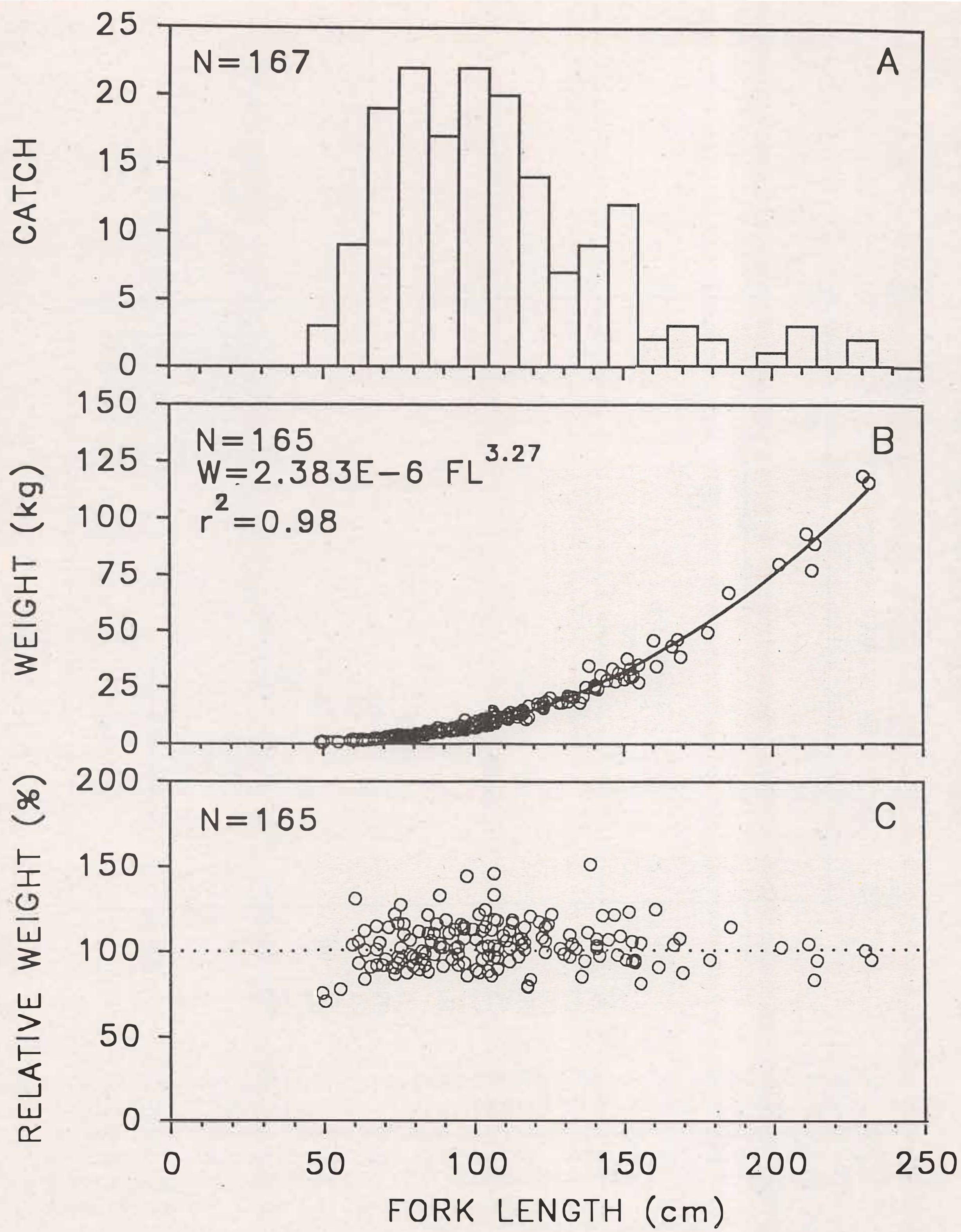


Figure 2. Frequency of catch (A), length-weight relationship (B), and relative weight (C) by fork length of white sturgeon collected in the McNary Reach, 1993.

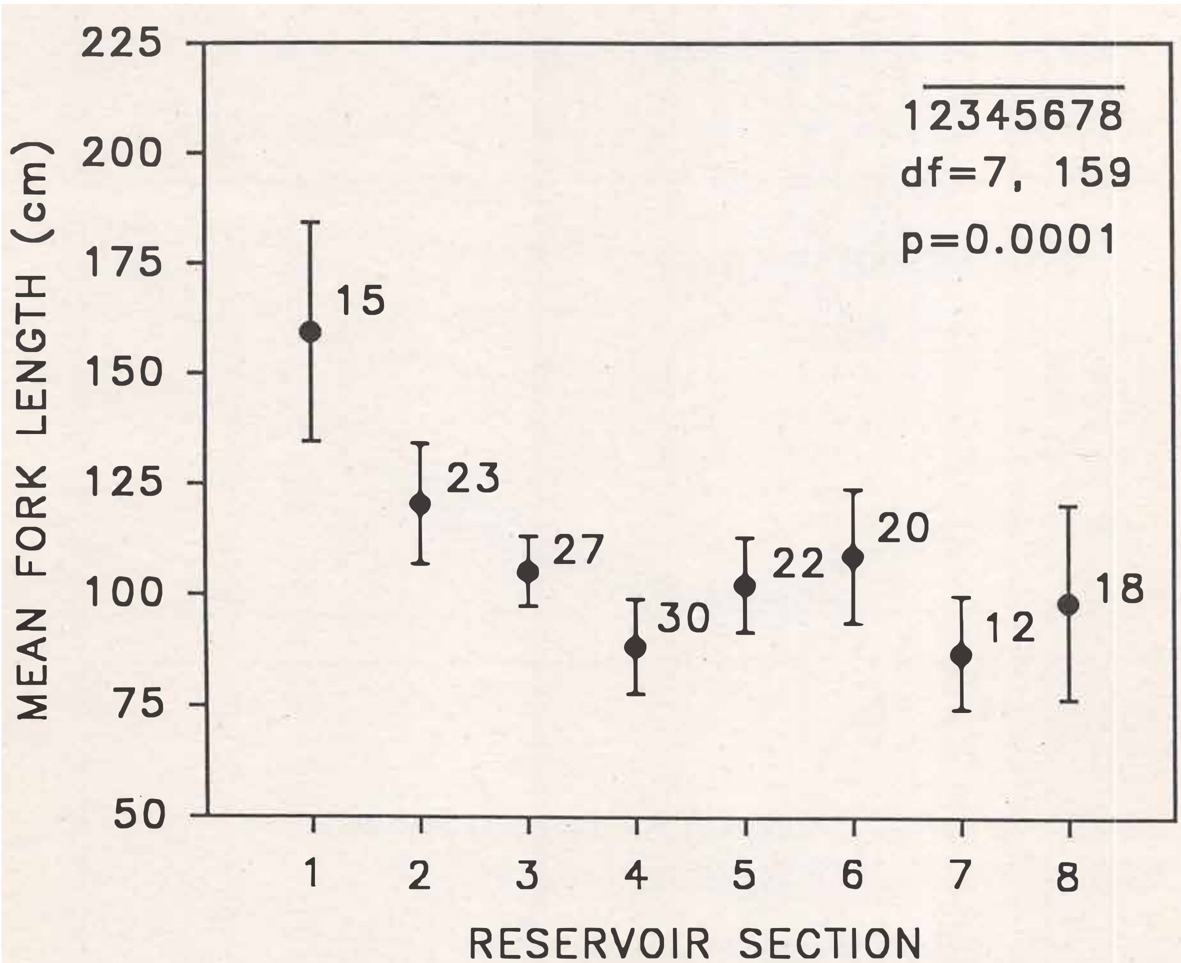


Figure 3. Mean fork length of white sturgeon by sampling section, McNary Reach, 1993. Sample size and 95% confidence limits for each section are indicated. The one-way analysis of variance (ANOVA) comparison results are indicated; degrees of freedom (df1, df2), and observed probability level (p). Sections, indicated by numbers in the upper left corner, have significantly different means if they are not 'covered' by the same line. Sections are: 1=Forebay, 2=Walla Walla, 3=Snake River, 4=Richland, 5=Hanford, 6=Savage Island, 7=Locke Island, 8=Priest Rapids Tailrace.

## Marking and Mark Recovery

We tagged 156 white sturgeon larger than 64 cm in the McNary Reach in 1993 (Table 1). We only recaptured one fish, which occurred at the same location and one day after initial capture. Recaptures of tagged white sturgeon were unlikely because we only sampled one three-day period in each section of the sampling area. Washington Department of Fish and Wildlife personnel recovered one tagged fish while sampling recreational fisheries. Sport anglers voluntarily reported three tagged fish they harvested. All recaptures occurred downstream of the initial tagging location. Distance moved ranged from 4.0 to 34.0 km (average 18.8 km). Fish were at-large 40-162 days (average 98 days). Of the four recaptures, two were recovered in John Day Reservoir.

## Distribution and Movement

We captured white sturgeon throughout the McNary Reach. Catch rates were not significantly different between sampling sections ($df=7$, $F=0.65$, $r^2=0.024$, $P=0.717$). Catch rates here highest in the Richland section and gradually decreased downstream. Catch rates among the four upstream sections were similar to one another, but averaged less than downstream sections. Mean catch rate at different depths ranged from 0.35/set at 20-25 m to 2.12/set at 25-30 m. While there were significant differences in catch rate among depth intervals ($df=5$, $F=4.20$, $r^2=0.102$, $P \leq 0.001$), there was no apparent trend.

## Age, Growth, and Morphometry

Ages assigned to 132 white sturgeon ranged from 6-63 years (Table 2).

Paired samples of fork length and weight were sufficient to calculate a regression equation with high degrees of confidence (Figure 2B). Mean $W_r$ for the McNary Reach was 103.3 (Figure 2C). Mean $W_r$ of white sturgeon captured in impounded sections of the McNary Reach was significantly greater than for white sturgeon captured in free-flowing areas ($df=1, 163$; $F=9.07$; $r^2=0.053$; $P=0.003$).

Head to snout length ratios were calculated for 165 white sturgeon. Snout length had a strong positive correlation with head length (Figure 4A). Two-way ANOVA (Type III sum of squares) showed that head/snout length ratio did not vary significantly between free-flowing and impounded reservoir areas ($df=1, 164$; $F=0.99$; $P=0.32$). However there was a significant, though weak, correlation of head/snout ratio to fork length ($df=1$; $F=15.24$; $P \leq 0.001$; Figure 4B). We estimated $W=0.93$ ($P<0.001$) for head/snout ratios, indicating the samples came from a normal distribution (Figure 4C).

## Reproduction

We surgically examined 15 white sturgeon (>155 cm), 9 of these were male, 5 were female, and 1 was undetermined. We collected four gonad tissue samples from the females. One sample, collected from a 151 cm fish at river kilometer (RK) 476 on June 9, was staged as late vitellogenic; this fish would be expected to spawn in 1993. The other three ovary samples were classified as pre-vitellogenic and those fish would not be expected to spawn in 1993.

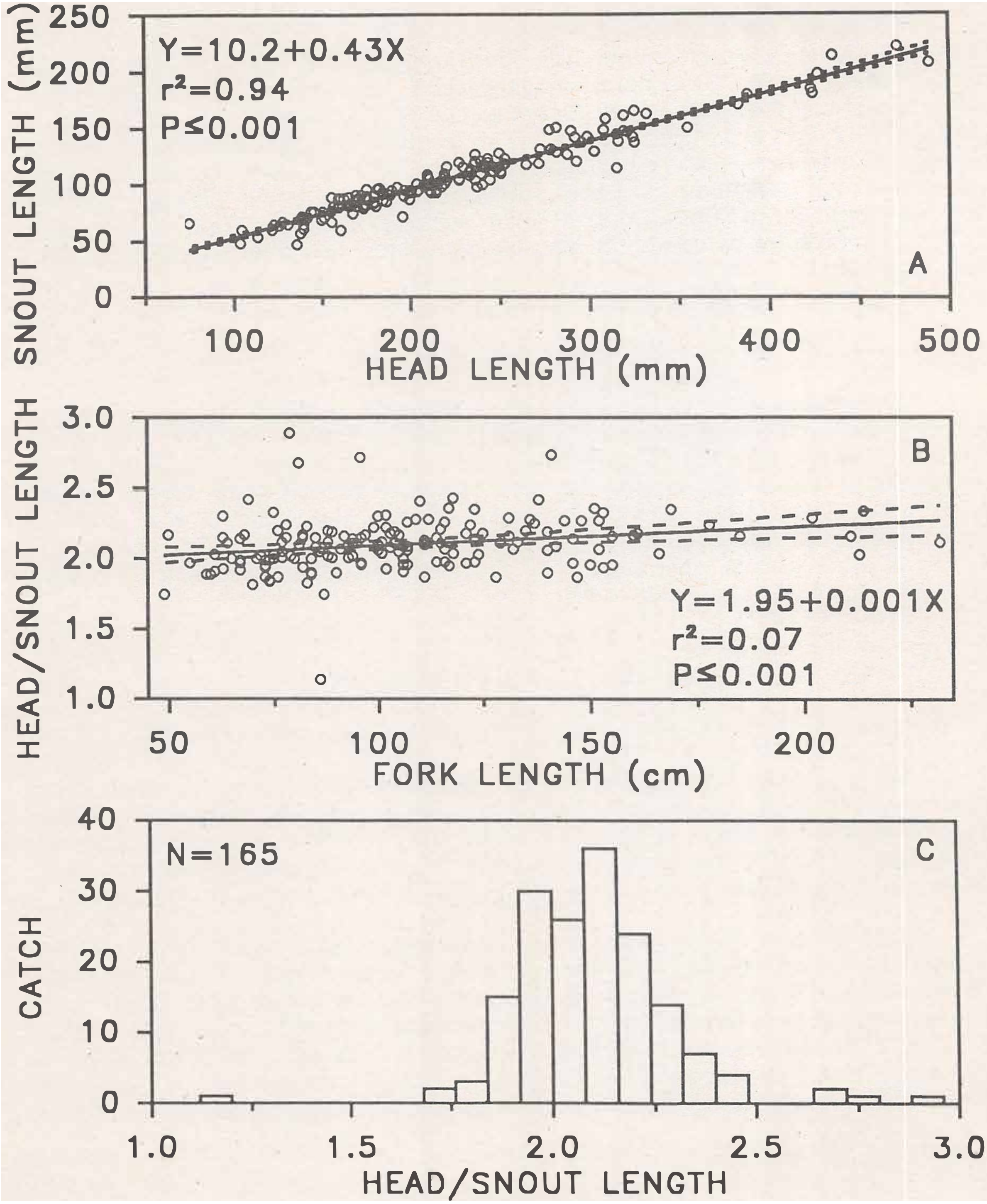


Figure 4. Head and snout length comparisons for white sturgeon from the McNary Reach of the Columbia River. Head length versus snout length (A), head/snout length ratio versus fork length (B), and frequency distribution of head/snout length ratio in the catch (C).

## DISCUSSION

Our sampling effort in the McNary Reach was sufficient to explore and select potential sampling sites, note hazardous areas for navigation, become familiar with access points, and identify potential limitations of our sampling gear. Conditions encountered in the McNary Reach were more dynamic than we have experienced in reservoirs below McNary Dam. Shallow water depths, fluctuations in water level and velocity, uneven bottom terrain, increased difficulty of navigation, and lack of improved launching sites complicated field sampling. Our sampling effort was low but adequate to estimate catch rates and size composition within sections of the sampling area. The comparability of catch per unit effort estimates may be constrained because of reduced efficiency of our setline gear in high water velocities encountered in the relatively shallow, free-flowing sections of the Columbia and Snake rivers above McNary Dam. Estimates of abundance must therefore rely on mark-recapture statistics.

Sampling in 1993 provided too few samples to confidently describe movement, abundance, growth rate, length-maturity, or length-fecundity relationships. A more intensive sampling effort will provide us with data necessary to estimate these parameters. In the future we see no need for reconnaissance sampling unless working in areas where physical conditions are drastically different from those already encountered.

Although white sturgeon were found throughout the McNary Reach, we suspect our setline gear did not operate with the same efficiency in all sections. High water velocities tangled and displaced setlines, and probably decreased the number of fish retained by our gear compared to reservoirs between Bonneville and McNary dams and low velocity areas of McNary Pool. White sturgeon catch rates in reservoirs below McNary Dam generally increase with proximity to the upstream dam. This pattern of increasing catch rate upstream occurred within impounded river sections above McNary Dam (RK 470.7-527.7), but catch rates decreased upstream from this area where free-flowing conditions exist. We will experiment with setline design and site selection during future research in an attempt to sample all sections of the McNary Reach in a more representative manner. Minor modifications in gangion material and length, and anchor design may reduce suspected bias resulting from increased water velocities.

We were unable to sample in the BRZs below Priest Rapids and Ice Harbor dams. Previous sampling in reservoirs downstream from McNary Dam indicates these unique sites typically support high concentrations of white sturgeon. We may attempt to sample these sites during future research, but conditions could prevent us from ever effectively sampling white sturgeon in these areas. We will attempt to use gill nets in future sampling of the McNary Reach to increase the number of small (<100 cm) white sturgeon we sample and provide corroborating recruitment data.

Our preliminary appraisal of molded nylon dart tags for marking white sturgeon is favorable. This tag is easily applied and has a clear vinyl sheath which protects the tag numbers from abrasion. Gutherz et al. (1990) reported tissue adherence and encapsulation of the dart tag head in red drum *Sciaenops ocellatus*, and noted that the tag entrance site healed. Spaghetti tags in white sturgeon frequently leave an open sore on fish at large one or more years (Rien et al. in press). We will use the molded nylon dart tag on white sturgeon during 1994 mark-recapture studies and estimate retention over time.

Mean $W_r$ in the McNary Reach (103) was less than reported for the Columbia River below Bonneville Dam (117) but greater than Bonneville (99), The Dalles (96), and John Day (100) reservoirs (Beamesderfer 1993). Our sample size was small, but the apparent improved condition of white sturgeon in this area may be related to the diversity of habitat types available in the McNary Reach. Further sampling in the area will allow us to substantiate $W_r$ estimates.

We did not find evidence of dimorphism in snout type for white sturgeon collected between McNary and Priest Rapids dams, unlike Crass and Gray (1982). Results of the original investigation in the McNary Reach indicated two snout shapes (long and short) and the researchers speculated this may be evidence of divergent evolution in the period since impoundment. However, the original work was based primarily on subjective assessment of snout shape and relatively few samples (10) were actually measured. Our results indicate that instead of two distinct phenotypes, differences in snout shape represent extremes of a normal distribution. We believe divergent evolution in the period since impoundment is unlikely, and that if phenotypic and genotypic variation exist among impoundments they are the result of isolating unique components of a freely interchanging population at the time of impoundment. While dams have created significant barriers to white sturgeon migration, we have aged individual fish older than the impoundments (Rien and Beamesderfer 1994), and we have documented downstream movement past dams (North et al. 1993). A relatively few migrants between impoundments can effectively counteract genetic drift (Allendorf and Phelps 1981). We will continue collecting morphology data from white sturgeon in other areas to determine if morphological differences exist among white sturgeon populations in the Columbia River system.

## Plans for 1994

In October 1993 we worked cooperatively with National Biological Survey and National Marine Fisheries Service to estimate potential sustained catch rates of juvenile sturgeon by trawling and marking fish at a known high catch site below Bonneville Dam. These data, along with experience gained in transporting and holding the fish, will be used to develop a proposal to evaluate the feasibility of capturing wild juvenile in areas where recruitment is high and transporting them to areas where recruitment is limiting productivity.

During the 1994 spring and summer field season we will conduct field sampling in Bonneville and The Dalles reservoirs to update stock assessments. Available information is outdated because of dynamic changes in the fisheries during the last 10-15 years. This sampling will provide current abundance estimates of harvestable-sized fish that will be used with target exploitation rates to calculate annual harvest guidelines.

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## APPENDIX A-1

### Feasibility of using radio telemetry to quantify habitat use by subadult and adult white sturgeon in Columbia River reservoirs

## INTRODUCTION

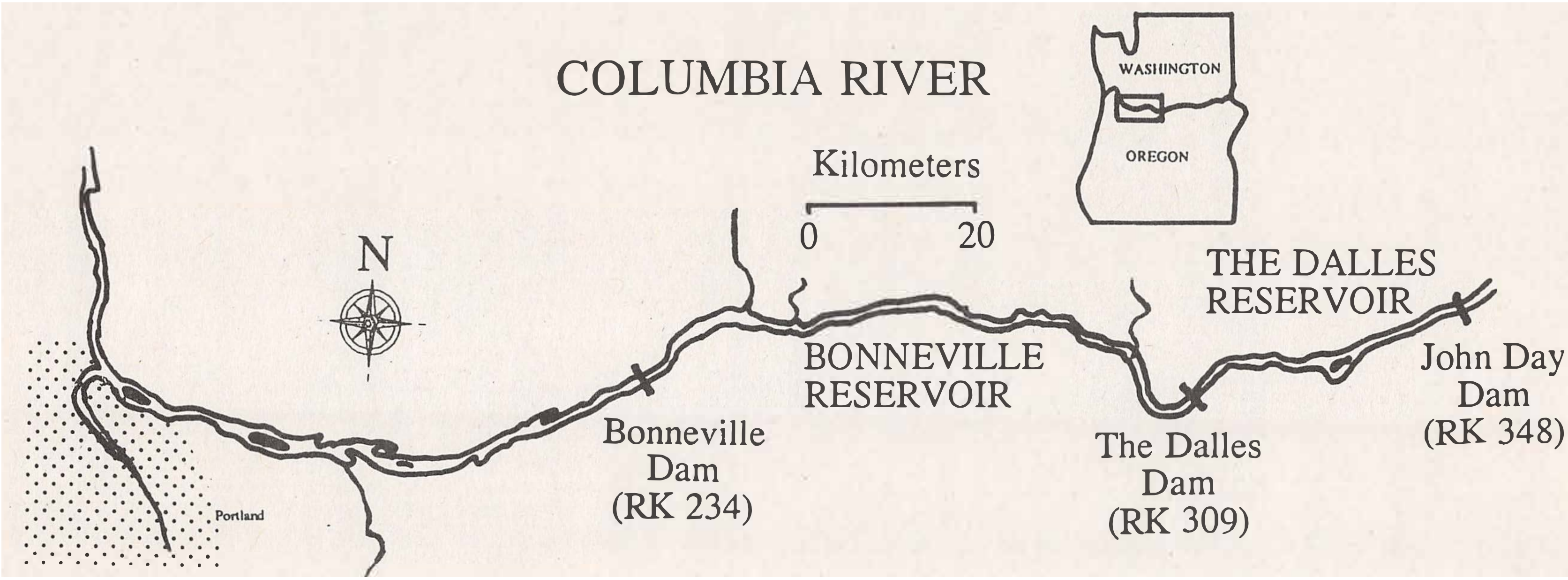
Habitat requirements of subadult and adult white sturgeon (*Acipenser transmontanus*) are poorly understood (Beamesderfer and Nigro 1993). Site specific observations of white sturgeon habitat use would allow availability and use of specific habitat types to be quantified under an array of hydropower system discharge levels and provide a relative index of carrying capacity for impounded and unimpounded areas. Parsley et al. (1993) used water temperature, depth, substrate type, mean water column velocity, and near substrate velocity at sites where eggs, larvae, young-of-the-year, and juveniles (age 1-7) were collected to describe habitat use of spawning and rearing white sturgeon. Several mark-recapture studies of white sturgeon (*Acipenser transmontanus*) have described broad-scale distribution and movement in the Columbia River below McNary Dam (Bajkov 1949, 1951; DeVore and Grimes 1993; North et al. 1993). Anders et al. (1993) evaluated the feasibility of radio telemetry for documenting fish movement and habitat use, but did not place transmitters on white sturgeon. Diel and seasonal movements of white sturgeon have been investigated in the free-flowing reach of the Columbia River above Richland, Washington (Haynes et al. 1978; Haynes and Gray 1981), but proximate measurement of specific parameters to quantify habitat use by subadult and adult white sturgeon has not been attempted. This report summarizes our efforts in 1993 to evaluate radio telemetry as a method for tracking white sturgeon to define habitat use and movement in Columbia River impoundments.

## METHODS

To select a radio-tag type, we compared signal reception of two tags at different depths and distances: a manufacturer's stock tag (6 volts, 180 day battery life, 75 pulses per minute, 49.868 Mhz) and a custom built tag (3 volts, 180 day battery life, >60 pulses per minute, 48.577 Mhz). In February, at river kilometer (RK) 171 in the Columbia River (Figure 1), both tags were placed in a cloth sack suspended by a weighted rope from a float at various depths (1-33 m). We used an Advanced Telemetry Systems "Challenger 200" receiver equipped with a closed-loop directional antenna based on a boat to determine the maximum distance the signals could be detected at each depth. Distances were estimated with a hand-held range finder (±1% at 100 m, ±3% at 300 m).

In August we used a similar technique to compare signal reception for three antenna types (closed-loop directional, Yagi multi-element, and drag style -- 10-m weighted co-axial cable towed behind the boat) using a custom-built tag at RK 192.

During April, we used setlines to capture 20 white sturgeon (fork lengths 87-231 cm) in Bonneville and The Dalles reservoirs (Table 1). Based on tests of signal reception at depth, we radio tagged these fish with custom-built tags (48.104-49.904 Mhz). The tags were made of medical grade inert resin, coated with an inert wax to blunt the edges. Tags weighed about 35 g out of water. Antenna lengths were 43 cm or shorter. On smaller fish the antenna was shortened so that it did not extend beyond




APPENDIX A-1 FIGURE 1. Map of the Columbia River between the Willamette River mouth and John Day Dam (RK = river kilometer).

APPENDIX A-1 TABLE 1. Summary of white sturgeon radio telemetry. Tagging locations and relocations of tagged fish.

| Fish[a] | Tag Placement | Fork Length (cm) | Tag Frequency (Mhz) | Date Tagged/ Relocated | Gear[b] | Area[c] | River Kilometer | Distance Moved[d] (km) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|
| A | External | 231 | 48.354 | 4/21/93 | I | BO | 309.7 | | |
| B | External | 220 | 49.204 | 6/18/93 | H | BB | 193.1 | | |
| | | | | 8/16/93 | F | BB | 167.3 | -25.8[e] | |
| C | External | 205 | 48.504 | 6/02/93 | H | BB | 193.1 | | |
| D | External | 193 | 48.104 | 4/21/93 | I | BO | 309.7 | | |
| | | | | 5/19/93 | B | BO | 307.2 | -2.5 | 43 |
| | | | | 8/13/93 | A | BO | 305.5 | -1.7 | |
| | | | | 8/17/93 | B | BO | 304.4 | -1.1 | 28 |
| E | External | 161 | 48.705 | 4/22/93 | I | TD | 348.3 | | |
| | | | | 6/14/93 | B | TD | 348.3 | 0.0 | 14 |
| F | External | 160 | 48.304 | 4/22/93 | I | TD | 348.3 | | |
| | | | | 5/04/93 | A | TD | 348.0 | -0.3 | |
| | | | | 5/05/93 | B | TD | 348.2 | 0.2 | 11 |
| | | | | 6/01/93 | A | BO | 309.7 | -38.5 | |
| G | External | 158 | 49.905 | 4/21/93 | I | BO | 309.7 | | |
| H | External | 131 | 49.104 | 4/22/93 | I | TD | 348.3 | | |
| | | | | 6/28/93 | R | TD | 345.9 | -2.4[f] | |
| I | External | 126 | 48.204 | 4/22/93 | I | TD | 348.3 | | |
| | | | | 7/26/93 | A | BB | 199.5 | -148.8 | |
| J | External | 107 | 48.805 | 4/21/93 | I | BO | 309.7 | | |
| K | External | 91 | 49.604 | 4/06/93 | I | BO | 261.0 | | |
| L | External | 87 | 49.304 | 4/22/93 | I | TD | 348.3 | | |

(Continued)

[a] Letters correspond to those used in Figure 3.

[b] Gears are: A = airplane radio tracking, B = boat radio tracking, C = shore (car) radio tracking, F = found dead, H = initial capture (wild fish used for private hatchery brood stock), I = initial capture (setlines), R = angler tag recovery.

[c] Areas are: BB = Below Bonneville Dam, BO = Bonneville Reservoir, TD = The Dalles Reservoir, UR = Umpqua River (southern Oregon).

[d] Negative number indicates downstream movement.

[e] Fish found dead. Tag failed, manufacturer couldn't determine why.

[f] Tag turned in by angler. Tag failed, manufacturer said crystal broken.

APPENDIX A-1 TABLE 1 (continued). Summary of white sturgeon radio telemetry. Tagging locations and relocations of tagged fish.

| Fish[a] | Tag Placement | Fork Length (cm) | Tag Frequency (Mhz) | Date Tagged/ Relocated | Gear[b] | Area[c] | River Kilometer | Distance Moved[d] (km) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|
| M | Internal | 199 | 49.503 | 4/21/93 | I | BO | 309.7 | | |
| | | | | 5/27/93 | C | BO | 310.2 | 0.5 | |
| N | Internal | 164 | 48.405 | 4/23/93 | I | TD | 348.3 | | |
| | | | | 5/05/93 | B | TD | 348.2 | -0.1 | |
| O | Internal | 160 | 48.577 | 4/22/93 | I | BO | 309.7 | | |
| | | | | 5/06/93 | B | BO | 309.9 | 0.2 | 19 |
| P | Internal | 155 | 48.904 | 4/23/93 | I | TD | 348.3 | | |
| Q | Internal | 143 | 49.868 | 4/21/93 | I | BO | 309.7 | | |
| | | | | 5/06/93 | B | BO | 309.9 | 0.2 | 30 |
| | | | | 6/16/93 | B | BO | 309.7 | -0.2 | 34 |
| | | | | 8/18/93 | B | BO | 275.5 | -34.2 | 13 |
| | | | | 8/19/93 | B | BO | 275.9 | 0.4 | 5 |
| R | Internal | 138 | 48.152 | 4/22/93 | I | TD | 348.3 | | |
| | | | | 2/05/94 | R | UR | -- | -644. | |
| S | Internal | 108 | 49.403 | 4/08/93 | I | BO | 289.8 | | |
| | | | | 5/04/93 | A | BO | 290.4 | 0.6 | |
| T | Internal | 107 | 49.704 | 4/22/93 | I | TD | 348.3 | | |
| U | Internal | 105 | 49.004 | 4/22/93 | I | TD | 348.3 | | |
| | | | | 5/04/93 | A | TD | 348.2 | -0.1 | |
| | | | | 6/14/93 | B | TD | 348.3 | 0.1 | 14 |
| V | Internal | 87 | 48.254 | 4/08/93 | I | BO | 306.7 | | |

a Letters correspond to those used in Figure 3.

b Gears are: A = airplane radio tracking, B = boat radio tracking, C = shore (car) radio tracking, F = found dead, H = initial capture (wild fish used for private hatchery brood stock), I = initial capture (setlines), R = angler tag recovery.

c Areas are: BB = Below Bonneville Dam, BO = Bonneville Reservoir, TD = The Dalles Reservoir, UR = Umpqua River (southern Oregon).

d Negative number indicates downstream movement.

the caudal peduncle. Because we were unsure how radio tag placement would affect fish behavior and habitat use, we attached half of the tags externally, and surgically implanted half (internal tags). In each reservoir, five fish were radio tagged externally and five fish were tagged internally. In June, we placed external radio tags on two wild white sturgeon (220 and 205 cm) captured below Bonneville Dam and held by private sturgeon hatchery personnel. These fish were captured with gill nets, held in captivity for 6-7 days, surgically spawned, radio tagged, and released.

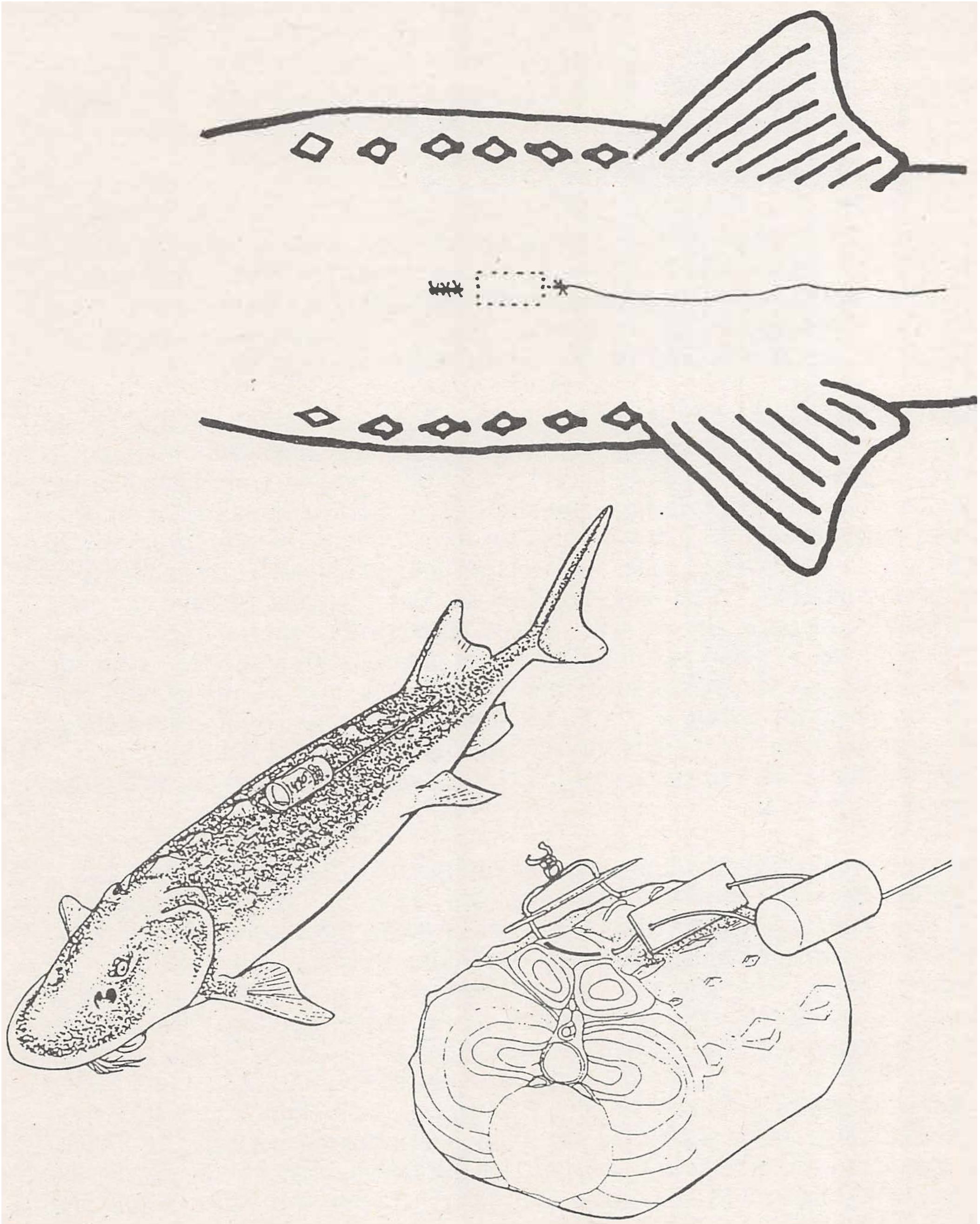
External radio tags were attached to the fish's dorsum at a point posterior to its maximum girth (Figure 2). To attach the tag we modified the technique used by Haynes et al. (1978): two 14 gauge hypodermic needles were inserted through a small neoprene pad, through the tissue 0.5-1.5 cm below the dorsal scutes, out the opposite side, and through a second pad. Two stainless steel wires (diameter 0.006 cm) attached to the tag were then threaded through the needles from the opposite side. The needles were removed and the tag was secured by twisting the wire ends together.

Internal tags were surgically implanted in the abdominal cavity. Using sterile procedures (hands scrubbed in betadyne, instruments and tags immersed in stored in alcohol or chlorhexidine diacetate), we made two incisions about 0.5 cm lateral to the midventral line, anterior to the pelvic fins, and about 8 cm apart. The anterior incision was 3-4 cm long (large enough to insert a radio tag through) and the posterior incision was about 0.5 cm. A sterile vinyl tube was inserted into the small posterior incision and out the anterior incision. The radio-tag antenna was threaded through the tube starting at the anterior incision, the tag was inserted through the anterior incision, and the tubing was removed. The two incisions were closed with a sterile, synthetic absorbable suture material (Polydioxanone) and the antenna was stabilized within a suture loop of the posterior incision. Both incisions were sealed with a formulated cyanoacrylate surgical adhesive. When finished the radio tag laid between the two incisions along the internal ventral surface of the body cavity and the antenna protruded through the ventral body wall.

We relocated radio-tagged white sturgeon with shore, airplane, and boat based receivers. Shore tracking involved stationing the receiver (with a closed-loop directional or Yagi antenna) at high, prominent points along the reservoirs (Table 2). Every two weeks an airplane flight was made over both reservoirs to facilitate later location of fish by boat. The airplane was outfitted with a closed loop directional antenna and was flown at 152-457 m elevation while radio tracking. Boat radio tracking effort was conducted 2 days/week in each reservoir. During May - July the boat receiver was fitted with a drag style antenna or a closed-loop antenna. In July we switched to exclusive use of a Yagi style antenna because we believed the Yagi-style antenna had greater range. Our search pattern while boat tracking consisted of slowly zig-zagging between one shore and mid-reservoir for the first half of a shift, during the second half we would return to the ramp searching between the other shore and mid-reservoir. In addition to our standard search pattern, we specifically and intensively searched for all fish at their last-known location whenever we were scheduled to be in that area. Upon hearing the signal of a radio-tagged fish we identified the location through triangulation and recorded the depth at the site to within 1 m, from a fathometer.

## RESULTS

Comparisons of stock and custom tag types showed the custom built tag was detectable at a greater distance over a range of depths. Comparison of antennas



APPENDIX A-1 FIGURE 2. Location and attachment of external and internal radio tags for white sturgeon. External tag drawing from Haynes et al. (1978).

APPENDIX A-1 TABLE 2. Effort (to the nearest 1 hr) to relocate radio-tagged white sturgeon in Bonneville and The Dalles reservoirs, Columbia River, 1994.

| | Boat | | Car | | Plane |
|---|---|---|---|---|---|
| Week | Bonneville | The Dalles | Bonneville | The Dalles | Both |
| May 02-08 | 6 | 6 | 0 | 0 | 2 |
| May 09-15 | 3 | 0 | 0 | 0 | 0 |
| May 16-22 | 15 | 0 | 0 | 2 | 0 |
| May 23-29 | 7 | 5 | 0 | 0 | 0 |
| May 30-June 5 | 7 | 4 | 0 | 0 | 2 |
| June 06-12 | 2 | 8 | 0 | 0 | 2 |
| June 13-19 | 5 | 8 | 0 | 0 | 0 |
| June 20-26 | 6 | 6 | 0 | 0 | 0 |
| June 27-July 03 | 0 | 3 | 0 | 0 | 2 |
| July 04-10 | 6 | 2 | 0 | 0 | 0 |
| July 11-17 | 3 | 2 | 2 | 2 | 2 |
| July 18-24 | 0 | 2 | 2 | 1 | 0 |
| July 25-31 | 0 | 0 | 0 | 0 | 2 |
| August 01-07 | 4 | 5 | 1 | 2 | 0 |
| August 08-14 | 2 | 1 | 0 | 0 | 2 |
| August 15-21 | 14 | 0 | 0 | 0 | 0 |
| August 22-28 | 0 | 3 | 0 | 0 | 2 |
| Aug 29-Sept 04 | 0 | 3 | 0 | 0 | 2 |
| September 05-11 | 0 | 0 | 0 | 0 | 3 |

showed the Yagi style antenna had the greatest detection range. The drag style antenna was ineffective at all depths. The range of detection for the closed-loop antenna of the custom tag was greater in August than in February (Table 3).

We relocated 11 of 22 radio tagged white sturgeon a total of 18 times (Table 1). We made 1 contact with shore based radio tracking, 10 contacts by boat, and 7 contacts by airplane. We relocated 6 of 12 externally tagged fish for a total of 10 contacts. Externally tagged fish moved 0.0-148.8 km; one of these moved downstream past The Dalles Dam, another moved downstream past The Dalles and Bonneville dams (Figure 3). We relocated 5 of 10 internally tagged fish for a total of 8 contacts. Internally tagged fish moved 0.2-644 km; one of these fish moved from The Dalles Reservoir out of the Columbia River system and was recovered by an angler in the Umpqua River in southern Oregon. Depths for the 10 fish relocated by boat ranged from 5-43 m (mean depth 21 m).

In addition to radio contacts, two of the radio tags were recovered from fish harvested by anglers and one fish, released after spawning at a private hatchery, was found dead. We were able to examine two of these tags -- neither of them were working. The manufacturer identified a broken crystal on one tag, but could not determine the cause of the second tag's failure.

## DISCUSSION

We had little success in locating radio-tagged white sturgeon because of multiple tag failures, low detectability of radio tags in deep water (depth often exceeded 65 m), and reservoir size (Bonneville 74 km, 8,400 ha; The Dalles 38 km, 4,500 ha).

Successful telemetry studies of other sturgeons have not dealt with deep water. Depths in the Merrimack River, Massachusetts, are generally <5 m, where shortnose and Atlantic sturgeons (*Acipenser brevirosrum* and *A. oxyrhynchus*) were successfully tracked using ultrasonic tags (Kieffer and Kynard 1993), and depths in the free-flowing reach of the Columbia River above Richland, Washington, are <20 m, where white sturgeon have been radio tagged previously (Haynes et al. 1978, Haynes and Gray 1981). In a radio telemetry study on the Yangtze River, People's Republic of China, depth and velocity interfered with tracking success (telephone interview with Boyd Kynard, U.S. Fish and Wildlife Service, Conte Anadromous Fish Research Center, Turners Falls, Massachussetts).

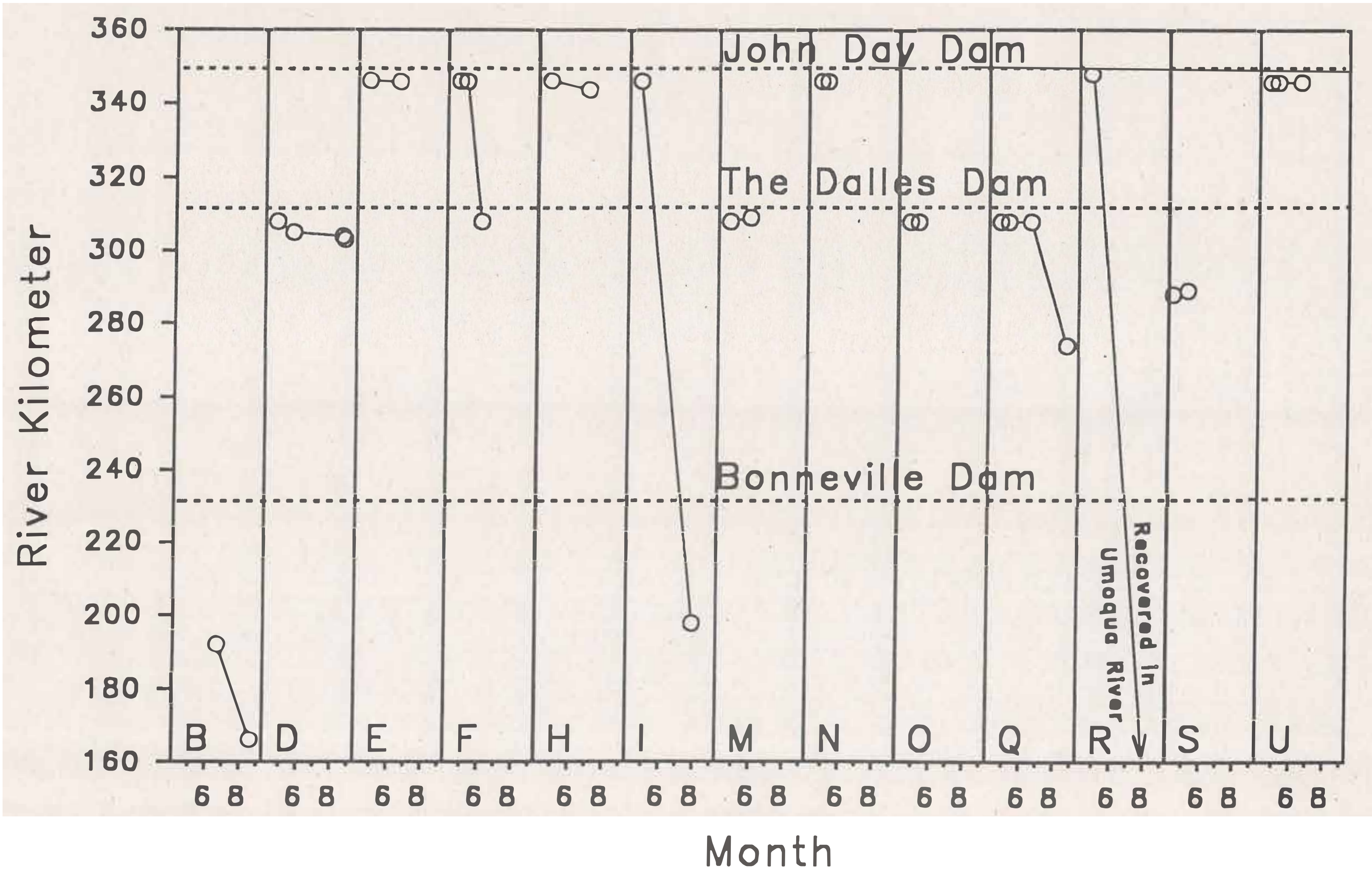
Relocations of radio-tagged northern squawfish (*Ptychocheilus oregonensis*) and walleye (*Stizosteidon vitreum*) in Columbia River reservoirs have been more effective because these species use shallower depths than white sturgeon. The crew tracking white sturgeon radio tracked northern squawfish at the same time. Northern squawfish were tagged with Lotek tags (3 volt, 149-150 MHz) and relocated using Lotek recievers (SRX1C 400). Seventy-four percent of northern squawfish were relocated at least once (100 of 135) while only 50% (11 of 22) of white sturgeon were relocated. Mean depth for northern squawfish was 3.4 m, and they were not found in depths >12 m (Zimmerman et al. 1994). A successful radio telemetry study on walleye in Lake Roosevelt, Columbia River, only found fish to a depth of 18 m (Beckman et al. 1985). White sturgeon typically use depths greater than 10 m (North et al. 1993). In depths >30 m, we would occasionally detect a faint signal of a radio-tagged white sturgeon, but the position could not be isolated to less than a 125-m radius.

APPENDIX A-1 TABLE 3. Maximum surface distance (m; ±1% at 100 m, ± 3% at 300 m) at which tag signal was detected for two tag types suspended at various depths using three styles of antenna. The tag types were a manufacturer's stock tag (6 volts, 180 day battery life, 75 pulses per minute, 49.868 Mhz), and a custom built tag (3 volts, 180 day battery life, >60 pulses per minute, 48.577 Mhz). The antenna styles were closed-loop (Loop), yagi, and drag.

| | Stock tag | Custom tag | | |
|---|---|---|---|---|
| Depth of tag (m) | Loop | Loop | Yagi | Drag |
| | February testing | | | |
| 8 | 150 | 175 | [a] | [a] |
| 11 | 10 | 100 | [a] | [a] |
| 24 | 10 | <10 | [a] | [a] |
| 33 | <1 | <10 | [a] | [a] |
| | August testing | | | |
| 9 | [a] | 275 | 275+ | [b] |
| 17 | [a] | 31 | 64 | [b] |
| 19 | [a] | 15 | 43 | [b] |

[a] Not tested.

[b] Not detected.




APPENDIX A-1 FIGURE 3. Tagging and subsequent relocation sites of white sturgeon in the Columbia River, April - September 1993. Letters correspond to letters in Table 1. Fish that were not relocated after tagging are not shown.

We did not find an acceptable radio tag that allowed us to locate fish at depths >30 m. While the tags we had custom made were detectable at greater depths than manufacturer's stock tags, both custom tags we recovered had failed. A suitable tag will need to be detectable at depths >50 m and provide reliable performance for 6 months or more.

Because the reservoirs were large, searching the reservoir for radio tag signals by boat was an inefficient use of personnel time. However, boat tracking is the only means of obtaining site-specific habitat measurements. Outside the tailrace boat restricted zones, few tags were detected that we were not aware of based on previous flight data. It may be more effective to increase the frequency of flights and use boats to track fish exclusively based on last known location, except in tailrace areas. In the tailrace areas there was a great deal of radio interference, which made it difficult to detect signals during airplane based tracking.

The emigration rate of radio-tagged white stugeon was much greater than expected. Three of 22 (13%) fish left the reservoir they were tagged in. North et al. (1993) reported 4% emigration among 635 recaptured white sturgeon at large up to 5 years in these same reservoirs.

Given current technology, radio tracking alone is an inadequate means of locating white sturgeon for the purpose of describing habitat use. With additional experience and effort we might increase the number of observations, but we would not be able to correct for the gear's inherent bias toward detecting fish in shallow areas. Ultrasonic tags are well suited for studies in deep water, but air bubbles and noise can interfere with signal reception, and because the receiver must be submerged underwater they are less suitable to searching for highly mobile species (Winter 1983). However, ultrasonic tags have effectively been used to relocate white sturgeon in the Kootenai River (Apperson and Anders 1990 and 1991). It may be that a combination of radio and sonic tags will allow detection of fish in the range of water conditions found in lower Columbia River impoundments. The radio tag would allow relocation of shallow fish in turbulent waters downstream from dams or when high winds cause high wave conditions, and the ultrasonic tag would allow relocation of fish at great depth. Researchers are currently working with tag manufacturers to develop technology for working in deep, fast waters (telephone interview with Boyd Kynard, U.S. Fish and Wildlife Service, Conte Anadromous Fish Research Center, Turners Falls, Massachussetts). Future studies may increase efficiency of telemetry sampling by concentrating tags in one reservoir and tagging more fish. While tags are expensive, the greatest cost in this study was personnel time to relocate fish.

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# REPORT B

1. Evaluate the success of annually developing and implementing a fish management plan for white sturgeon in reservoirs between Bonneville and McNary dams in enhancing production.

2. Describe the life history and population dynamics of subadult and adult white sturgeon in McNary Reservoir and downstream from Bonneville Dam.


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# CONTENTS

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## ABSTRACT

The Washington Department of Fish and Wildlife (WDFW) conducted a limited survey of the recreational fisheries between Bonneville and McNary dams (Zone 6) on the Columbia River to estimate white sturgeon harvest. Zone 6 recreational fisheries were managed by WDFW and the Oregon Department of Fish and Wildlife (ODFW) with the direction of the Sturgeon Management Task Force (SMTF). The SMTF established 1993 recreational fishery harvest guidelines of 1,350 fish for Bonneville Reservoir, 100 fish for The Dalles Reservoir, and 100 fish for John Day Reservoir. Anglers in 1993 were allowed a daily bag limit of one fish 40 to <48 inches in length and one fish 48 to 72 inch in Bonneville Reservoir. Anglers fishing The Dalles and John Day reservoirs were allowed a daily bag limit of one fish 48 to 66 inches.

An estimated 2,145 white sturgeon were harvested from Bonneville Reservoir by anglers making an estimated 14,347 trips March through October. Anglers targeting sturgeon comprised 57% of an estimated 25,236 total trips. Anglers made an estimated 3,960 trips (14% of total trips) for white sturgeon in The Dalles Reservoir, harvesting an estimated 128 fish. Anglers harvested an estimated 134 white sturgeon from John Day Reservoir during 7,674 trips (21% of total trips).

Preliminary 1993 harvest estimates were presented to the SMTF in a draft Zone 6 white sturgeon annual management plan authored by WDFW and ODFW. After review, new 1994 minimum (42 inches) and maximum (66 inches) size regulations were recommended for the recreational fishery in Bonneville Reservoir and it was recommended that the annual bag limit be reduced from 15 to 10 fish in all three reservoirs for 1994. Approximately 40% of the 1993 legal size catch from Bonneville Reservoir was less than 42 inches resulting in a 1994 expected harvest within the SMTF guidelines. It is unclear whether reducing the annual bag limit in The Dalles and John Day reservoirs will bring 1994 harvest within SMTF guidelines for those reservoirs.

The annual Zone 6 white sturgeon management plan also documented 1993 Treaty Indian commercial and subsistence harvest. A total of 1,415 white sturgeon were harvested from Bonneville Reservoir during commercial setline and setnet fisheries, 579 were harvested from The Dalles Reservoir, and 12 were harvested from John Day Reservoir. The Columbia River Inter-Tribal Fisheries Commission (CRITFC) estimated an additional 263 fish were harvested during subsistence fisheries.

In addition to evaluating harvest, the Zone 6 annual management plan called for an update of the status of the white sturgeon populations in Bonneville and The Dalles reservoirs for 1994. The plan also recommended a trial juvenile transplant program for the population in The Dalles Reservoir.

Progress was made on developing a more comprehensive strategic framework plan for managing Zone 6 sturgeon populations involving WDFW, CRITFC, and ODFW. This plan would be used to guide long term management and enhancement activities to offset the impacts of the hydropower system and overfishing.

## INTRODUCTION

This annual report describes work completed by the Washington Department of Fish and Wildlife (WDFW) and the Columbia River Inter-Tribal Fish Commission (CRITFC) as part of the BPA white sturgeon (*Acipenser transmontanus*) research project 86-50. The WDFW and CRITFC are responsible for portions of tasks related to Objective 1: to experimentally implement and evaluate the success of selected measures to protect and enhance white sturgeon populations and mitigate for effects of the hydropower system on the productivity of white sturgeon in the Columbia River downstream from McNary Dam. The WDFW also shares responsibility for tasks relating to Objective 3: to evaluate the need and identify potential measures for protecting and enhancing populations and mitigating for effects of the hydropower system on productivity of white sturgeon in the Columbia and Snake rivers upstream from McNary Dam.

### Activities conducted from March 1993 through March 1994

The primary focus of this report describes progress on activities involving efforts to evaluate the success of annually developing and implementing a fish management plan in enhancing white sturgeon production in reservoirs between Bonneville and McNary dams (Zone 6 of the Columbia River). The WDFW and the Oregon Department of Fish and Wildlife (ODFW) were responsible for conducting a creel survey of recreational fisheries in Bonneville, The Dalles, and John Day reservoirs from March through October 1993 and monitoring Treaty Indian commercial fisheries to estimate 1993 white sturgeon harvest. The CRITFC was responsible for monitoring tribal subsistence fisheries to assist in estimating harvest. The WDFW, in conjunction with ODFW, was also responsible for preparing an annual white sturgeon management plan incorporating 1993 fishery results. This plan outlining management recommendations by WDFW and ODFW for 1994 Zone 6 fisheries and enhancement options was submitted to the Sturgeon Management Task Force (SMTF) in December 1993.

The WDFW, CRITFC, and ODFW also made progress on developing a comprehensive strategic framework plan for managing Zone 6 sturgeon populations. This plan will address short and long-term harvest management and enhancement strategies to offset the impacts of hydroelectric development and overfishing. Responsibilities of WDFW include preparing sections on management of the hydropower system for optimizing white sturgeon production, recreational fisheries, passage, and programatic goals and constraints in managing sturgeon resources. Responsibilities of CRITFC include preparing sections on hatchery supplementation, passage (with WDFW), and tribal commercial and subsistence fisheries. Responsibilities of ODFW include sections on habitat and stock status, transplant supplementation, and exploitation modeling.

One report covering phase 1 research authored by WDFW entitled "Dynamics and potential production of white sturgeon in the unimpounded lower Columbia River" was prepared for submission to Transactions of the

American Fisheries Society. A second report authored by WDFW entitled "Length at age relationships for white sturgeon in the Columbia River downstream from Bonneville Dam" is being revised for re-submission to a professional journal.

The following annual report consists of a summary of Zone 6 recreational fisheries conducted from March through October 1993 and the annual white sturgeon management plan entitled "1994 Recommendations for white sturgeon management in Zone 6 of the Columbia River".

## Activities planned for March 1994 through March 1995

In addition to the above activities, WDFW developed plans to sample the March-October 1994 recreational fishery between McNary Dam and Priest Rapids Dam on the Columbia River and Ice Harbor Dam on the Snake River. The CRITFC plans to participate in the trial transport program in October 1994. In addition, CRITFC plans to develop and implement an on-board monitoring project during 1995 Zone 6 commercial sturgeon fisheries in conjunction with the Yakama Indian Nation fisheries staff. The WDFW also developed plans to continue monitoring 1994-1995 Zone 6 recreational and Treaty Indian commercial fisheries.

Preliminary 1994 recreational and commercial harvest estimates will be incorporated into a 1994-1995 annual fish management plan for review by the SMTF in August 1994. A draft of the comprehensive strategic framework plan is scheduled for completion in December 1994.

## Recreational fisheries in the Columbia River between Bonneville and McNary dams, 1993

The Washington Department of Fish and Wildlife has sampled recreational fisheries on the Columbia River between Bonneville and McNary dams since 1987 as part of a multi-agency research project to determine the status and habitat requirements of white sturgeon populations downstream from McNary Dam (Hale and James 1993). A significant conclusion from the first phase of this research was that construction and operation of dams had functionally isolated white sturgeon in these impoundments and decreased their relative production potential by altering critical habitats (Beamesderfer and Rien 1993; Parsley et al. 1993). Reduced production has increased the risk of overexploitation. White sturgeon fisheries in The Dalles and John Day reservoirs have recently declined and continued high exploitation risks severe stock depletion.

One recommendation from phase 1 research was that future harvest management strategies be tailored to the unique attributes of each impounded population to help offset the adverse effects hydroelectric system operation has had on production (Beamesderfer and Rien 1993). Tasks identified for the current phase (2) of research include development and evaluation of annual management plans that closely monitor and regulate sturgeon fisheries to maintain exploitation at optimum sustainable rates.

Harvest management of Columbia River white sturgeon fisheries during 1993 was again coordinated through the SMTF, consisting of representatives from WDFW, ODFW, and the Columbia River Treaty Indian tribes. The SMTF recommended recreational fishery harvest guidelines for 1993 were: 1,350 sturgeon from Bonneville Reservoir, 100 sturgeon from The Dalles Reservoir, and 100 sturgeon from John Day Reservoir. The Oregon and Washington recreational sturgeon fishery regulations in effect during 1993 are listed in Appendix Table B-1.1.

Results from the creel survey presented in this report were used to help develop reservoir specific recreational fishery management plans for review by the SMTF prior to implementation in 1994. This report summarizes estimates of March through October 1993 angling effort, harvest, and numbers of fish caught and released for white sturgeon, anadromous salmonids, shad, walleye, smallmouth bass, northern squawfish, and other resident fish for Bonneville, The Dalles, and John Day reservoirs.

### Methods

A limited creel survey was conducted during 1993 to estimate white sturgeon recreational harvest in Bonneville, The Dalles, and John Day reservoirs (Figures 1 and 2). This survey was based upon extensive angler survey work conducted on Bonneville Reservoir from 1988-1990, The Dalles Reservoir from 1987-1989, and John Day Reservoir from 1989-1991 (Hale and James 1993). During previous surveys two creel checkers per reservoir were assigned to sample the recreational fishery in each

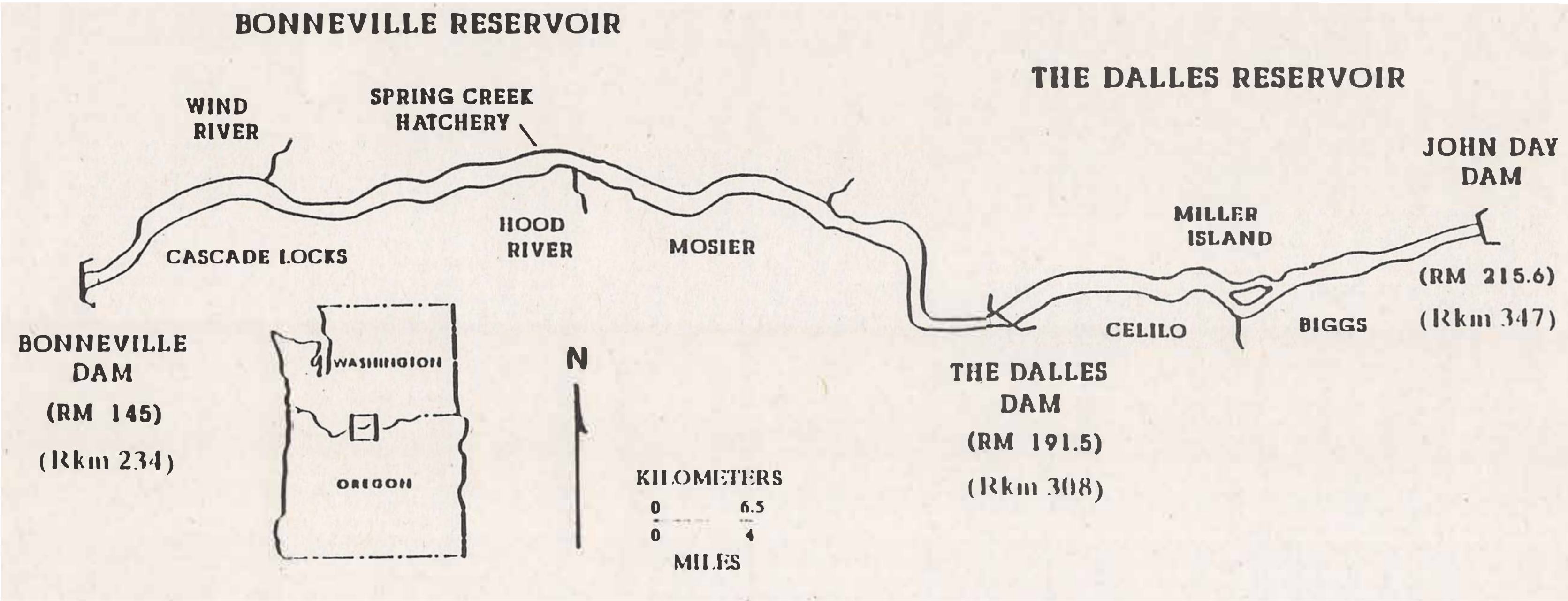


Figure 1. Location of Bonneville and The Dalles reservoirs on the Columbia River.

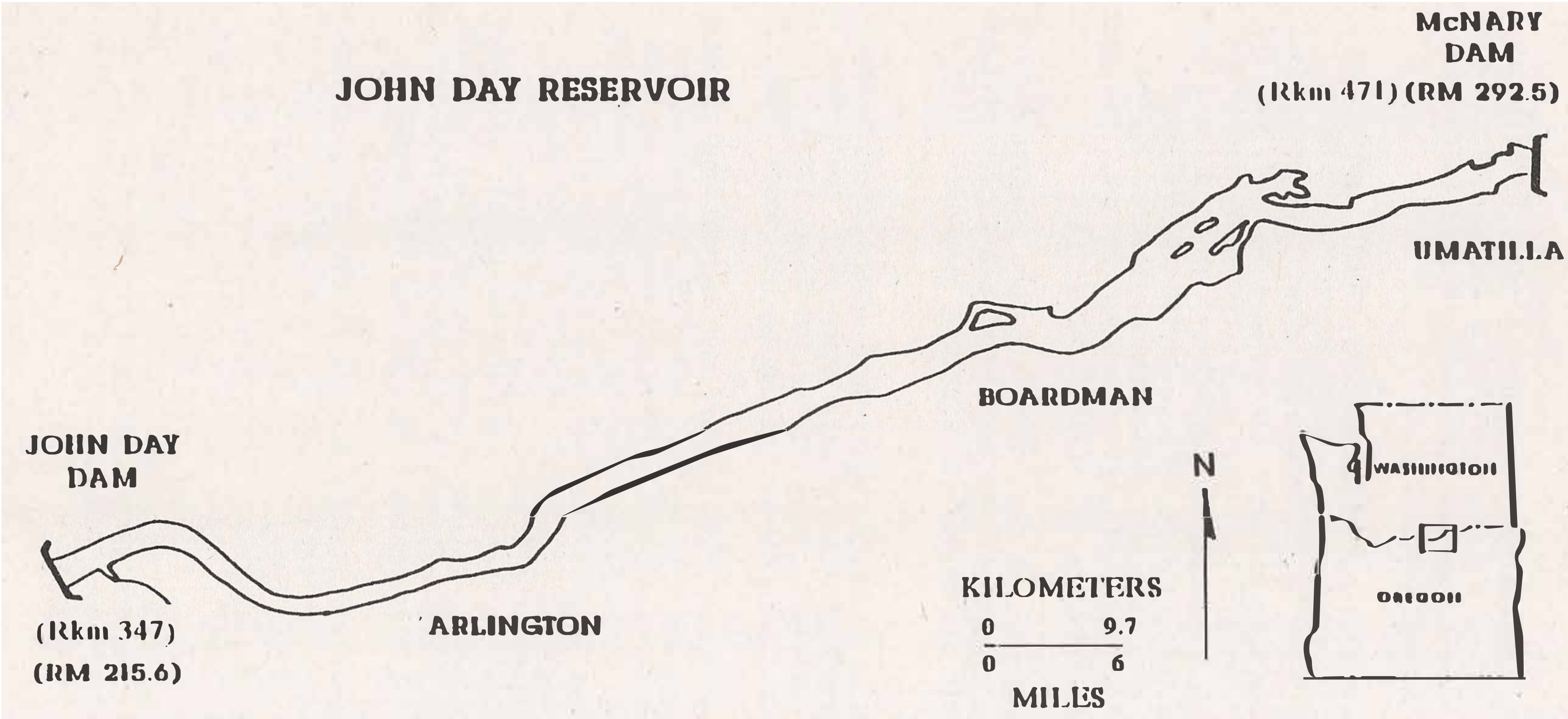


Figure 2. Location of John Day Reservoir on the Columbia River.

reservoir with a goal of sampling about twenty percent of the harvest. Angling effort estimation during these surveys involved weekly angler pressure counts from the air, counts from the ground of anglers within indices every three hours through the day (dawn to dusk) on selected days, and single counts of angling pressure within indices on all other days sampled. However, funding was not available in 1993 to conduct flight and dawn to dusk pressure counts.

Sampling effort was adequate in 1993 to make single daily counts of angling pressure within indices and to conduct angler interviews. Sampling in 1993 was conducted by one full time creel checker hired by ODFW, three staff from the WDFW Columbia River Management Office, and personnel operating two northern squawfish sport reward registration stations. This was an increase over the 1992 level of sampling (James and Hale 1993). The angling pressure data collected in 1993 were compared to similar but more complete information collected during previous surveys to derive 1993 estimates of angling effort. Estimates of angling effort and harvest were not stratified by state.

The recreational fisheries in each reservoir were sampled 9-12 days a month from March through October. An additional 4-8 angler pressure counts per month were made in The Dalles Reservoir (Appendix Table B-1.2).

Index areas for angler pressure counts were established at popular fishing locations and vantage points in each reservoir. These were the same areas used in the 1987-1991 surveys (Hale and James 1993). Angling effort was counted at least once during the day within index areas.

The daily average number of bank anglers and recreational fishing boats counted within index areas by 3-hour period and stratified by weekend and weekday were derived monthly for each reservoir in 1993. These average counts were compared to similarly stratified index count data from previous surveys to estimate 1993 total angling effort relative to previous years' angling effort estimates. Two angling effort estimates, each based on a previous year's estimate, were calculated for each reservoir, then averaged for the final 1993 effort estimate. Bonneville Reservoir estimates were extrapolated from 1989 and 1990 survey data, The Dalles Reservoir estimates from 1988 and 1989 data, and John Day Reservoir estimates from 1990 and 1991 data.

Creel checkers interviewed anglers at bank fishing sites and boat ramps to determine angler type (target species) and catch per hour of effort for each species in the creel. Checkers collected data from both incomplete and completed angler trips. Interview data collected included angling method (bank or boat), target species, hours fished, number of anglers in the party, fishing location, residence, species and number of fish caught and number released, and data on marked sturgeon, salmonids, and walleye. Anglers were also asked if they had registered with the northern squawfish sport reward program and if so, the station where they registered.

Effort and catch data were stratified by angling method, reservoir subsection, and weekend and weekday type to account for differential catch and sampling rates. Samplers operating northern squawfish sport reward check stations at Cascade Locks and Umatilla conducted random interviews of most anglers exiting those ramps, resulting in a much higher sample rate than that conducted throughout the rest of the reservoir. Therefore, interview data collected at these two stations were applied only to effort estimates for adjacent reservoir subsections.

Harvest estimates were derived monthly. Harvest estimates were calculated by multiplying the observed catch per hour for each angling method within a reservoir subsection by the total estimated effort for each angling method for that subsection.

## Results

Washington and Oregon anglers made an estimated 90,825 trips from March through October 1993 to fish in the Columbia River between Bonneville and McNary dams and harvested an estimated 49,289 fish. Angling for white sturgeon comprised 29% of the estimated angler trips (Table 1) and 5% of the total harvest (Table 2).

*Bonneville Reservoir:* Washington and Oregon anglers fished an estimated 163,580 hours (25,236 trips) in Bonneville Reservoir from March through October (Table 1). Most anglers fished for sturgeon (57%) followed by anglers targeting anadromous salmonids (25%), bass (8%), walleye (4%), northern squawfish (2%), and shad (<1%). Two percent of the anglers targeted other resident fish and one percent were anglers participating in tournaments.

Similar numbers of bank and boat anglers fished the entire reservoir for white sturgeon and angling effort was strong throughout the census period, peaking in July with 2,660 trips (Table 3). These anglers harvested an estimated 2,145 white sturgeon from March through October, with peak catches in March and June through August (Table 3). The average harvest per trip was 0.14 for bank anglers and 0.17 for boat anglers.

The 1,760 sturgeon anglers interviewed comprised 6% of the estimated bank effort and 14% of the estimated boat effort for white sturgeon (Table 4). Anglers were allowed a daily bag limit of one fish 40 to <48 inches in length and one fish 48 inches to 72 inches, causing anglers to release 26% of the reported catch of legal size (40-72 inch) fish. The ratio of sublegal (<40 in., <102 cm TL) to legal (40-72 in., 102-183 cm TL, both kept and released) to oversize (>72 in., >183 cm TL) sturgeon in the sampled catch was 198:27:1 (Table 4). Fish less than 42 inches in length comprised 40% of the sampled catch (Table 5).

*The Dalles Reservoir:* Washington and Oregon anglers fished an estimated 175,018 hours (29,081 trips) in The Dalles Reservoir from March through October (Table 1). Most anglers fished for anadromous salmonids (41%) followed by anglers targeting walleye (22%), white sturgeon (14%), shad (8%), northern squawfish (5%), and bass (4%). Six percent of the anglers targeted other resident fish.

Table 1. Combined Oregon and Washington recreational fishery angling effort estimates for Bonneville, The Dalles, and John Day reservoirs, March through October 1993.

| Species, | Bonneville | | The Dalles | | John Day | |
|---|---|---|---|---|---|---|
| Bank/Boat | Hours | Trips | Hours | Trips | Hours | Trips |
| Sturgeon | | | | | | |
| Bank | 49,487 | 7,599 | 17,171 | 2,058 | 19,286 | 3,207 |
| Boat | 40,659 | 6,748 | 10,314 | 1,902 | 24,727 | 4,467 |
| Total | 90,146 | 14,347 | 27,485 | 3,960 | 44,013 | 7,674 |
| Salmonid | | | | | | |
| Bank | 35,243 | 3,501 | 15,120 | 1,513 | 2,407 | 613 |
| Boat | 16,286 | 2,914 | 63,545 | 10,521 | 9,367 | 1,852 |
| Total | 51,529 | 6,415 | 78,665 | 12,034 | 11,774 | 2,465 |
| Shad | | | | | | |
| Bank | 288 | 68 | 13,571 | 2,164 | 1,436 | 506 |
| Boat | 16 | 2 | 53 | 29 | 561 | 148 |
| Total | 304 | 70 | 13,624 | 2,193 | 1,997 | 654 |
| Walleye | | | | | | |
| Bank | 86 | 18 | 110 | 23 | 29 | 7 |
| Boat | 4,430 | 991 | 35,071 | 6,442 | 43,476 | 8,842 |
| Total | 4,516 | 1,009 | 35,181 | 6,465 | 43,505 | 8,849 |
| Bass | | | | | | |
| Bank | 2,682 | 699 | 1,276 | 294 | 4,443 | 962 |
| Boat | 6,399 | 1,294 | 3,899 | 987 | 32,277 | 7,459 |
| Total | 9,081 | 1,993 | 5,175 | 1,281 | 36,720 | 8,421 |
| Squawfish | | | | | | |
| Bank | 1,539 | 306 | 1,729 | 303 | 1,047 | 221 |
| Boat | 704 | 153 | 5,552 | 1,178 | 932 | 215 |
| Total | 2,243 | 459 | 7,281 | 1,481 | 1,979 | 436 |
| Other | | | | | | |
| Bank | 2,406 | 499 | 4,393 | 914 | 14,038 | 3,505 |
| Boat | 319 | 104 | 3,214 | 753 | 12,913 | 3,059 |
| Total | 2,725 | 603 | 7,607 | 1,667 | 26,951 | 6,564 |
| Tournament | | | | | | |
| Bank | 0 | 0 | 0 | 0 | 0 | 0 |
| Boat | 3,036 | 340 | 0 | 0 | 13,092 | 1,445 |
| Total | 3,036 | 340 | 0 | 0 | 13,092 | 1,445 |
| Combined total | | | | | | |
| Bank | 91,731 | 12,690 | 53,370 | 7,269 | 42,686 | 9,021 |
| Boat | 71,849 | 12,546 | 121,648 | 21,812 | 137,345 | 27,487 |
| Total | 163,580 | 25,236 | 175,018 | 29,081 | 180,031 | 36,508 |

Table 2. Combined Oregon and Washington recreational fishery harvest and catch and release estimates for Bonneville, The Dalles, and John Day reservoirs, March through October 1993.

| Species | Bonneville | The Dalles | John Day |
|---|---|---|---|
| White sturgeon | | | |
| Legals kept | 2,145 | 128 | 134 |
| Sublegals released | 24,146 | 4,646 | 4,826 |
| Legals released | 651 | 15 | 11 |
| Oversize released | 122 | 9 | 91 |
| Total | 27,064 | 4,799 | 5,062 |
| Fall chinook | | | |
| Adults kept | 271 | 768 | 90 |
| Jacks kept | 9 | 22 | 0 |
| Total | 280 | 790 | 90 |
| Coho | | | |
| Adults kept | 74 | 12 | 0 |
| Jacks kept | 18 | 0 | 0 |
| Total | 92 | 12 | 0 |
| Steelhead | | | |
| 'Hatchery' kept | 666 | 1,941 | 133 |
| 'Wild' released | 141 | 684 | 40 |
| Shad | | | |
| Kept | 166 | 10,384 | 191 |
| Released | 0 | 4,345 | 712 |
| Walleye | | | |
| Kept | 82 | 2,200 | 2,746 |
| Released | 98 | 4,073 | 1,673 |
| Smallmouth bass | | | |
| Kept | 1,764 | 1,381 | 8,044 |
| Released | 4,601 | 1,524 | 12,155 |
| Northern squawfish kept | 2,515 | 9,340 | 1,711 |
| Other kept resident fish | 360 | 141 | 1,853 |

Table 3. Estimates of angling effort and white sturgeon harvest for recreational fisheries in Bonneville, The Dalles, and John Day reservoirs, March through October 1993.

| Month | Bonneville | | | The Dalles | | | John Day | | |
|---|---|---|---|---|---|---|---|---|---|
| Method | Trips | CPUE | Harvest | Trips | CPUE | Harvest | Trips | CPUE | Harvest |
| March | | | | | | | | | |
| Bank | 945 | 0.28 | 267 | 93 | 0.08 | 7 | 111 | 0.00 | 0 |
| Boat | 957 | 0.08 | 73 | 443 | 0.00 | 0 | 142 | 0.00 | 0 |
| Total | 1,902 | 0.18 | 340 | 536 | 0.01 | 7 | 253 | 0.00 | 0 |
| April | | | | | | | | | |
| Bank | 894 | 0.08 | 73 | 106 | 0.00 | 0 | 126 | 0.06 | 8 |
| Boat | 712 | 0.12 | 83 | 67 | 0.00 | 0 | 315 | 0.01 | 3 |
| Total | 1,606 | 0.10 | 156 | 173 | 0.00 | 0 | 441 | 0.02 | 11 |
| May | | | | | | | | | |
| Bank | 868 | 0.03 | 23 | 265 | 0.01 | 3 | 200 | 0.01 | 1 |
| Boat | 746 | 0.18 | 133 | 5 | 0.00 | 0 | 377 | 0.00 | 0 |
| Total | 1,614 | 0.10 | 156 | 270 | 0.01 | 3 | 577 | 0.00 | 1 |
| June | | | | | | | | | |
| Bank | 977 | 0.19 | 185 | 745 | 0.01 | 10 | 966 | 0.01 | 5 |
| Boat | 954 | 0.14 | 131 | 289 | 0.08 | 22 | 841 | 0.04 | 33 |
| Total | 1,931 | 0.16 | 316 | 1,034 | 0.03 | 32 | 1,807 | 0.02 | 38 |
| July | | | | | | | | | |
| Bank | 1,540 | 0.11 | 165 | 291 | 0.04 | 11 | 1,235 | 0.00 | 1 |
| Boat | 1,120 | 0.22 | 244 | 225 | 0.04 | 8 | 1,185 | 0.03 | 38 |
| Total | 2,660 | 0.15 | 409 | 516 | 0.04 | 19 | 2,420 | 0.02 | 39 |
| August | | | | | | | | | |
| Bank | 779 | 0.18 | 144 | 141 | 0.04 | 6 | 438 | 0.00 | 0 |
| Boat | 1,482 | 0.19 | 280 | 270 | 0.00 | 0 | 692 | 0.01 | 9 |
| Total | 2,261 | 0.19 | 424 | 411 | 0.01 | 6 | 1,130 | 0.01 | 9 |
| September | | | | | | | | | |
| Bank | 776 | 0.16 | 128 | 272 | 0.02 | 6 | 89 | 0.01 | 1 |
| Boat | 486 | 0.15 | 71 | 332 | 0.10 | 33 | 526 | 0.05 | 24 |
| Total | 1,262 | 0.16 | 199 | 604 | 0.06 | 39 | 615 | 0.04 | 25 |
| October | | | | | | | | | |
| Bank | 820 | 0.05 | 44 | 145 | 0.08 | 12 | 43 | 0.00 | 0 |
| Boat | 291 | 0.35 | 101 | 271 | 0.04 | 10 | 388 | 0.03 | 11 |
| Total | 1,111 | 0.13 | 145 | 416 | 0.05 | 22 | 431 | 0.03 | 11 |
| Combined | | | | | | | | | |
| Bank | 7,599 | 0.14 | 1,029 | 2,058 | 0.03 | 55 | 3,208 | 0.00 | 16 a |
| Boat | 6,748 | 0.17 | 1,116 | 1,902 | 0.04 | 73 | 4,466 | 0.03 | 118 |
| Total | 14,347 | 0.15 | 2,145 | 3,960 | 0.03 | 128 | 7,674 | 0.02 | 134 |

a *No observed bank harvest. At least sixteen fish were reported harvested on non-sampled days.*

Table 4. Numbers of white sturgeon anglers interviewed and numbers of white sturgeon reported, by size group, during sampling of recreational fisheries in Bonneville, The Dalles, and John Day reservoirs, March through October 1993.

| Reservoir, Method/Month | Anglers checked | Hours fished | Sublegal | Legal released | Legal kept | Oversize |
|---|---|---|---|---|---|---|
| Bonneville | | | | | | |
| Bank | | | | | | |
| March | 156 | 469 | 138 | 0 | 21 | 0 |
| April | 139 | 475 | 133 | 0 | 6 | 0 |
| May | 88 | 327 | 132 | 0 | 3 | 0 |
| June | 102 | 423 | 150 | 0 | 12 | 0 |
| July | 160 | 547 | 117 | 1 | 10 | 0 |
| August | 78 | 335 | 129 | 0 | 11 | 0 |
| September | 78 | 324 | 77 | 4 | 9 | 0 |
| October | 38 | 128 | 43 | 1 | 2 | 0 |
| Boat | | | | | | |
| March | 46 | 240 | 72 | 1 | 4 | 0 |
| April | 45 | 207 | 53 | 0 | 4 | 5 |
| May | 126 | 779 | 274 | 12 | 23 | 0 |
| June | 229 | 1,492 | 742 | 23 | 68 | 10 |
| July | 229 | 1,350 | 549 | 37 | 90 | 0 |
| August | 125 | 742 | 313 | 19 | 25 | 1 |
| September | 67 | 449 | 109 | 6 | 14 | 0 |
| October | 54 | 269 | 141 | 10 | 21 | 0 |
| Combined total | 1,760 | 8,556 | 3,172 | 114 | 323 | 16 |
| The Dalles | | | | | | |
| Bank | | | | | | |
| March | 35 | 122 | 21 | 0 | 1 | 0 |
| April | 56 | 219 | 28 | 0 | 0 | 0 |
| May | 94 | 477 | 65 | 0 | 2 | 0 |
| June | 117 | 601 | 40 | 0 | 2 | 0 |
| July | 86 | 424 | 36 | 1 | 2 | 0 |
| August | 53 | 158 | 22 | 0 | 2 | 0 |
| September | 97 | 314 | 38 | 0 | 2 | 0 |
| October | 58 | 179 | 27 | 0 | 2 | 1 |
| Boat | | | | | | |
| March | 14 | 69 | 41 | 0 | 0 | 0 |
| April | 16 | 76 | 15 | 0 | 0 | 0 |
| May | 2 | 6 | 4 | 0 | 0 | 0 |
| June | 28 | 145 | 60 | 1 | 3 | 0 |
| July | 26 | 145 | 32 | 0 | 0 | 0 |
| August | 7 | 42 | 24 | 0 | 1 | 0 |
| September | 27 | 108 | 89 | 0 | 2 | 0 |
| October | 25 | 172 | 119 | 1 | 2 | 1 |
| Combined total | 741 | 3,257 | 661 | 3 | 21 | 2 |

Table 4. Continued.

| Reservoir, Type / Month | Anglers checked | Hours fished | Sublegal | Legal released | Legal kept | Oversize |
|---|---|---|---|---|---|---|
| John Day | | | | | | |
| Bank | | | | | | |
| March | 20 | 57 | 17 | 0 | 0 | 0 |
| April | 41 | 132 | 12 | 0 | 0 | 0 |
| May | 60 | 151 | 9 | 0 | 0 | 1 |
| June | 70 | 205 | 12 | 0 | 0 | 0 |
| July | 100 | 312 | 16 | 0 | 0 | 0 |
| August | 68 | 134 | 9 | 0 | 0 | 0 |
| September | 17 | 38 | 4 | 0 | 0 | 0 |
| October | 21 | 63 | 3 | 0 | 0 | 0 |
| Boat | | | | | | |
| March | 21 | 99 | 35 | 0 | 0 | 1 |
| April | 67 | 386 | 117 | 0 | 1 | 3 |
| May | 39 | 149 | 16 | 0 | 0 | 0 |
| June | 118 | 605 | 170 | 0 | 11 | 3 |
| July | 379 | 2,198 | 445 | 0 | 12 | 7 |
| August | 310 | 1,667 | 357 | 3 | 6 | 11 |
| September | 149 | 749 | 161 | 2 | 7 | 2 |
| October | 22 | 107 | 14 | 0 | 1 | 1 |
| Combined total | 1,502 | 7,052 | 1,397 | 5 | 38 | 29 |

Table 5. Length frequencies of white sturgeon measured during sampling of recreational fisheries in Bonneville, The Dalles, and John Day reservoirs, March through October 1993.

| Total length (cm) | Bonneville | The Dalles | John Day | Total length (cm) | Bonneville | The Dalles | John Day |
|---|---|---|---|---|---|---|---|
| 100 | 2 | | | 143 | | 1 | |
| 101 | 5 | | | 144 | | | |
| 102 | 27 | | | 145 | 1 | | |
| 103 | 15 | | | 146 | | | |
| 104 | 39 | | | 147 | | | |
| 105 | 14 | | | 148 | | | 2 |
| 106 | 23 | | | 149 | | | 1 |
| 107 | 26 | | | | | | |
| 108 | 6 | | | 150 | | | 1 |
| 109 | 28 | | | 151 | | | |
| | | | | 152 | | | |
| 110 | 6 | | | 153 | | | |
| 111 | 4 | | | 154 | | | |
| 112 | 27 | | | 155 | 1 | 1 | |
| 113 | 5 | | | 156 | | | 1 |
| 114 | 10 | | | 157 | | | |
| 115 | 3 | | | 158 | | | 1 |
| 116 | 1 | | | 159 | | | |
| 117 | 11 | | | | | | |
| 118 | 4 | | 1 | 160 | | | 1 |
| 119 | 6 | | | 161 | | | |
| | | | | 162 | | | |
| 120 | 3 | | 1 | 163 | | | 1 |
| 121 | 2 | 3 | 1 | 164 | | | 1 |
| 122 | 7 | 1 | 4 | 165 | | | |
| 123 | 4 | | 4 | 166 | | | |
| 124 | 10 | 3 | | 167 | | 1 | |
| 125 | 1 | 1 | 1 | 168 | 1 | | |
| 126 | 1 | | 1 | 169 | | | |
| 127 | 2 | 1 | 1 | | | | |
| 128 | | 1 | | 170 | | | |
| 129 | 1 | | | 171 | | | |
| | | | | 172 | | | |
| 130 | | 1 | 1 | 173 | 1 | | |
| 131 | 1 | 1 | 2 | 174 | | | |
| 132 | 2 | 1 | 1 | 175 | | | |
| 133 | | 1 | | 176 | | | |
| 134 | | | | 177 | | | |
| 135 | 4 | 1 | 2 | 178 | 1 | | |
| 136 | | 1 | | 179 | | | |
| 137 | | | 2 | | | | |
| 138 | 1 | | 1 | 180 | | | |
| 139 | | | 1 | 181 | | | |
| | | | | 182 | | | |
| 140 | 1 | | | 183 | | | |
| 141 | | | | | | | |
| 142 | 1 | | | Total | 308 | 19 | 33 |

The recreational fishery for white sturgeon extended from the John Day Dam tailrace downstream to Miller Island, with similar numbers of anglers fishing from the bank and from boats. Catch was poor during March and May but improved in June and July and again in September and October (Table 3). An estimated 128 white sturgeon were harvested during the census period (Table 3). The average harvest per trip was 0.03 for anglers (combined bank and boat) targeting sturgeon.

The 741 sturgeon anglers interviewed comprised 15% of the estimated bank effort and 7% of the estimated boat effort for sturgeon (Table 4). The ratio of sublegal (<48 in., <122 cm TL) to legal (48-66 in., 102-167 cm TL) to oversize (>66 in., >167 cm TL) sturgeon in the sampled catch was 331:12:1 (Table 4). The length distribution of the sampled catch is presented in Table 5.

*John Day Reservoir:* Oregon and Washington anglers fished an estimated 180,031 hours (36,508 trips) in John Day Reservoir from March through October (Table 1). Most anglers fished for walleye (24%), bass (23%), and white sturgeon (21%) followed by anglers targeting anadromous salmonids (7%), shad (2%), and northern squawfish(1%). Eighteen percent of the anglers fished for other resident fish and four percent were participating in tournaments.

The recreational fishery for white sturgeon was concentrated from McNary Dam downstream to Irrigon, with some additional boat effort upstream from Boardman and at Crow Butte Island. Anglers harvested an estimated 134 white sturgeon during the sample period, with most catch occurring after May (Table 3). No sturgeon were harvested by the 397 bank anglers interviewed. However, these same anglers reported harvesting at least 16 white sturgeon on days when no sampling took place. The average harvest per trip for boat anglers targeting sturgeon was 0.03 (Table 3).

The 1,502 sturgeon anglers interviewed comprised 6% of the estimated bank effort and 24% of the estimated boat effort for sturgeon (Table 4). The ratio of sublegal (<48 in., <122 cm TL) to legal (48-66 in., 102-167 cm TL) to oversize (>66 in., >167 cm TL) sturgeon in the reported catch was 48:1:1 (Table 4). The length distribution of the sampled harvest is presented in Table 5.

## Discussion

Recreational sturgeon harvest in 1993 was greater than the SMTF guidelines in all three reservoirs. An increase in harvestable numbers of fish in Bonneville Reservoir was expected based on recruitment to fisheries of sub-102 cm TL (sub-40 inch) fish protected from harvest since April 1988. Enactment of the 42 inch (107 cm TL) minimum and 66 inch (168 cm TL) maximum size limit should reduce 1994 harvest to the SMTF guideline of 1,350 fish since fish 101-106cm comprised 40% of the measured harvest in 1993. Harvest in The Dalles and John Day reservoirs may continue to exceed recommended guidelines since the 1994 regulation change to a 10 fish annual limit is expected to reduce harvest only slightly.

Comparing 1987 through 1993 angling effort and sturgeon harvest estimates indicates that we under estimated white sturgeon harvest in 1992 (Table 6). The 1992 index area effort count ratios were similar to previous surveys but the proportion of anglers interviewed targeting sturgeon was particularly low. It appears that we did not randomly sample all angler types in 1992. Last year creel checkers tended to avoid boat ramps with sport reward registration stations (Hale and James 1993). These happened to be some of the primary ramps used by sturgeon anglers.

We achieved higher sampling rates in 1993 than in 1992 with the help of crews operating sport reward registration stations at Cascade Locks and Umatilla. They randomly sampled boat anglers exiting those ramps allowing us to concentrate on other areas. Sampling rates for 1993 bank and boat sturgeon fisheries ranged from 15-28% (sampled harvest/ estimated total harvest) compared with just 4-6% in 1992 (James and Hale 1993). This was still below the 25-42% range achieved during the 1987-1991 surveys (Hale and James 1993).

We continued to have difficulty representatively sampling bank fisheries for sturgeon on The Dalles and John Day reservoirs because of the one fish daily bag limit. The chance of encountering a successful bank angler was dependent upon the angler remaining in the area until a creel sampler arrived. This year on John Day Reservoir we did not observe a single bank harvested sturgeon although bank anglers reported harvesting fish on non-sampled days. Our harvest estimate, which includes 16 sturgeon reportedly harvested by bank anglers on non-sampled days, is therefore a minimum estimate of total harvest.

We compared our estimates of northern squawfish harvest with the number of northern squawfish turned in to registration stations to gauge the accuracy of our harvest estimates. Our estimate of northern squawfish harvest for John Day and The Dalles reservoirs (11,051) was slightly less than the 12,848 fish turned in to registration stations for those two reservoirs (Dan Klaybor, personal communication). Our harvest estimate of 2,515 northern squawfish for Bonneville Reservoir was far below the 11,619 fish turned in to registration stations. Some of this difference may be due to registered anglers delivering northern squawfish harvested from locations outside our study area. Also, our estimates do not include harvest by anglers fishing at night. We did not sample boat anglers using the ramp at Bingen, site of the registration station reporting the largest catch of northern squawfish. Identifying the source of these differences should be a task for the 1994 survey and continued cooperation with the northern squawfish sport reward program is needed.

Table 6. Estimates of angling effort, white sturgeon harvest, and SMTF harvest guidlines for recreational fisheries in Bonneville, The Dalles, and John Day reservoirs, 1987-1993.

| Reservoir, Year | Period | Angler trips | CPUE | Harvest | Annual SMTF guidline |
|---|---|---|---|---|---|
| Bonneville | | | | | |
| 1987 | a | | | | b |
| 1988 | Mar-Oct | 10,429 | 0.15 | 1,532 | b |
| 1989 | Mar-Oct | 13,820 | 0.20 | 2,798 | b |
| 1990 | Mar-Oct | 14,562 | 0.15 | 2,114 | b |
| 1991 | Mar-Oct | n/a | -- | 1,410 | 1,350 |
| 1992 | Apr-Oct | 8,550 | 0.10 | 880 | 1,350 |
| 1993 | Mar-Oct | 14,347 | 0.15 | 2,145 | 1,350 |
| The Dalles | | | | | |
| 1987 | Jun-Oct | 8,637 | 0.23 | 1,990 | b |
| 1988 | Mar-Oct | 7,609 | 0.12 | 907 | b |
| 1989 | Mar-Oct | 5,419 | 0.09 | 499 | b |
| 1990 | a | | | | b |
| 1991 | Mar-Oct | n/a | -- | 100 | 100 |
| 1992 | Apr-Oct | 2,590 | 0.04 | 110 | 100 |
| 1993 | Mar-Oct | 3,960 | 0.03 | 128 | 100 |
| John Day | | | | | |
| 1987 | a | | | | b |
| 1988 | a | | | | b |
| 1989 | May-Jul | 6,973 | 0.04 | 283 | b |
| 1990 | Mar-Dec | 6,869 | 0.05 | 314 | b |
| 1991 | Apr-Sep | 4,440 | 0.03 | 143 | 100 |
| 1992 | May-Oct | 2,740 | 0.03 | 90 | 100 |
| 1993 | Mar-Oct | 7,674 | 0.02 | 134 | 100 |

*a The fishery was not sampled.*
*b SMTF harvest guidelines were first established in 1991.*

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Appendix Table B-1.1. History of recreational fishery sturgeon regulations for the Columbia River between Bonneville and McNary dams, 1987-1994.

| Year | Daily bag limit | Size limit | Other |
|---|---|---|---|
| 1987 | 2 | 36" min<br>72" max | Oregon - Sturgeon catch record and 30 fish annual bag limit required since 1986.<br>Washington - No gaffing of sturgeon. |
| 1988 | 2 | 40" min<br>72" max | Washington - Sturgeon catch record required. Size limit increase effective April 30, 1988. |
| 1989 | 2 | 40" min<br>72" max | Washington - 15 fish annual limit. |
| 1990 | 2 | 40" min<br>72" max | Oregon - 15 fish annual limit, no gaffing of sturgeon.<br>Oregon and Washington - Single point barbless hooks. |
| 1991 | 1/1 | 40" min<br>72" max | Oregon and Washington - Bag limit changed to 1 fish less than 48" and one fish greater than or equal to 48" (1/1 regulation) for waters downstream of The Dalles Dam . |
| | 1 | 48" min<br>66" max | Oregon and Washington - Size limit change effective April 16, 1991 for waters upstream of The Dalles Dam. |
| 1992 | 1/1 | 40" min<br>72" max | Oregon - No change from 1991 regulations for waters downstream of The Dalles Dam. |
| | 1 | 48" min<br>66" max | Oregon - No change from 1991 regulations for waters upstream of The Dalles Dam. |
| | 1/1 | 40" min<br>60" max | Washington - Size limit change effective April 16, 1992 for waters downstream of The Dalles Dam. |
| | 1 | 48" min<br>60" max | Washington - Size limit change effective April 16, 1992 for waters upstream of The Dalles Dam. |
| 1993 | 1/1 | 40" min<br>72" max | Oregon - No change from 1991 regulations for waters downstream of The Dalles Dam. |
| | 1 | 48" min<br>66" max | Oregon - No change from 1991 regulations for waters upstream of The Dalles Dam. |
| | 1/1 | 40" min<br>72" max | Washington - Size limit change effective April 16, 1993 for waters downstream of The Dalles Dam. |
| | 1 | 48" min<br>66" max | Washington - Size limit change effective April 16, 1993 for waters upstream of The Dalles Dam. |
| 1994 | 1/1 | 42" min<br>66" max | Oregon and Washington - Size limit effective January 1, 1994 for waters downstream of The Dalles Dam. 10 fish annual limit. |
| | 1 | 48" min<br>66" max | Oregon and Washington - No change in size limits from final 1993 regulations for waters upstream of The Dalles Dam. 10 fish annual limit. |

Appendix Table B-1.2. Numbers of days angling effort within index areas was counted on Bonneville, The Dalles, and John Day reservoirs, March through October 1993.

| Month | Bonneville | The Dalles | John Day |
|---|---|---|---|
| March | 10 | 14 | 9 |
| April | 11 | 19 | 11 |
| May | 11 | 19 | 11 |
| June | 9 | 15 | 11 |
| July | 12 | 19 | 10 |
| August | 9 | 18 | 11 |
| September | 11 | 18 | 10 |
| October | 11 | 17 | 9 |
| Total | 84 | 139 | 82 |

## 1994 Recommendations for white sturgeon management in Zone 6 of the Columbia River

### Introduction

Habitat changes and exploitation have reduced the distribution and abundance of white sturgeon throughout the Columbia River basin. Hydroelectric development and operation have lowered production by dampening spring flows, segmenting populations within reservoirs, and reducing the abundance of anadromous forage species (Beamesderfer and Rien 1993; DeVore et al. 1993; DeVore and Grimes 1993; Parsley et al. 1993). Relatively unproductive populations in impoundments have been depleted by harvest levels which can be sustained by more productive, unimpounded populations.

Sturgeon are especially susceptible to overexploitation because of slow growth rates, late maturation, and sensitivity to habitat alterations (Rochard et al. 1990). Overharvest collapsed Columbia River sturgeon fisheries before 1900 (Craig and Hacker 1940). Rapid expansion of recreational and commercial fisheries between Bonneville and McNary Dams (Zone 6) through the 1980's precipitated the need for current harvest restrictions. Recovery of Zone 6 white sturgeon fisheries will depend on habitat-based enhancement and careful regulation of harvest. This document details the history of white sturgeon management in Zone 6, the current status of populations, options for enhancement, and recommendations for 1994 fisheries. A comprehensive, long-term plan will be developed in 1994 for white sturgeon management and enhancement.

### History of Fisheries

Indian subsistence fisheries for Columbia River sturgeon have been documented by explorers and settlers. Some sturgeon were traded to settlers in the region but exploitation of sturgeon was minimal until the mid 19th century. At first, most of the sturgeon catch was incidental to early commercial salmon harvest and sturgeon were considered a nuisance to gillnetters and trap operators who killed large numbers (Craig and Hacker 1940).

By 1880 directed fisheries sent brined sturgeon to eastern markets and smoked sturgeon to California markets. The market expanded in 1883 when the first rail line was extended to Portland and in 1888 with the advent of freezing technology. The fishery targeted large fish for their caviar and was seasonal, operating in the winter months when Atlantic sturgeon were scarce in eastern markets. Sturgeon fisheries expanded rapidly, peaking in 1892 when about 5.5 million pounds were landed (Craig and Hacker 1940). The fishery expanded to new areas in the upper Columbia and Snake rivers as lower river numbers were depleted. By 1899 landings collapsed to less than 100,000 pounds, despite establishment of a four month season, enactment of a 4 ft. minimum commercial size limit, and prohibition of Chinese gang lines in 1897-1899. The fishery remained at a low incidental level through the next 60-70 years of salmon target fisheries (Figure 1).

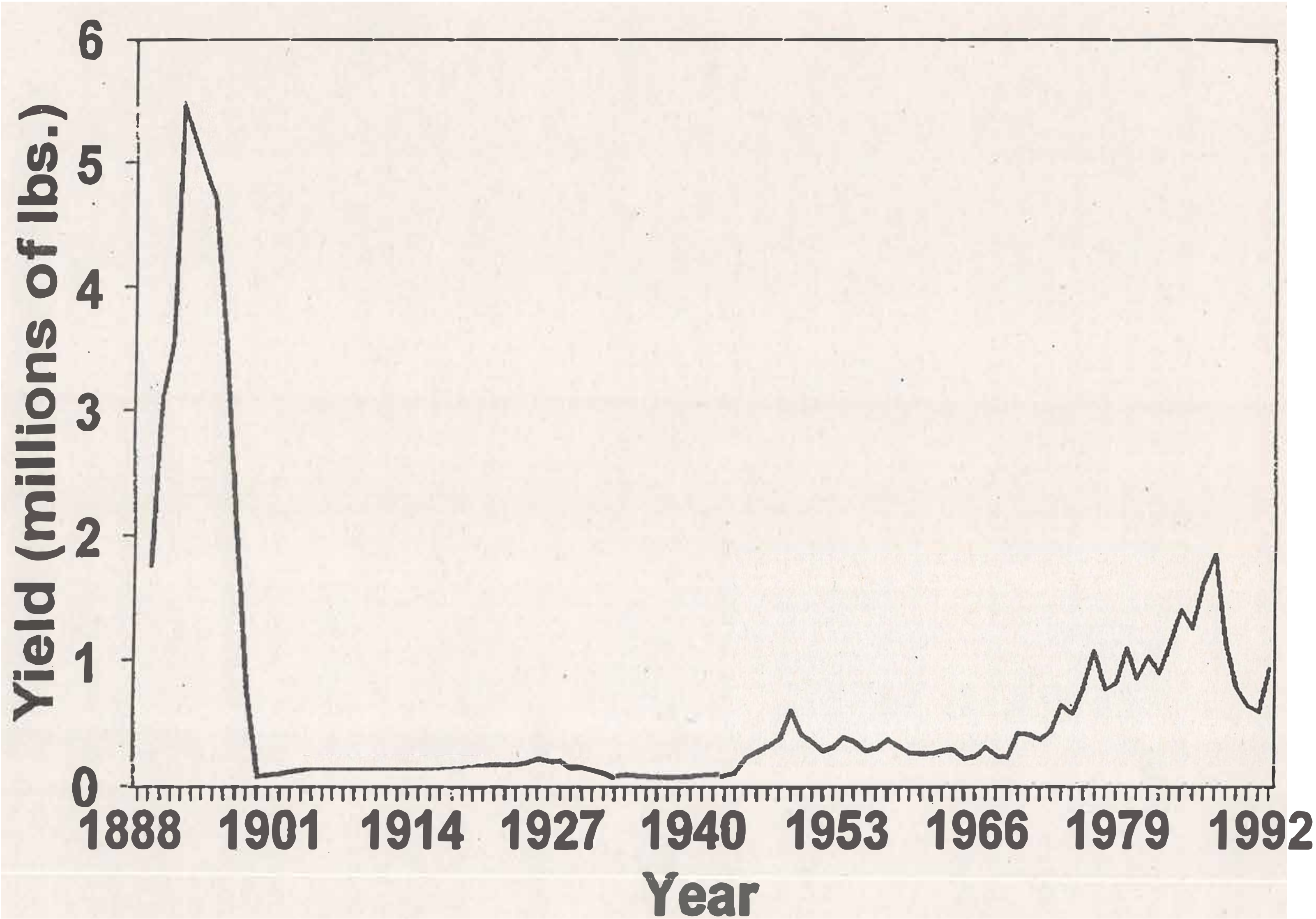


**Figure 1. Annual yield in pounds of Columbia River white sturgeon.**

In 1950 a 6 ft. maximum allowable size regulation was enacted to conserve mature broodstock fish and a 2½ ft. minimum size limit was imposed on recreational fisheries. In 1958 the recreational fishery was restricted to a 3 ft. minimum size limit. These management actions, particularly the maximum size limit, were responsible for a significant rebound of sturgeon stocks. Annual harvests doubled within twenty years and doubled again by the 1980's in response to stock recovery and the decline in salmon fishing opportunities.

State and tribal managers became concerned after combined Indian and non-Indian fisheries harvested over 16,000 white sturgeon in Zone 6 in 1987; an 82% increase in harvest relative to the previous five year average (Figure 2, Table 1). The Sturgeon Management Task Force (SMTF), comprised of representatives from the four Columbia River Indian tribes and the states of Washington and Oregon, was created to address these concerns. Their charge was to jointly develop strategies to achieve sustainable exploitation in Zone 6. The Indian position was that harvest restrictions would be balanced with enhancement.

The strategy for 1988 Zone 6 fisheries was to reduce the combined sturgeon harvest to 78% or less of the 1985-87 average. The specific goal for the Indian commercial fishery was a 40% reduction which was accomplished by reducing the setline season from 10 to 4 months (January-April) and prohibiting sale of sturgeon after September 3 during the fall season. A 25% reduction in the non-Indian recreational fishery was the goal set by SMTF and accomplished by raising the minimum size limit from 36 to 40 inches on April 30. The SMTF goals were realized for both fisheries with a catch of 4,150 in the Indian commercial fishery (Table 1, a 52% reduction from the 1985-87 average Indian commercial catch) and a catch of 3,337 in the non-Indian recreational fishery (Table 2, a 50% reduction from the 1985-87 average non-Indian catch).

In 1989 and 1990 the SMTF mandated that Zone 6 fisheries be managed for the same harvest impact levels as in 1988. The SMTF also adopted fishing sanctuaries in August 1989. The 6 ft. maximum size limit was adopted for all Indian fisheries in 1989. The 1989 Indian setline season was four months (January-April) and sale of sturgeon was prohibited during the entire fall season. The 1990 tribal commercial fishery was restricted to the same four month setline season as in 1988 and 1989 and sale of sturgeon was allowed during all commercial seasons including the fall season. Indian commercial fisheries harvested 3,500 sturgeon in 1989 and 1990 (Table 1). An annual limit of 15 sturgeon per year was imposed on Washington anglers in 1989 and Oregon anglers in 1990. Zone 6 recreational fisheries harvested 3,979 sturgeon in 1989 and 3,062 sturgeon in 1990 (Table 2). Impacts were believed to be higher in 1990 due to declines in stock abundance.

With the advent of pool-specific abundance estimates for Zone 6 populations, the SMTF agreed to harvest guidelines by pool for Indian commercial and non-Indian recreational fisheries in 1991-93 (Table 3). These guidelines corresponded to a combined fisheries' impact of a 15% harvest rate on 3-6 foot sturgeon in Bonneville Pool and a 10% harvest rate in The Dalles and John Day pools. The Columbia River Indian tribes

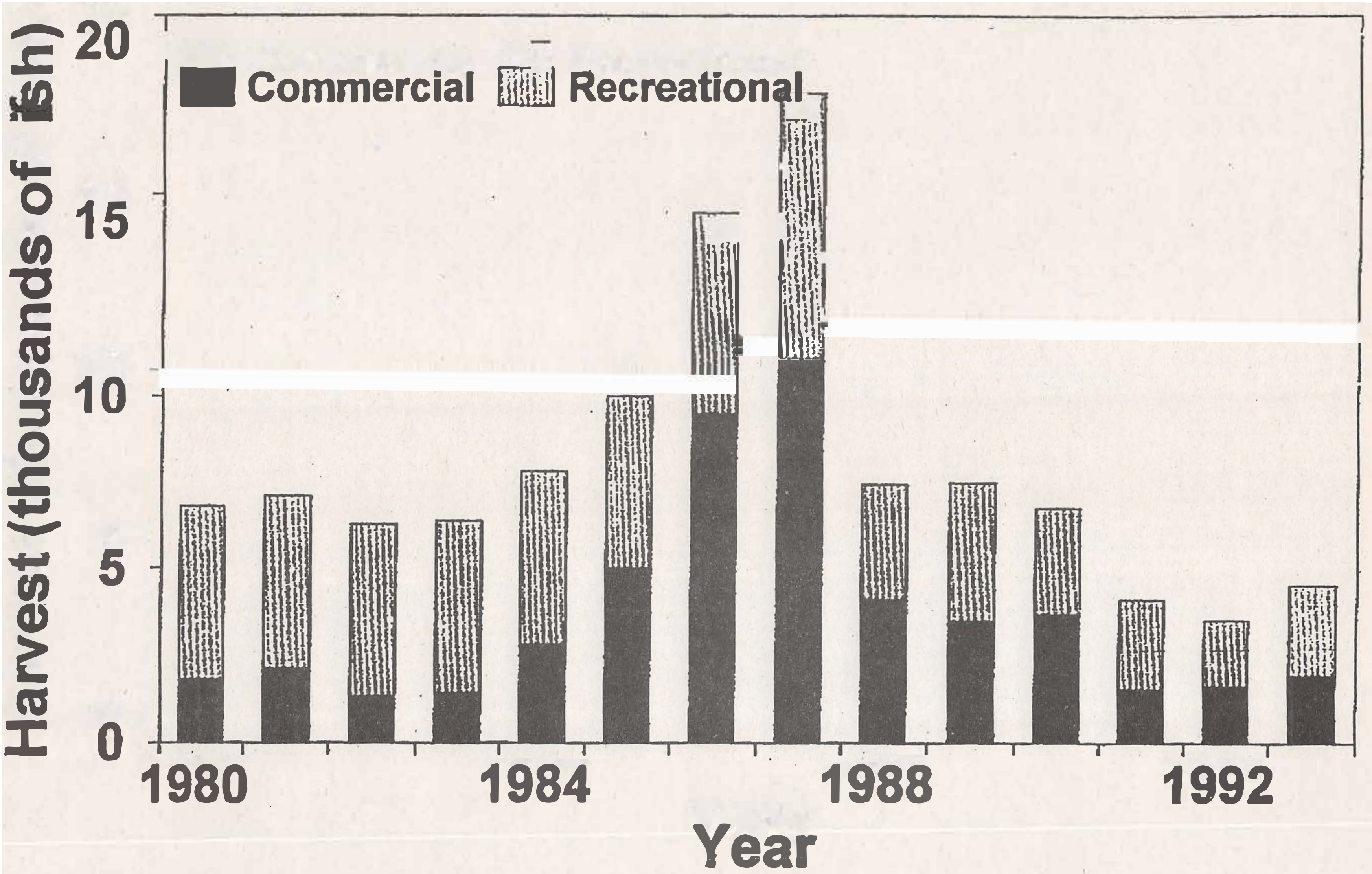


Figure 2. Harvest by fishery of Zone 6 white sturgeon, 1980-1993.

Table 1. Treaty commercial seasons and white sturgeon catch in the Columbia River, Bonneville to McNary Dams, 1983-93.

| Year | Fishery | Date | Length | Mesh Size | Catch |
|---|---|---|---|---|---|
| 1983 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 350 |
| | | Aug 1 - Dec 31 | 5 mo. | -- | 750 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 70 |
| | Fall | Aug 31 - Oct 7 | 15 days | None | 200 |
| | Total | | | | 1,370 |
| 1984 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 330 |
| | | Aug 1 - Dec 31 | 5 mo. | -- | 1,380 |
| | Winter | Feb 1 - Mar 21 | 49 days | None | 400 |
| | Fall | Aug 6 - Oct 15 | 32 days | 6-1/2" Max., None & 8" Min. | 700 |
| | Total | | | | 2,810 |
| 1985 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 600 |
| | | Jul 1 - Dec 31 | 6 mo. | -- | 1,400 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 1,090 |
| | Sockeye | Jun 22 - Jul 10 | 18 days | 4-1/2" Max. | 150 |
| | Fall | Aug 23 - Sep 28 | 29 days | None & 8" Max. | 1,770 |
| | Total | | | | 5,010 |
| 1986 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 510 |
| | | Jul 1 - Dec 31 | 6 mo. | -- | 2,820 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 1,740 |
| | Sockeye | Jun 25 - Jun 28 | 3 days | 4-1/2" Max. | 120 |
| | Fall | Aug 18 - Oct 4 | 37 days | None & 8" Max. | 4,300 |
| | Total | | | | 9,490 |
| 1987 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 960 |
| | | Jul 1 - Dec 31 | 6 mo. | -- | 2,270 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 3,070 |
| | Sockeye | Jun 23 - Jul 10 | 13 days | 4-1/2" Max. | 430 |
| | Fall | Aug 10 - Oct 15 | 46 days | None | 4,410 |
| | Total | | | | 11,140 |
| 1988 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 370 |
| | Winter | Feb 1 - Mar 21 | 49 days | None | 1,610 |
| | Sockeye | Jun 22 - Jul 9 | 14 days | 4-1/2" Max. | 210 |
| | Fall | Sug 10 - Sep 3 | 16 days | None & 8" Min. | 1,960 |
| | Total | | | | 4,150 |
| 1989 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 440 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 3,060 |
| | Total | | | | 3,500 |

Table 1. (continued)

| Year | Fishery | Date | Length | Mesh Size | Catch |
|---|---|---|---|---|---|
| 1990 | Setline | Jan 1 - Apr 30 | 4 mo. | -- | 300 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 1,500 |
| | Fall | Aug 8 - Sep 29 | 34 days | None & 8" Min. | 1,700 |
| | Total | | | | 3,500 |
| 1991 | Setline | Jan 1 - Jan 31 | 1 mo. | -- | 80 |
| | | Apr 3 - May 4 | 1 mo. | -- | 180 |
| | Winter | Feb 1 - Mar 21 | 48 days | None | 1,230 |
| | Total | | | | 1,490 |
| 1992 | Setline | Jan 1 - Mar 5 | 2 mo. | -- | 285 |
| | | Apr 1 - Apr 30 | 1 mo. | -- | 220 |
| | | Jul 1 - Jul 31 | 1 mo. | -- | 280 |
| | | Oct 26 - Nov 30 | 35 days | -- | 180 |
| | Winter | Feb 1 - Mar 5 | 34 days | None | 625 |
| | Total | | | | 1,590 |
| 1993 | Setline | Jan 1 - Jan 31 | 1 mo. | -- | 3 |
| | Winter | Feb 1 - Mar 20 | 47 days | None | 1,890 |
| | Fall | Closed season | -- | -- | 30 |
| | Total | | | | 2,010 |

Table 2. Estimated recreational fishery harvest of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1987-93.

| | Census period estimates | | | Annual estimates | | |
|---|---|---|---|---|---|---|
| Reservoir, Year | Period | Angler trips | Harvest | Period | Angler trips[a] | Harvest |
| Bonneville | | | | | | |
| 1987 | --[b] | | | Jan-Dec | n/a | 3,300[c] |
| 1988 | Mar-Oct | 10,429 | 1,532 | Jan-Dec | 12,727 | 1,870[a] |
| 1989 | Mar-Oct | 13,820 | 2,798 | Jan-Dec | 14,730 | 2,982[a] |
| 1990 | Mar-Oct | 14,562 | 2,114 | Jan-Dec | 15,495 | 2,249[a] |
| 1991 | Mar-Oct | n/a | 1,410[d] | Jan-Dec | n/a | 2,270[c] |
| 1992 | Apr-Oct | 8,550 | 880[d] | Jan-Dec | n/a | 1,717[c] |
| 1993 | Mar-Oct | 14,346 | 2,145 | Jan-Dec | 15,431 | 2,307[a] |
| The Dalles | | | | | | |
| 1987 | Jun-Oct | 8,637 | 1,990 | Jan-Dec | 10,685 | 2,462[a] |
| 1988 | Mar-Oct | 7,609 | 907 | Jan-Dec | 9,087 | 1,083[a] |
| 1989 | Mar-Oct | 5,419 | 499 | Jan-Dec | 7,521 | 693[a] |
| 1990 | --[b] | | | Jan-Dec | n/a | 482[c] |
| 1991 | Mar-Oct | n/a | 100 | Jan-Dec | n/a | 199[c] |
| 1992 | Apr-Oct | 2,590 | 110 | Jan-Dec | 3,282 | 139[c] |
| 1993 | Mar-Oct | 4,254 | 128 | Jan-Dec | 5,257 | 158[a] |
| John Day | | | | | | |
| 1987 | --[b] | | | Jan-Dec | n/a | 960[c] |
| 1988 | --[b] | | | Jan-Dec | n/a | 384[c] |
| 1989 | May-Jul | 6,973 | 283 | Jan-Dec | 7,499 | 304[a] |
| 1990 | Mar-Dec | 6,869 | 314 | Jan-Dec | 7,247 | 331[a] |
| 1991 | Apr-Sep | 4,440 | 143 | Jan-Dec | 4,658 | 150[a] |
| 1992 | May-Oct | 2,740 | 90[d] | Jan-Dec | n/a | 147[c] |
| 1993 | Mar-Oct | 8,130 | 134 | Jan-Dec | 8,737 | 144[c] |
| Combined | | | | | | |
| 1987 | | n/a | 1,990 | Jan-Dec | n/a | 6,721 |
| 1988 | | n/a | 2,439 | Jan-Dec | n/a | 3,337 |
| 1989 | | 26,212 | 3,580 | Jan-Dec | 29,750 | 3,979 |
| 1990 | | n/a | 2,428 | Jan-Dec | n/a | 3,062 |
| 1991 | | n/a | 1,653 | Jan-Dec | n/a | 2,619 |
| 1992 | | 13,880 | 1,080 | Jan-Dec | n/a | 2,003 |
| 1993 | | 26,730 | 2,407 | Jan-Dec | 29,425 | 2,609 |

[a]*Census estimate expanded for months not sampled using catch record monthly harvest proportions.*
[b]*No sampling conducted.*
[c]*Catch record estimate corrected by the ratio: (census estimate)/(census period catch record estimate), Bonneville = 1988-90 average, The Dalles = 1987-89 average, John Day = 1989-91 average.*
[d]*Census estimate biased because of minimal sampling.*

Table 3. Harvest guidelines and catches of white sturgeon by reservoir in Zone 6 of the Columbia River, 1991-93.

| Fishery | Year | Reservoir | | | | |
|---|---|---|---|---|---|---|
| | | Bonneville | The Dalles | John Day | Unknown | Total |
| Indian commercial | Guideline | 1,250 | 300 | 100 | 0 | 1,650 |
| | 1991 | 1,160 | 340 | 40 | 0 | 1,540 |
| | 1992 | 1,136 | 431 | 23 | 0 | 1,590 |
| | 1993 | 1,415 | 579 | 12 | 0 | 2,006 |
| Non-Indian recreational | Guideline | 1,350 | 100 | 100 | 0 | 1,550 |
| | 1991 | 2,270 | 199 | 150 | 0 | 2,619 |
| | 1992 | 1,717 | 139 | 147 | 0 | 2,003 |
| | 1993[a] | 2,307 | 158 | 144 | 0 | 2,609 |
| Combined fisheries | Guideline[b] | 2,600 | 400 | 200 | 0 | 3,200 |
| | 1991 | 3,430 | 539 | 190 | 0 | 4,159 |
| | 1992 | 2,853 | 570 | 170 | 0 | 3,593 |
| | 1993[a] | 3,722 | 737 | 156 | 0 | 4,615 |
| Indian subsistence | Guideline[b] | None | None | None | None | None |
| | 1991 | --[c] | --[c] | --[c] | --[c] | --[c] |
| | 1992 | 89 | --[c] | --[c] | 119 | 208 |
| | 1993 | 146 | 31 | 30 | 56 | 263 |

[a]*Preliminary.*
[b]*Indian subsistence catches haven't counted against the guideline.*
[c]*Not available.*

managed to the 1991-93 harvest guidelines by closing areas when harvest goals were reached. In 1991 the setline season was reduced to 2 months (January and April 3-May 4), sale of sturgeon was prohibited during the fall season, and Indian commercial catch totaled 1,500. The 1992 setline season was five months in duration (January 1-March 5, April 1-30, July 1-31, and October 26-November 30). Setline fishing was closed after March 5 in The Dalles Pool and after April 30 in John Day Pool to stay within the SMTF harvest guidelines. Sturgeon sales were again prohibited during the fall setnet season and total Indian commercial catch was 1,600. In 1993 sturgeon were only allowed for sale during the January setline season and the winter setnet season which occurred February 1-March 20. Sturgeon sales were prohibited for the rest of the year because the SMTF harvest guideline was exceeded during the winter season (Table 3). There was also some confusion with recording of catch area on fish receiving tickets: some of The Dalles Reservoir catch was recorded as coming from Bonneville Pool.

Recreational fisheries in Zone 6 were limited during 1991-93 by reducing size and bag limits to meet the SMTF harvest guidelines. In Bonneville Pool the daily bag limit was reduced from 2 fish per day to the "1 and 1" daily bag limit where 1 fish less than 48 in. plus 1 fish greater than or equal to 48 in. were allowed per day. Harvest reductions for the recreational fisheries in The Dalles and John Day pools, where the populations were much more depressed, were accomplished by reducing the daily bag limit to one fish per day and reducing the allowable size slot to 48-66 in. Washington adopted further restrictions in April 1992 when the maximum size limit for sturgeon was reduced to 60 in. for all state waters. This regulation was not adopted by Oregon and therefore rescinded by Washington in April 1993 because non-concurrent regulations were unenforceable. The annual non-Indian recreational catch was 2,619 in 1991 and 2,003 in 1992 (Table 3). The harvest guideline for the Zone 6 recreational fishery was exceeded in all three pools in 1993 with a total catch of 2,609 (Table 3).

## Current Stock Status

No recent estimates of sturgeon numbers or exploitation rates are available. Current estimates of numbers, exploitation rates, and harvests corresponding to sustainable exploitation rates are based on mark and recapture sampling conducted as part of BPA-funded research from 1987-90 (Table 4). More recent information on stock status is available only from summary reports on surveys of recreational sturgeon anglers (Table 5). Effort and catch per trip of legal sturgeon generally declined as more restrictive regulations were enacted, however, it was unclear whether decreases in legal catch per trip resulted from a narrower inclusive harvest size range, restricted bag limits, or from true declines in abundance. In Bonneville Reservoir where regulation changes were minor from 1988-93, annual variation in legal catch rate was substantial (plus or minus 30-40%). No trends were obvious among years since harvests were restricted in the late 1980's, in catch per trip for the 48-66" size range or for all sizes combined. Catch rates were variable, results from boat and bank fisheries did not correspond, and changes in abundance of sizes affected by fisheries

Table 4. Abundance of white sturgeon based on mark-recapture estimates (N̂ for fish 31-72 in. FL) in three lower Columbia River reservoirs, 1987-90. Confidence intervals (95%) are in parentheses. (from Beamesderfer and Rien 1993).

| | | Fork Lengths (in.) | | | | | Age | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | N̂ | 24-35 | 36-47 | 48-72 | >72 | Σ | 1 | 10 | 25 | No. per Ha | Kg per Ha |
| **Bonneville Reservoir** | | | | | | | | | | | |
| 1989 | 35,400 (27,500 - 45,400) | 32,900 | 16,700 | 1,200 | 600 | 51,400 | 25,700 | 3,020 | 340 | 6.12 | 30.0 |
| **The Dalles Reservoir** | | | | | | | | | | | |
| 1987 | 23,600 (15,700 - 33,600) | 7,800 | 11,000 | 7,900 | 1,000 | 27,700 | 13,600 | 1,600 | 160 | 6.16 | 81.4 |
| 1988 | 9,000 (7,300 - 11,000) | 4,200 | 4,300 | 2,000 | 800 | 11,300 | 1,200 | 140 | 40 | 2.51 | 35.5 |
| **John Day Reservoir** | | | | | | | | | | | |
| 1990 | 3,900 (2,300 - 6,100) | 3,600 | 1,700 | 500 | 500 | 6,300 | 3,200 | 380 | 60 | 0.30 | 3.6 |

Table 5. Summary of effort and catch rates by recreational anglers in Zone 6, 1983-93. Surveys include variable periods between March and October.

| | Size Limits (inches) | | Effort (trips) | Catch per trip | | | |
|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | | Legal | 48-66 in. | >72" | All |
| | | | Bonneville Reservoir | | | | |
| Boat anglers | | | | | | | |
| 1988 | 40 | 72 | 4,776 | 0.207 | 0.030 | 0.018 | 1.256 |
| 1989 | 40 | 72 | 5,792 | 0.228 | 0.043 | 0.009 | 1.669 |
| 1990 | 40 | 72 | 7,349 | 0.182 | 0.045 | 0.003 | 1.386 |
| 1992 | 40 | 60/72[a] | 3,210 | 0.128 | 0.031 | 0.006 | 1.500 |
| 1993 | 40 | 60/72[a] | 6,747 | 0.237 | 0.025 | 0.011 | 1.740 |
| Bank anglers | | | | | | | |
| 1988 | 40 | 72 | 5,653 | 0.126 | 0.019 | 0.000 | 0.726 |
| 1989 | 40 | 72 | 8,028 | 0.196 | 0.037 | 0.001 | 1.456 |
| 1990 | 40 | 72 | 7,213 | 0.124 | 0.031 | 0.001 | 1.188 |
| 1992 | 40 | 60/72[a] | 5,340 | 0.090 | 0.023 | 0.005 | 1.056 |
| 1993 | 40 | 60/72[a] | 7,599 | 0.146 | 0.020 | 0.000 | 1.822 |
| | | | The Dalles Reservoir | | | | |
| Boat anglers | | | | | | | |
| 1987 | 36 | 72 | 3,618 | 0.272 | 0.094 | 0.007 | 1.161 |
| 1988 | 40 | 72 | 2,566 | 0.146 | 0.064 | 0.007 | 1.358 |
| 1989 | 40 | 72 | 1,760 | 0.140 | 0.055 | 0.005 | 1.392 |
| 1992 | 48 | 60/66[a] | 1,090 | 0.032 | 0.028 | 0.016 | 1.112 |
| 1993 | 48 | 60/66[a] | 2,196 | 0.041 | 0.028 | 0.004 | 1.629 |
| Bank anglers | | | | | | | |
| 1987 | 36 | 72 | 5,019 | 0.304 | 0.093 | 0.016 | 0.945 |
| 1988 | 40 | 72 | 5,043 | 0.117 | 0.049 | 0.024 | 0.517 |
| 1989 | 40 | 72 | 3,659 | 0.076 | 0.032 | 0.007 | 0.684 |
| 1992 | 48 | 60/66[a] | 1,500 | 0.061 | 0.045 | 0.030 | 2.105 |
| 1993 | 48 | 60/66[a] | 2,058 | 0.029 | 0.023 | 0.002 | 0.606 |

Table 5. (continued)

| | Size Limits (inches) | | Effort (trips) | Catch per trip | | | |
|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | | Legal | 48-66 in. | >72" | All |
| | | | John Day Reservoir | | | | |
| Boat anglers | | | | | | | |
| 1983[b] | 36 | 72 | 611 | 0.514 | -- | 0.028 | 1.433 |
| 1984 | 36 | 72 | 3,295 | 0.153 | -- | 0.016 | 0.619 |
| 1985 | 36 | 72 | 6,287 | 0.127 | -- | 0.006 | 0.600 |
| 1986 | 36 | 72 | 5,885 | 0.085 | -- | 0.009 | 0.701 |
| 1989 | 40 | 72 | 3,401 | 0.076 | 0.010 | 0.006 | 1.001 |
| 1990 | 40 | 72 | 3,063 | 0.082 | 0.028 | 0.024 | 1.041 |
| 1991 | 48 | 66 | 2,463 | 0.041 | 0.029 | 0.027 | 1.461 |
| 1992 | 48 | 60/66[a] | -- | 0.061 | -- | 0.030 | 1.449 |
| 1993 | 48 | 60/66[a] | 4,467 | 0.029 | 0.021 | 0.020 | 1.005 |
| Bank anglers | | | | | | | |
| 1983[b] | 36 | 72 | 2,783 | 0.308 | -- | 0.017 | 0.859 |
| 1984 | 36 | 72 | 4,948 | 0.059 | -- | 0.006 | 0.236 |
| 1985 | 36 | 72 | 4,927 | 0.234 | -- | 0.010 | 1.105 |
| 1986 | 36 | 72 | 4,902 | 0.135 | -- | 0.015 | 1.119 |
| 1989 | 40 | 72 | 3,572 | 0.033 | 0.006 | 0.013 | 0.354 |
| 1990 | 40 | 72 | 3,806 | 0.030 | 0.009 | 0.012 | 0.117 |
| 1991 | 48 | 66 | 1,977 | 0.038 | 0.018 | 0.028 | 0.624 |
| 1992 | 48 | 60/66[a] | 1,760 | 0.017 | 0.013 | 0.008 | 0.404 |
| 1993 | 48 | 60/66[a] | 3,663 | 0.005 | 0.003 | 0.003 | 0.155 |

[a]*Nonconcurrent regulations in Oregon and Washington during part of year.*
[b]*Survey in tailrace only.*

could be masked by changes in abundance of fish of other sizes. Catch rates of oversized fish provided no useful trend information because oversized fish were rare in the catch.

Information from sport angler surveys is poorly suited for evaluating trends in abundance of sturgeon sizes susceptible to fisheries unless the legal size range remains constant. Large annual variability in catch rate could make trends difficult to discern even when the legal size range is fixed. This limited information provides no basis for concluding sturgeon numbers have changed within the last 6-11 years. Assessments should be made based on updated mark-recapture surveys and computer population simulations.

We believe current sturgeon numbers are similar to those estimated from 1987-90 and that the 1991-93 harvest guidelines correspond to exploitation rates which will continue to provide the maximum sustained yield. Updated stock assessments based on mark-recapture sampling are currently planned for all three Zone 6 reservoirs beginning in 1994 or 1995.

## Enhancement Options

All three Zone 6 reservoirs provide large areas of suitable sturgeon habitat but the productivity of populations in The Dalles and John Day reservoirs is limited by poor recruitment (Beamesderfer and Rien 1993). High river discharge in spring increases availability of spawning habitat and appears correlated with spawning success (Parsley et al. 1993). Spawning habitat in The Dalles and John Day reservoirs is scarce at flows less than 200 and 250 kcfs (Parsley 1993, in Appendix) and a series of dry years has depressed recruitment in those reservoirs. Without enhancement, sturgeon fisheries in The Dalles and John Day reservoirs will remain depressed for at least 10-15 years as recent weak year-classes are recruited to catchable sizes. Maximum production from these reservoirs will result from full seeding of available habitat but prospects for full seeding appear poor without enhancement.

Recruitment does not limit production of sturgeon in Bonneville Reservoir. Tailrace morphology provides adequate spawning habitat at a wide range of discharges and recruitment is significant during most years. Higher densities of sturgeon in Bonneville Reservoir than in other reservoirs are accompanied by reduced growth rate, poorer condition factor, and smaller size at maturity. This pattern implies that numbers are at or near carrying capacity in Bonneville Reservoir and that additional fish will not increase numbers available to fisheries. Improved growth and condition should compensate for greater harvest rates in Bonneville Reservoir (15%) than in other reservoirs (10%).

Research results suggest that the most effective enhancement measures for Zone 6 will improve recruitment in The Dalles and John Day reservoirs. We propose evaluations of the feasibility of increased discharge and of juvenile transplants for enhancing depressed sturgeon populations. Benefits from flow augmentation will be delayed for 10 or more years until fish are recruited to fisheries. A transplant program would provide a stop-gap measure to replace poor year-classes during the last 10-15 years. A transplant program could also indicate whether supplementation of The Dalles and John Day populations can be effective.

Work by the U.S. Fish and Wildlife Service has established a mechanism explaining apparent correlations between flow and sturgeon spawning success. Greater spring discharges increase spawning habitat, but it remains unclear how much spawning habitat for what period of time will be effective. More work is needed to verify the correlation between flow and recruitment, to identify specific, defensible flow-augmentation measures, and to predict the benefits of specific flow-augmentation measures. Current research is reanalyzing historical data and supplementing with additional sampling. We propose using this research to develop flow augmentation experiments to evaluate the feasibility of stimulating sturgeon spawning in McNary Dam tailrace. These experiments could be based on project operations in contrast to the system-wide water budget needed to enhance salmonid survival, although this research and sturgeon recruitment would probably benefit from flow augmentation to improve salmonid survival.

We propose conducting a trial transport program during the next 4 years, if results of test sampling in 1993 indicate that evaluation of the program is feasible. In October of 1993 ODFW, USFWS, and NMFS collaborated to trawl for juvenile sturgeon downstream from Bonneville Dam to determine if large numbers could be caught, marked, and released alive. ODFW is currently preparing a written proposal including a detailed experimental design for collecting juvenile sturgeon (<36″) from downstream of Bonneville Dam and/or from Bonneville Reservoir, releasing these fish in The Dalles or John Day reservoirs, and then sampling in release areas to estimate survival, growth, condition, and potential benefits to fisheries. Various alternatives will be discussed but transplants of several thousand fish per year for several years should be sufficient to evaluate whether a continued or expanded program is necessary. Transplants of these numbers would have minimal effects on the populations in collection or release areas. Evaluation of the transport program would include state/tribal discussions concerning development of a harvest plan for The Dalles and John Day reservoirs should the program be successful. The harvest plan should be based on realized benefits from the transport program for white sturgeon population in these reservoirs. The ongoing sturgeon research program is adding a representative from CRITFC in 1994 to facilitate tribal review and application of research results and proposals including the detailed ″trawl and haul″ proposal.

We are not proposing passage improvements at this time. Existing fish ladders seldom pass sturgeon but a fish elevator has been used with some success after construction of Bonneville Dam (Warren and Beckman 1993). However, construction or modification of passage facilities would be costly and could affect passage efficiency of adult salmonids including ESA-listed stocks. Passage improvements might be reconsidered if transplants and flow augmentation do not appear feasible.

Nor are we proposing development of a sturgeon hatchery at this time. Wild spawning of sturgeon in other areas or during higher spring flows should be adequate to seed available habitat in The Dalles and John Day reservoirs to carrying capacity. Benefits of a sturgeon hatchery program would be constrained by rearing habitat limitations. Stocking juvenile sturgeon in excess of carrying capacity would reduce numbers and sizes available to fisheries by depressing growth, reducing condition, and delaying recruitment. This situation contrasts with that of salmon where additional releases increase adult returns because of weak density-dependent effects at current run sizes. Introductions of hatchery-reared sturgeon from a few broodstock could reduce genetic diversity of wild fish and ultimately reduce productivity of the wild stock. A sturgeon hatchery program would also be costly, controversial, and subject to unknown disease risks. Evaluation of the potential benefits of hatchery supplementation should be based on ongoing stocking programs in the upper Snake and Willamette rivers where wild sturgeon populations are small or absent. A hatchery program might be reconsidered if transplants and flow augmentation do not appear feasible.

We have little or no basis for expecting significant benefits to sturgeon production from other proposed alternatives like pollution abatement, substrate additions, or food enhancement. Limited testing of sturgeon tissue samples from throughout the basin has detected low levels of some pollutants but sample sizes are low and results are inconclusive. The ongoing sturgeon research program is investigating potential pollutant problems. Spawning success in all reservoirs is limited by flow rather than substrate which is abundant in all dam tailraces. Alternatives for and benefits of food enhancement are unclear. Sturgeon growth and condition in The Dalles and John Day reservoirs are similar to below Bonneville Dam. Benthic standing crops are often greater in the reservoirs than downstream from Bonneville Dam.

## Recommendations for Zone 6 Fisheries

Recent harvests continue to exceed optimum rates despite current restrictions. Harvest at rates greater than optimum will reduce average long-term yield from the fisheries and reproductive potential of the population. Zone 6 sport anglers in Oregon and Washington will be subject to the following changes in regulations beginning January 1, 1994: a 66 in. maximum size limit for Bonneville Reservoir (currently 72 in.), a 42 in. minimum size in Bonneville Reservoir (currently 40 in.), and a 10 fish annual limit in all areas (currently 15 fish). These changes are expected to reduce non-Indian harvest by 40% in Bonneville Reservoir and by a slight amount in The Dalles and John Day reservoirs.

The following changes in Indian commercial and subsistence fisheries are proposed for SMTF consideration for 1994 to maintain harvest at exploitation rates which should provide the maximum sustained yield:

*Size Limits*: It is recommended that size limits identical to the non-Indian regulations be adopted by Indian tribes for commercial and subsistence fisheries. These regulations should include a 66 in. maximum for all fisheries, a 42 in. minimum for subsistence fisheries in Bonneville Reservoir, and a 48 in. minimum for subsistence fisheries in The Dalles and John Day reservoirs. These more-restrictive size limits would dampen harvest rates and increase recruitment of broodstock fish.

*Delivery in the Round*: Dressing of fish before delivery to the buyer has increased during 1992 and 1993 Indian winter seasons. Current state and tribal regulations stipulate that sturgeon must be possessed with the head and tail on while in the field. It is currently lawful to deliver sturgeon to buyers that have had guts, gills, scutes, and fins removed. Some fishermen began doing their own partial butchering during the mid-1980's, when summertime setline seasons were open. Now most fish are delivered dressed even during the winter. Nearly all fish were dressed prior to receipt at buyers during the winter season of 1993. Fishermen are compensated by the buyer for this activity.

The consequence of dressing sturgeon in the field is that these fish cannot be sampled at buyer stations for biological data including length, weight, sex, tags, and fin rays for aging. This compromises the ability to estimate catch and accurately monitor the effectiveness of management schemes. It is recommended that the states and tribes adopt regulations for commercial fisheries stipulating that sturgeon must be possessed unbutchered and "in the round" while in the field. Butchering of commercially-sold fish should be restricted to buying stations.

*Minimum Carcass Length*: It is also recommended that the tribes and the state of Washington adopt a minimum carcass length rule of 28 in. to match the current regulation adopted by the state of Oregon for Indian and non-Indian commercial fisheries. The carcass length limit of 28 in. corresponds to the total length of 48 in. based on measurement of 100's of sturgeon before and after butchering. Although it is still possible to obtain a butchered carcass of 28 in. from some fish that were smaller than 48 in., this regulation would improve enforcement of size limits.

*Sales of Eggs*: No harvest management strategy will be effective without adequate protection of broodstock. Poaching of broodstock is a sure way of decimating the sturgeon resource. High prices for caviar and flesh continue to provide a financial incentive for illegally exploiting these fish. For instance, a Seattle federal court recently convicted a fisherman and fish buyer who sold and bought 3,200 lbs. of white sturgeon caviar illegally taken in the Columbia River between October 1985 and December 1990. This quantity approximately equals the entire legal caviar production from Indian and non-Indian commercial fisheries in the Columbia River over that same period.

We therefore recommend consideration be given by the states and tribes to prohibit marketing of sturgeon roe and caviar from the Columbia River and other state waters. With the inception of a 66 in. maximum size limit for non-Indian commercial fisheries (effective January 1993) and adoption of the 66 in. maximum regulation for Indian commercial fisheries, the amount of lawfully-taken sturgeon eggs will be only 33% of the previous amount when the maximum size limit was 72 in. Although some legally-obtained roe/caviar may be foregone in regional markets, this regulation would improve protection of valuable broodstock.

*Subsistence Harvests*: Subsistence harvests are currently accounted for and should be counted in Zone 6 harvest guidelines. Guidelines were developed in 1991 based on pool-specific abundance estimates and sustainable exploitation rates suggested by population modeling. In subsequent negotiations by the SMTF to determine allocation between Indian and non-Indian fisheries in Zone 6, it was agreed not to count subsistence harvests in the guidelines. Since a harvested fish is removed whether caught for commercial or subsistence purposes, this decision has eroded the effectiveness of the SMTF guidelines. Accuracy of subsistence catch estimates has improved in recent years and it is recommended that these catches be included in harvest guidelines for each reservoir.

## SMTF Harvest Guideline Recommendations

TAC discussed current stock status on December 3. There was general consensus that, in the absence of updated information, the harvest guidelines in place since 1991 are recommended for 1994 fisheries.

## Future Stock Assessment

Finally, it is recommended that stock assessments for Zone 6 sturgeon populations be conducted at least once every 5 years to monitor the effectiveness of enhancement and harvest management strategies. Coupled with adequate sampling of all fisheries, periodic mark-recapture studies will provide updated abundance, exploitation, and recruitment estimates. Abundance estimates can be used to determine harvest goals corresponding to sustainable exploitation rates. Observed exploitation rates describe whether regulatory measures have achieved desired rates. Recruitment estimates allow projections of future trends and should improve the basis for flow-related enhancement arguments.

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River downstream from McNary Dam, Vol. 1. Final Report (Contract DE-AI79-86BP63584) to Bonneville Power Administration, Portland, OR.

# APPENDIX B-2

DATE: June 8, 1993
REPLY TO
ATTN OF: Mike Parsley

SUBJECT: Discharges and sturgeon spawning habitat

TO: Sturgeon Project Cooperators

# memorandum

Draft 1/8/93

U.S. Fish and Wildlife Service
National Fishery Research Center
Columbia River Field Station
Star Route
Cook, Washington 98605

At our last project coordination meeting, we discussed the possibility of pursuing minimum discharge requirements in the McNary Dam tailrace to provide habitat for spawning white sturgeon. Our recommendation, based on the information provided in the manuscript detailing habitat availability that was in the final report, would be to maintain a minimum instantaneous river discharge of 250,000 cfs at McNary Dam during the time period when river temperatures are between 13 and 15 °C. The reservoir forebay elevation at John Day Dam should be kept at or lower than 264 ft above mean sea level. This discharge is the lowest discharge we simulated that provided water velocities that we deemed were best suited for spawning white sturgeon. Greater discharges would provide more habitat, lesser discharges would not provide any areas with what we have defined as high quality spawning habitat.

The effects that this minimum discharge may have had on the index of spawning habitat, had it been implemented during the past few years, are shown in the enclosed graphics. Each figure is a time series analysis detailing the index of spawning habitat (temperature conditioned weighted usable area) present each year in the McNary Dam tailrace (solid line). The dotted line is the water temperature for that year, and the dashed line indicates what the index of spawning habitat may have been with the aforementioned minimum discharge in effect.

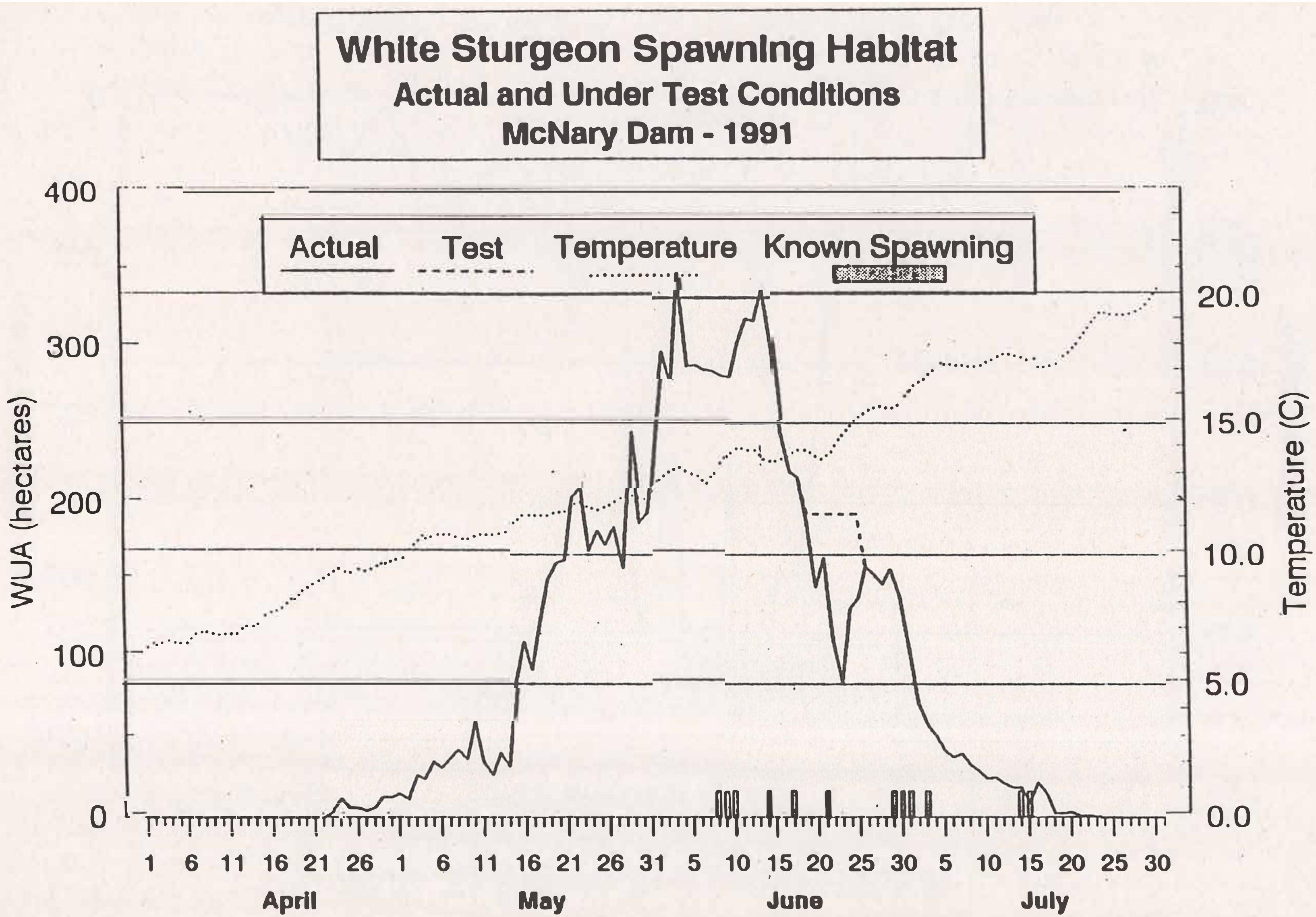
Spawning habitat would have increased greatly during low water years (1987, 1988) and because of annual variation in discharge, the minimum discharge requirement would have added additional spawning habitat at the beginning and end of the spawning season during 1990 and 1991. During 1986 river discharges exceeded 250,000 cfs for the entire time that river temperatures were between 13 and 15 °C.

The success of implementing a minimum discharge requirement would be difficult to access. Spawning could be monitored during periods when the minimum discharge is in effect, but there would be no control for comparison to determine if spawning would or would not have occurred. Spawning was not monitored in the McNary Dam tailrace during the last three low-water years (1987, 1988, 1992) which precludes using them as comparisons. Arguments supporting a minimum discharge may be strengthened each year as we relate young-of-the-year recruitment with the weighted usable spawning area that occurred.

Minimum discharge requirements for the other tailraces (Bonneville, The Dalles, and John Day) would be lower if the same criteria (lowest discharge that provides a minimal area of highly suitable spawning habitat) were used. We would recommend an instantaneous minimum discharge of 75,000 cfs at Bonneville Dam, 150,000 cfs at The Dalles, and 200,000 cfs at John Day Dam to provide habitat for spawning white sturgeon.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

Much of this information is provided in the final report for the work conducted from Phase I. However, there is a lot of detail that was not presented in the reports, such as the daily time series analysis, and pseudo-maps that portray where the spawning habitat is located as discharges change. Please call me if you have any questions or need anything clarified.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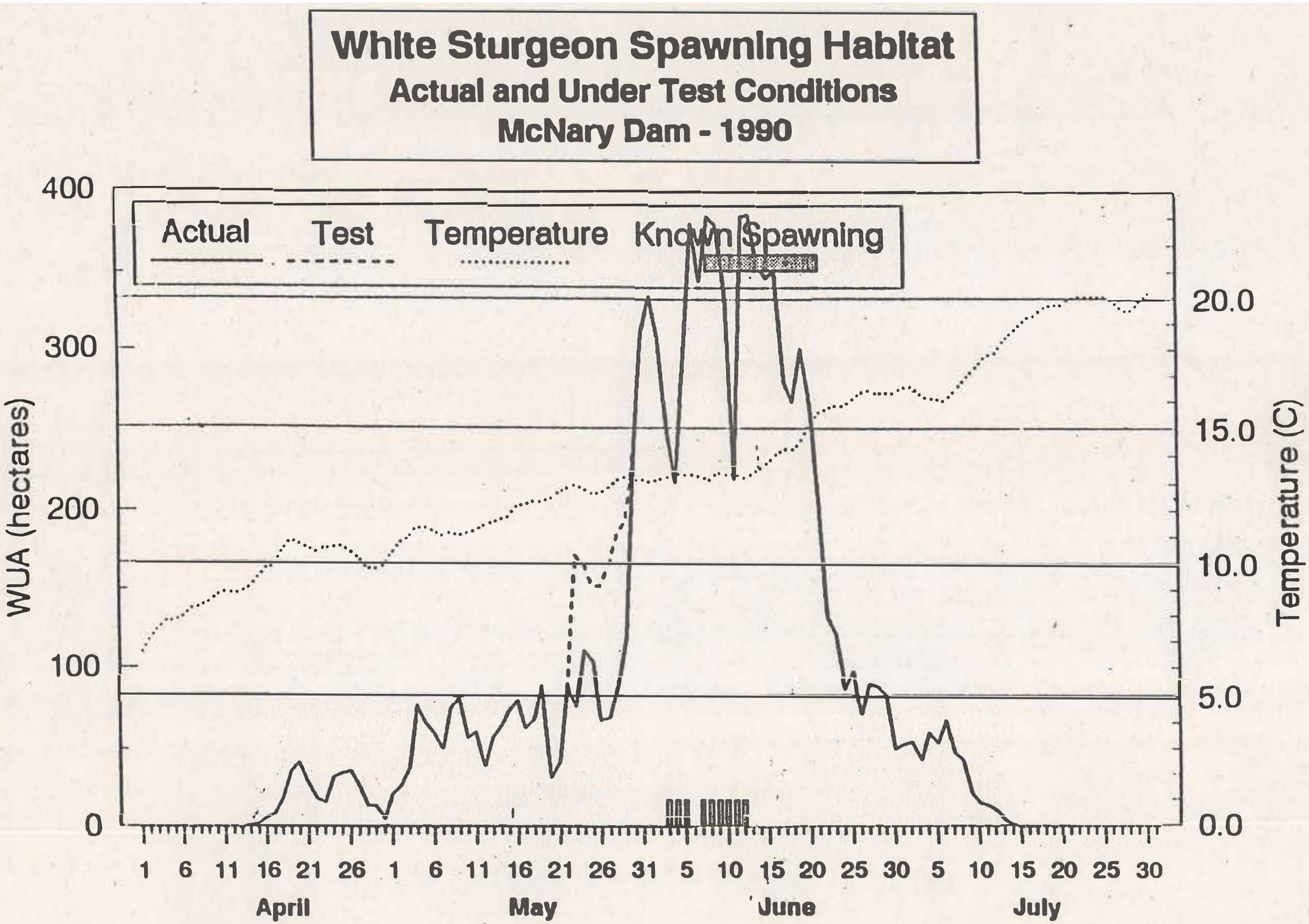
Actual and Under Test Conditions
McNary Dam - 1991
Actual
Test
Temperature
Known Spawning
WUA (hectares)
400
300
200
100
0
Temperature (C)
20.0
15.0
10.0
5.0
0.0
1 6 11 16 21 26 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30
April
May
June
July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Actual and Under Test Conditions
McNary Dam - 1990
Actual
Test
Temperature
Known Spawning
WUA (hectares)
400
300
200
100
0
Temperature (C)
20.0
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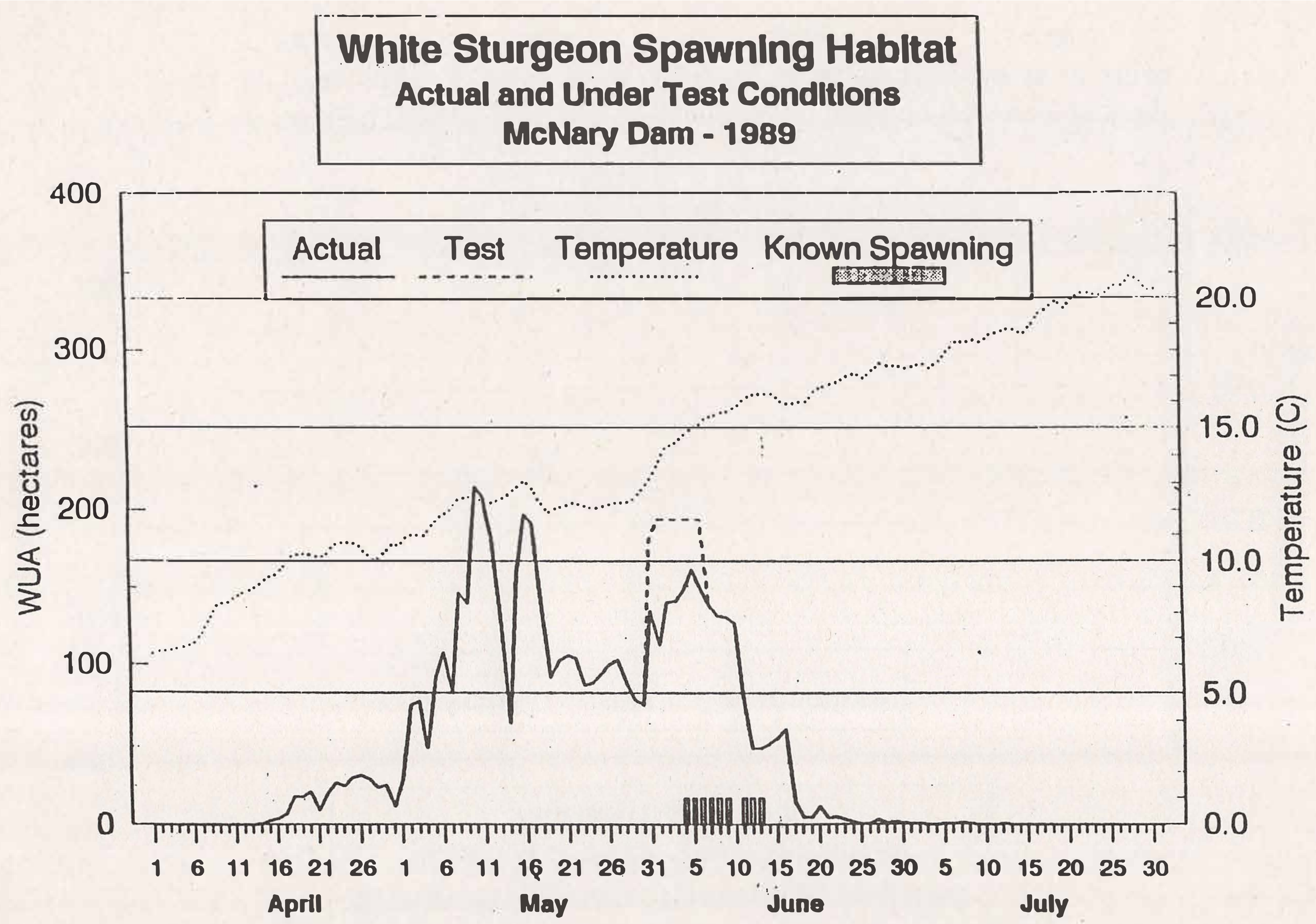
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Actual
Test
Temperature
Known Spawning
WUA (hectares)
Temperature (C)
400
300
200
100
0
20.0
15.0
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0.0
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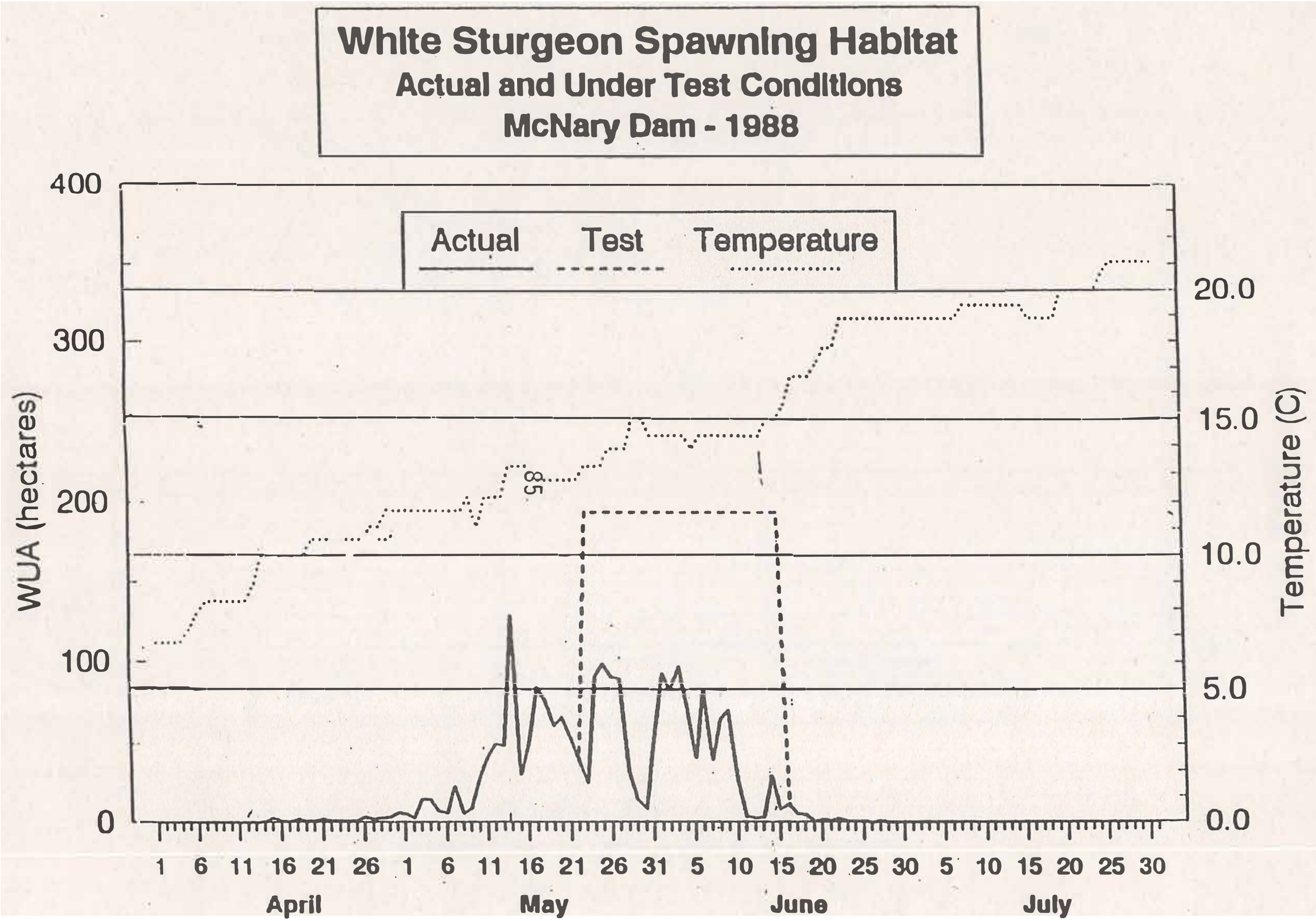
April
May
June
July



White Sturgeon Spawning Habitat
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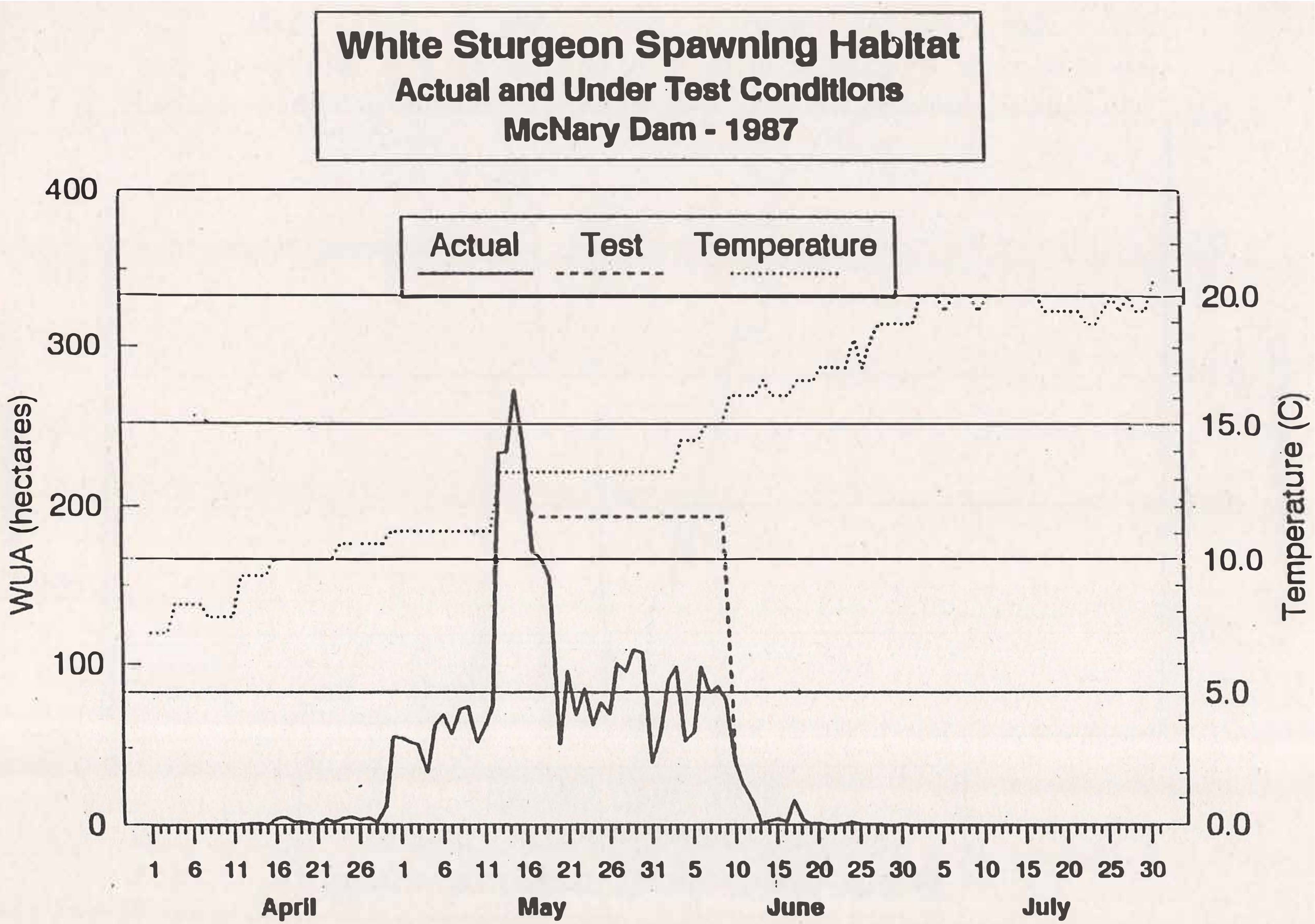
Actual
Test
Temperature
WUA (hectares)
Temperature (C)
400
300
200
100
0
20.0
15.0
10.0
5.0
0.0
1 6 11 16 21 26 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30
April
May
June
July


White Sturgeon Spawning Habitat
Actual and Under Test Conditions
McNary Dam - 1987
Actual
Test
Temperature
WUA (hectares)
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300
200
100
0
Temperature (C)
20.0
15.0
10.0
5.0
0.0
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April
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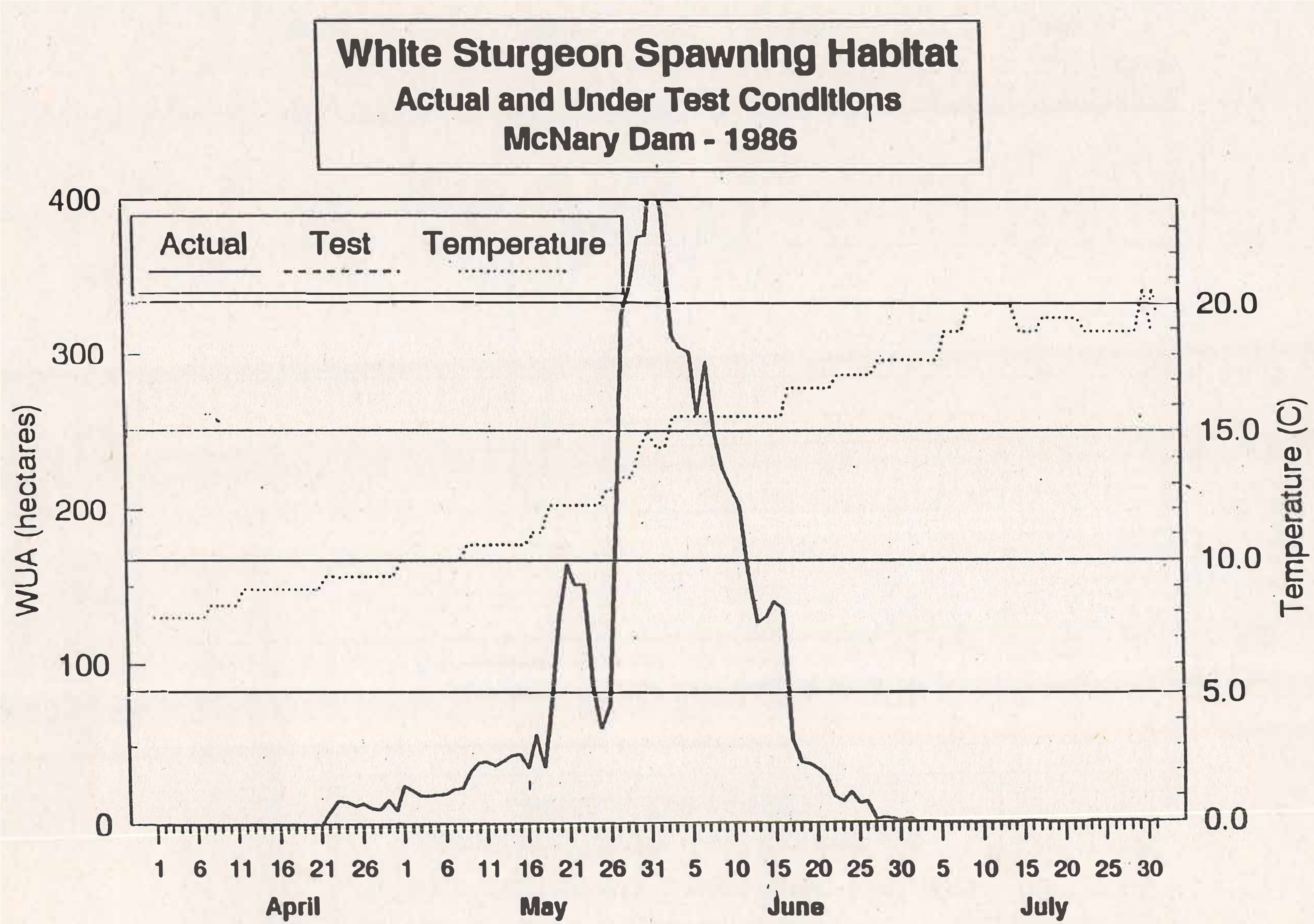
June
July


White Sturgeon Spawning Habitat
Actual and Under Test Conditions
McNary Dam - 1986
Actual
Test
Temperature
WUA (hectares)
400
300
200
100
0
Temperature (C)
20.0
15.0
10.0
5.0
0.0
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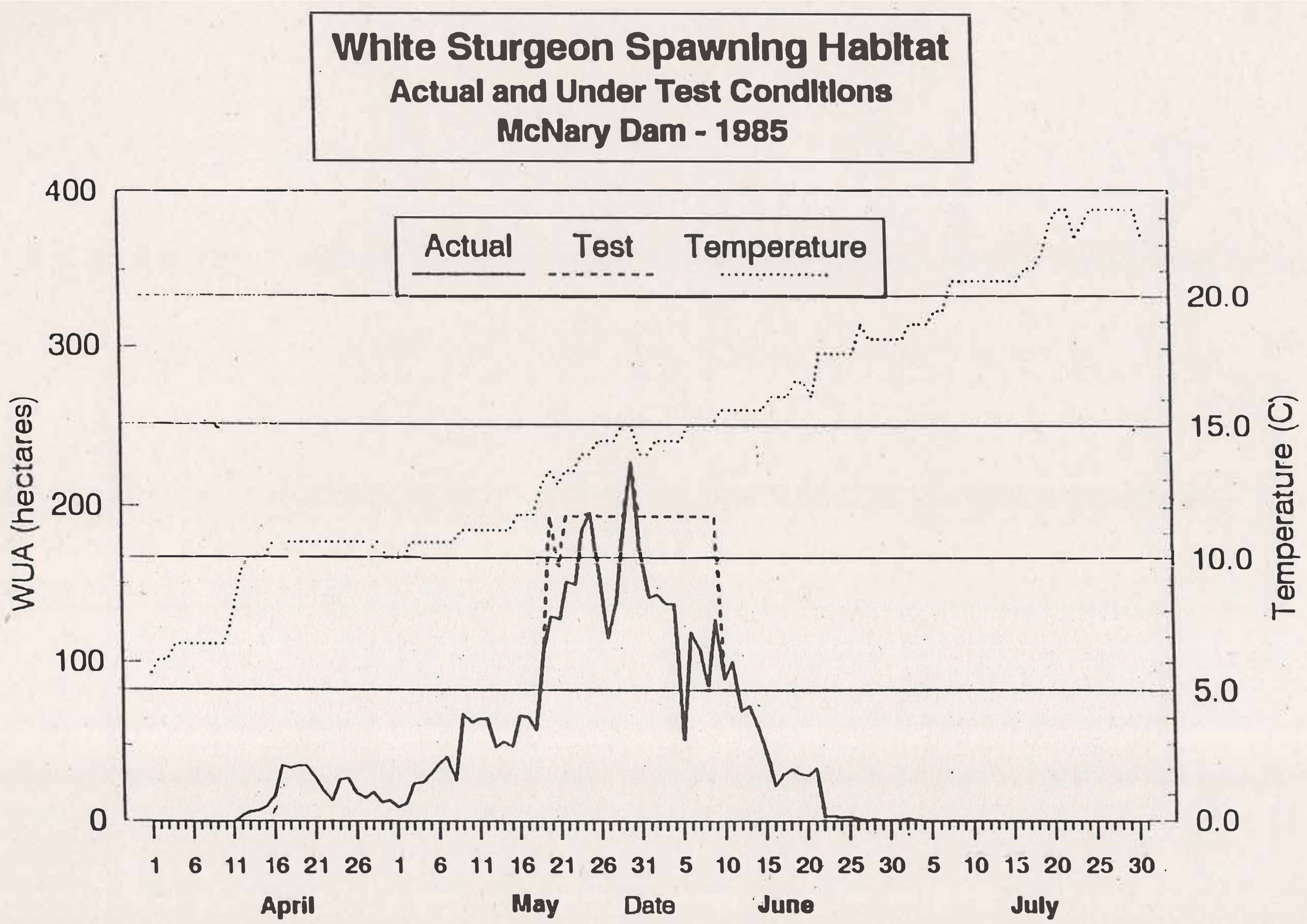
April
May
June
July



White Sturgeon Spawning Habitat
Actual and Under Test Conditions
McNary Dam - 1985
Actual
Test
Temperature
WUA (hectares)
0
100
200
300
400
Temperature (C)
0.0
5.0
10.0
15.0
20.0
1 6 11 16 21 26 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30
April
May
Date
June
July

**REPORT C**

1. Describe reproduction and early life history characteristics of white sturgeon populations in the Columbia River between Bonneville and Priest Rapids dams.

2. Define habitat requirements for spawning and rearing of white sturgeon and quantify the extent of habitat available in the Columbia River between Bonneville and Priest Rapids dams.

Prepared by:

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## CONTENTS

## ACKNOWLEDGEMENTS

We would like to thank Bill Nelson and the cooperating agencies of this study for providing critical reviews of this report. We would also like to express our appreciation to Bonneville Power Administration, and especially Rick Westerhof (Project Manager), for providing funding and support for this study.

## ABSTRACT


The National Biological Survey sampled early lifestages of white sturgeon in the Columbia River between Bonneville and Priest Rapids dams and in the Snake River downstream from Ice Harbor Dam. Contrary to trends seen in previous years egg catches were greatest in The Dalles Pool and lowest in Bonneville Pool. Catches of eggs and larvae in 1993 were also lower than for other years with similar peak discharges. These trends may be an artifact of the intensity of our sampling or altered channel hydraulics causing a change in the distribution of eggs in the channel. It is also possible that the characterization of water years as average or low may be an oversimplification of the effect of discharge patterns on white sturgeon spawning behavior. Juvenile and young-of-the-year (YOY) catches displayed a trend similar to previous years; catches were highest in Bonneville Pool and lowest in John Day Pool. The white sturgeon spawning period (estimated from back-calculated spawning dates of white sturgeon eggs and larvae) started earliest and lasted longest (53 d) in Bonneville Pool.

We documented spawning in the Hanford Reach and in the Snake River below Ice Harbor Dam for the first time. White sturgeon eggs were collected at sites up to 27 miles below Priest Rapids Dam. This contrasts with impounded reaches of the Columbia River where eggs have only been collected within several miles below each dam. Many areas of the Hanford Reach meet white sturgeon spawning habitat criteria that were developed in impounded reaches. However, spawning was only detected at sites where water turbulence appeared to be greater and substrates rougher than in adjacent areas. The estimated spawning period began 24 d earlier in the Snake River than in The Hanford Reach; however spawning began when water temperatures reached 14°C and ended at 17°C in both areas. Only 3 YOY and no juveniles were captured in McNary Pool suggesting that populations of these lifestages may be sparse. High-rise trawls were ineffective for collecting YOY and older juvenile white sturgeon in the Hanford Reach, probably due to gear avoidance related to high water velocities and low turbidity.

## INTRODUCTION

The National Biological Survey (NBS) is responsible for tasks related to Objectives 1 and 3 of this study. Objective 1 is to describe reproduction and early life history characteristics of white sturgeon *Acipenser transmontanus* populations in the Columbia River between Bonneville and Priest Rapids dams and in the Snake River below Ice Harbor Dam (Figure 1); objective 3 is to define habitat requirements for white sturgeon spawning and rearing and quantify the extent of available habitat in the same areas described in objective 1.

Specific tasks for 1993 were to: 1) document the timing and duration of white sturgeon spawning between Bonneville and McNary Dams; 2) document recruitment of young-of-the-year (YOY) white sturgeon between Bonneville and McNary dams; 3) conduct exploratory sampling in the Columbia River between McNary and Priest Rapids dams and in the Snake River below Ice Harbor Dam to document spawning of white sturgeon, document recruitment of YOY white sturgeon, and to establish standard sites to be used in the subsequent years of this study and; 4) initiate efforts to quantify the extent of spawning and rearing habitat available within the area described in task 3.

## METHODS

White sturgeon eggs, larvae, YOY, and juveniles were sampled at standard sites in Bonneville, The Dalles, and John Day pools. The standard sites represent those sites in each pool with the highest catch per unit effort (CPUE) for each particular lifestage as calculated from data collected during Phase I of this study (Parsley et al. 1989; Duke et al. 1990; Miller et al. 1991). White sturgeon egg and larval sampling was conducted weekly from May through July with D-shaped larval nets at three standard sites located in each of The Dalles, John Day, and McNary tailraces (Figure 2). Young-of-the-year and juvenile white sturgeon were sampled biweekly during August and September with a high-rise bottom trawl at four, five, and six standard sites in John Day, The Dalles, and Bonneville pools, respectively. In the Columbia River above McNary Dam, exploratory white sturgeon egg and larval sampling was conducted weekly from May through July between river mile (RM) 341.8 and 396.3 with a beam trawl and in the Snake River below Ice Harbor Dam between RM 2.0 and 9.2 with D-shaped larval nets (Figure 3). Young-of-the-year and juveniles were sampled biweekly during August and September between RM 302.4 and 394.1 in the Columbia River above McNary Dam. Collection techniques remained the same as those used in 1991 (Miller et al. 1991).

Site designations represent RM and position within the channel. The last digit of site designations represent position in the channel with 0 and 5 designating backwater areas and 1, 2, 3, and 4 designating 1/4 channel width increments from left to right facing upstream. Digits preceding the last number represent RM to 0.1 mile (i.e., site 504 represents the right 1/4 of the channel at river mile 5.0). In this report the Hanford Reach refers to that section of the Columbia River above RM 342 to Priest Rapids Dam and McNary Pool refers to that section below RM 342 to McNary Dam. Egg and larval collections were preserved in the field in 10% unbuffered formalin tinted with phloxine

B and sorted in the laboratory. Non-sturgeon eggs were counted and non-sturgeon larvae were identified to family and enumerated. In this study larvae refers to white sturgeon < 25 mm TL. Larval white sturgeon were measured to total length (nearest 0.1 mm) and weighed (nearest 0.001g). White sturgeon eggs and larvae were assigned developmental stages based on criteria described by Beer (1981). To back-calculate time of egg fertilization for eggs and larvae, we used the relationship developed by Wang et al. (1985). Water temperatures at the time of collection were used in the relationship and assumed to have been constant during incubation. The timing and duration of white sturgeon spawning periods were determined from the first and last back-calculated spawning dates. Young-of-the-year white sturgeon were measured (nearest mm), weighed (nearest 1 g), and released. Juvenile white sturgeon were measured (nearest mm), weighed (nearest 10 grams), and released. In this study YOY refers to white sturgeon ≥ 25 mm TL, which are less than age 1. Juvenile refers to white sturgeon ≥ age 1 which are < 800 mm fork length (FL) (about age 8).

Catch-per-unit-effort of white sturgeon was expressed as number caught/15 minutes (CPT) for each gear type, number caught/hectare (CPHA) with the high-rise trawl, and number caught/1000 $m^3$ with the D-shaped larval net. Only efforts from the period when water temperatures were between 12 and 19°C were used in calculations of egg CPUE. Larval CPUE was calculated using only efforts from the period when water temperatures were between 12 and 20°C. Young-of-the-year and juvenile CPUE were calculated using all efforts with the high-rise trawl in the Columbia River between Bonneville and McNary dams. For the exploratory sampling above McNary Dam, egg, larval, YOY, and juvenile CPUE were calculated using only those sites where at least one member of the respective lifestages were collected.

Habitat descriptors calculated, measured, or obtained were discharge at each dam, water temperature, water velocity, water depth, and weighted usable spawning habitat. Mean daily discharge records for The Dalles, John Day, McNary, Priest Rapids, and Ice Harbor dams of the Columbia River and of Ice Harbor Dam of the Snake River were obtained for April through July, 1993 from the Fish Passage Center. Water temperatures were recorded every two hours with Ryan Tempmentor thermographs[1] in the Columbia River between Bonneville and McNary dams. Thermographs were placed on the substrate downstream from each dam at RM's 190.8, 214.3, and 290.6. Water temperatures for the Columbia River between McNary and Priest Rapids dams and for the Snake River below Ice Harbor Dam were obtained from the Fish Passage Center. Water temperature was also measured with a digital thermometer prior to most efforts with each gear.

Water velocity was measured prior to most efforts made with the beam trawl and D-shaped larval nets. Mean water column velocity (an average of the velocities measured at 0.2 and 0.8 of the total depth) and bottom velocity (measured 0.4 m from the substrate) at sample sites were measured with a cable suspended Price type "AA"

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[1] Use of trade names does not imply endorsement by NBS.

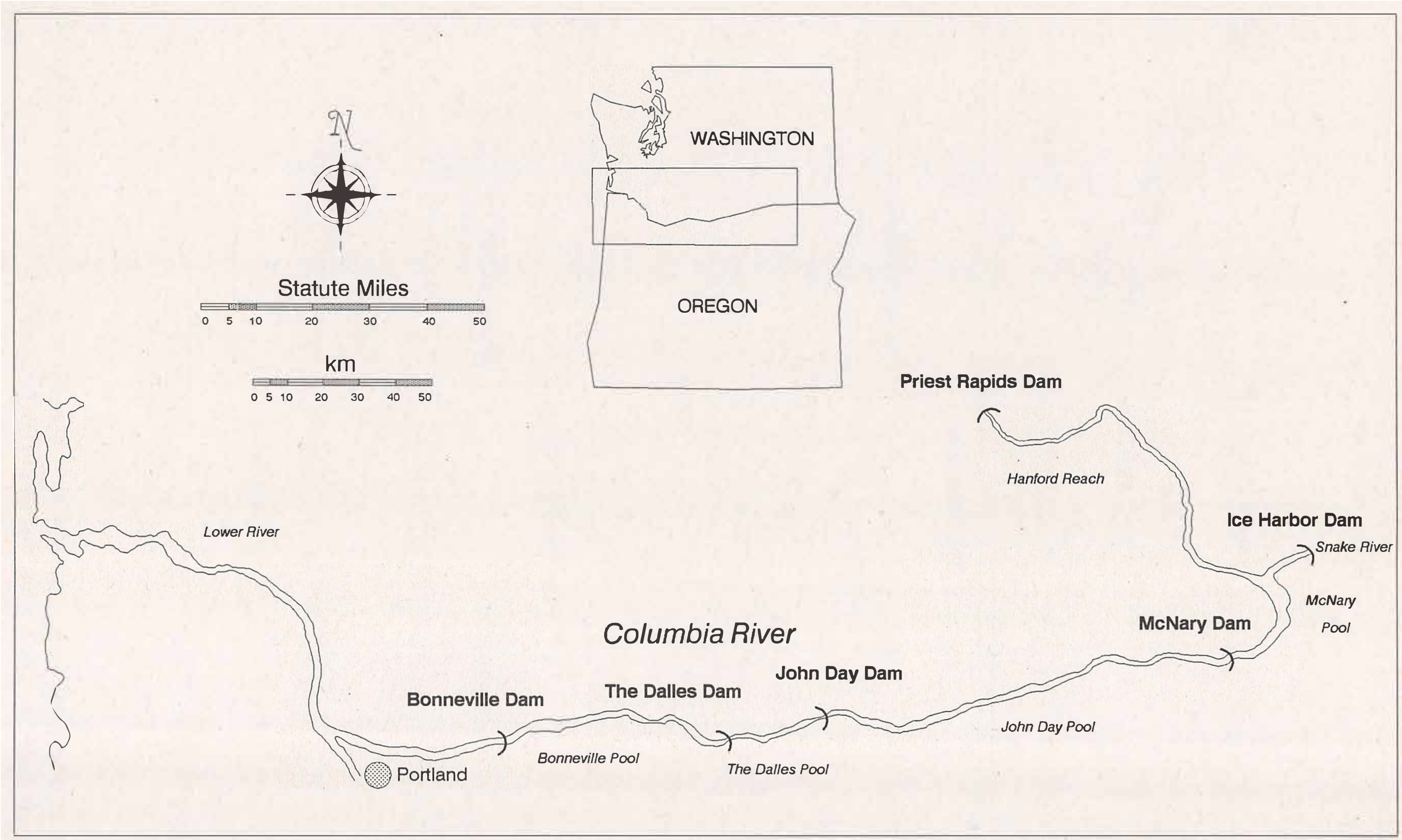


Figure 1. Location of study area between Bonneville and Priest Rapids dams on the Columbia River and downstream from Ice Harbor Dam on the Snake River.

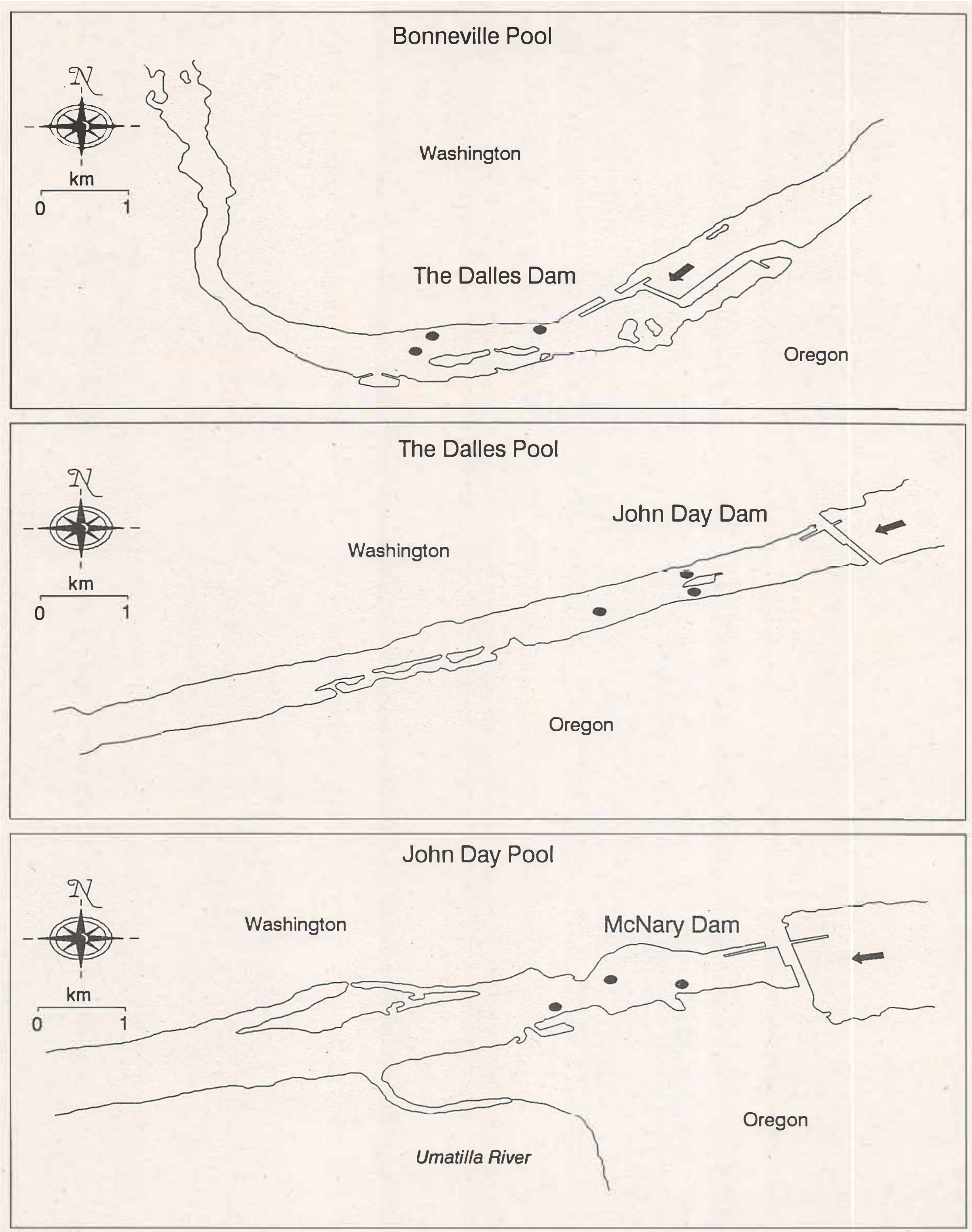


Figure 2. D-shaped larval net standard sites used for white sturgeon egg and larval sampling in Bonneville, The Dalles, and John Day pools during 1993.

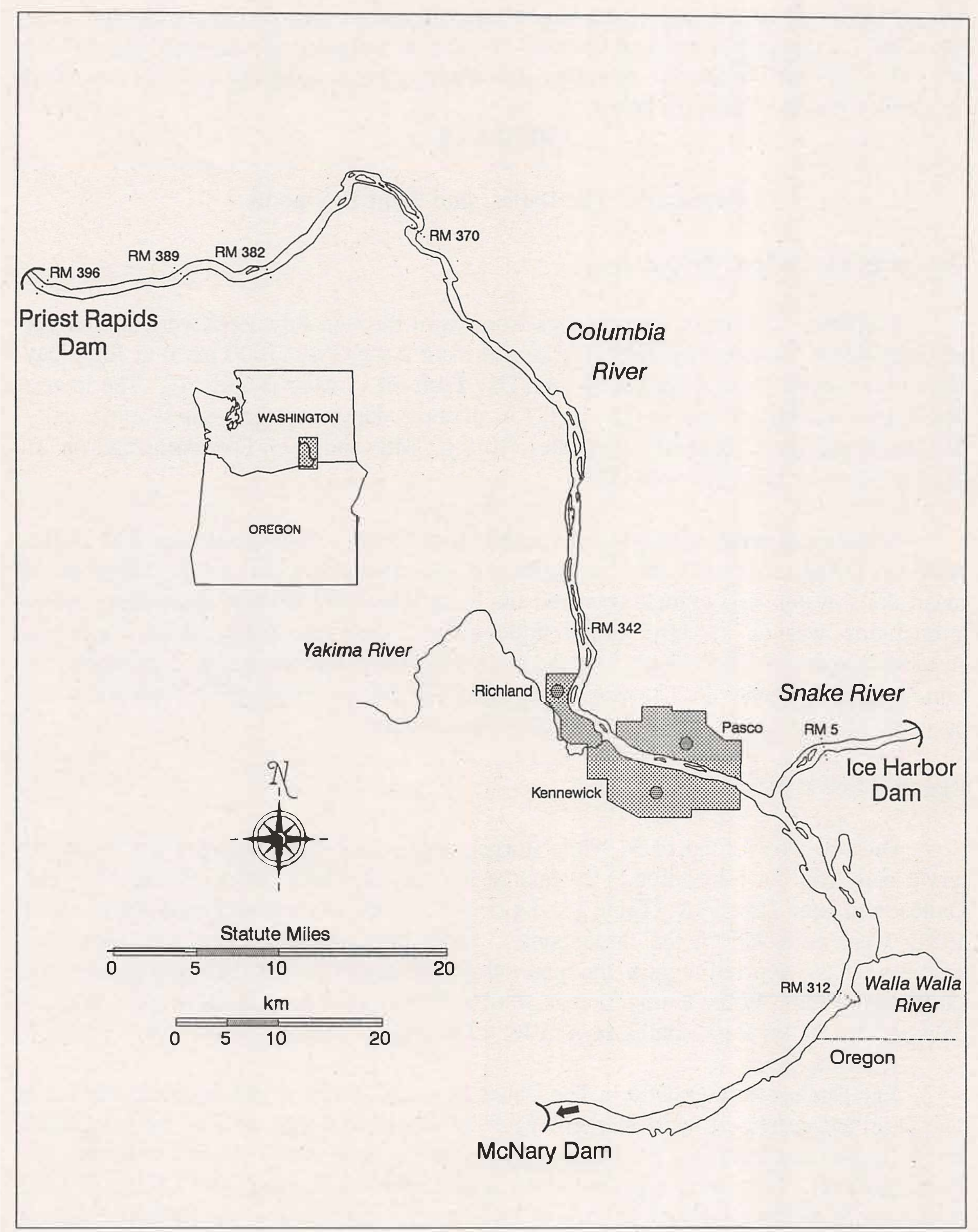


Figure 3. Location of study area between McNary and Priest Rapids dams on the Columbia River and below Ice Harbor Dam on the Snake River.

sensors connected to Swoffer Instruments Model 2200 direct reading current velocity meters. Water depth was measured to the nearest 0.3 m with a recording fathometer. When depth varied during a sampling effort, minimum and maximum depths were recorded. A composite index of monthly and annual weighted usable spawning habitat was calculated for Bonneville, John Day, and McNary pools using the methods described by Parsley and Beckman (in press).

## RESULTS

### Bonneville, The Dalles, and John Day pools

#### Discharge and water temperature

Discharge and water temperatures from April through July 1993 were similar for all three pools. Mean daily discharge ranged from 2.9 KCMS (1000 $m^3/s$) at John Day Dam on 15 April to 11.4 KCMS at John Day Dam on 17 May (Figure 4). The lowest mean daily discharge was on 15 April for all three dams and the highest mean daily discharge was on 17 May at The Dalles (10.8 KCMS) and John Day dams and on 21 May at McNary Dam (11.0 KCMS).

Mean daily water temperatures ranged from 6.9°C in Bonneville and The Dalles pools on 1 April to 19.3°C in The Dalles and John Day pools on 31 July. The lowest mean daily water temperature occurred on 1 April and the highest mean daily water temperature was on 31 July for all three pools. Optimum temperatures for white sturgeon spawning (14.0-17.0°C; Wang et al. 1985) occurred during approximately the same period in Bonneville (22 May-1 July) and The Dalles (23 May-30 June) pools and occurred slightly later in John Day Pool (4 June-6 July).

#### Egg and larval sampling

During 1993 a total of 34 white sturgeon eggs were collected with the D-shaped larval nets from 24 May through 29 June at the nine standard sites in Bonneville, The Dalles, and John Day pools (Table 1). Eggs in 12 of the 19 developmental stages (Beer 1981) were collected in the three pools. Only two adhesive eggs, indication that spawning has occurred within the previous three hours, were collected during the sampling period. White sturgeon eggs were collected on 4 days in Bonneville Pool, 5 days in The Dalles Pool, and 3 days in John Day Pool.

Egg catches were greatest in The Dalles Pool and lowest in Bonneville Pool (Table 1). Dead and fungused white sturgeon eggs comprised 21% and 23% of the total catch in The Dalles and John Day pools, respectively, while none were collected in Bonneville Pool (Table 1). Eggs were collected at water temperatures ranging from 13.3 to 17.0°C and at water depths ranging from 5.2 to 16.8 m. Mean water column velocities during efforts that collected eggs varied from 0.8 to 1.9 m/s and bottom velocities varied from 0.6 to 1.6 m/s.

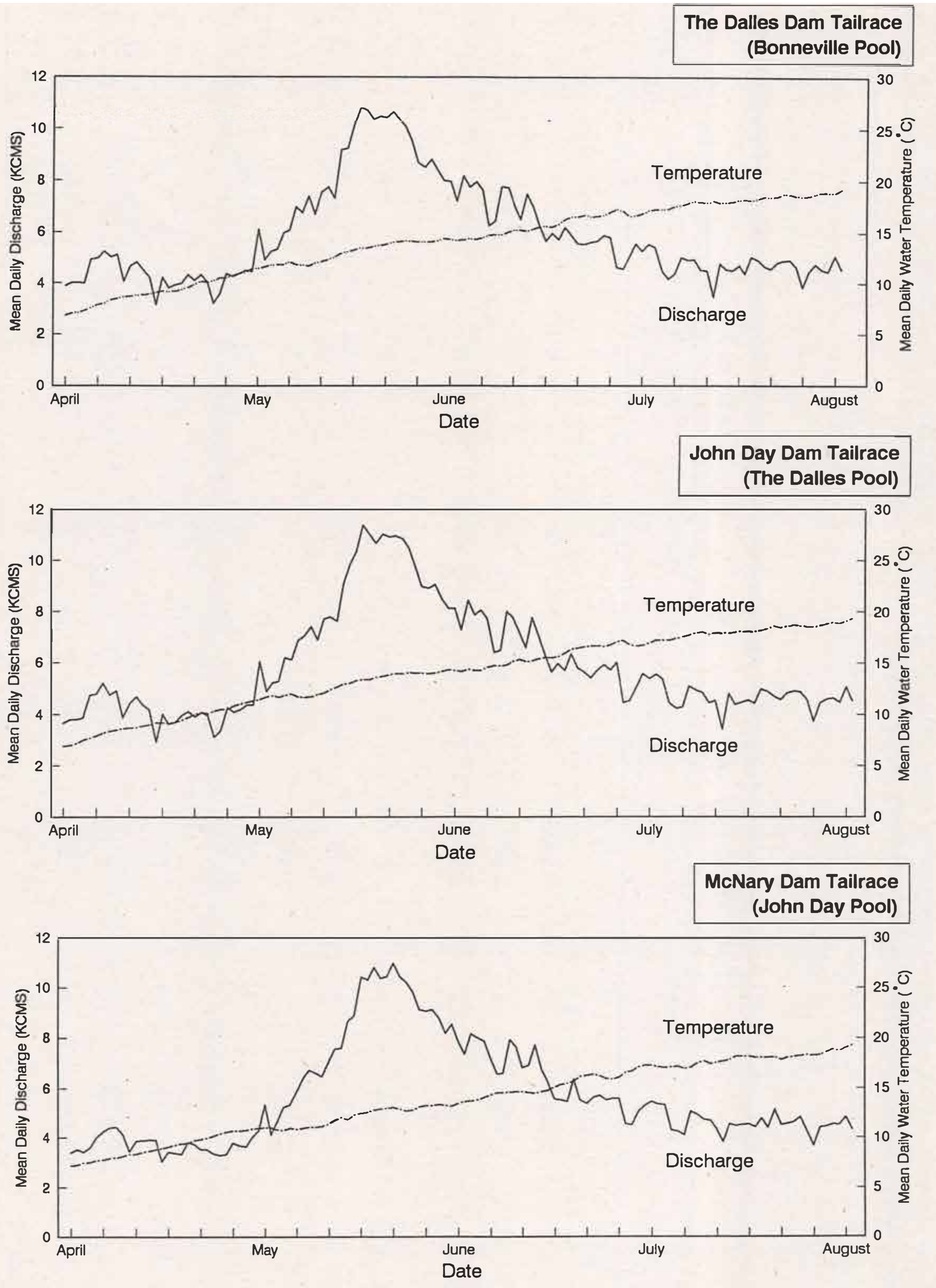


Figure 4. Mean daily discharge (KCMS) and water temperatures (°C) in The Dalles, John Day, and McNary tailraces from 1 April through 31 July 1993.

Table 1. Total number, catch/15 minutes (CPT), and catch/1000 m$^3$ of white sturgeon eggs and number, percent of total catch, CPT, and catch/1000 m$^3$ of dead and fungused white sturgeon eggs collected with the D-shaped larval net at standard sites from 24 May through 29 June 1993 in Bonneville, The Dalles, and John Day pools.

| | | Total Number of Eggs | | | Dead and Fungused Eggs | | | |
|---|---|---|---|---|---|---|---|---|
| Reservoir | Site | Number | CPT | Catch/ 1000 m$^3$ | Number | Percent of total catch | CPT | Catch/ 1000 m$^3$ |
| Bonneville Pool | 19022 | 2 | 0.04 | 0.17 | 0 | 0 | 0 | 0 |
| | 19041 | 2 | 0.04 | 0.20 | 0 | 0 | 0 | 0 |
| | 19081 | 3 | 0.06 | 0.72 | 0 | 0 | 0 | 0 |
| Total | | 7 | 0.05 | 0.27 | 0 | 0 | 0 | 0 |
| The Dalles Pool | 21303 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 21381 | 11 | 0.25 | 0.85 | 3 | 27 | 0.07 | 0.23 |
| | 21424 | 3 | 0.07 | 0.30 | 0 | 0 | 0 | 0 |
| Total | | 14 | 0.10 | 0.40 | 3 | 21 | 0.02 | 0.09 |
| John Day Pool | 29034 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 29102 | 3 | 0.07 | 0.30 | 1 | 33 | 0.02 | 0.10 |
| | 29134 | 10 | 0.25 | 1.60 | 2 | 20 | 0.05 | 0.32 |
| Total | | 13 | 0.10 | 0.48 | 3 | 23 | 0.02 | 0.11 |

Seventy-four white sturgeon larvae were collected with the D-shaped larval nets at the standard sites from 1 June through 21 July 1993 (Table 2). Larval developmental stages (Beer 1981) collected ranged from post-hatch to > 10 d post-hatch (< 25 mm total length (TL) but fins not fully developed). Of these developmental stages, post-hatch and 1 d post-hatch represented 74% of the total catch. Total lengths ranged from 10.6 mm to 21.9 mm ($\bar{x}$ = 13.6 *mm*). Larvae were collected at water temperatures ranging from 14.4 to 18.6°C and at water depths ranging from 5.2 to 16.5 m. Mean water column velocities varied from 0.7 to 1.9 m/s and bottom water velocities varied from 0.3 to 1.5 m/s. The number of white sturgeon larvae captured, CPT, and the number of larvae caught/1000 $m^3$ were higher in Bonneville and The Dalles pools than in John Day Pool (Table 2).

The timing and duration of the estimated white sturgeon spawning period varied among the three pools (Figure 5). The onset of white sturgeon spawning (estimated from back-calculated spawning dates of white sturgeon eggs and larvae) was earliest in Bonneville Pool and began 2 days later in John Day Pool and 3 days later in The Dalles Pool. The beginning date of the estimated spawning period began in Bonneville Pool on the day the mean daily water temperature and one day after the mean daily temperature reached 14°C in The Dalles Pool (Figure 4). The earliest collection of a sturgeon egg in John Day Pool occurred at a temperature of 13.3°C. However, this egg was abnormally developed; the first back-calculated date from a viable sturgeon egg was 11 days later when the mean daily water temperature reached 14.0°C. The spawning period was longest in Bonneville Pool (53 d) and shortest in John Day Pool (30 d). In The Dalles Pool spawning occurred over a 34 day period.

**Availability of spawning habitat**

A composite index of temperature conditioned annual weighted usable spawning area was calculated for 1988, 1991, and 1993; the peak discharge in 1998 was considerably lower than 1991 and 1993 (Figure 6). The composite index of annual weighted usable spawning area was higher in 1993 than in 1988 and similar to that of 1991 in all three pools. While the annual composite index of annual weighted usable spawning area was similar between 1991 and 1993, there are differences in the mean monthly temperature conditioned weighted usable spawning area. During 1991 the peak of weighted usable spawning area occurred in June while in 1993 the peak occurred in May (Figure 7).

**Young-of-the-year and juvenile sampling**

A total of 42 YOY white sturgeon were captured with the high-rise bottom trawl at the standard sites in the three pools from 4 August through 21 September 1993 (Table 3). The number of YOY captured was greater in Bonneville Pool (39) than in The Dalles Pool (2) and John Day Pool (1). The YOY had total lengths ranging from 75 to 295 mm and weights varied from 2.2 to 162 g. The weight-length relationship for the 39 YOY white sturgeon captured in Bonneville Pool is described by the equation $\log_{10} W = -11.240 + \log_{10} TL(2.8050)$. Catch/15 minutes and CPHA of YOY displayed

Table 2. Number and catch/15 minutes (CPT), and catch/1000 m$^3$ of white sturgeon larvae collected with the D-shaped larval net at standard sites from 1 June through 21 July 1993 in Bonneville, The Dalles, and John Day pools.

| Reservoir | Site | Number | CPT | Catch/1000 m$^3$ |
|---|---|---|---|---|
| Bonneville Pool | 19022 | 10 | 0.19 | 0.86 |
| | 19041 | 18 | 0.35 | 1.78 |
| | 19081 | 2 | 0.04 | 0.48 |
| Total | | 33 | 0.19 | 1.16 |
| The Dalles Pool | 21303 | 3 | 0.06 | 0.26 |
| | 21381 | 20 | 0.45 | 1.54 |
| | 21424 | 8 | 0.18 | 0.81 |
| Total | | 31 | 0.22 | 0.89 |
| John Day Pool | 29034 | 2 | 0.05 | 0.18 |
| | 29102 | 1 | 0.02 | 0.10 |
| | 29134 | 7 | 0.18 | 1.13 |
| Total | | 10 | 0.08 | 0.37 |

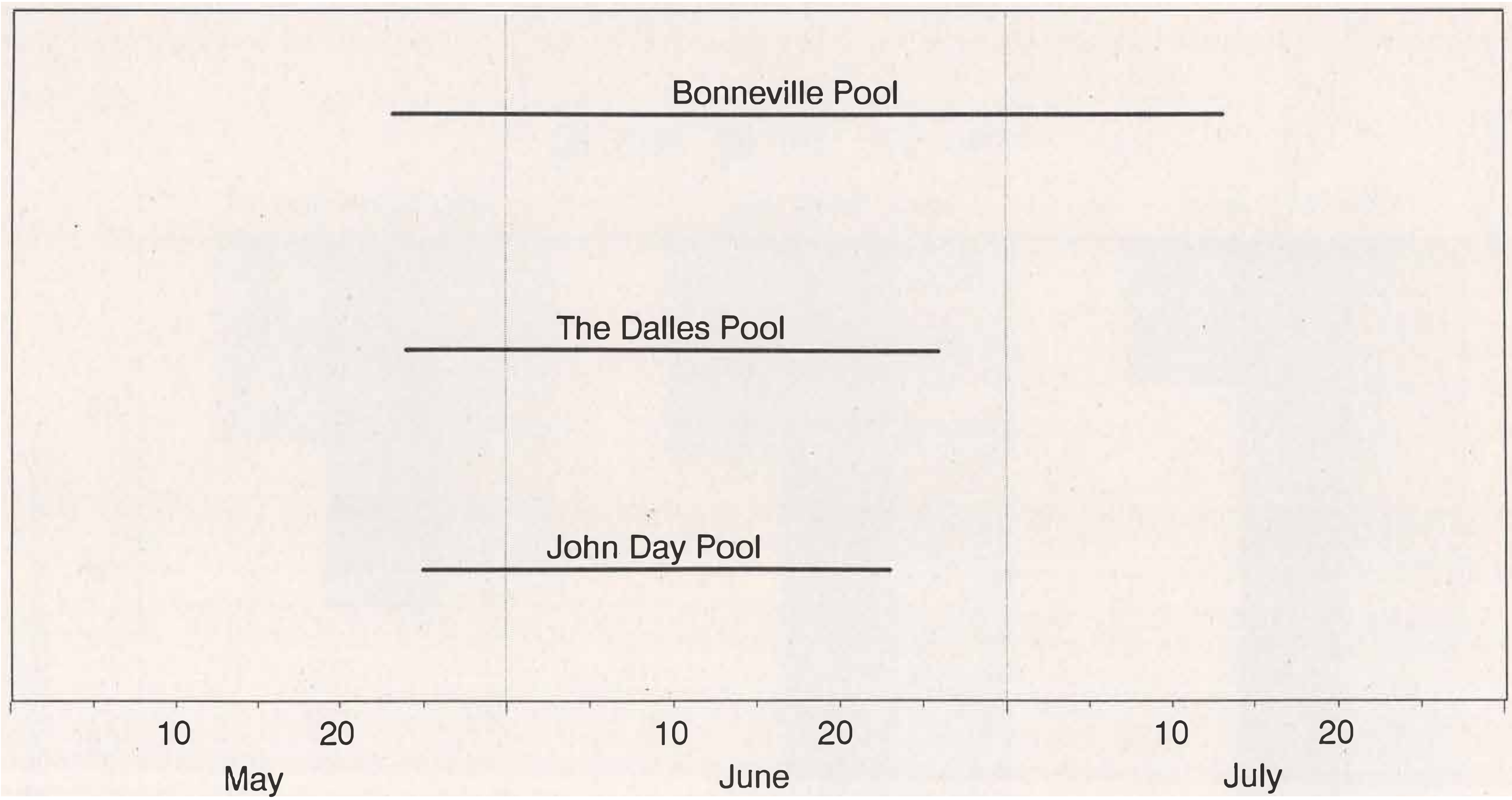


Figure 5. White sturgeon spawning period for 1993 in Bonneville, The Dalles, and John Day pools estimated from back-calculated spawning dates of white sturgeon eggs and from both white sturgeon eggs and larvae.

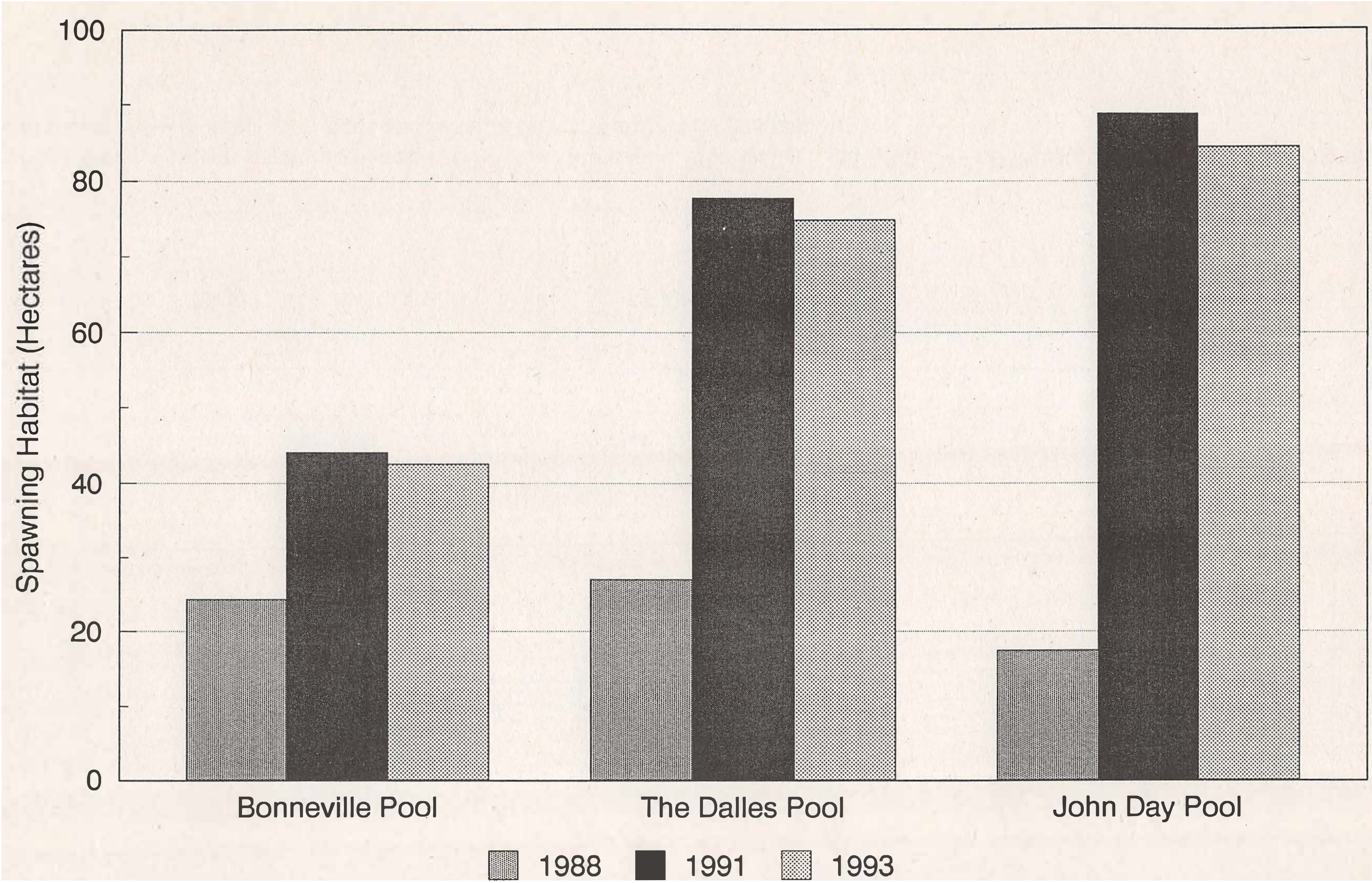


Figure 5. White sturgeon spawning period for 1993 in Bonneville, The Dalles, and John Day pools estimated from back-calculated spawning dates of white sturgeon eggs and from both white sturgeon eggs and larvae.

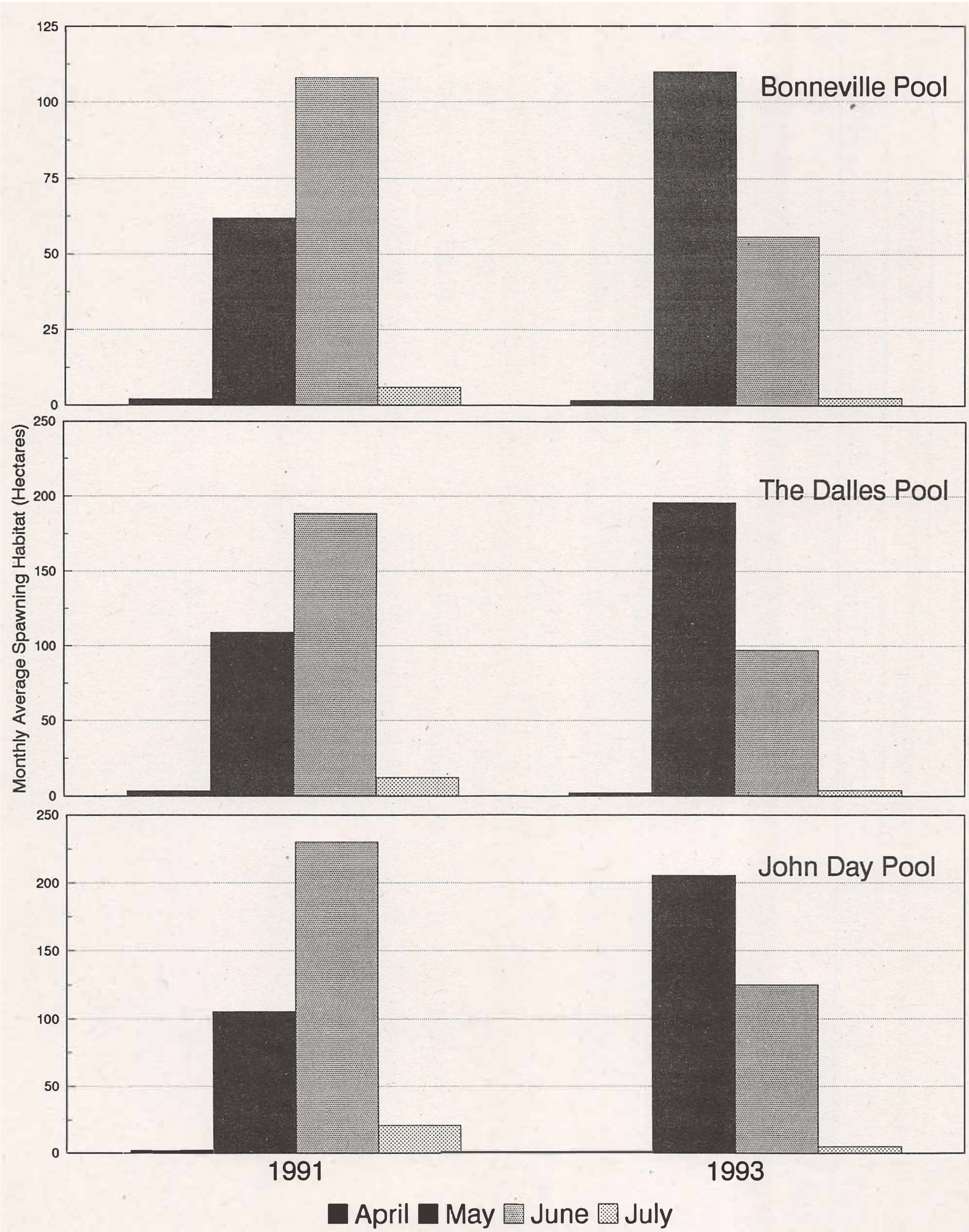


Figure 7. Mean monthly temperature conditioned weighted usable spawning area from April through July during 1991 and 1993 for Bonneville, The Dalles, and John Day pools.

Table 3. Number, catch/15 minutes (CPT), and catch/hectare (CPHA) of young-of-the-year and juvenile white sturgeon captured with the high-rise bottom trawl from 3 August through 21 September 1993 at standard trawling sites in Bonneville, The Dalles, and John Day reservoirs.

| | | Young-of-the-year | | | Juveniles | | |
|---|---|---|---|---|---|---|---|
| Reservoir | Site | Number | CPT | CPHA | Number | CPT | CPHA |
| Bonneville Pool | 15734 | 1 | 0.50 | 1.29 | 0 | 0 | 0 |
| | 15951 | 22 | 8.25 | 20.5 | 2 | 0.75 | 1.86 |
| | 17063 | 5 | 1.88 | 4.47 | 2 | 0.75 | 1.79 |
| | 17374 | 5 | 1.88 | 4.87 | 15 | 5.62 | 14.6 |
| | 17911 | 0 | 0 | 0 | 27 | 10.1 | 26.9 |
| | 18531 | 6 | 2.37 | 6.70 | 12 | 4.73 | 13.4 |
| Total | | 39 | 2.57 | 6.62 | 58 | 3.81 | 9.84 |
| The Dalles Pool | 19433 | 1 | 0.38 | 0.79 | 1 | 0.37 | 0.79 |
| | 19901 | 1 | 0.38 | 0.93 | 1 | 0.37 | 0.93 |
| | 19932 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 20531 | 0 | 0 | 0 | 4 | 1.50 | 3.43 |
| | 20904 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 0.15 | 0.37 | 6 | 0.45 | 1.11 |
| John Day Pool | 26272 | 1 | 0.38 | 1.10 | 0 | 0 | 0 |
| | 26783 | 0 | 0 | 0 | 3 | 1.12 | 2.26 |
| | 27284 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 27904 | 0 | 0 | 0 | 2 | 0.75 | 1.89 |
| Total | | 1 | 0.09 | 0.22 | 5 | 0.47 | 1.12 |

similar trends in the three pools. Catch/15 minutes was 17 times and CPHA was 18 times greater in Bonneville Pool than in The Dalles Pool. Young-of-the-year white sturgeon were captured at sites where water depths varied from 12.2 to 48.2 m. Water temperatures during the trawling period ranged from 18.4 to 20.9°C.

Sixty-nine juvenile white sturgeon were captured at standard trawling sites from 3 August to 21 September 1993 (Table 3). The number of juveniles captured, CPT, and CPHA were greatest in Bonneville Pool and essentially the same in The Dalles and John Day pools. Trawling sites at which juveniles were captured had water depths ranging from 4.3 to 48.2 m. Fork lengths (FL) of juvenile white sturgeon ranged from 359 to 758 mm and weights ranged from 380 to 3800 g.

### Catch of other fish species

A total of 17 fish species other than white sturgeon were captured with the D-shaped larval nets and high-rise bottom trawl in Bonneville, The Dalles, and John Day pools during 1993. Larval cyprinids, larval catostomids, and larval cottids comprised 88% of the total catch of other fish species collected in all three pools with the D-shaped larval net (Table 4). Of the fishes other than white sturgeon captured with the high-rise bottom trawl, numbers of prickly sculpin were greatest in Bonneville and John Day pools and numbers of American shad were greatest in The Dalles Pool (Table 5).

## The Columbia River between McNary and Priest Rapids dams and the Snake River below Ice Harbor Dam

### Discharge and water temperature

Mean daily discharge through Priest Rapids Dam during April through July 1993 ranged from a minimum of 1.5 KCMS on 9 April to a maximum of 5.9 KCMS on 21 May (Figure 8). The lowest mean daily discharge through Ice Harbor Dam for this period occurred on 31 July (1.1 KCMS) and the highest occurred on 20 May (4.9 KCMS).

Water temperature in the Priest Rapids Dam tailrace varied from 7.2°C on 16 April (the first day temperatures were recorded for April through July, 1993) to 18.3°C on 31 July. In the Ice Harbor Dam tailrace the lowest water temperature was recorded on 8 April (8.9°C) and the highest was recorded on 28 July (20.3°C). Water temperature data were not available for the period of 4 May to 12 May and 17 May to 24 May downstream from Ice Harbor Dam. Optimum temperatures for white sturgeon spawning (14.0-17.0°C; Wang et al. 1985) occurred between 16 May and 24 June in the Ice Harbor tailrace and from 14 June and 17 July in the Priest Rapids tailrace.

**Egg and larval sampling**

A total of 48 white sturgeon eggs were collected in the Hanford Reach of the Columbia River between RM 370.0 and 396.3 on five days from 15 June to 20 July, 1993 (Table 6). Eggs from 10 of the 19 developmental stages described by Beer (1981) were collected. The two developmental stages preceding hatch (Formation of the Heart, Stage 16; Prehatch, Stage 17) comprised 39.6% of the total catch. No eggs prior to developmental Stage 7 (Late Cleavage) were present in the catch. The number of eggs collected and CPT was greatest at site 38883. The number, percent of total catch, and CPT of dead and fungused eggs was also greatest at site 38883. Dead and fungused eggs comprised 15% of the total catch of eggs. Eggs were collected at temperatures ranging from 14.0 to 17.3°C and at water depths ranging from 4.6 to 18.3 m. Mean water column velocities during efforts that collected eggs varied from 1.8 to 2.6 m/s and bottom water velocities varied from 1.0 to 2.2 m/s.

Eighteen white sturgeon larvae were collected in the Hanford Reach between RM 388.7 and 395.9 on six days from 22 June to 27 July 1993 (Table 6). Larval developmental stages (Beer 1981) varied from post-hatch to 5 days post-hatch. Larvae that were one day post-hatch made up 61% of the total catch of larvae. Total lengths of the larvae collected varied from 10.3 to 15.1 mm. Larvae were collected at water temperatures ranging from 15.3 to 18.1°C and at water depths ranging from 10.1 to 18.3 m. Mean water column velocities during efforts that collected larvae ranged from 1.3 to 2.1 m/s and bottom velocities ranged from 1.0 to 1.6 m/s. The number of larvae collected was highest at site 38883. However, in contrast to the egg CPT, CPT of larvae was greatest at site 39582 (Table 6).

In the Snake River downstream from Ice Harbor Dam, 39 eggs were collected on 2 June and 8 June at site 524 and two eggs were collected on 28 June at site 561. Seven of the nineteen egg developmental stages were represented in the catch. Eleven adhesive eggs (27% of the total catch) were collected. Eggs were collected at water depths ranging from 4.6 to 6.7 m and at water temperatures ranging from 14.5 to 17.1°C. Mean water column velocities varied from 1.5 to 1.6 m/s and bottom water velocities varied from 0.76 to 1.2 m/s during efforts that collected eggs. Egg CPT and catch/1000 $m^3$ for site 524 were greater than that for site 561 (Table 7). Seven dead and fungused eggs were collected at site 524 during the sampling period.

Five white sturgeon larvae were collected on 2 June and 23 June in the Snake River at site 524 (Table 7). All five larvae were at the post-hatch developmental stage (Beer 1981). The larvae were collected at water temperatures of 14.5 and 15.9°C and at water depths of 4.6 and 5.5 m. The mean water column water velocities during the two efforts that collected larvae were 1.1 and 1.5 m/s and the bottom water velocities were 0.61 and 1.1 m/s. Catch/1000 $m^3$ was 1.31 for site 524 and 1.03 for the two sites combined (Table 7). Catch/15 minutes was 0.31 for site 524 and 0.25 for both sites combined.

Table 4. Number, catch/15 minutes (CPT), and catch/1000 $m^3$ of fishes other than white sturgeon collected with the D-shaped larval nets at standard sites from 3 May through 27 July 1993 in Bonneville, The Dalles, and John Day reservoirs.

| | Bonneville Pool | | | The Dalles Pool | | | John Day Pool | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | No. | CPT | Catch/ 1000 $m^3$ | No. | CPT | Catch/ 1000 $m^3$ | No. | CPT | Catch/ 1000 $m^3$ |
| American shad | 0 | 0 | 0 | 1 | < 0.01 | 0.03 | 2 | 0.01 | 0.07 |
| Chinook salmon | 0 | 0 | 0 | 1 | < 0.01 | 0.03 | 0 | 0 | 0 |
| Pacific lamprey | 2 | 0.01 | 0.07 | 0 | 0 | 0 | 0 | 0 | 0 |
| UID[1] larval cottids | 7 | 0.04 | 0.3 | 19 | 0.1 | 0.5 | 6 | 0.04 | 0.2 |
| UID[1] larval cyprinids | 4 | 0.03 | 0.2 | 15 | 0.1 | 0.4 | 0 | 0 | 0 |
| UID[1] larval catostomids | 17 | 0.1 | 0.6 | 10 | 0.07 | 0.3 | 10 | 0.07 | 0.3 |
| UID[1] fishes | 2 | 0.01 | 0.07 | 0 | 0 | 0 | 4 | 0.3 | 0.1 |

[1] unidentified

Table 5. Number, catch/15 min (CPT), and catch/hectare (CPHA) of fishes other than white sturgeon captured with the high-rise bottom trawl from 3 August through 21 September 1993 at standard trawling sites in Bonneville, The Dalles, and John Day reservoirs.

| | Bonneville Pool | | | The Dalles Pool | | | John Day Pool | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | No. | CPT | CPHA | No. | CPT | CPHA | No. | CPT | CPHA |
| American shad | 5 | 0.3 | 0.8 | 621 | 46.7 | 114.9 | 199 | 14.9 | 34.8 |
| Bridgelip sucker | 1 | 0.06 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown bullhead | 1 | 0.06 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel catfish | 0 | 0 | 0 | 2 | 0.2 | 0.4 | 7 | 0.5 | 1.2 |
| Common carp | 0 | 0 | 0 | 1 | 0.08 | 0.2 | 77 | 5.8 | 13.5 |
| Largemouth bass | 0 | 0 | 0 | 1 | 0.08 | 0.2 | 0 | 0 | 0 |
| Largescale sucker | 1 | 0.06 | 0.2 | 7 | 0.5 | 1.3 | 38 | 2.9 | 6.6 |
| Pacific lamprey | 1 | 0.06 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Peamouth | 12 | 0.8 | 2.0 | 10 | 0.8 | 1.9 | 0 | 0 | 0 |
| Prickly sculpin | 344 | 21.6 | 55.8 | 69 | 5.2 | 12.8 | 1988 | 149.4 | 347.5 |
| Pumpkinseed | 0 | 0 | 0 | 1 | 0.08 | 0.2 | 0 | 0 | 0 |
| Redside shiner | 20 | 1.3 | 3.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sandroller | 32 | 2.0 | 5.2 | 17 | 1.3 | 3.2 | 305 | 22.9 | 53.3 |
| Smallmouth bass | 0 | 0 | 0 | 13 | 1.0 | 2.4 | 0 | 0 | 0 |
| Walleye | 0 | 0 | 0 | 3 | 0.2 | 0.6 | 0 | 0 | 0 |
| Yellow perch | 0 | 0 | 0 | 2 | 0.2 | 0.4 | 1 | 0.8 | 0.2 |
| UID[1] catostomids | 0 | 0 | 0 | 27 | 2.0 | 5.0 | 0 | 0 | 0 |

[1] unidentified

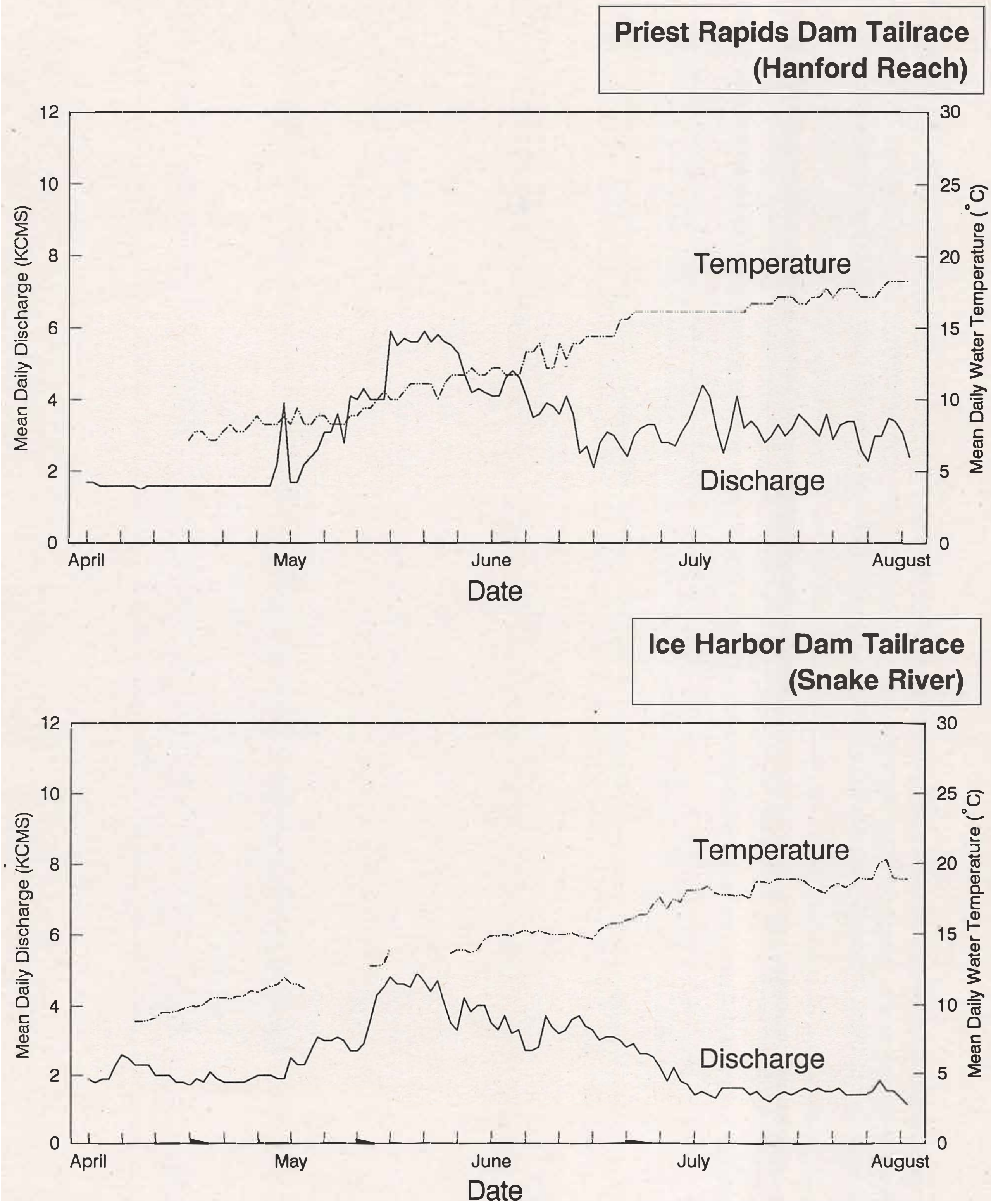


Figure 8. Mean daily discharge (KCMS) and water temperature (°C) in Ice Harbor (Snake River) and Priest Rapids (Columbia River) tailraces from 8 April through 31 July 1993 (Ice Harbor) and from 16 April through 31 July 1993 (Priest Rapids).

Table 6. Total number and catch per 15 minutes (CPT) of white sturgeon eggs and larvae; and the number, percent of total catch, and catch per 15 minutes of dead and fungused white sturgeon eggs collected with the beam trawl from 15 June through 27 July 1993 at sites where at least one of these lifestages were collected in the Columbia River between McNary and Priest Rapids dams.

| | Total number of eggs | | Dead and fungused eggs | | | Larvae | |
|---|---|---|---|---|---|---|---|
| Site | Number | CPT | Number | Percent of total catch | CPT | Number | CPT |
| 37003 | 2 | 0.17 | 0 | 0 | 0 | 0 | 0 |
| 38173 | 1 | 0.06 | 0 | 0 | 0 | 0 | 0 |
| 38193 | 1 | 0.25 | 0 | 0 | 0 | 0 | 0 |
| 38873 | 0 | 0 | 0 | 0 | 0 | 2 | 0.20 |
| 38883 | 23 | 1.64 | 6 | 26 | 0.43 | 7 | 0.50 |
| 38912 | 8 | 1.33 | 0 | 0 | 0 | 2 | 0.33 |
| 39582 | 1 | 0.17 | 0 | 0 | 0 | 5 | 0.83 |
| 39592 | 2 | 0.50 | 0 | 0 | 0 | 2 | 0.50 |
| 39621 | 3 | 0.50 | 0 | 0 | 0 | 0 | 0 |
| 39622 | 3 | 1.50 | 0 | 0 | 0 | 0 | 0 |
| 39633 | 4 | 0.20 | 1 | 25 | 0.05 | 0 | 0 |
| Total | 48 | 0.48 | 7 | 15 | 0.07 | 18 | 0.18 |

Table 7. Total number, catch/15 minutes (CPT), and catch/1000 $m^3$ of white sturgeon eggs and larvae collected with the D-shaped larval nets; and the number, CPT, and catch/1000 $m^3$ of dead and fungused white sturgeon eggs collected in the Snake River below Ice Harbor Dam from 2 June to 28 June 1993 at sites where at least one of these lifestages were collected.

| | Total number of eggs | | | Dead and fungused eggs | | | | Larvae | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | Number | CPT | Catch/ 1000 $m^3$ | Numbe r | Percent of total catch | CPT | Catch/ 1000 $m^3$ | Number | CPT | Catch/ 1000 $m^3$ |
| 524 | 39 | 2.44 | 10.2 | 7 | 17.9 | 0.44 | 1.83 | 5 | 0.31 | 1.31 |
| 561 | 2 | 0.50 | 1.96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 41 | 2.05 | 8.47 | 7 | 17.1 | 0.35 | 1.45 | 5 | 0.25 | 1.03 |

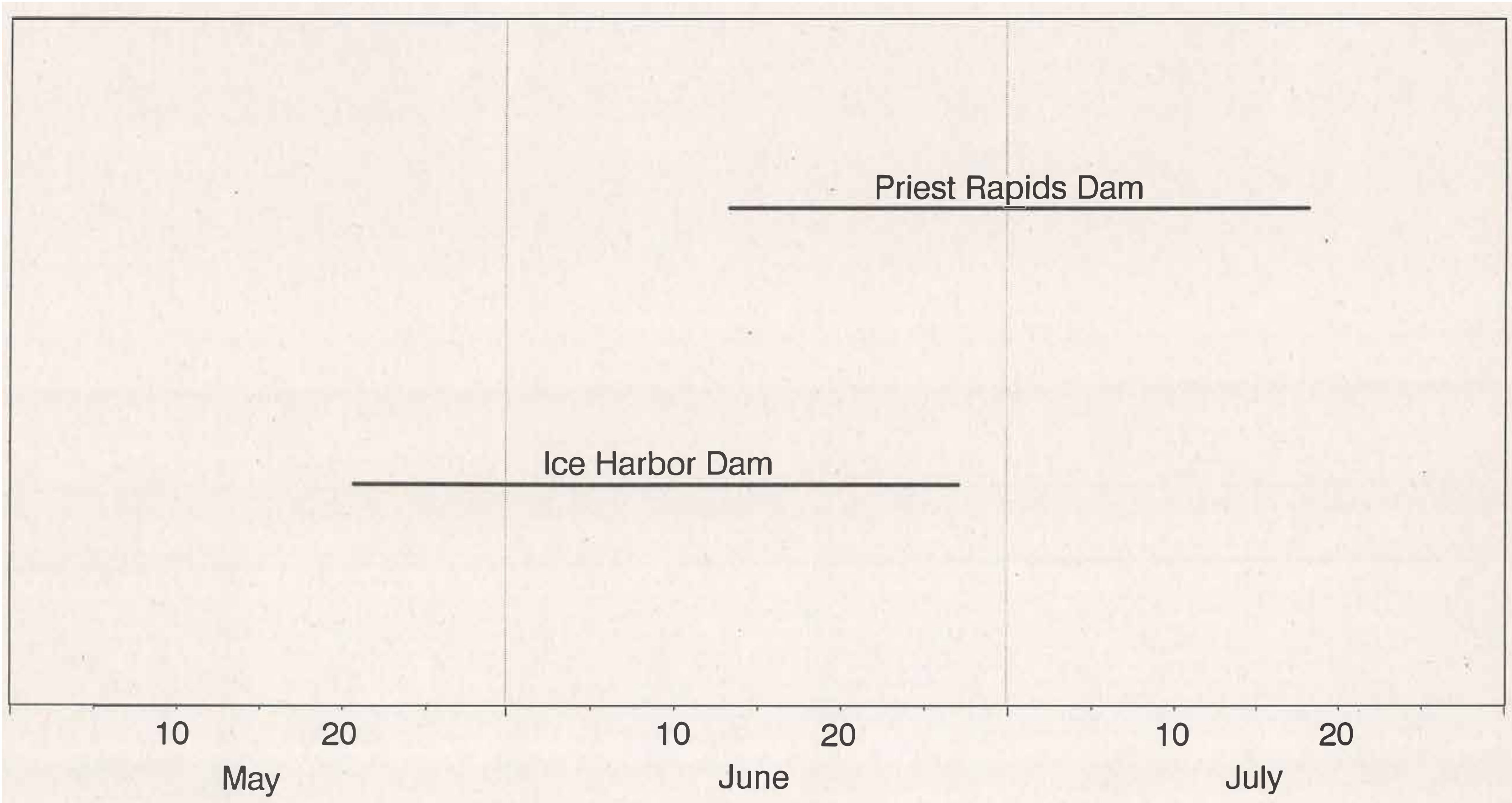


Figure 9. White sturgeon spawning period for 1993 in the Columbia River above McNary Dam and in the Snake River below Ice Harbor Dam estimated from back-calculated spawning dates of white sturgeon eggs and from both white sturgeon eggs and larvae.

The white sturgeon spawning period, estimated from the back-calculated spawning dates of both eggs and larvae, began 24 days earlier in the Snake River below Ice Harbor Dam than in the Columbia River between McNary and Priest Rapids dams (Figure 9). However, the beginning date of the estimated spawning period occurred five days after the mean daily water temperature reached 14.0°C at Ice Harbor Dam and the ending date occurred three days after the mean daily water temperature reached 17.0°C (Figure 8). Downstream from Priest Rapids Dam, the estimated spawning period began one day before the mean daily water temperature reached 14.0°C and ended one day after the mean daily water temperature did not fluctuate below 17.0°C. The duration of the estimated spawning period was 37 days in the Columbia River and 38 days in the Snake River.

Egg and larval sampling efforts in the Columbia and Snake rivers occurred at sites that should have been suitable for spawning based on the habitat descriptors provided by Parsley and Beckman (in press). After water temperatures reached 14°C in the Hanford Reach and Snake River, all egg and larval sampling efforts occurred over depths and velocities considered suitable for white sturgeon spawning (Figures 10 and 11). Substrates at these sites have not been quantitatively described, but appeared to be suitable.

### Young-of-the-year and juvenile sampling

Three YOY white sturgeon and no juveniles were captured in McNary Pool. One YOY was captured at site 31254 on 23 August. This YOY had a FL of 158 mm, a TL of 182 mm, and weighed 28 g. The water depth at this site varied from 18.5 to 19.1 m and the water temperature was 20.0°C. One YOY was captured at site 31193 on 14 September and another was captured at this site on 27 September. The YOY captured on 14 September had a FL of 197 mm, a TL of 235 mm, and weighed 65 g. The YOY captured on 27 September had a FL of 279 mm, a TL of 326 mm, and weighed 145 g. The water temperature was 17.6°C during the trawling effort conducted on 27 September and 19.3°C on 14 September. The water depth at site 31193 ranged from 14.9 to 41.1 m. No YOY or juveniles were captured in the Snake River.

### Catch of fishes other than white sturgeon

American shad were the most abundant fish captured with the high-rise bottom trawl, followed by sandrollers and cottids (Table 8). Of the fish other than white sturgeon captured with the beam trawl, numbers of larval catostomids were the greatest followed by larval cottids.

## DISCUSSION

During 1993, white sturgeon spawning was documented in Bonneville, The Dalles, and John Day pools. Contrary to trends seen in previous years the total number of eggs collected, catch/15 minutes, and catch/1000 $m^3$ were greater in The Dalles and John Day pools than in Bonneville Pool. Anders and Beckman (1993a) reported that for 1987-1991

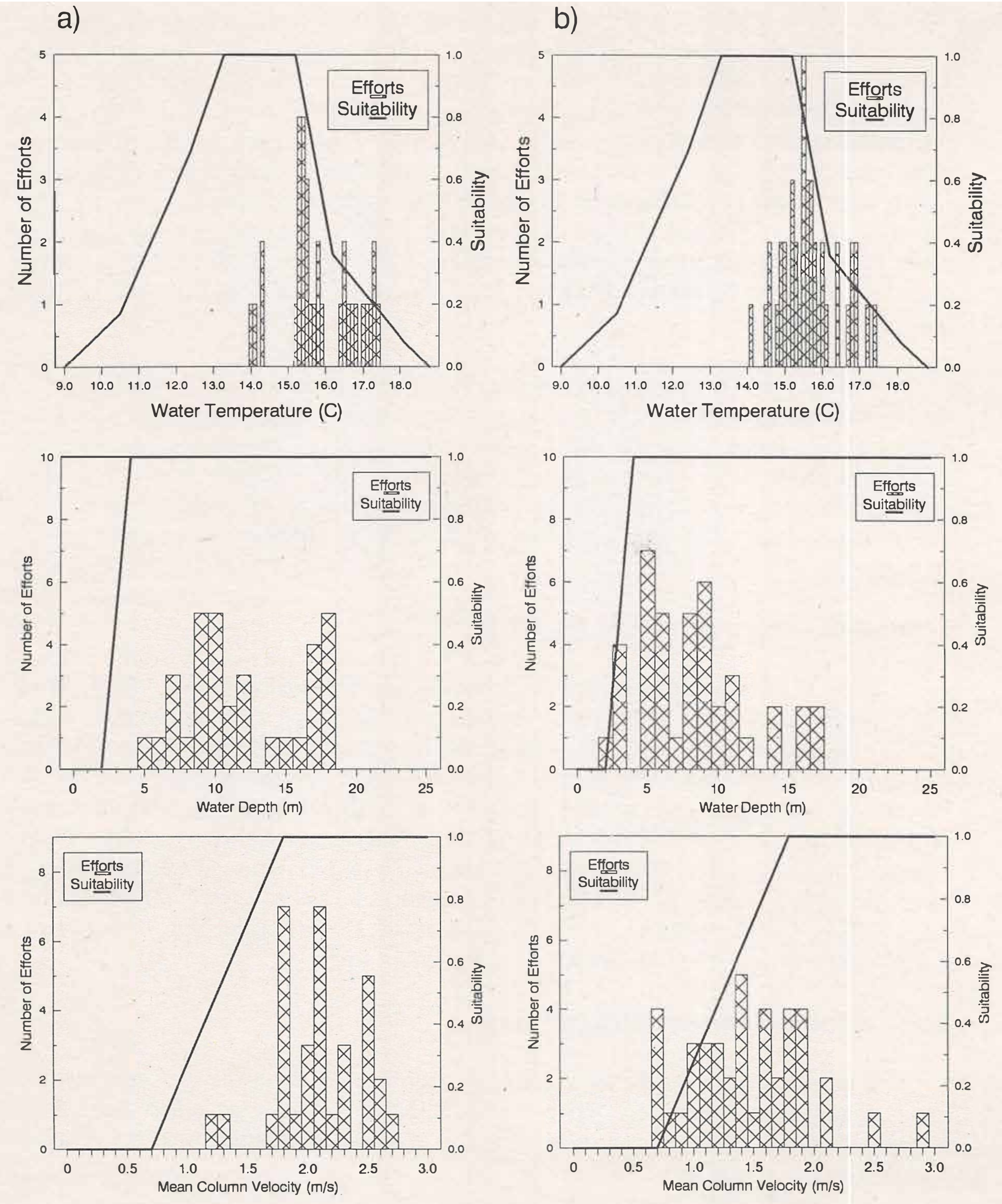


Figure 10. The frequency of occurrence of water temperatures (C), water depths (m), and mean water column velocities (m/s) during sampling efforts conducted in the Hanford Reach of the Columbia River during the white sturgeon spawning period (20 June - 27 July) in relation to spawning suitability curves (Parsley and Beckman in press) at a) sites where white sturgeon eggs were collected and b) sites where no eggs were collected.

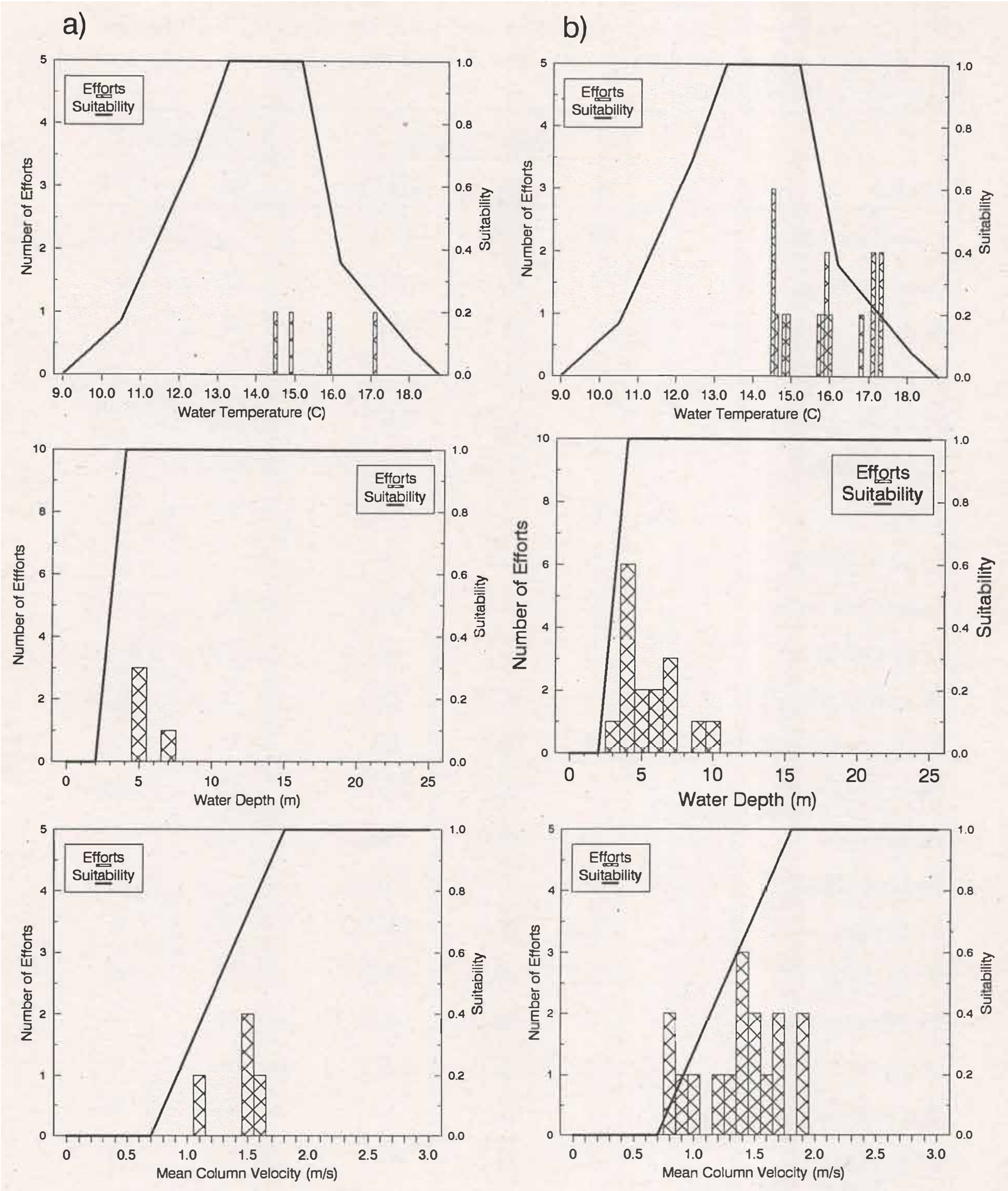


Figure 11. The frequency of occurrence of water temperatures (C), water depths (m), and mean water column velocities (m/s) during sampling efforts conducted in the Snake River below Ice Harbor Dam during the white sturgeon spawning period (2 June - 28 June) in relation to spawning suitability curves (Parsley and Beckman in press) at a) sites where white sturgeon eggs were collected and b) sites where no eggs were collected.

Table 8. Number and catch per unit effort (CPT = catch per 15 min; CPHA = catch per hectare) of fishes other than white sturgeon captured with the high-rise bottom trawl and beam trawl from May through September, 1993 in the Columbia River above McNary Dam.

| | High-rise trawl | | | Beam trawl | |
|---|---|---|---|---|---|
| Species | No. | CPT | CPHA | No. | CPT |
| American shad | 667 | 17.7 | 43.5 | 2 | <0.01 |
| Black crappie | 1 | 0.03 | 0.07 | 0 | 0 |
| Bridgelip sucker | 5 | 0.1 | 0.3 | 0 | 0 |
| Channel catfish | 126 | 3.3 | 8.2 | 0 | 0 |
| Chinook salmon[1] | 1 | 0.03 | 0.07 | 2 | 0.02 |
| Chislemouth | 3 | 0.08 | 0.2 | 0 | 0 |
| Common carp | 87 | 2.3 | 5.7 | 0 | 0 |
| Lake whitefish | 0 | 0 | 0 | 1 | <0.01 |
| Largescale sucker | 65 | 1.7 | 4.2 | 0 | 0 |
| Longnose dace | 0 | 0 | 0 | 3 | 0.01 |
| Mountain whitefish | 3 | 0.08 | 0.2 | 2 | <0.01 |
| Northern squawfish | 4 | 0.1 | 0.3 | 0 | 0 |
| Pacific lamprey | 1 | 0.03 | 0.07 | 10 | 0.04 |
| Peamouth | 24 | 0.6 | 1.6 | 0 | 0 |
| Redside shiner | 3 | 0.08 | 0.2 | 2 | <0.01 |
| Sandroller | 332 | 8.8 | 21.7 | 0 | 0 |
| UID[2] cottids | 248 | 6.6 | 16.2 | 43 | 0.2 |
| Smallmouth bass | 1 | 0.03 | 0.07 | 0 | 0 |
| Walleye | 1 | 0.03 | 0.07 | 0 | 0 |
| White crappie | 2 | 0.05 | 0.1 | 0 | 0 |
| Yellow perch | 125 | 3.3 | 8.2 | 0 | 0 |
| UID[2] larval cyprinids | 0 | 0 | 0 | 14 | 0.05 |
| UID[2] salmonids | 0 | 0 | 0 | 2 | <0.01 |
| UID[2] larval catostomids | 0 | 0 | 0 | 144 | 0.5 |
| UID[2] fishes | 0 | 0 | 0 | 12 | 0.04 |

[1] all were young-of-the-year and were released
[2] unidentified

the total number of eggs collected in Bonneville Pool was nearly twice that of The Dalles Pool and nearly eight times that of John Day Pool. The number of eggs collected and egg CPUE were also found to be greater in two average water years (1990-1991) than in low water years (1987-1988) (Miller and Beckman 1993). This trend was not evident in the CPUE values calculated for 1993. Although the peak discharge in 1993 was greater than that of 1991, catch/1000 $m^3$ was 19 times greater in 1991 than 1993 in Bonneville Pool, 4 times greater in The Dalles Pool, and the same in John Day Pool for the sites sampled during 1993 in all three pools.

The differences in egg catch trends during 1993 when compared to previous study years may be a reflection of the intensity of our sampling. In 1993, we sampled approximately 1/20,000 % of the flow that passed through The Dalles Dam during the egg and larval sampling period. Given this low level of intensity it is possible that we were not able to adequately document the majority of spawning events that occurred during 1993. Votinov and Kas'yanov (1978) observed a low reproduction efficiency of Siberian sturgeon *Acipenser baeri* in a year with the second highest discharge recorded during their study. They attributed this observation to the timing of the peak discharge. When examining the spawning habitat requirements of the Colorado squawfish *Ptychocheilus lucius*, Harvey et al. (1994) also found that the timing and magnitude of discharges in the Yampa River, Colorado played an important role in the formation of suitable Colorado squawfish spawning habitat. Similar processes may be necessary for white sturgeon spawning.

When both eggs and larvae were used to back-calculate spawning dates, the trend between pools was similar to that seen in previous years (Anders and Beckman 1993). Spawning was initiated first and lasted the longest in Bonneville Pool and began last and was shortest in John Day Pool. Contrary to most of the previous years of this study, egg stages later than stage 2 (Beer 1981) as well as sturgeon larvae were used to estimate the white sturgeon spawning period. The lack of newly spawned eggs in the 1993 catch did not allow us to confidently estimate the spawning period based on this stage 2 eggs alone.

In contrast to this year's egg catch data, trends in the YOY and juvenile catches generally displayed similar trends to those seen in previous years. The number of YOY caught and catch/hectare was greatest in Bonneville Pool and least in John Day Pool. This is only the second year that YOY have been captured in John Day Pool (two YOY were captured in 1991). Young-of-the-year CPUE has also been found to be greater during years of average discharge than in years with low discharge (Miller and Beckman 1993). When compared to 1991, CPUE of YOY during 1993 was slightly higher in Bonneville Pool. However, CPUE was nine times lower in The Dalles Pool in 1993 than 1991. The absence of YOY in John Day Pool precludes this type of comparison. The juvenile white sturgeon catch exhibited similar trends shown by YOY catches.

We documented white sturgeon spawning in the Hanford Reach of the Columbia River for the first time. White sturgeon eggs were collected at sites approximately 1, 8, 15, and 27 miles below Priest Rapids Dam. This contrasts with collections from 1987 to 1991 in the three lower pools, where eggs were never collected further than several

8, 15, and 27 miles below Priest Rapids Dam. This contrasts with collections from 1987 to 1991 in the three lower pools, where eggs were never collected further than several miles below the dam at the upper end of each pool (Anders and Beckman 1993a). Since the Hanford Reach more closely resembles historic hydraulic conditions than other reaches of the Columbia River (Haynes et al. 1978), the water velocities, water depths, and substrate types suitable for white sturgeon spawning are not subject to the hydraulic constraints that exist in impounded areas and therefore may exist throughout much of this section of the Columbia River. Spawning may be localized near these four areas since no eggs or larvae were collected at sites sampled between each of these areas. It was also noted that the sites in the Hanford Reach where eggs were collected appeared (based on visual observation of the water surface and sonar chart recordings) to have coarser substrates and more turbulent flows. However, substrate composition and water turbulence have not yet been quantitatively measured.

White sturgeon spawning was also documented in the Snake River below Ice Harbor Dam for the first time. Eggs were collected 2.1 and 2.5 miles downstream from Ice Harbor Dam. Eggs were collected within the ranges of water depths, water temperatures, mean water column velocities, and bottom velocities reported for sites that collected eggs in previous years (Parsley and Beckman 1993b). White sturgeon eggs were collected at only two sites during 1993. As was true with the sites located in the Hanford Reach of the Columbia River, it appears that spawning may be localized near these areas. Several attempts were made to collect eggs at sites upstream and adjacent to site 524 after eggs were collected at this site. Site 524, where the majority of the eggs were collected, was characterized by turbulent flow that appeared to be the result of boulder substrate immediately upstream of the site and was adjacent to areas with boulder and cobble substrates.

While the amount of available spawning habitat (the combination of suitable water velocity, water depth, substrate, and temperature) (Parsley and Beckman 1994), has yet to be quantified; visual observations from 1993 indicate that spawning appears to be occurring in the most turbulent areas in the Hanford Reach of the Columbia River and the Snake River below Ice Harbor Dam. Heede and Rinne (1990) suggest that turbulence has been overlooked in past fish habitat studies. Turbulent flow may help to flush substrates of fine sediments and may also facilitate the downstream movement of young fish (Heede and Rinne 1990). They suggested the use of either Reynolds or the Froude number as potential measures of turbulence in lotic habitats.

The estimated spawning period began and ended earlier in the Snake River below Ice Harbor Dam than in the Hanford Reach of the Columbia, however, the beginning and ending temperatures were similar in both tailraces. Temperature varied little between sites, and no apparent temperature difference existed between sites where eggs and larvae were and were not collected. The percentages of white sturgeon eggs that were dead when collected were similar for these portions of the Snake and Columbia rivers, and were within the range reported for the four downstream tailraces for 1987-1991 (Anders and Beckman 1993b) and 1993.

YOY was collected at a moderately deep site. All of the YOY were captured downstream from the confluence of the Snake River with the Columbia River. No YOY were collected in the Hanford Reach. The high-rise bottom trawl is successful in collecting YOY and older juveniles up to about 800 mm FL in impounded reaches of the Columbia River, but may not be suitable for collecting those life-stages in free-flowing areas with higher water velocities such as the Hanford Reach. Gear avoidance by YOY and older juveniles may be greater in the Hanford Reach due to increased audio and visual stimuli. Catch-per-unit-effort values for 1993 with the high-rise trawl indicate that gear avoidance may be greater in the Hanford Reach than in the impounded portion of McNary Pool. Catch-per-unit-effort combined for all fish species collected at sites in McNary Pool below the Hanford Reach was greater (catch/15 minutes = 61.5; catch/hectare = 130) than at sites in the Hanford Reach (catch/15 minutes = 0.95; catch/hectare = 4.2).

White sturgeon and other fish species are known to inhabit the Hanford Reach. Haynes et al. (1978) reported collecting and attaching radio transmitters to 29 white sturgeon in the Hanford Reach. Nearly all of the 29 fish remained in the Hanford Reach year-round. Gray and Dauble (1977) reported collecting 37 species of fish in the Hanford Reach during 1973-1975 with gillnets, hoopnets, and beach seines. Gunderson (1993) reported that many fish species react to (and potentially avoid) light or noise produced by sampling equipment. Visual and audio stimuli may be greater, or easier for fish to detect in the Hanford Reach than in impounded reaches; Water depth is less, water velocity is greater on average, and turbidity is less on average (NBS unpublished data) in the Hanford Reach than in the three downstream pools. Visual and audio avoidance may be greater under those conditions. No juvenile white sturgeon were collected in McNary Pool or the Hanford Reach, suggesting a sparse juvenile population in that pool or distribution concentrated in the Hanford Reach where vulnerability to the high-rise trawl may be decreased.

## Plans for 1994

Plans for 1994 include sampling for white sturgeon eggs and larvae in the Hanford Reach and in the Snake River below Ice Harbor Dam. Increased emphasis will be placed on locating specifically where spawning is occurring in these areas and developing a quantitative measure of turbulence.

Trawling with the high-rise bottom trawl for YOY and juvenile white sturgeon will continue in Bonneville and McNary pools. The effort in Bonneville Pool will be increased from that expended during 1993 with the expectation that this data will aid us in developing a recruitment index that can be used in subsequent years of this study. In addition to using the trawling efforts, we will examine the effectiveness of using hoop nets to capture YOY and juvenile white sturgeon in Bonneville Pool.

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**APPENDIX C-1**

Common and scientific names of fishes collected between Bonneville and Priest Rapids dams in 1993.

| Common name | Scientific name |
|---|---|
| Pacific lamprey | *Lampetra tridentata* |
| White sturgeon | *Acipenser transmontanus* |
| American shad | *Alosa sapidissima* |
| Chinook salmon | *Oncorhynchus tshawytshcha* |
| Lake whitefish | *Coregonus clupeaformis* |
| Mountain whitefish | *Prosopium williamsoni* |
| Chiselmouth | *Acrocheilus alutaceus* |
| Common carp | *Cyprinus carpio* |
| Peamouth | *Mylocheilus caurinus* |
| Northern squawfish | *Ptychocheilus oregonensis* |
| Longnose dace | *Rhinichthys cataractae* |
| Redside shiner | *Richardsonius balteatus* |
| Largescale sucker | *Catostomus macroheilus* |
| Bridgelip sucker | *Catostomus columbianus* |
| Channel catfish | *Ictalurus punctatus* |
| Brown bullhead | *Ictalurus nebulosus* |
| Sandroller | *Percopsis transmontana* |
| Pumpkinseed | *Lepomis gibbosus* |
| Sunfishes | *Lepomis* spp. |
| Smallmouth bass | *Micropterus dolomieui* |
| Largemouth Bass | *Micropterus salmoides* |
| Crappies | *Pomoxis* spp. |
| Yellow perch | *Perca flavescens* |
| Walleye | *Stizostedion vitreum vitreum* |
| Sculpins | *Cottus* spp. |

## APPENDIX C-2

The location, total time sampled, and the catch/15 minutes of white sturgeon eggs and larvae of sites sampled with the beam trawl in the Columbia River between McNary and Priest Rapids dams.

| | | Catch/15 minutes | |
|---|---|---|---|
| Site | Minutes sampled | Eggs | Larvae |
| 34182 | 150 | 0 | 0 |
| 34183 | 120 | 0 | 0 |
| 34372 | 90 | 0 | 0 |
| 34373 | 30 | 0 | 0 |
| 34572 | 30 | 0 | 0 |
| 34574 | 120 | 0 | 0 |
| 34584 | 120 | 0 | 0 |
| 34622 | 30 | 0 | 0 |
| 34893 | 120 | 0 | 0 |
| 35133 | 270 | 0 | 0 |
| 35493 | 30 | 0 | 0 |
| 35543 | 270 | 0 | 0 |
| 35712 | 120 | 0 | 0 |
| 36112 | 180 | 0 | 0 |
| 36483 | 150 | 0 | 0 |
| 36922 | 60 | 0 | 0 |
| 36932 | 60 | 0 | 0 |
| 37003 | 180 | 0.2 | 0 |
| 37423 | 120 | 0 | 0 |
| 37634 | 150 | 0 | 0 |
| 38173 | 210 | 0.07 | 0 |
| 38193 | 60 | 0.3 | 0 |
| 38873 | 150 | 0 | 0.2 |
| 38883 | 210 | 1.6 | 0.5 |
| 38912 | 90 | 1.3 | 0.3 |

APPENDIX C-2 (continued)

| Site | Minutes sampled | Catch/15 minutes | |
|---|---|---|---|
| | | Eggs | Larvae |
| 39132 | 30 | 0 | 0 |
| 39163 | 30 | 0 | 0 |
| 39282 | 30 | 0 | 0 |
| 39423 | 30 | 0 | 0 |
| 39433 | 240 | 0 | 0 |
| 39582 | 90 | 0.2 | 0.8 |
| 39592 | 60 | 0.5 | 0.5 |
| 39614 | 30 | 0 | 0 |
| 39621 | 60 | 0.8 | 0 |
| 39622 | 30 | 1.5 | 0 |
| 39633 | 300 | 0.2 | 0 |
| Total | 4050 | | |

**APPENDIX C-3**

The location, total time sampled, volume of water sampled, catch/15 minutes of white sturgeon eggs and larvae, catch/1000 m$^3$ of white sturgeon eggs of sites sampled with the D-shaped larval nets in the Snake River below Ice Harbor Dam.

| | | | Catch/15 minutes | | Catch/1000 m$^3$ | |
|---|---|---|---|---|---|---|
| Site | Minutes sampled | m$^3$ sampled | Eggs | Larvae | Eggs | Larvae |
| 201 | 60 | 322 | 0 | 0 | 0 | 0 |
| 223 | 60 | 409 | 0 | 0 | 0 | 0 |
| 303 | 60 | 994 | 0 | 0 | 0 | 0 |
| 314 | 60 | 460 | 0 | 0 | 0 | 0 |
| 322 | 60 | 732 | 0 | 0 | 0 | 0 |
| 354 | 60 | 276 | 0 | 0 | 0 | 0 |
| 381 | 60 | 629 | 0 | 0 | 0 | 0 |
| 383 | 60 | 381 | 0 | 0 | 0 | 0 |
| 393 | 60 | 483 | 0 | 0 | 0 | 0 |
| 403 | 60 | 469 | 0 | 0 | 0 | 0 |
| 421 | 60 | 586 | 0 | 0 | 0 | 0 |
| 491 | 60 | 779 | 0 | 0 | 0 | 0 |
| 494 | 60 | 930 | 0 | 0 | 0 | 0 |
| 512 | 60 | 700 | 0 | 0 | 0 | 0 |
| 514 | 240 | 1745 | 0 | 0 | 0 | 0 |
| 521 | 180 | 3374 | 0 | 0 | 0 | 0 |
| 522 | 180 | 3101 | 0 | 0 | 0 | 0 |
| 523 | 120 | 1393 | 0 | 0 | 0 | 0 |
| 524 | 240 | 3817 | 2.4 | 0.3 | 10.2 | 1.3 |
| 532 | 60 | 1162 | 0 | 0 | 0 | 0 |
| 534 | 60 | 537 | 0 | 0 | 0 | 0 |
| 553 | 60 | 1257 | 0 | 0 | 0 | 0 |
| 561 | 60 | 1023 | 0.5 | 0 | 2.4 | 0 |
| 581 | 60 | 529 | 0 | 0 | 0 | 0 |
| 591 | 60 | 783 | 0 | 0 | 0 | 0 |

## APPENDIX C-3 (continued)

| Site | Minutes sampled | $m^3$ sampled | Catch/15 minutes Eggs | Catch/15 minutes Larvae | Catch/1000 $m^3$ Eggs | Catch/1000 $m^3$ Larvae |
|---|---|---|---|---|---|---|
| 594 | 60 | 520 | 0 | 0 | 0 | 0 |
| 603 | 60 | 605 | 0 | 0 | 0 | 0 |
| 611 | 60 | 602 | 0 | 0 | 0 | 0 |
| 613 | 60 | 500 | 0 | 0 | 0 | 0 |
| 641 | 60 | 542 | 0 | 0 | 0 | 0 |
| 651 | 120 | 1698 | 0 | 0 | 0 | 0 |
| 702 | 60 | 1023 | 0 | 0 | 0 | 0 |
| 713 | 60 | 1205 | 0 | 0 | 0 | 0 |
| 714 | 60 | 1177 | 0 | 0 | 0 | 0 |
| 721 | 60 | 714 | 0 | 0 | 0 | 0 |
| 722 | 60 | 1004 | 0 | 0 | 0 | 0 |
| 723 | 120 | 2084 | 0 | 0 | 0 | 0 |
| 724 | 34 | 467 | 0 | 0 | 0 | 0 |
| 731 | 180 | 3605 | 0 | 0 | 0 | 0 |
| 782 | 60 | 1241 | 0 | 0 | 0 | 0 |
| 801 | 60 | 1230 | 0 | 0 | 0 | 0 |
| 803 | 26 | 387 | 0 | 0 | 0 | 0 |
| 831 | 60 | 899 | 0 | 0 | 0 | 0 |
| 832 | 60 | 1567 | 0 | 0 | 0 | 0 |
| 842 | 60 | 1305 | 0 | 0 | 0 | 0 |
| 861 | 60 | 1119 | 0 | 0 | 0 | 0 |
| 923 | 120 | 2090 | 0 | 0 | 0 | 0 |
| Total | 3720 | 54,455 | | | | |

**APPENDIX C-4**

The location, total time sampled, total area sampled, catch/15 minutes, and catch/hectare of sites sampled with the high-rise bottom trawl in the Columbia River between McNary and Priest Rapids dams.

| Site | Total time sampled (min) | Area sampled (Hectares) | Number of YOY collected | Catch/15 minutes | Catch/hectare |
|---|---|---|---|---|---|
| 30242 | 120 | 0.5381 | 0 | 0 | 0 |
| 30511 | 10 | 0.3339 | 0 | 0 | 0 |
| 30712 | 40 | 1.4746 | 0 | 0 | 0 |
| 30934 | 40 | 1.4910 | 0 | 0 | 0 |
| 31193 | 40 | 1.2388 | 2 | 0.75 | 1.61 |
| 31254 | 50 | 1.6863 | 1 | 0.30 | 0.59 |
| 31402 | 10 | 0.3260 | 0 | 0 | 0 |
| 31432 | 40 | 1.3203 | 0 | 0 | 0 |
| 31443 | 10 | 0.3339 | 0 | 0 | 0 |
| 31651 | 20 | 0.6353 | 0 | 0 | 0 |
| 31751 | 30 | 0.9208 | 0 | 0 | 0 |
| 32063 | 28 | 0.7655 | 0 | 0 | 0 |
| 32392 | 3 | 0.1139 | 0 | 0 | 0 |
| 32662 | 20 | 0.6437 | 0 | 0 | 0 |
| 32863 | 10 | 0.3339 | 0 | 0 | 0 |
| 33443 | 20 | 0.5050 | 0 | 0 | 0 |
| 34193 | 20 | 0.3093 | 0 | 0 | 0 |
| 34903 | 20 | 0.2362 | 0 | 0 | 0 |
| 35133 | 20 | 0.2362 | 0 | 0 | 0 |
| 35702 | 8 | 0.1302 | 0 | 0 | 0 |
| 36243 | 20 | 0.3014 | 0 | 0 | 0 |
| 37002 | 20 | 0.2446 | 0 | 0 | 0 |
| 37633 | 20 | 0.5050 | 0 | 0 | 0 |
| 38863 | 20 | 0.2767 | 0 | 0 | 0 |

**APPENDIX C-4 (continued)**

| Site | Total time sampled (min) | Area sampled (Hectares) | Number of YOY collected | Catch/15 minutes | Catch/hectare |
|---|---|---|---|---|---|
| 38903 | 9 | 0.1628 | 0 | 0 | 0 |
| 39413 | 22 | 0.2687 | 0 | 0 | 0 |
| | 670 | 15.3321 | | | |

# REPORT D

1. Describe reproductive and early life history characteristics of white sturgeon in McNary Reservoir and downstream from Bonneville Dam.

2. Evaluate growth, mortality, and contributions to fisheries of juvenile white sturgeon transplanted from areas downstream from The Dalles Dam to areas in The Dalles and John Day Reservoirs.


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## CONTENTS

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Lawrence Davis, Roy Pettit, Dennis Umphfres, and Washington Department of Fish and Wildlife (WDFW) personnel assisted in the field sampling. The WDFW determined the developmental stages of white sturgeon eggs and larvae and provided summaries of the egg and larval sampling efforts. The U.S. Army Corps of Engineers provided water temperature and water discharge information for Bonneville Dam.

## ABSTRACT

During 1993, the National Marine Fisheries Service sampled white sturgeon *Acipenser transmontanus* eggs, larvae, and juveniles in the Columbia River downstream from Bonneville Dam (River Mile (RM) 145). In conjunction with the Washington Department of Fish and Wildlife, 3,048 white sturgeon eggs were collected with plankton nets and artificial substrates between RM 120 and 145. Viable white sturgeon eggs were collected first on 27 April, and last on 14 July. The sampling site near Ives Island (RM 143) was used as the primary index station to monitor white sturgeon spawning throughout the season. Between 27 April and 14 July, white sturgeon egg densities near Ives Island (in plankton nets) ranged from 0.0 to 274.1 eggs/1,000 $m^3$ of water sampled, with the highest density on 27 April. Based on egg collections, we estimated that white sturgeon spawned on at least 46 days in 1993, beginning on 26 April and ending on 13 July. Spawning was estimated to have occurred at Bonneville Dam discharges (mean hourly discharge by day) ranging from 3,962 to 11,139 $m^3/s$, and water temperatures ranging from 11 to 18°C. A total of 170 white sturgeon larvae was collected in plankton nets between RM 120 and 145. Larvae were first collected on 10 May, and last collected on 6 July. Densities of larvae near Ives Island ranged from 0.0 to 4.8 larvae/1,000 $m^3$.

In September 1993, 210 juvenile white sturgeon were collected with a 7.9-m (headrope length) semiballoon shrimp trawl between RM 28 and 132 in the Columbia River downstream from Bonneville Dam. Distributions of juvenile white sturgeon were patchy; not only were there differences in catches among different areas of the river, but also differences in catches among parallel transects within the same area. We collected 55 young-of-the-year (YOY) white sturgeon between RM 28 and 131; YOY comprised about 26% of the total catch of juvenile white sturgeon. Densities of YOY white sturgeon at 13 index sampling stations averaged 2.9 fish/hectare during the first survey (7-10 September) and 9.0 fish/hectare during the second survey (20-24 September); the mean for both surveys combined was 5.9 fish/hectare.

## INTRODUCTION

Under an agreement with the Oregon Department of Fish and Wildlife (ODFW), the National Marine Fisheries Service (NMFS) is responsible for segments of two objectives of the White Sturgeon Study. The first objective is to describe reproductive and early life history characteristics of white sturgeon in McNary Reservoir and downstream from Bonneville Dam. The second objective is to evaluate growth, mortality, and contributions to fisheries of juvenile white sturgeon transplanted from areas downstream from The Dalles Dam to areas in The Dalles and John Day Reservoirs. The NMFS's research is conducted in the Columbia River downstream from Bonneville Dam. This lower reach of the river was used as a control area for Phase I of the White Sturgeon Study (1986-1992) and will be used in a similar manner for Phase II (1992-1997). Data collected in the control area will be used to determine the effects of the development and operation of the hydropower system and assess the effects of recommended flow and project operations on white sturgeon spawning and recruitment in the impoundments upstream from Bonneville Dam.

Specific research goals for 1993 were 1) to determine the timing of spawning in the Columbia River downstream from Bonneville Dam; 2) to estimate the effects of river flow, water velocity, and water temperature on white sturgeon spawning; 3) to estimate the success of young-of-the-year (YOY) white sturgeon recruitment in 1993; and 4) to collect juvenile white sturgeon in selected areas of the Columbia River downstream from Bonneville Dam for an ODFW evaluation on the feasibility of transporting juvenile white sturgeon from fully-seeded habitats (e.g., the river downstream from Bonneville Dam) to under-seeded habitats upstream from The Dalles Dam. This report describes progress on NMFS studies from March 1993 to March 1994.

## METHODS

### Egg and Larval Sampling

In 1993, NMFS and the Washington Department of Fish and Wildlife (WDFW) sampled for white sturgeon eggs and larvae in the Columbia River downstream from Bonneville Dam. Sampling began in April and ended in July; generally, sampling was conducted weekly. A D-ring plankton net was used to collect white sturgeon eggs and larvae. This net was 0.8 m wide at the bottom of the mouth opening and was constructed of 7.9-mesh/cm nylon marquisette netting (Kreitman 1983). Depending upon the water velocity, two to eight lead weights (4.5 or 9.1 kg each) were attached to two corners of the net frame to hold the net on the river bottom. A digital flow meter (General Oceanics Model 2030[1]) was suspended in the mouth of the net to estimate the water volume sampled. Typically, two plankton nets were fished simultaneously for about 30 min from an anchored 12.2-m research vessel.

Artificial substrates constructed of latex-coated animal hair were also used to collect white sturgeon eggs. Substrates were cut into 76 X 91-cm sections and secured to an angle iron frame. Two sections of artificial substrate were placed back to back in each frame.

[1] *Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.*

Because two pieces were used in each frame, it made no difference what side of the frame rested on the river bottom. Two short sections of cable were used to attach the frame to an anchor, which held the substrate and frame in place on the bottom. A buoy line was attached to the anchor to allow retrieval of the substrate, frame, and anchor.

White sturgeon egg or larval sampling was done at various stations in the lower Columbia River from River Mile (RM) 120 to 145 (Table 1, Figure 1). Four of the stations (RM 120, 139, 140, and 143) had been routinely occupied during Phase I of the White Sturgeon Study. Sampling stations at RM 122 and 145 were newly established in 1993. The sampling station near Ives Island (RM 143), which has been routinely sampled in past years by WDFW and NMFS, was considered the primary index station for monitoring white sturgeon spawning in the Columbia River downstream from Bonneville Dam.

White sturgeon eggs and larvae were fixed in an approximately 4% buffered formaldehyde solution and transferred to WDFW.

## Juvenile Sampling

A 7.9-m (headrope length) semiballoon shrimp trawl, identical to that used from 1987 through 1991, was used to collect juvenile white sturgeon, including YOY. Mesh size in the trawl was 38 mm (stretched measure) in the body; a 10-mm mesh liner was inserted in the cod end of the net. Shrimp trawl efforts were normally 5 min in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable were let out, and the effort was considered ended when 5 min elapsed. We estimated the distance the net fished during each sampling effort using a radar range-finder.

Trawling was conducted during two surveys in September at 36 sampling stations established during Phase I of the White Sturgeon Study in the lower Columbia River between RM 28 and 132 (Table 1). The sampling stations were originally selected primarily to determine habitat use by juvenile white sturgeon; no attempt was made to randomly select the stations. At some areas, two or three trawling efforts were completed along parallel transects. Transect 1 was closest to the Washington shore, Transect 2 was the middle transect, and Transect 3 was closest to the Oregon shore. In certain river sections where only two transects were established, Transect 2 was closest to the Oregon shore. Thirteen of the 36 sampling stations were selected as index sites for estimating YOY white sturgeon densities in the lower Columbia River (Figure 1).

Fishes captured in the bottom trawls were identified and counted. All white sturgeon from each sampling effort were measured (total and fork lengths (mm)) and weighed (g). Small YOY sturgeon do not have a distinct fork in their tails; therefore we estimated the fork lengths of small YOY sturgeon (less than 150 mm fork length) to ensure consistency in data analysis. In previous years, all length comparisons of older juveniles were done using fork lengths, since natural total lengths are much less reliable. On older juvenile sturgeon (those with a fork in their tails), we observed that the distal end of an imaginary line, extended along the lateral row of scutes (before it turns upward) onto the caudal fin, approximated the location of the fork. We routinely examined juvenile white sturgeon for the nematode parasite *Cystoopsis acipenseri* (Chitwood and McIntosh 1950). When present, the parasite is encased in blister-like cysts under the skin.

Table 1. Numbers of sampling efforts for white sturgeon eggs, larvae, and young-of-the-year in the Columbia River downstream from Bonneville Dam, 1993. When two plankton nets were fished simultaneously, the data were combined and considered as one sampling effort. Location is shown in River Miles (RM).

| Location | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|
| **Plankton net** | | | | | | | |
| RM 120-122 | 3 | 7 | 10 | 6 | 0 | 0 | 26 |
| RM 139-140 | 6 | 8 | 10 | 6 | 0 | 0 | 30 |
| RM 143-145 | 6 | 8 | 10 | 6 | 0 | 0 | 30 |
| **Artificial substrate** | | | | | | | |
| RM 143 | 2 | 5 | 10 | 6 | 0 | 0 | 23 |
| RM 145 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| **Shrimp trawl** | | | | | | | |
| RM 28-60 | 0 | 0 | 0 | 0 | 0 | 22 | 22 |
| RM 61-90 | 0 | 0 | 0 | 0 | 0 | 28 | 28 |
| RM 91-120 | 0 | 0 | 0 | 0 | 0 | 15 | 15 |
| RM 121-132 | 0 | 0 | 0 | 0 | 0 | 14 | 14 |

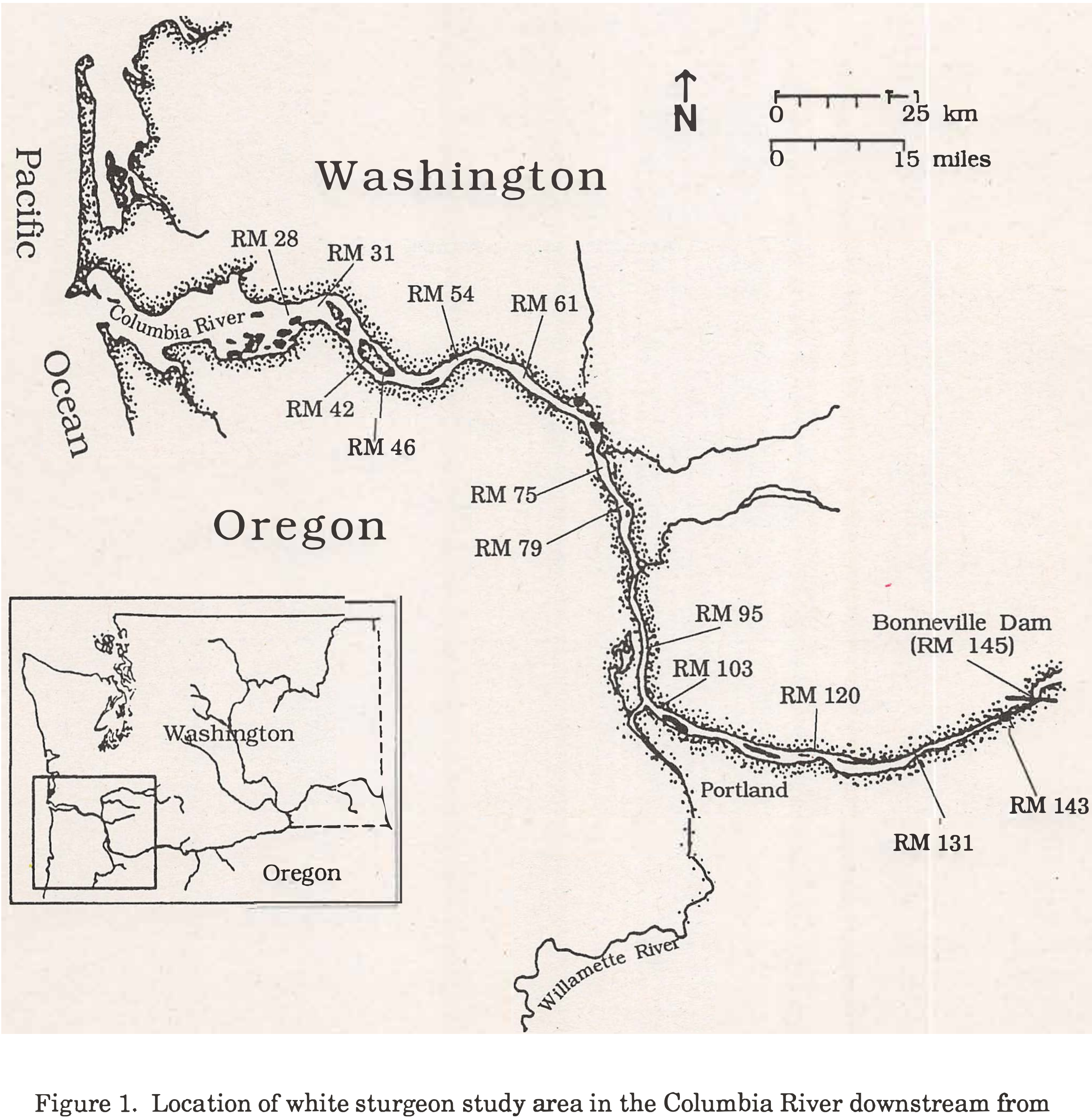


Figure 1. Location of white sturgeon study area in the Columbia River downstream from Bonneville Dam.

From 25 to 27 October, NMFS assisted ODFW in collecting juvenile white sturgeon between RM 131 and 132 with the 7.9-m shrimp trawl described above. The ODFW is evaluating the feasibility of collecting juvenile white sturgeon in the Columbia River downstream from Bonneville Dam and transporting them to impoundments upstream from The Dalles Dam (see Report A for further details and results of the ODFW study).

## Physical Conditions

The following physical parameters were measured in conjunction with biological sampling: bottom depth (m) (minimum and maximum); bottom-water temperature (°C); bottom-water turbidity (NTU); and water velocities at 0.2 of the total depth, 0.8 of the total depth, and about 0.6 m above the bottom. By averaging water velocities measured at 0.2 and 0.8 of the total depth, we calculated a mean water-column velocity (Buchanan and Somers 1969). Water velocities were measured only during egg and larval sampling. Depth was measured with electronic depth sounders, and velocity with a Price Type "AA" current meter attached to a 45.4-kg lead fish. A Van Dorn water bottle was used to collect water samples just above the bottom. The water temperature of each sample was measured immediately after collection, and a subsample of water was removed and placed in a glass bottle. The turbidity of the sample was determined in the laboratory using a Hach Model 2100A Turbidimeter.

## Data Analyses

Physical and biological data collected during the field season were entered into computer files following formats agreed to by the four cooperating agencies involved in the White Sturgeon Study: the National Biological Survey (NBS), ODFW, NMFS, and WDFW.

Developmental stages of white sturgeon eggs and larvae were determined by WDFW, based on descriptions by Beer (1981). Timing of egg deposition was estimated using developmental stages of eggs and temperature-egg developmental data from Wang et al. (1985). Water temperature at the time of egg collection was used in making estimates of timing of egg deposition, and a daily index of spawning activity was calculated based on these estimated spawning dates. The index of spawning activity was treated as a dichotomous variable: spawning occurred or did not occur on a particular day. The WDFW's descriptions for larval stages 1-7 correspond to Beer's descriptions for his stages 1-day post hatch through 7-day post hatch. We were unable to estimate the number of days required to reach a specific larval stage because water temperatures in the Columbia River were not always comparable to laboratory temperatures in Beer's study.

Using the distance fished during a shrimp trawl effort and the estimated fishing width of the net (5.3 m), we calculated the area fished for each effort. Fish densities (by species) for each effort were calculated and expressed as number/hectare (10,000 $m^2$).

The YOY white sturgeon were distinguished from older juvenile sturgeon using length frequencies.

# RESULTS

## Egg and Larval Sampling

In 1993, 3,048 white sturgeon eggs were collected between RM 120 and 145 (Table 2); 1,315 eggs were collected with plankton nets and 1,733 eggs were collected with artificial substrates. Viable white sturgeon eggs were first collected on 27 April at RM 140 and near Ives Island (RM 143) and were last collected on 14 July at RM 139, RM 140, and near Ives Island. In 1993, less than 1% of white sturgeon eggs collected in plankton nets were infected with fungus; fungus infection indicated infertile or dead eggs (Table 2).

The sampling station near Ives Island was used as the primary index station to monitor white sturgeon spawning during 1993 (Table 3). White sturgeon eggs were collected at this station on 10 of the 12 sampling days from 27 April to 14 July. The abundance (density) of white sturgeon eggs at Ives Island was highest on 27 April (274.1 eggs/1,000 $m^3$). At Ives Island, stage 2 (freshly fertilized) eggs represented 80% of the total eggs collected in plankton nets and were collected on 5 of the 10 sampling days when eggs were collected at this location (Table 4). Stage 2 eggs were first collected on 27 April and last collected on 25 May.

In areas downstream from Ives Island, only 8% of the total eggs collected in plankton nets were stage 2 eggs (Table 4). No stage 2 eggs were collected downstream from RM 139. A small number of stage 2 eggs was also collected in plankton nets upstream from Ives Island, representing 6% of the total eggs collected in plankton nets in this area. These data suggest that spawning intensity was greater in the area near or just upstream from Ives Island than in the other areas sampled.

Artificial substrates placed along Ives Island, just upstream from Ives Island, and about 600 m downstream from the spillways at Bonneville Dam (at the lower boundary of the restricted zone) collected white sturgeon eggs. Total egg collections using substrates at these stations were 1,239 eggs for Ives Island, 491 eggs for the site just upstream from Ives Island, and 3 for the site downstream from the spillways. Sampling effort was much less at the station downstream from the spillways than at the other two stations. Collection of white sturgeon eggs near the spillways indicated that the upper boundary of sturgeon spawning in the Columbia River downstream from Bonneville Dam is very close to the dam.

Based on back calculations using the developmental stages of eggs, we estimated spawning began on 26 April and ended on 13 July. During this period, spawning was estimated to have occurred on at least 46 days: 5 days in late April, 23 days in May, 14 days in June, and 4 days in July. Spawning was estimated to have occurred at water temperatures ranging from 11 to 18°C and Bonneville Dam discharges (mean hourly discharge by day) ranging from 3,962 to 11,139 $m^3/s$ (Figure 2).

In 1993, 170 white sturgeon larvae were collected in plankton nets between RM 120 and 145 (Table 2). Larvae were first collected on 10 May at RM 139, 140, and Ives Island, and last collected on 6 July at RM 139 and 140. Overall, 61% of the larvae that were staged were classified as post hatch or stage 1 (Table 5). Densities of larvae near Ives Island ranged from 0.0 to 4.8 larvae/1,000 $m^3$ (Table 3).

Table 2. Numbers of white sturgeon eggs and larvae collected in the Columbia River downstream from Bonneville Dam, 1993; plankton nets and artificial substrates were used to collect eggs, and plankton nets were used to collect larvae. Fungus-infected eggs collected in plankton nets are shown in parentheses and are included in the numbers reported for the nets. Area refers to the geographic range in River Miles (RM).

| Sampling period | Eggs | | | Larvae | |
|---|---|---|---|---|---|
| | Area (RM) | Net | Substrate | Area (RM) | Net |
| 13-30 Apr | 140-143 | 349 | 73 | - | 0 |
| 1-15 May | 120-145 | 247 | 789 | 120-143 | 15 |
| 16-31 May | 139-145 | 457 (1) | 167 | 122-145 | 7 |
| 1-15 Jun | 120-145 | 226 (2) | 649 | 120-145 | 118 |
| 16-30 Jun | 139-145 | 24 (1) | 29 | 139-145 | 27 |
| 1-15 Jul | 139-143 | 11 (2) | 26 | 139-140 | 3 |
| 16-27 Jul | 140 | 1 (1) | 0 | - | 0 |
| TOTAL | | 1,315 (7) | 1,733 | | 170 |

Table 3. White sturgeon egg and larval catches near Ives Island (RM 143) in the Columbia River downstream from Bonneville Dam, 1993. Water temperatures were measured just above the bottom; Bonneville Dam flows were average hourly discharges (for each day). Generally, two plankton net samples were collected on each sampling day.

| Date | Temp. (°C) | Velocity (m/s) | | Bonneville Dam total discharge (1,000 $m^3$/s) | Eggs/ 1,000 $m^3$ | Larvae/ 1,000 $m^3$ |
|---|---|---|---|---|---|---|
| | | Mean column | Bottom | | | |
| 13 Apr | 9 | 1.7 | 1.1 | 4.73 | 0.0 | 0.0 |
| 19 Apr | 10 | 1.7 | 0.9 | 4.32 | 0.0 | 0.0 |
| 27 Apr | 11 | 1.7 | 1.0 | 4.77 | 274.1 | 0.0 |
| 3 May | 12 | 2.0 | 1.1 | 5.46 | 21.2 | 0.0 |
| 10 May | 13 | 2.1 | 1.4 | 7.33 | 103.5 | 1.1 |
| 17 May | 14 | 2.7 | 1.5 | 10.92 | 193.0 | 0.0 |
| 25 May | 14 | 2.7 | 1.9 | 9.74 | 2.3 | 0.3 |
| 1 Jun | 15 | 2.4 | 1.6 | 7.89 | 17.5 | 0.0 |
| 7 Jun | 15 | 2.1 | 1.6 | 6.61 | 3.0 | 4.8 |
| 14 Jun | 16 | 2.1 | 1.5 | 6.65 | 4.4 | 0.0 |
| 21 Jun | 17 | 1.6 | 1.0 | 5.63 | 0.0 | 0.0 |
| 28 Jun | 17 | 1.5 | 1.2 | 4.89 | 3.0 | 0.8 |
| 6 Jul | 17 | 1.6 | 1.1 | 4.99 | 0.0 | 0.0 |
| 14 Jul | 18 | 1.6 | 1.0 | 4.82 | 2.8 | 0.0 |
| 26 Jul | 19 | 1.2 | 0.9 | 4.55 | 0.0 | 0.0 |

Table 4. Numbers of white sturgeon eggs (by developmental stage) collected with plankton nets in three areas downstream from Bonneville Dam, 1993. Upstream and downstream areas were defined in relation to Ives Island.

| Date (RM) | Egg developmental stage | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| UPSTREAM | | | | | | | | | | | | | | | | | | |
| 17 May (145) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 25 May (145) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 9 | 0 | 11 |
| 1 Jun (145) | 3 | 3 | 0 | 0 | 7 | 2 | 8 | 4 | 6 | 2 | 5 | 3 | 0 | 1 | 0 | 0 | 0 | 44 |
| 7 Jun (145) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 4 |
| 14 Jun (145) | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 28 Jun (145) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Total | 4 | 3 | 0 | 0 | 10 | 4 | 8 | 4 | 8 | 3 | 6 | 3 | 0 | 2 | 2 | 13 | 0 | 70 [a] |
| IVES ISLAND | | | | | | | | | | | | | | | | | | |
| 27 Apr | 328 | 0 | 0 | 0 | 9 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 346 |
| 3 May | 28 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 31 |
| 10 May | 176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 3 | 0 | 185 |
| 17 May | 265 | 0 | 0 | 0 | 0 | 38 | 38 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 19 | 0 | 379 |
| 25 May | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 6 |
| 1 Jun | 0 | 0 | 0 | 0 | 1 | 5 | 6 | 1 | 3 | 1 | 6 | 4 | 2 | 0 | 0 | 1 | 0 | 30 |
| 7 Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 4 |
| 14 Jun | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 28 Jun | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 4 |
| 14 Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| Total | 799 | 1 | 0 | 1 | 11 | 56 | 45 | 2 | 3 | 1 | 7 | 25 | 3 | 1 | 7 | 33 | 0 | 995 [b] |
| DOWNSTREAM | | | | | | | | | | | | | | | | | | |
| 27 Apr (140) | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 3 May (139) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| 3 May (140) | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 2 | 6 | 2 | 1 | 1 | 0 | 0 | 16 |
| 10 May (140) | 5 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 9 |
| 11 May (120) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 17 May (139) | 3 | 1 | 0 | 0 | 1 | 4 | 7 | 1 | 2 | 1 | 2 | 3 | 1 | 0 | 4 | 3 | 0 | 33 |
| 17 May (140) | 0 | 0 | 0 | 0 | 4 | 5 | 1 | 0 | 1 | 1 | 1 | 3 | 0 | 2 | 3 | 2 | 0 | 23 |
| 1 Jun (140) | 5 | 5 | 0 | 3 | 5 | 9 | 3 | 3 | 4 | 7 | 6 | 13 | 11 | 5 | 13 | 0 | 0 | 92 |
| 2 Jun (120) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 Jun (140) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 8 Jun (120) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 14 Jun (139) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 14 Jun (140) | 4 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 4 | 1 | 3 | 7 | 2 | 1 | 0 | 0 | 0 | 27 |
| 28 Jun (139) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 28 Jun (140) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 | 3 | 1 | 0 | 0 | 0 | 15 |
| 14 Jul (139) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 14 Jul (140) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 5 |
| Total | 18 | 9 | 1 | 3 | 11 | 20 | 15 | 6 | 12 | 10 | 17 | 45 | 21 | 12 | 24 | 8 | 0 | 232 [c] |

*Does not include 1 egg of unknown developmental stage.*

[b] *Does not include 5 eggs of unknown developmental stages.*

[c] *Does not include 12 eggs of unknown developmental stages.*

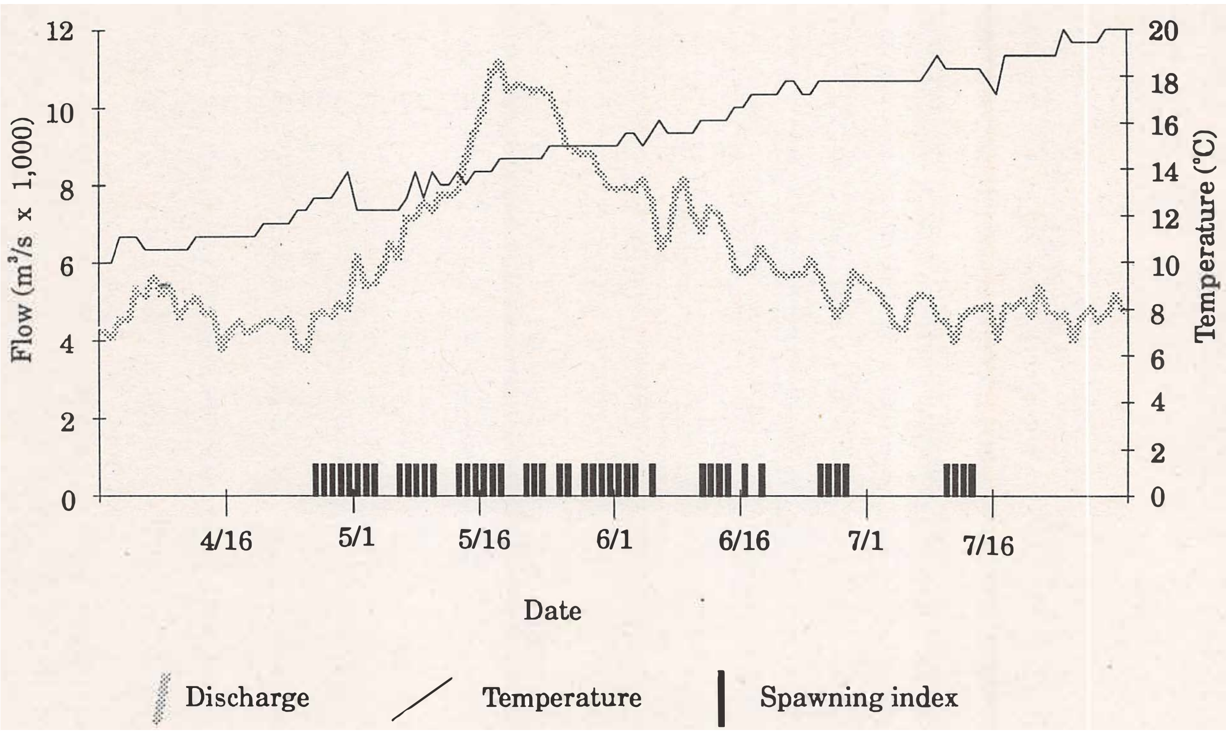


Figure 2. Water temperatures (°C) and Bonneville Dam discharges (mean hourly water discharges by day) from 1 April through 31 July 1993; discharge is shown as $m^3/s \times 1{,}000$. Water temperatures were measured at Bonneville Dam. The spawning index shows the days on which we estimated that white sturgeon spawned.

Table 5. Numbers of white sturgeon larvae (by stage) collected with plankton nets downstream from Bonneville Dam, 1993.

| Date (RM) | Larval stage | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Post hatch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| IVES ISLAND | | | | | | | | | |
| 10 May | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 25 May | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 Jun | 3 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 8 |
| 28 Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total | 5 | 5 | 1 | 0 | 0 | 0 | 0 | 1 | 12 |
| OTHER LOCATIONS | | | | | | | | | |
| 10 May (139) | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 10 May (140) | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 11 May (120) | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 11 May (122) | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 17 May (139) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 25 May (145) | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 26 May (122) | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 Jun (139) | 1 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 9 |
| 7 Jun (140) | 5 | 41 | 27 | 0 | 0 | 0 | 0 | 0 | 73 |
| 7 Jun (145) | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 6 |
| 8 Jun (120) | 1 | 7 | 7 | 0 | 0 | 0 | 0 | 1 | 16 |
| 8 Jun (122) | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 4 |
| 14 Jun (140) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 21 Jun (139) | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| 21 Jun (140) | 1 | 0 | 6 | 1 | 1 | 0 | 0 | 0 | 9 |
| 21 Jun (145) | 0 | 6 | 7 | 0 | 0 | 0 | 0 | 0 | 13 |
| 28 Jun (139) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 6 Jul (139) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 6 Jul (140) | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| Total | 22 | 71 | 53 | 3 | 2 | 2 | 0 | 4 | 157[a] |

[a] *Does not include one larva of an unknown stage.*

Physical conditions under which eggs and larvae were collected were generally similar. Bottom-water temperatures at sites where eggs (not including a fungus-infected egg collected on 26 July) were collected in plankton nets ranged from 11 to 18°C. Bottom-water turbidities at these sites ranged from 2.7 to 13.0 NTU, and mean water-column velocities ranged from 1.0 to 2.7 m/s. Water velocities about 0.6 m above the bottom ranged from 0.7 to 2.4 m/s, and depths ranged from 3.4 to 21.9 m. White sturgeon larvae were captured where bottom-water temperatures ranged from 12 to 17°C, bottom-water turbidities ranged from 2.7 to 13.0 NTU, and mean water-column velocities ranged from 1.0 to 2.7 m/s. Water velocities about 0.6 m above the bottom ranged from 0.7 to 1.9 m/s, and depths ranged from 3.4 to 21.9 m.

## Juvenile Sampling

In September 1993, 210 juvenile white sturgeon were collected in 79 trawling efforts between RM 28 and 132. Distribution of juvenile white sturgeon in this section of the river was patchy. There were differences in catches among different areas of the river and among parallel transects at the same river mile.

The YOY group was the only age group that was easily discernible in a length-frequency histogram, as there was considerable overlap in the lengths of the older age groups (Figure 3). The mean fork length (± SD) and weight (± SD) of 55 YOY white sturgeon collected were 182 mm (± 27 mm) and 47 g (± 18 g). Variations in the lengths and weights of YOY were considerable--lengths ranged from 87 to 223 mm and weights ranged from 5 to 90 g. At times, there was considerable variation in the lengths and weights of YOY collected on the same day.

In 1993, 55 YOY white sturgeon were collected between RM 28 and 131; YOY comprised about 26% of the total catch of juvenile white sturgeon. Densities of YOY white sturgeon at 13 index sampling stations averaged 2.9 fish/hectare during the first survey (7-10 September) and 9.0 fish/hectare during the second survey (20-24 September); the mean for both surveys combined was 5.9 fish/hectare (Table 6, Figure 1).

Only 23 (11.9%) of 193 juvenile white sturgeon were infected with the nematode parasite *Cystoopsis acipenseri*. The mean fork length of infected fish was 373 mm, with a range from 313 to 451 mm.

## Publication Status of Phase I Manuscripts

Five manuscripts that were prepared as part of the Phase I work in the two-volume 1993 final report have been published or accepted for publication in professional journals (Table 7).

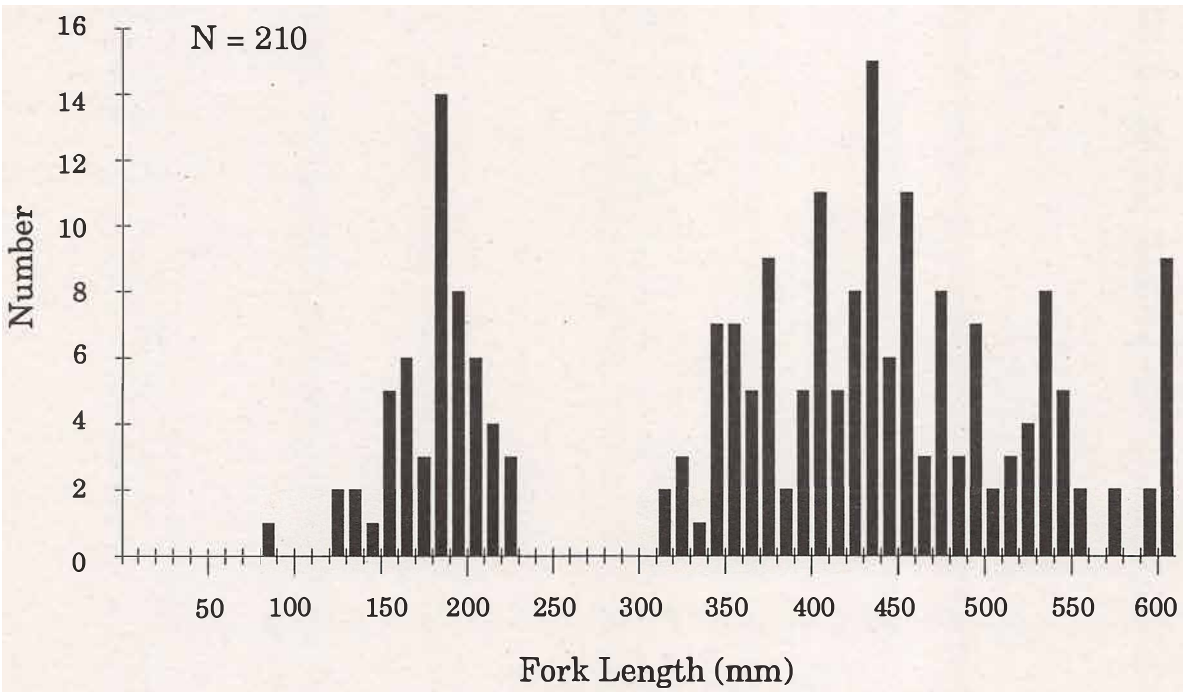


Figure 3. Length-frequency histogram for juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam, 1993. Sturgeon longer than 600 mm are included in the 600-mm interval.

Table 6. Catches of young-of-the-year white sturgeon in September 1993 at 13 sampling stations in the Columbia River downstream from Bonneville Dam. Location is shown in River Mile (RM) and in some instances a transect number is shown when parallel trawling efforts were done at the same RM.

| Location (RM) | 7-10 September | | 20-24 September | |
|---|---|---|---|---|
| | Number | Number/hectare | Number | Number/hectare |
| 31 | 0 | 0.0 | 0 | 0.0 |
| 42 | 2 | 10.7 | 0 | 0.0 |
| 46 | 1 | 4.1 | 1 | 5.7 |
| 54 | 0 | 0.0 | 3 | 14.5 |
| 61 | 0 | 0.0 | 1 | 5.1 |
| 75 | 2 | 9.3 | 4 | 17.7 |
| 79-1 | 0 | 0.0 | 8 | 35.4 |
| 79-2 | 0 | 0.0 | 2 | 8.9 |
| 95-1 | 0 | 0.0 | 0 | 0.0 |
| 95-2 | 0 | 0.0 | 0 | 0.0 |
| 103 | 1 | 3.8 | 1 | 4.6 |
| 131-1 | 0 | 0.0 | 3 | 15.3 |
| 131-2 | 2 | 10.2 | 2 | 9.3 |
| Mean | 0.6 | 2.9 | 1.9 | 9.0 |

Table 7. Publication status of manuscripts prepared as part of Phase I work in the 1993 white sturgeon final report.

| |
|---|
| McCabe, G. T., Jr., and L. G. Beckman.<br>1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76:248-250. |
| McCabe, G. T., Jr.<br>1993. Prevalence of the parasite *Cystoopsis acipenseri* (Nematoda) in juvenile white sturgeons in the lower Columbia River. Journal of Aquatic Animal Health 5:313-316. |
| McCabe, G. T., Jr., R. L. Emmett, and S. A. Hinton.<br>1993. Feeding ecology of juvenile white sturgeon (*Acipenser transmontanus*) in the lower Columbia River. Northwest Science 67:170-180. |
| McCabe, G. T., Jr., and C. A. Tracy.<br>Spawning and early life history of white sturgeon *Acipenser transmontanus* in the lower Columbia River. Accepted for publication in Fishery Bulletin. |
| Parsley, M. J., L. G. Beckman, and G. T. McCabe, Jr.<br>1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122:217-227. |

## DISCUSSION

### Egg and Larval Sampling

White sturgeon successfully spawned in the Columbia River downstream from Bonneville Dam in 1993, as evidenced by egg, larval, and YOY collections. Timing of spawning in 1993, which was estimated to have begun on 26 April and ended on 13 July, was similar to that observed in 1988-1991 (McCabe and Tracy 1993). In 1988, the spawning period was estimated to have extended from 22 April to 22 June; in 1989, from 22 April to 2 July; in 1990, from 23 April to 14 July; and in 1991, from 5 May to 14 July. From 1988 through 1991, spawning was estimated to have occurred on 38 to 48 days each year; in 1993, we estimated spawning occurred on at least 46 days.

Spawning in 1993 occurred during water temperature regimes suitable for incubation. Successful white sturgeon egg incubation occurs at temperatures between 10 and 18°C, with highest survival and uniform hatching between 14 and 16°C (Wang et al. 1985). In 1993, we estimated that spawning occurred at water temperatures of 11 to 18°C; however, water temperatures on more than 90% of the days on which spawning was estimated to have occurred were less than 18°C. Survival of the eggs spawned at a water temperature of 18°C was probably less than for eggs spawned at lower water temperatures. Wang et al. (1985) observed that substantial white sturgeon egg mortalities may occur at water temperatures of 18 to 20°C, and that temperatures greater than 20°C are clearly lethal. Based on larval collections of white or green sturgeon *Acipenser medirostris*, Kohlhorst (1976) estimated sturgeon in the Sacramento River spawned at water temperatures ranging from 7.8 to 17.8°C, with peak spawning at 14.4°C.

White sturgeon spawning in 1993 was estimated to have occurred over a wide range of Bonneville Dam discharges (daily). Apparently, water velocities, which are directly related to dam discharge, did not limit white sturgeon spawning downstream from Bonneville Dam in 1993. Based on computer simulations by Parsley and Beckman (1993) and daily Bonneville Dam discharges in 1993, more than 140 hectares of usable spawning habitat should have been present from April through July, even at the lowest discharges.

### Young-of-the-Year

Catches (number/hectare) of YOY white sturgeon at eight index trawling stations in September 1993 were not significantly different (Kruskal-Wallis, $P > 0.05$) than catches at the same sites in September of 1990 and 1991. Catches at the eight sites averaged 6.4, 8.0, and 5.3 YOY/hectare in 1990, 1991, and 1993, respectively. In all years, catches at 50% or more of the stations were zero.

### Plans for 1994

Plans for 1994 include sampling for white sturgeon eggs, larvae, and juveniles downstream from Bonneville Dam. Specifically, we plan to use plankton nets, artificial substrates, and bottom trawls to study the spawning and early life history of white sturgeon in the Columbia River downstream from Bonneville Dam. These data collected downstream from Bonneville Dam, an area designated as a control for the overall White Sturgeon Study, will be provided to NBS, which is conducting similar research in impoundments upstream from Bonneville Dam. As in previous years, physical measurements will be made in conjunction with the biological sampling.

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# REPORT E

1. Quantify physical habitat used by spawning and rearing white sturgeon in the free-flowing portion of the Columbia River between McNary Reservoir and Priest Rapids Dam and in the free-flowing portion of the Snake River between McNary Reservoir and Ice Harbor Dam.

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## INTRODUCTION

This report describes work conducted by the U.S. Fish and Wildlife Service from October 1, 1993 to May 15, 1994 and work planned for the remainder of fiscal year 1994 through September 30, as part of the white sturgeon (Acipenser transmontanus) studies on the mainstem Columbia and Snake Rivers. The U.S. Fish and Wildlife Service is responsible for Task 3.3 under Objective 3 of the study. Objective 3 is to evaluate the need and identify potential measures for protecting and enhancing white sturgeon populations and mitigating for effects of the hydropower system on productivity of white sturgeon in the Columbia and Snake Rivers upstream from McNary Dam. The goal of Task 3.3 is to quantify physical habitat available to spawning and rearing white sturgeon in the mainstem Columbia River between McNary Reservoir and Priest Rapids Dam and the mainstem Snake River between McNary Reservoir and Ice Harbor Dam.

# METHODS

The sampling program was designed to acquire field data for analysis within the Physical Habitat Simulation System (PHABSIM) developed as part of the Instream Flow Incremental methodology (IFIM; Bovee 1982). Main channel sections of the Columbia River between White Bluffs near river mile (RM) 368 and Priest Rapids Dam at RM 397 and Snake River below Ice Harbor Dam (RM10) were selected for study in fiscal year 1994. Several reconnaissance surveys were conducted in fall 1993 to evaluate channel morphology and variation in hydraulic characteristics and to determine the sampling plan and required number of cross sections to adequately describe physical habitat in the two river reaches. The high degree of variation in channel morphology and size of the Columbia River precluded traditional habitat mapping and classification methods. As a result, a test was designed to determine the appropriate level of sampling effort to quantify spawning and rearing habitat for white sturgeon. Channel morphology in the Snake River was more uniform and cross sections were selected to be representative of habitat conditions in the segment between Ice Harbor tailrace and McNary Reservoir.

Forty test cross sections were established over a five-mile, controlled (pool/run) main channel section of the Columbia River and cross sectional profiles, velocity distributions, and stage-discharge information were collected for a range of discharges. Field data sets were subsequently reduced, formatted, and entered into hydraulic and habitat models within PHABSIM. Integration of depth and velocity profiles for each cross section with microhabitat suitability criteria for each lifestage (Parsley and Beckman, in press) produced multiplicative composite suitability index (CIS) values representing habitat quality. Using CSI values as an indicator of habitat variability , a sensitivity analysis was conducted to determine the number of cross sections required to quantify habitat in the study area. Three randomly selected subsets of 5, 10, 15, 20, 25, 30, and 35 cross sections were used to determine the frequency distribution of CSI values for each level of effort. These distributions were then compared to the distribution of CSI values for all 40 cross sections. Following the analysis, cross sections were randomly selected within each controlled segment and marked with rebar and painted lath on both river banks. Uncontrolled segments (riffles) were more uniform in structure and cross sections were selected at quarter-mile intervals.

An acoustic doppler current profiler (ADCP) was used to collect depth and velocity data on each cross section, and an electronic total station was used to measure river bank profiles and water surface elevations. The ADCP used the Doppler effect to measure velocity throughout the water column at a variable number of verticals determined by cross section length. Integration of the return signals from the four ADCP tranducers also measures cross section length. Portable electromagnetic flowmeters were used to collect velocity data from inshore areas on each cross section which were too shallow for ADCP data collection.

Digital thermographs were installed in the Columbia River near Richland, Washington, and in the Snake River below Ice harbor Dam for collection of continuous water temperature data for evaluation of the effect of water temperature on white sturgeon habitat. Water temperature data is currently being collected by other researchers below Priest Rapids Dam and near Ringold on the Columbia River and will be available for our analysis.

## RESULTS

Results of the test conducted to determine sampling effort were based on comparison of the frequency distributions of CIS values for randomly selected subsets of cross sections to the frequency distribution for the total 40 cross sections measured. Velocity distributions and stage-discharge data used to calculate CSI values were collected at river discharges ranging from 55,000 to 119,000 cubic feet/second (cfs). The analysis indicated 20 randomly selected cross sections would be required to adequately represent microhabitat characteristics in each controlled section of the study area. A total of 122 cross sections were established for data collection in main channel sections of the Columbia River. Seven cross sections were established in the lower Snake River.

Measurement of velocity distributions and cross section profiles began in May 1994 and will continue through the end of fiscal year 1994.

Other activities conducted this fiscal year included preparation of boats and field sampling gear and development of an interagency agreement with the U.S. Geological Survey for the use of their ADCP for data collection.

### Plans for Remainder of FY94

The primary field task for the remainder year 1994 is collection of hydraulic data for the main channel sections of the Columbia and Snake Rivers. The goal is collection of cross sectional profiles and two stage-discharge data points for each cross section over a range of streamflows. Analytical tasks will consist of field data reduction and formatting for input to one of several hydraulic models.

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# REPORT F

## Preparation of a Strategic Framework Plan for Management of White Sturgeon in Zone 6

## and

## Coordination and Planning of White Sturgeon Research Upstream of McNary Dam

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## ABSTRACT

White Sturgeon (*Acipenser transmontanus*) in the Columbia River have been managed as a sport and commercial species for approximately one hundred years, although much of this management was "blind" since little was known of its life history until recently. Bonneville Power Administration funded research in the Columbia downstream of McNary Dam has yielded much information regarding white sturgeon early life history and population dynamics. Data from this research indicate that sturgeon populations within Zone 6 range from a stable population in Bonneville Pool to declining populations in the The Dalles and John Day pools.

This volume of research has provided fishery managers with the necessary information to draft a strategic management plan to guide enhancement efforts within Zone 6. In addition to addressing sport, commercial and subsistence harvest issues, other topics affecting white sturgeon recovery will be addressed, including supplementation, passage, the hydroelectric system, contaminants, and habitat changes. Additional benefits of this plan include increased coordination among agency personnel, greater involvement of tribal fish managers, and the increased awareness of alternatives for managing sturgeon populations within Zone 6. This strategic framework will likely serve as a template for forthcoming enhancement plans as researchers assess white sturgeon populations upstream of McNary Dam in the coming years.

# INTRODUCTION

White sturgeon (*Acipenser transmontanus*) in the Columbia River have been managed as a sport and commercial fish since the late 1890's, after nearly being extirpated by unregulated commercial fishing (Galbreath 1985). Prior to this, white sturgeon were viewed as a nuisance by commercial salmon fishers because of damage to their nets. In fact, sturgeon caught in salmon gear were generally killed and thrown back in the river in an effort to reduce their numbers (Bajkov 1949). Ultimately, harvest restrictions allowed remaining fish to repopulate much of their former habitat. Specific research on sturgeon was confined to occasional research efforts by state biologists (Bajkov 1951; Hess 1983) until the mid-1980's when increased sport and commercial catches began to approach historic levels (Hess 1983; Rieman and Beamesderfer 1990).

Since 1986 research efforts on white sturgeon in the Columbia River downstream of McNary Dam have documented previously unknown aspects of white sturgeon early life history, habitat use, movement and distribution, and recruitment and exploitation. This information will be used to prepare a strategic plan addressing the short and long-term management needs of white sturgeon in Zone 6 (the Columbia River between Bonneville and McNary dams). Although white sturgeon research activities were conducted by state and federal agencies, coordination and technical input was requested for plan preparation. Tribal responsibilities include preparing sections on supplementation, passage (in conjunction with WDFW), and tribal commercial and subsistence fisheries. Additional responsibilities include coordination and participation in future white sturgeon research and management within the Columbia and Snake rivers.

# METHODS

## Strategic Plan Responsibilities

Strategic plan preparation required working knowledge of published literature on white sturgeon as well as other species. Literature was obtained from other sturgeon cooperators, external requests, and internal office sources. Literature was reviewed and key elements filed in a database for future reference. Conversations with sturgeon researchers were conducted and key aspects recorded and filed for reference. Meetings with specialists were pursued as necessary, with pertinent information recorded and filed for reference. Meetings and phone conversations were particularly important for collection of supplementation information, since many findings are proprietary and not recorded in the literature.

## Coordination and Planning Responsibilities

Coordination and planning with tribal staff and sturgeon cooperators were conducted by phone and routine meetings. Arrangement for in-field observation of sampling techniques were coordinated with various sturgeon cooperators. Opportunities for regional and international perspectives on sturgeon research and management were utilized when ever possible. Involvement in planning meetings and coordinating people and ideas were pursued as they became available. These activities provided valuable opportunities to make new contacts and develop resources for sturgeon research and management.

# RESULTS AND DISCUSSION

## Strategic Plan Responsibilities

Reading and recording of selected literature has continually improved the working knowledge of white sturgeon early life history, habits and distributions, and recruitment and exploitation of white sturgeon populations within the Columbia Basin and throughout much of their range. Increased emphasis was placed on supplementation, passage, and harvest within Zone 6. Frequent personal contacts with other cooperators and other researchers, aquaculturists, and academia often provided new or evolving insights on the current situation of a particular aspect of research. Visits to hydroelectric facilities and a commercial aquaculture operation were particularly useful for developing insights into passage and supplementation. Work with other strategic plan authors has yielded detailed outlines and task assignments. Most effort has been targeted to synthesizing the literature and available information. Forthcoming meetings with cooperators will develop the draft plan by September 1994.

## Coordination and Planning Responsibilities

Previously, tribal staff involvement with white sturgeon in Zone 6 dealt with harvest regulation coordination with the state (e.g. Sturgeon Task Force). Access to current literature and research was made available for planning and coordination purposes. This position provided opportunities of coordinated tribal input and involvement in FY 1995 planning for research and management activities. Unlike previous years, tribal proposals were submitted for funding consideration in fiscal year 1995. Proposals emphasized management related activities in Zone 6. Input was also given on funding considerations regarding 1995 research in McNary Pool.

Additional coordination and planning benefits with regional issues of threatened stocks and their management was pursued via attendance at Kootenai River White Sturgeon Steering Committee Meeting in April 1994. Plans were also made to attend The International Conference on Sturgeon Biodiverstiy and Conservation in New York City in July 1994.

Benefits of international information exchange would provide valuable insights and new ideas for continued management of white sturgeon in the Columbia Basin.

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