July 1997

Effects of Mitigative Measures on Productivity of White Sturgeon Populations in the Columbia River Downstream from McNary Dam

Determine the Status and Habitat Requirements of White Sturgeon Populations in the Columbia and Snake Rivers Upstream from McNary Dam

Annual Report 1995

DOE/BP-63584-11

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Edited by:

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Oregon Department of Fish and Wildlife

In Cooperation With:

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

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Project Number 86-50
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July 1997

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EXECUTIVE SUMMARY

This project 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 and Snake rivers.

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 from Phase I. The status and habitat requirements of white sturgeon populations upstream from McNary Dam (between McNary Dam and Priest Rapids Dam on the mainstem Columbia River and from below Hells Canyon Dam to the mouth of the Snake River) are also being examined in Phase II.

This report describes activities conducted during the third 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.

The work was conducted jointly by the Oregon Department of Fish and Wildlife (ODFW; Reports A1 and A2), Washington Department of Fish and Wildlife (WDFW; Report B), National Biological Service (NBS; Report C), National Marine Fisheries Service (NMFS; Report D), U.S. Fish and Wildlife Service (USFWS; Report E), and the Columbia River Inter-Tribal Fish Commission (CRITFC; Report F). Highlights of results of our work from April 1995 through March 1996 are:

Report A1

(1) Abundance of 70-166 cm fork length white sturgeon in McNary Reservoir and Hanford Reach was estimated to be 5,200 fish.

(2) The density of white sturgeon in McNary Reservoir and Hanford Reach was 0.45 fish/ha, which is similar to John Day Reservoir in 1990, but much less than Bonneville or The Dalles reservoirs in 1994.

(3) The estimated proportion of white sturgeon <82 cm fork length in McNary Reservoir and Hanford Reach was smaller than that in Bonneville, The Dalles, or John Day reservoirs. This estimate may be negatively biased by gear limitations, but low recruitment is likely limiting abundance.

(4) The annual recreational harvest rate of white sturgeon 110-151 cm fork length is at least 12.5% in McNary Reservoir and Hanford Reach.

Report A2

(1) In 1994 and 1995, 8,449 fish (30-92 cm fork length) were captured with trawl gear from an area downstream from Bonneville Dam and transplanted by boat and truck to The Dalles Reservoir. All transported fish were injected with a PIT (passive integrated transponder) tag for individual identification in a future evaluation of survival and growth.

(2) A subsample of trawl catches in 1994 and 1995 from an area downstream from Bonneville Dam was evaluated to measure short-term mortality due to capture, sampling, and transportation. Mortality rates during the initial eight days of holding ranged from 1.8-5.0% but increased significantly thereafter. Unnatural conditions within the holding environments (increased exposure to sunlight, abrasion, uncommon depths, and crowding) probably increased mortality.

Report B

(1) Continuous monitoring of 1995 Zone 6 recreational fisheries combined with weekly estimates of projected harvest enabled managers to enact emergency measures that kept white sturgeon recreational harvest at or below Sturgeon Management Task Force guidelines for the first time since they were established in 1991. We estimated that in 1995 anglers harvested 101% of the annual 1350 fish guideline for Bonneville Reservoir, 50% of the 100 fish guideline for The Dalles Reservoir, and 80% of the 100 fish guideline for John Day Reservoir.

(2) Treaty Indian commercial landings exceeded the combined pool commercial guideline of 1,650 white sturgeon for the first time since it was established in 1991. Commercial fishermen harvested an estimated 2,041 white sturgeon in 1995 from all three reservoirs. Treaty Indian subsistence harvest was also up in 1995 at 1,150 white sturgeon.

Report C

(1) White sturgeon spawning occurred downstream from Ice Harbor, Priest Rapids, and The Dalles dams during 1995.

(2) Artificial substrates were better than D-shaped plankton nets as sampling gear for white sturgeon.

(3) Young-of-year white sturgeons were captured with bottom trawls in McNary and Bonneville reservoirs.

(4) Data were collected to begin assessment of hydropower system operations at The Dalles Dam on spawning by white sturgeons.

Report D

(1) The NMFS collected 310 white sturgeon including 111 young-of-year, during two bottom trawling surveys in September 1995.

(2) The young-of-year, which were collected between river miles 28 and 112, comprised approximately 38% of the total trawl catch of juvenile white sturgeon.

(3) Densities of young-of-year white sturgeon at 13 index sampling stations averaged 14.6 fish/ha during the first survey (1-8 September) and 11.0 fish/ha during the second survey (18-21 September); the mean for both surveys was 12.8 fish/ha.

Report E

(1) Columbia River discharges sampled for hydraulic model calibration ranged from a low of 2,080.8 m^3/s to a high of 5,546.6 m^3/s over the course of the year. We were able to successfully measure up to 8,493.8 m^3/s with the Acoustic Doppler Current Profiler (ADCP), although this particular discharge was not used for modeling. Dicharge fluctuations of up to 3,806.1 m^3/s were observed within a 24-hour period.

(2) In some areas, Columbia River water surface elevations increased over 4.9 vertical meters from the lowest to the highest calibration flow. Maximum water surface elevation change associated with calibration data within a 24-hour period was 1.9 meters.

(3) Cross section depth and velocity ranged to maximums of 22 meters and 3.35 m/s respectively, for calibration data sets.

(4) Preliminary calibration of hydraulic models has indicated that cross-sectional area and water column velocity simulation can be conducted for the range of Columbia River discharges between 707.8 m^3/s and 14,156 m^3/s. This will allow us to include hydrographs for nearly all years, including extremely low and high years, from the period of record for the eventual time-series analysis of pre- and post-hydrosystem habitat conditions for white sturgeon.

(5) The ADCP and Global Positioning System (GPS) receiver were successfully used to efficiently collect high resolution hydraulic and geographic data over a wide range of conditions and river discharges. Data were linked to geographic locations and output is produced in a format easily utilized by most GIS databases. In addition, the GPS facilitates efficient relocation of cross section headpins and reference marks and is a useful aid for subsequent navigation between cross sections as well as traversing cross sections.

(6) The McNary pool backwater was found to extend up to Ice Harbor Dam in the Snake River. The occurrence of this variable backwater has required the accumulation of additional data over a wide range of discharges to allow reasonable modeling of hydraulic conditions over the range required for time-series analysis of habitat for white sturgeon.

Report F

(1) Winter gill-net fisheries did not result in by-catch mortality of sublegal white sturgeon.

(2) Winter gillnetting using professional gill-netters in conjunction with trained technicians may be a cost effective method to increase the number of tagged/marked fish for population estimates.

(3) Diver gill nets were highly effective in catching white sturgeon with nominal by-catch of other fish species.

(4) Floating gill nets were ineffective on white sturgeon, but were effective on steelhead, carp, and walleye.

(5) Two-day sets were the most common set time used among Zone 6 commercial fishers.

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report A1

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

This report includes: Work to determine life history parameters and population dynamics of white sturgeon in McNary Reservoir and the Hanford Reach

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July 1997

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ABSTRACT

We report on work performed from April 1995 to March 1996 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 1,250 setlines and caught 818 white sturgeon. We applied molded nylon dart tags to 613 of these fish (70-166 cm fork length) and applied passive integrated transponder (PIT) tags to 784 fish (51-272 cm fork length). We recaptured 24 fish with fork lengths 70-166 cm fork length and estimate an abundance of 5,200 fish of that size range. The density of white sturgeon was 0.35 fish/ha, which is similar to John Day Reservoir in 1990, but much less than Bonneville or The Dalles reservoirs in 1994. The estimated proportion of white sturgeon <82 cm fork length in the population estimate was smaller than that in Bonneville, The Dalles, or John Day reservoirs. While this estimate may be negatively biased by gear limitations, low recruitment is likely limiting abundance. We estimate a minimum 12.5% annual harvest rate on white sturgeon 110-151 cm fork length in the recreational fishery.

INTRODUCTION

In 1986, the Bonneville Power Administration (BPA) funded a 6-year study of white sturgeon *Acipenser transmontanus* in the Columbia River downstream from McNary Dam. The study addressed objectives of a research program implementation plan developed in response to the Northwest Power Planning Council's 1987 Fish and Wildlife Program measure 903(e)(1). Phase I of this research was completed in 1992. In 1993, BPA extended funding for further white sturgeon research in the original study area and areas upstream from McNary Dam. In this report we describe our activities and results from April 1995 through March 1996, 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 (McNary Reservoir and the Hanford Reach; Figure 1).

METHODS

We sampled for white sturgeon in McNary Reservoir and the Hanford Reach from mid April through early September 1995 to estimate population statistics. The sampling area was divided into 14 sections 12.9 to 14.0 km long (Figure 1). Fast shallow water prevented sampling in several areas: closed navigation areas immediately downstream from Ice Harbor and Priest Rapids dams, areas outside the navigation channel in the Snake River, and some shallow areas in the free-flowing portion of the Columbia River. Also, much of the near-shore area at the mouth of the Walla Walla River was too shallow for our boats and was not sampled.

We used setlines as our primary gear for sampling because they provide the greatest catch rate and are less size selective than other gears (Elliott and Beamesderfer 1990). Lines were fished overnight for 12.1 to 67.6 h (average 22.8 h; Table 1). Lines had 12/0, 14/0, and 16/0 hooks that were baited with pieces of Pacific lamprey *Lampetra tridentata* or salted pieces of American shad *Alosa sapidissima*. We had not used American shad before, but we elected to use a new bait because Pacific lamprey were less available in 1995. Each line had 40 hooks and we used only one type of bait per line. In fast water areas, we used rocker anchors on the upstream end of the line and clipped weights (<1 kg) at several points along the ground line to ensure it rested near the bottom.

Gill nets, described by Rien et al. (1991), were used in an attempt to increase our catch of white sturgeon <80 cm fork length. Gill nets were fished for 1.0 to 1.8 h (average 1.3 h; Table 1).

We measured fork length (cm), and looked for tags, tag scars, fin marks, and scute marks on each white sturgeon captured. We weighed and removed a pectoral fin-ray section from a subsample of white sturgeon captured (about 30 fish per 20-cm length interval). Most white sturgeon were tagged with a 125 MHz passive integrated transponder (PIT) tag. Those fish longer than 79 cm were also tagged with a molded-nylon dart tag placed near the anterior origin of the dorsal fin and about 2.5 cm beneath the fin insertion. The fifth right lateral scute was removed as a secondary mark to indicate the fish was tagged or marked in 1995.

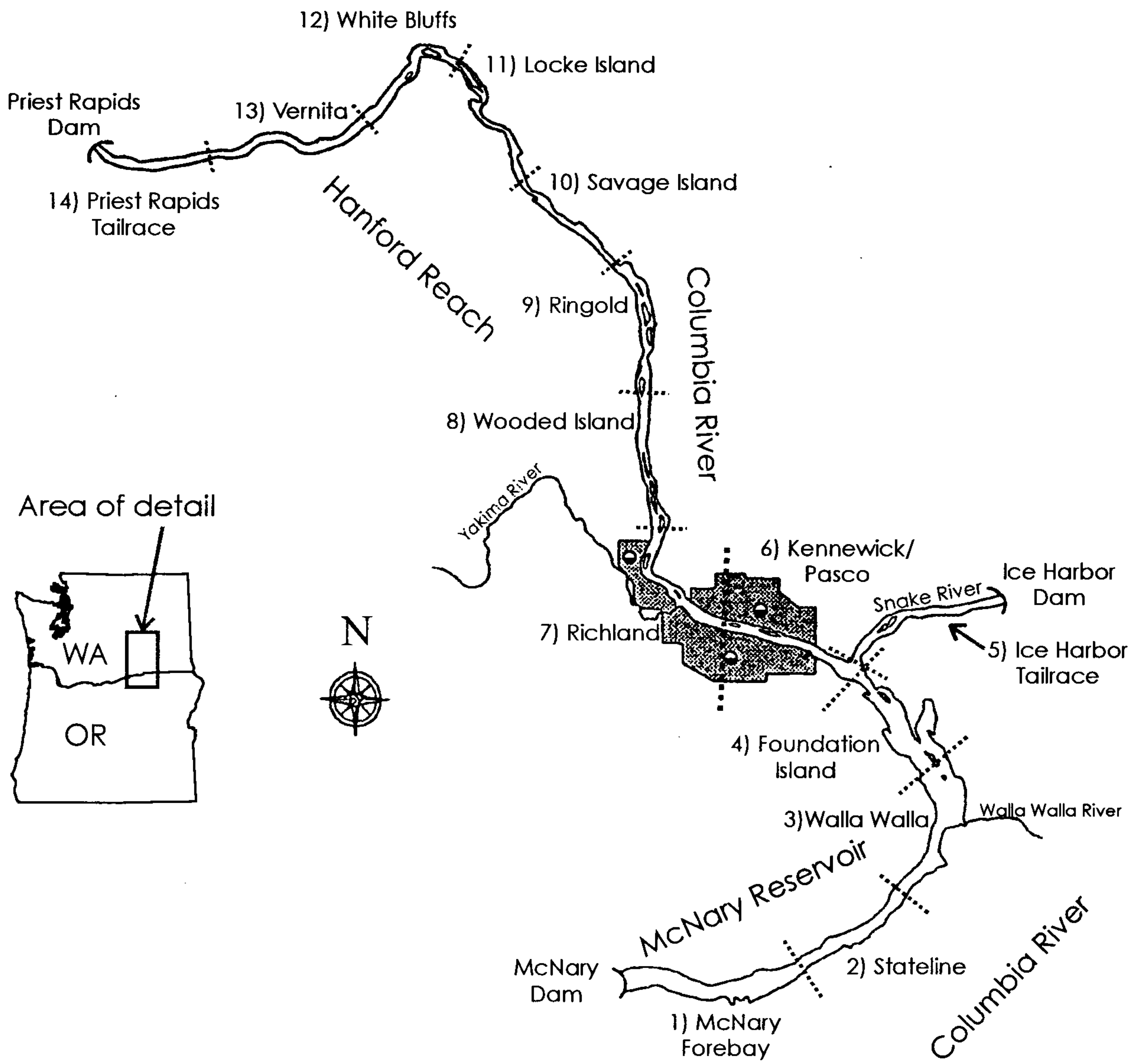

Figure 1. Columbia and Snake rivers between McNary, Priest Rapids and Ice Harbor dams (McNary Reservoir and the Hanford Reach). Sampling area boundaries are indicated by dashed lines. Sampling areas 1-4, and 6 were considered impounded and areas 5, and 7-14 were considered free-flowing in analyses. The map is not drawn to scale.

We injected 509 white sturgeon (<80 cm or >155 cm) with oxytetracycline (OTC) to validate age interpretations from fin-ray sections that may be obtained from fish recaptured in future years (Rien and Beamesderfer 1994). We injected 100 mg/ml OTC into the red muscle under the dorsal scutes immediately posterior to the head. Doses were adjusted such that each fish received about 25 mg/kg of body weight (McFarlane and Beamish 1987). The second right lateral scute was removed from OTC injected fish to identify injected white sturgeon when recaptured.

We surgically examined the gonads of 107 white sturgeon >155 cm to determine sex and stage of maturity following procedures outlined in Beamesderfer et al. (1989). A small sample (<1 g) of the gonad was removed from females using biopsy forceps. Samples were preserved in 10% buffered formalin solution. Incisions were closed with sutures and sealed with a surgical adhesive.

Distribution of white sturgeon was examined by comparing setline catch rate among sampling sections. 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; SAS 1988b). Comparisons between sample means were made using analysis of variance (ANOVA) and Tukey's studentized range test. We also calculated average length and length frequency distributions of white sturgeon in free-flowing (Sections 5, and 7-14) and impounded (Sections 1-4, and 6) portions of the study area. Movement of individual fish was examined by comparing river kilometer at capture and recapture.

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. We compared fork lengths of fish from free-flowing and impounded areas using a Student’s t-test. Relative weights were used to estimate the condition of white sturgeon captured (Beamesderfer 1993). We used Student’s t-tests to compare relative weights of fish from free-flowing and impounded areas, and to compare relative weights from McNary Reservoir and the Hanford Reach in 1993 and 1995 (North 1995).

Abundance of fish 70-166 cm was estimated with a Schnabel multiple mark-recapture estimator (Ricker 1975). Mark-recapture samples were grouped by sampling period. We accounted for harvest of tagged fish voluntarily reported by fishers. Fish that lost all tags were identified from secondary marks. We examined the size selectivity of our gear by calculating size-specific recapture rates for fish in 70-81, 82-109, 110-166, and ≥167-cm size classes for free-flowing and impounded sections of the study area. We adjusted the observed length frequency based on size-specific transformed recapture rates [arcsine(recapture rate)$^{0.5}$] (Sokal and Rohlf 1981), and expanded our abundance estimate based on the adjusted length frequency (Beamesderfer and Rieman 1988; Beamesderfer et al. 1995).

Table 1. Sampling effort (number of setline or gill net sets) for white sturgeon in McNary Reservoir and the Hanford Reach, April through September 1995.

Gear,	Sampling section[a]														
Week of year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Setlines															
16	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6
17	0	0	0	0	26	26	0	0	0	0	0	0	0	0	52
18	19	20	0	0	0	0	0	0	0	0	0	0	0	0	39
19	0	0	0	0	0	0	29	32	0	0	0	0	0	0	61
20	0	0	33	29	0	0	0	0	0	0	0	0	0	0	62
21	0	0	0	0	0	0	0	0	28	27	0	0	0	0	55
22	0	0	0	0	0	0	0	0	0	0	0	0	28	32	60
23	0	0	0	0	0	0	0	0	0	0	27	31	0	0	58
24	0	0	0	0	29	25	0	0	0	0	0	0	0	0	54
25	0	0	0	0	0	0	0	0	0	0	0	0	29	33	62
26	30	36	0	0	0	0	0	0	0	0	0	0	0	0	66
27	0	0	0	0	0	0	21	24	0	0	0	0	0	0	45
28	0	0	0	0	0	0	0	0	36	31	0	0	0	0	67
29	0	0	27	39	0	0	0	0	0	0	0	0	0	0	66
30	0	0	0	0	0	0	0	0	0	0	30	27	0	0	57
31	0	0	0	0	33	32	0	0	0	0	0	0	0	0	65
32	0	0	0	0	0	0	0	0	0	0	0	0	30	31	61
33	0	0	0	0	0	0	0	0	0	0	30	27	0	0	57
34	0	0	0	0	0	0	0	0	34	30	0	0	0	0	64
35	0	0	0	0	0	0	31	29	0	0	0	0	0	0	60
36	34	33	0	0	0	0	0	0	0	0	0	0	0	0	67
37	0	0	30	36	0	0	0	0	0	0	0	0	0	0	66
Total	83	89	96	104	88	83	81	85	98	88	87	85	87	96	1,250
Gill nets															
30	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
32	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
33	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
34	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3
35	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
36	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
37	0	0	2	1	0	0	0	0	0	0	0	0	0	0	3
Total	1	1	2	1	0	0	1	1	0	3	0	9	2	0	21

[a] Sampling sections are: 1 = McNary Dam Forebay, 2 = Stateline, 3 = Walla Walla, 4 = Foundation Island, 5 = Ice Harbor Dam Tailrace, 6 = Kennewick / Pasco, 7 = Richland, 8 = Wooded Island, 9 = Ringold, 10 = Savage Island, 11 = Locke Island, 12 = White Bluffs, 13 = Vernita, 14 = Priest Rapids Dam Tailrace.

To corroborate the Schnabel abundance estimate we used recaptures of fish in 1995 that were 70-166 cm when marked in 1993 to perform a Petersen estimate of abundance. Known harvest and emigration prior to April 1995 were used to adjust the marks at large in the 1995 sampling period. We estimated the minimum annual harvest rate from the ratio of tagged fish harvested (voluntarily reported by anglers) to the number of fish that were legal sized (110-151 cm) when tagged in 1993.

RESULTS

Catch

We caught 818 white sturgeon (51-272 cm) with setlines in McNary Reservoir and the Hanford Reach (0.65 fish per setline set) (Table 2; Figure 2A). We did not catch any white sturgeon with gill nets. The catch consisted of 54% sublegal (≤109 cm), 29% legal (110-151 cm), and 17% "over-size" (≥152 cm) white sturgeon.

Distribution and Movement

We captured white sturgeon throughout McNary Reservoir and the Hanford Reach. There were significant differences in log-transformed catch rates among sampling sections (df=13, F=7.36, r^2=0.071, P≤0.001). Catch rates averaged ≥0.9 white sturgeon per setline-day in sections 1, 2, 3, 11, and 12, and other sections (4-10, 13, and 14) had catch rates averaging ≤0.6 white sturgeon per setline-day (Table 3). White sturgeon caught in free-flowing areas were shorter than those from impounded areas (97 cm versus 136 cm), but the difference was not significant (P=0.52; Figure 2A).

Comparison of capture and recapture data did not show a clear trend in upstream or downstream movement (Figure 3A; Table 4). Most recaptured fish were found one kilometer or more from their initial capture site (Figure 3B).

Gear selectivity

There was an apparent difference in size-specific recapture rates between impounded and free-flowing sections of the study area (Figure 4A). Large fish were more vulnerable to capture in impounded sections and small fish were more vulnerable to capture in free-flowing sections. Impounded sections yielded few captures and no recaptures of fish ≤69 cm; free-flowing sections yielded few captures and no recaptures of fish ≥110 cm. Stratifying by impounded and free-flowing areas resulted in small sample sizes. We chose to combine the size-specific gear vulnerabilities from all sections (Figure 4B) and used these to adjust the length frequency and estimate abundance.

Table 2. Catches of white sturgeon (all lengths) with setlines and gill nets in McNary Reservoir and the Hanford Reach, April through September 1995.

Gear,	Sampling section[a]														
Week of year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Setlines															
16	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2
17	-	-	-	-	2	6	-	-	-	-	-	-	-	-	8
18	29	20	-	-	-	-	-	-	-	-	-	-	-	-	49
19	-	-	-	-	-	-	15	11	-	-	-	-	-	-	26
20	-	-	22	0	-	-	-	-	-	-	-	-	-	-	22
21	-	-	-	-	-	-	-	-	6	8	-	-	-	-	14
22	-	-	-	-	-	-	-	-	-	-	-	-	20	7	27
23	-	-	-	-	-	-	-	-	-	-	47	16	-	-	63
24	-	-	-	-	1	11	-	-	-	-	-	-	-	-	12
25	-	-	-	-	-	-	-	-	-	-	-	-	15	8	23
26	32	36	-	-	-	-	-	-	-	-	-	-	-	-	68
27	-	-	-	-	-	-	6	12	-	-	-	-	-	-	18
28	-	-	-	-	-	-	-	-	19	20	-	-	-	-	39
29	-	-	28	25	-	-	-	-	-	-	-	-	-	-	53
30	-	-	-	-	-	-	-	-	-	-	24	31	-	-	55
31	-	-	-	-	18	16	-	-	-	-	-	-	-	-	34
32	-	-	-	-	-	-	-	-	-	-	-	-	20	18	38
33	-	-	-	-	-	-	-	-	-	-	32	36	-	-	68
34	-	-	-	-	-	-	-	-	22	10	-	-	-	-	32
35	-	-	-	-	-	-	22	13	-	-	-	-	-	-	35
36	18	40	-	-	-	-	-	-	-	-	-	-	-	-	58
37	-	-	61	13	-	-	-	-	-	-	-	-	-	-	74
Total	79	96	113	38	21	33	43	36	47	38	103	83	55	33	818
Gill nets															
30	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0
32	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
33	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0
34	-	-	-	-	-	-	-	-	-	0	-	-	-	-	0
35	-	-	-	-	-	-	0	0	-	-	-	-	-	-	0
36	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0
37	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] Sampling sections are: 1 = McNary Dam Forebay, 2 = Stateline, 3 = Walla Walla, 4 = Foundation Island, 5 = Ice Harbor Dam Tailrace, 6 = Kennewick / Pasco, 7 = Richland, 8 = Wooded Island, 9 = Ringold, 10 = Savage Island, 11 = Locke Island, 12 = White Bluffs, 13 = Vernita, 14 = Priest Rapids Dam Tailrace.

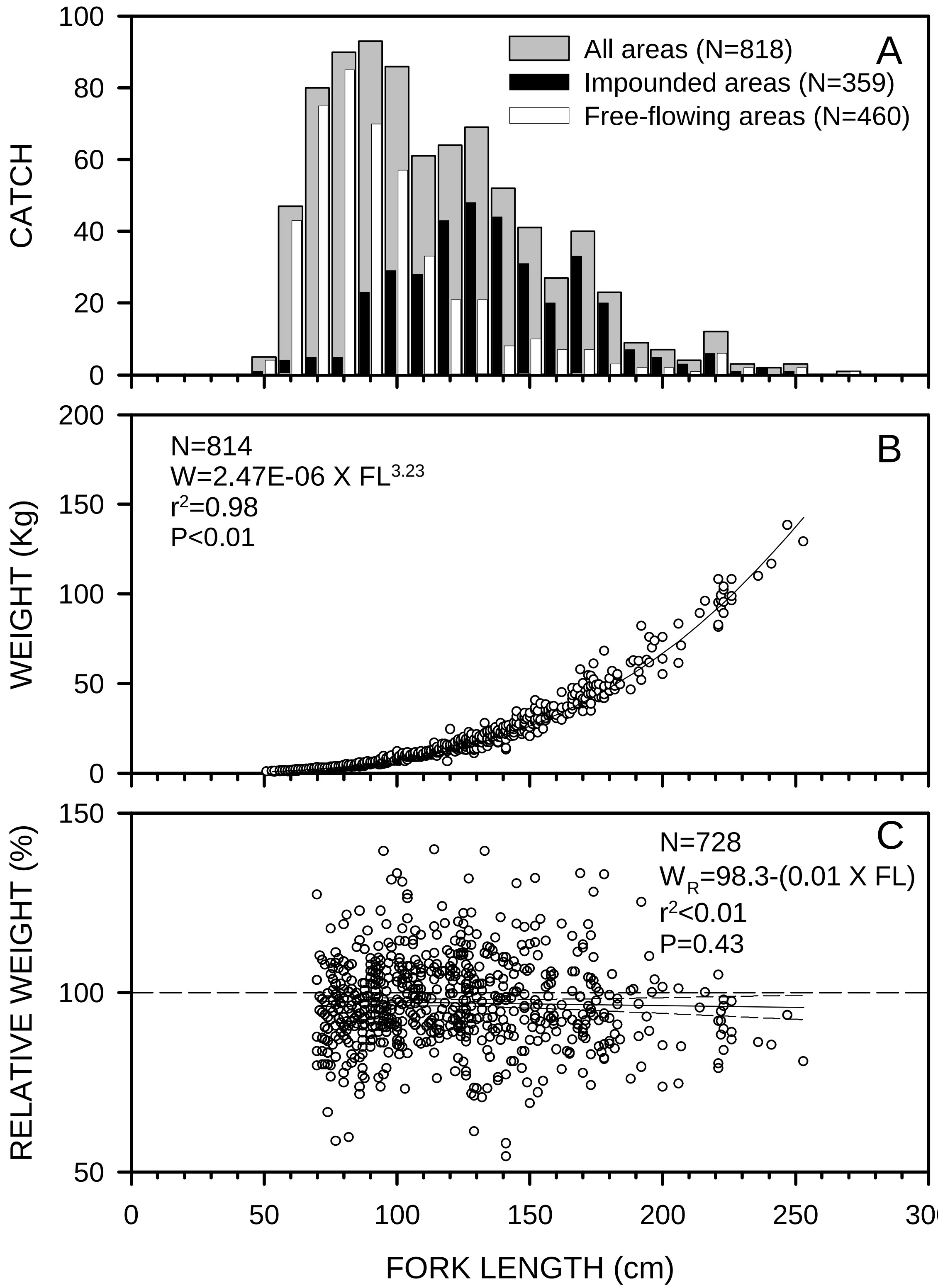

Figure 2. Frequency of catch (A), length-weight relationship (B), and relative weight (Wr; C) by fork length (FL) of white sturgeon collected in McNary Reservoir and the Hanford Reach, April through September 1995.

Table 3. Mean catch of white sturgeon per setline day (40 hooks) by month and for all months combined in McNary Reservoir and the Hanford Reach, 1995.

Month	Setline days	Section[a] 1	2	3	4	5	6	7	8	9	10	11	12	13	14
April	58			0.33		0.08	0.23								
May	234	1.53	1.00	0.67	0.00			0.52	0.34	0.21	0.30			1.38	0.11
June	283	1.07	1.00			0.03	0.44					1.74	0.52	0.49	0.25
July	235			1.04	0.64			0.29	0.50	0.53	0.65	0.80	1.15		
August	307					0.55	0.50	0.71	0.45	0.65	0.33	1.07	1.33	0.67	0.58
September	133	0.53	1.21	2.03	0.36										
All months	1,250	0.95	1.08	1.18	0.37	0.24	0.40	0.53	0.42	0.48	0.43	1.18	0.98	0.63	0.34

[a] Sampling sections are: 1 = McNary Dam Forebay, 2 = Stateline, 3 = Walla Walla, 4 = Foundation Island, 5 = Ice Harbor Dam Tailrace, 6 = Kennewick / Pasco, 7 = Richland, 8 = Wooded Island, 9 = Ringold, 10 = Savage Island, 11 = Locke Island, 12 = White Bluffs, 13 = Vernita, 14 = Priest Rapids Dam Tailrace.

Table 4. Number of white sturgeon (all lengths) marked and recovered in McNary Reservoir and the Hanford Reach, April through September, 1995.

Tagging section	Number tagged	Recapture section 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. McNary Forebay	79				1										
2. Stateline	93		1	2											
3. Walla Walla	107		2												
4. Foundation Island	37			2											
5. Ice Harbor Tailrace	21														
6. Kennewick / Pasco	32							1				1			
7. Richland	42			1				1							
8. Wooded Island	35						1		1						
9. Ringold	47														
10. Savage Island	37										1				
11. Locke Island	92			1								9			
12. White Bluffs	78											1	5		
13. Vernita	53													2	
14. Priest Rapids Tailrace	32														1
Total	785	0	3	6	1	0	1	2	1	0	1	11	5	2	1

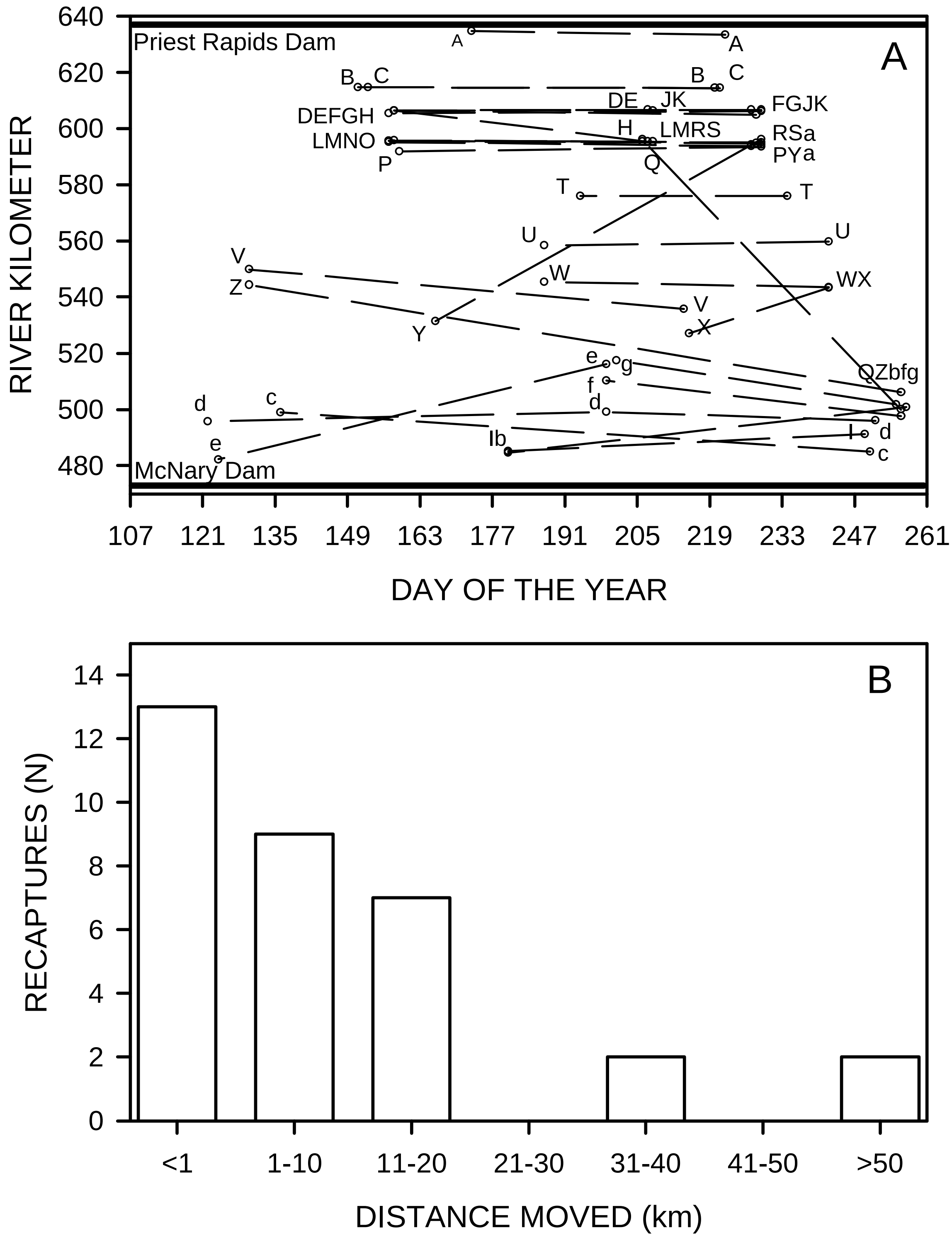

Figure 3. Movements of recaptured white sturgeon in McNary Reservoir and the Hanford Reach, April through September 1995. Letters in plot A represent capture and recapture sites by day of the year for individual fish. Plot B shows the number of recaptures by distance traveled between release and recapture.

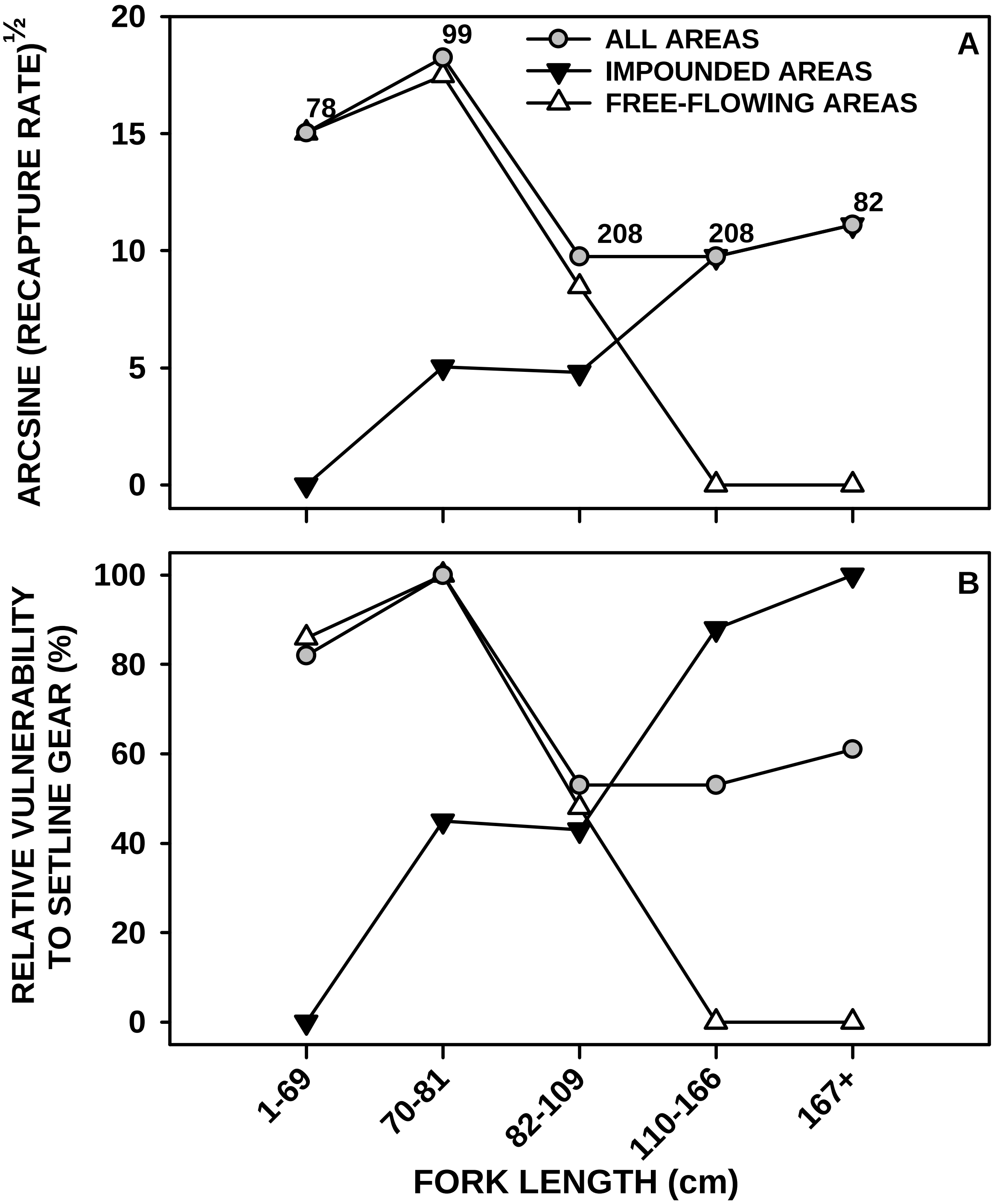

Figure 4. (A) Angular transformation of setline-recapture rate for white sturgeon by length interval in McNary Reservoir and Hanford Reach, April through September 1995. Numbers above data points are the number of fish at large summed for two recapture periods. (B) Relative vulnerability to setline gear for white sturgeon by length interval in McNary Reservoir and the Hanford Reach, April through September 1995. Sections 5, and 7-14 were considered "free-flowing" and sections 1-4 and 6 were considered "impounded".

Marking and Mark Recovery

We tagged or marked 613 white sturgeon (70-166 cm), including 15 fish that were previously marked in 1993. We recaptured 24 of these fish (Table 5). We also recaptured 9 white sturgeon <70 cm or >166 cm, but they were not used in the abundance estimate. Abundance of white sturgeon (70-166 cm) was estimated to be 5,200 fish (95% confidence limits 3,800-9,100) using a Schnabel mark-recapture estimator based on 1995 mark-recapture work (Table 6) and 5,200 fish (95% confidence limits 3,200-8,900 using a Petersen estimator based on recaptures of fish marked in 1993. We estimate 0.35 white sturgeon/ha in McNary Reservoir and the Hanford Reach (Table 7).

Between September 1993 and August 1995, eight of 32 legal-sized fish tagged in 1993 were harvested (12.5% annually) by anglers who voluntarily reported the tags. Another three legal-sized fish tagged in 1993 in McNary Reservoir and the Hanford Reach were captured and released by anglers downstream from John Day Dam (James et al. this report).

All fish recaptured in 1995 had retained their PIT tags. We released 784 fish with PIT tags and recaptured 32, all with PIT tags still present. Molded-nylon dart tag retention was 69% for fish at large less than one year. Of 613 fish released, 11 were recaptured with dart tags, and five were recaptured that had lost dart tags. Among 10 recaptures of fish dart tagged in 1993, none retained a dart tag. The reason for some molded-nylon dart tag losses may have been the monofilament-nylon line breaking, rather than the entire tag "shedding". Careful examination of seven dart tag losses revealed that three dart heads were present under the skin, and four were completely lost.

Age and Growth

We assiged ages from 4 to 50 years to 195 white sturgeon 51 to 272 cm collected in McNary Reservoir and Hanford Reach in 1995 (Table 8). Combined with samples collected and aged in 1993, this gives us 327 aged fin-ray samples in from the study area, and we have ≥30 samples per 20-cm fork length increment for fish between 60 and 159 cm (Table 9). Initial age assignments have been made independently by two readers. Final ages have not been assigned to samples where initial age assignments differed. We collected fin-ray samples from 28 fish previously injected with OTC that will be utilized for age validation.

Paired samples of fork length and weight were sufficient to calculate a regression equation with high degrees of confidence (Figure 2B). Mean relative weight for McNary Reservoir and the Hanford Reach was 97. Linear regression did not show a significant trend with increasing fork length (Figure 2C), and there was substantial individual variation (coefficient of variation=13). Mean relative weights averaged 95 in the impounded area and 99 in free-flowing areas. This difference was significant ($F=1.54$; $DF= 350, 376$; $P<0.001$). Mean relative weights for fish collected in 1993 and 1995 (103 and 97) were not significantly different ($F=1.25$; $DF= 731, 148$; $P=0.097$).

Table 5. Mark and recapture data for white sturgeon 70-166 cm fork length captured with setlines and recovered from surveyed recreational anglers in McNary Reservoir and the Hanford Reach, 1995.

Period	Number caught	Number marked [a]	Number recaptured	Number removed [b]		Number of marks at large
				Unmarked	Marked	
4/17 - 6/11	159	159	0	0	0	
6/12 - 7/30	210	206	5	0	0	159
7/31 - 9/17	267	248	19	0	0	365
Total	636	613	24	0	0	

[a] Includes recaptures of previous year marks which are counted as new marks for population estimation.

[b] There was no recreational fisheries creel program in McNary Reservoir and the Hanford Reach in 1995, and we did not receive any reports of fish tagged in 1995 that were harvested by anglers.

Table 6. Abundance of white sturgeon based on mark-recapture estimates (Ñ for fish 70-166 cm fork length) in McNary Reservoir and the Hanford Reach, 1995. Areas of the Columbia River upstream from Bonneville Dam are also included for comparison. Confidence intervals (95%) are in parentheses.

Year	Ñ	Number of fish by fork length interval [a]					kg/ha[b]
		54-81	82-109	110-166	>166	Sum	
McNary Reservoir and the Hanford Reach							
1995	5,200 (3,800-9,100)	1,100	2,100	2,500[b]	800	6,500	6.6
Bonneville Reservoir							
1989[c]	35,400 (27,500-45,400)	32,900	16,700	1,200	600	51,400	30.0
1994[d]	35,200 (24,800-66,000)	31,300	18,300	1,500	900	52,000	--
The Dalles Reservoir							
1987[c]	23,600 (15,700-33,600)	7,800	11,000	7,900	1,000	27,700	81.4
1988[c]	9,000 (7,300-11,000)	4,200	4,300	2,000	800	11,300	35.5
1994[d]	9,700 (7,500-14,000)	5,800	5,700	800	300	12,600	--
John Day Reservoir							
1990[c]	3,900 (2,300-6,100)	3,600	1,700	500	500	6,300	3.6

[a] Fork length intervals correspond to total lengths of 24-35, 36-47, 48-72, and >72 inches.

[b] 110-137 cm fork length (48-60 inches total length) = 1,600 fish; 110-151 cm fork length (48-66 inches total length) = 2,200 fish; 152-166 cm (67-72 inches total length) = 300 fish.

[c] Beamesderfer et al. 1995.

[d] North et al. 1996.

Table 7. Estimated density of white sturgeon in McNary Reservoir and the Hanford Reach, 1995. Areas of the Columbia River above Bonneville Dam are also included for comparison.

Columbia River Reach	Area of	Density (fish/ha) by fork length interval [a]				
(year of estimate)	Reach (ha)	54-81	82-109	110-166	>166	All
McNary Reservoir and Hanford Reach (1995)	18,400 [b]	0.06	0.11	0.14	0.04	0.35
Bonneville Reservoir (1994)	8,400	3.73	2.18	0.18	0.11	6.19
The Dalles Reservoir (1994)	4,500	1.29	1.27	0.18	0.07	2.80
John Day Reservoir (1990)	21,000	0.17	0.08	0.02	0.02	0.30

[a] Fork length intervals correspond to total lengths of 24-35, 36-47, 48-72, and >72 inches.

[b] Geographic Information System, personal communication with Mike Parsley, National Biological Service, Cook, Washington.

Reproduction

We surgically examined 104 white sturgeon (>155 cm), 56 of these were male, 26 were female, and we could not determine the sex of 22 fish. Of 25 tissue samples collected from females, 7 were classified as early vitellogenic, 4 were late vitellogenic, 2 were ripe, 11 were pre-vitellogenic, and 1 was pre-vitellogenic with attritic oocytes.

DISCUSSION

White sturgeon densities were lower than expected in McNary Reservoir and the Hanford Reach. A relatively stable sport fishery and apparently diverse spawning habitat lead us to expect good recruitment and a large population. However, density (0.35 fish/ha) was similar to that estimated in John Day Reservoir in 1990 (0.30 fish/ha; Beamesderfer et al. 1995) and much less than the densities estimated in Bonneville and The Dalles reservoirs in 1994 (6.19 and 2.80 fish/ha; North et al. 1996).

The Schnabel abundance estimate of 5,200 fish is corroborated by the Petersen estimate of 5,200 fish. Our methods violate some key assumptions of a Petersen estimate, including undocumented tag losses, and emigration since the fish were tagged in 1993, which will overestimate abundance. We are uncertain of the magnitude of this bias, but we believe the agreement between the two estimates indicates an estimate of 5,200 fish is reasonable.

The estimated density of white sturgeon >109 cm in McNary Reservoir and the Hanford Reach is somewhat less than those in Bonneville and The Dalles reservoirs, and the estimated density of fish <82 cm is much less than those in Zone 6 reservoirs (Table 7). This may be an indication of poor recruitment, though interpretation of size-specific densities may be confounded by low vulnerability of white sturgeon <82 cm to setlines in reservoir sections. If we had applied specific vulnerabilities for impounded and free-flowing areas, we would have estimated dramatically larger numbers of small fish.

Table 8. Age-length frequency distribution for white sturgeon <240 cm fork length collected in McNary Reservoir and the Hanford Reach, April through September 1995.

	Fork length interval (cm)[a]											
Age	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean length	STD	N
1												0
2												0
3												0
4	2									55.5	2.1	2
5												0
6	2	1								60.7	11.2	3
7	2									55.0	2.8	2
8	1									57.0	-	1
9	4	1								58.6	2.2	5
10	4	1		1						65.3	17.6	6
11	2	1		2						79.6	27.6	5
12	1	5	2	4	3					94.1	26.6	15
13	1		5		4	2				107.4	27.4	12
14		1	1	4	2	2				114.1	20.4	10
15	1	2	3	1	2					95.1	28.2	9
16		3	1	2	2	2				110.7	30.1	10
17		2	1		1	2	2			124.9	42.5	8
18	2	2	2	1	2	6	1			116.6	38.9	16
19	1		1		2		3	3		146.8	44.4	10
20			1	1		1	6	1		155.1	33.7	10
21		2	1	3	2	2		2		122.7	39.8	12
22			3	1	2	1	2	1		131.6	33.1	10
23			1	1	1	2	5		2	157.4	34.8	12
24					1	2	2	3		165.5	24.1	8
25			1	1			1	1		135.5	52.8	4
26					1		1	1		164.3	24.0	3
27												0
28								1	1	197.0	12.7	2
29								1	1	194.5	16.3	2
>30							1	5	12	216.8	27.0	18
N	23	21	23	22	25	22	24	19	16	128.0	51.1	195

[a] To clarify trends, this table is not zero-filled.

Table 9. Age-length frequency distribution for white sturgeon <240 cm fork length collected in McNary Reservoir and the Hanford Reach, 1993 and 1995 combined.

	Fork length interval (cm)[a]											
Age	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean length	STD	N
1												0
2												0
3												0
4	2									55.5	2.1	2
5												0
6	3	1								57.7	10.9	4
7	2	1								57.7	5.0	3
8	2									53.5	4.9	2
9	5	3		1						67.6	16.9	9
10	4	9	3	2						74.1	14.7	18
11	2	4	3	5						82.9	20.2	14
12	1	7	4	6	3	1				95.0	26.5	22
13	1	8	7	2	4	2				93.5	26.0	24
14		2	5	6	2	2				104.4	21.2	17
15	1	2	7	2	5	1				102.4	26.1	18
16		5	1	5	3	3				109.6	26.9	17
17		3	2		3	2	2			118.8	37.4	12
18	2	4	5	1	3	7	2			113.4	36.9	24
19	1		2	2	3	4	3	3		138.9	36.9	18
20			1	3	1	2	6	1		146.6	33.2	14
21		2	3	4	2	3	1	2		121.9	38.1	17
22			6	4	2	1	2	1		119.6	30.6	16
23			1	3	1	2	6		2	153.1	35.0	15
24				2	1	3	2	3		153.8	30.8	11
25			1	2	2	1	1	1		132.9	37.4	8
26			1	1	3		2	1		140.6	30.4	8
27			1	1	1	2				127.4	23.2	5
28				1			1	1	1	169.5	39.3	4
29								1	1	194.5	16.3	2
>30							1	5	17	217.0	24.4	23
N	26	51	53	53	39	36	29	19	21	119.6	46.8	327

[a] To clarify trends, this table is not zero-filled.

Angler tag returns afford an opportunity to describe exploitation. While the 12.5% exploitation rate is an underestimate because of tag losses, emigration of tagged fish, and non-reporting of tags by anglers, it is substantiated by angler harvest card returns. Estimates of harvest based on these returns average about 400 fish annually (personal communication with John D. DeVore, Washington Department of Fish and Wildlife, Battle Ground, Washington). This equals an annual exploitation rate of about 17% (400 fish harvested/2,200 legal-sized fish in the population).

Annual exploitation rates of between 5% and 15% of white sturgeon 82-166 cm provided the greatest yield per recruit in models of Zone 6 white sturgeon populations (Beamesderfer et al. 1995). Because the legal-size range in McNary Reservoir and the Hanford Reach (110-151 cm) is much narrower than the modeled range for Zone 6, the exploitation rates are not directly comparable. The legal-size range in McNary Reservoir and the Hanford Reach probably affects fewer year classes than the modeled size range in Zone 6. If so, egg production per recruit and survival to over-legal size under current legal-size regulations would be greater than the modeled population in Zone 6. Data collected this year will allow us to estimate potential production of this population, make comparisons with other Columbia River populations, and simulate exploitation scenarios.

The current exploitation rate in McNary Reservoir and the Hanford Reach may result in exploitation similar to the harvest guidelines established for Zone 6 white sturgeon populations (James et al. this report). However there are indications harvest may increase. As harvest has been restricted and seasons curtailed in Zone 6 reservoirs, the popular press has reported relatively good catch rates for large fish in the McNary Reservoir area (Bagett 1996). Also, Native American fishers have expressed interest in commercial fishing opportunities in the area. Given the apparent low recruitment in McNary Reservoir and the Hanford Reach and the susceptibility of sturgeons to overexploitation (Rieman and Beamesderfer 1990; Birstein 1993; Beamesderfer et al. 1995; Boreman, in press), initial analyses suggest greater exploitation rates cannot be sustained by this population.

The key question remains -- why aren't there more white sturgeon in McNary Reservoir and the Hanford Reach? Harvest numbers over the last decade have been stable, and the current exploitation rate is similar to rates recommended for Zone 6. Ongoing quantification of habitat in McNary Reservoir and the Hanford Reach will help clarify if available spawning habitat is a limiting resource (Anglin et al. this report). Mean daily discharge fluctuates widely in the free-flowing portions of the Columbia River below Priest Rapids Dam (Parsley et al. this report), which potentially impacts rearing habitat for young of the year and juvenile white sturgeon. We have documented a downstream emigration trend for white sturgeon in Zone 6 (North et al. 1996); and 9% of legal-sized fish tagged in McNary Reservoir and the Hanford Reach in 1993 were recaptured downstream from John Day Dam in the first two years after tagging. Emigration may also impact recruitment in McNary Reservoir and the Hanford Reach, particularly if the area does not receive immigration from upstream reservoirs. Mark-recapture sampling in John Day Reservoir, 1996, will allow us to describe downstream emigration from McNary Reservoir and the Hanford Reach.

Gear selectivity in free-flowing areas continued to be a concern in 1995. The low recapture rate for large fish in these areas points to the concerns we had in 1993 (North et al. 1995). Large fish are difficult to retain on 24-h setlines when they can use the current to fight the gear. Modifications to the setline anchor system reduced the incidence of tangles and movement of setlines in fast water areas, but we believe this gear simply does not work as well for large fish in fast water.

We did not capture any white sturgeon in bottom gill nets. This gear would likely catch white sturgeon if fished for longer periods, or if drifted with the current, but the risk of catching adult salmonids would increase. At specific sites in Bonneville, The Dalles, and John Day reservoirs we have found gill nets set for 1-2 h can effectively catch small white sturgeon. We were unable to locate similar sites in McNary Reservoir and the Hanford Reach. This reflects our inexperience with the area and the low abundance of small sturgeon.

Retention of PIT tags continues to be very high. We did not observe any losses in 1995. After three years of nylon-dart tag use we have found the tag loss rate is too high and we will quit using them. Dart tag retention was only 69% during the 1995 sampling period, and after two years at large all recaptures of fish tagged in 1993 had lost their dart tags. In Bonneville and The Dalles reservoirs, during the 1994 sampling period, dart tag retention was 85% (North et al. 1996). An enduring tag easily recognized by fishers is important to account for harvest in population estimates, and to estimate exploitation from voluntary returns.

PLANS FOR NEXT YEAR

During the April 1996 through March 1997 period, we will complete aging of fin-ray samples collected in McNary Reservoir and the Hanford Reach. This will allow us to estimate potential production of this population, make comparisons with other Columbia River populations, and simulate exploitation scenarios. We will conduct mark and recapture sampling in John Day Reservoir that will provide information required to update the stock status there for the first time since 1990. This will provide an ideal opportunity to document the extent of downstream emigration by white sturgeon from McNary Reservoir and the Hanford Reach. In 1996 we will begin using and evaluating retention of latex-coated wire-core spaghetti tags. We will also compare relative catch rates for setlines baited with Pacific lamprey to those baited with American shad.

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report A2

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

This report includes: A summary of work performed from 1993-96 to determine the feasibility of collecting white sturgeon for transplantation as a means of supplementing recruitment in areas with diminished stocks

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CONTENTS

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ABSTRACT

We report on work performed by cooperating agencies from October 1993 through March 1996 to determine the feasibility of collecting white sturgeon *Acipenser transmontanus* for transplantation as a means of supplementing recruitment in areas with diminished stocks. We captured an estimated 10,689 subadult white sturgeon ≥15 cm fork length with bottom trawls in the Columbia River downstream from Bonneville Dam. A total of 8,449 fish (30-92 cm fork length) were transported by boat and truck to The Dalles Reservoir for future evaluation of survival and growth. All transplanted fish were injected with a passive integrated transponder (PIT) tag. We evaluated a subsample of the catch each year to measure short-term mortality due to capture, processing (measure length and weight, remove scutes, PIT tag, and inject with oxytetracycline), and transportation. Mortality rates during the first 8 days of holding ranged from 1.8 to 5.0% but increased significantly thereafter. Unnatural conditions within the holding environments (e.g., increased exposure to sunlight, abrasion, shallow water, and crowding) may have increased mortality.

INTRODUCTION

In this report we describe activities and results of work conducted from October 1993 through March 1996 to address the feasibility of transplanting wild white sturgeon *Acipenser transmontanus* from areas of stable recruitment within the lower Columbia River to impoundments where recruitment limits productivity (Beamesderfer et al. 1995).

Results of work conducted during October and November 1993 are presented in DeVore et al. 1995, but are provided in more detail here. Our objectives in 1993 were to estimate catch rate, and evaluate handling procedures and short-term mortality associated with capture, processing (measure length and weight, remove scutes, PIT tag, and inject with oxytetracycline), and transportation of subadult white sturgeon. During 1994 and 1995 we concentrated on transporting white sturgeon from areas downstream of Bonneville Dam to The Dalles Reservoir for future evaluation of growth and survival, and continuation of our assessment of short-term mortality.

METHODS

Fish Collection and Processing

Staff from Columbia River Inter-Tribal Fish Commission (CRITFC), National Biological Service (NBS), National Marine Fisheries Service (NMFS), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and numerous volunteers captured, processed, and transported subadult white sturgeon in the Columbia River during October 1993 and October-November, 1994-1995. In 1993-1994, trawling was conducted by personnel from NMFS and NBS. In 1995 all trawling was conducted by NMFS. During all years, fish processing was conducted primarily by ODFW with assistance from WDFW, CRITFC, and many volunteers.

Trawling efforts occurred primarily in the navigation channel of the Columbia River between river kilometers (rkm) 209 and 212 (Figure 1). This area was selected because it was the nearest site to The Dalles Reservoir with previously documented high catch rates of subadult white sturgeon.

Two different trawl types and vessels were used for fish collection. The NMFS deployed a 7.9-m (headrope length) semi-balloon shrimp trawl from a 12.2-m research vessel. Trawl mesh size was 38.0 mm (stretched measure) except a 10.0-mm liner was inserted in the cod end of the net (McCabe 1996). The NBS operated a 7.3-m research vessel and fished a 6.2-m high-rise shrimp trawl with and without a cod-end liner (Parsley et al. 1996). The number and duration of tows conducted each day varied with catch rate and transport goal. The NMFS conducted tows while traveling upstream and downstream; the NBS only made upstream tows.

The net was emptied after completion of each tow. White sturgeon were removed from the trawl and placed into containers with circulating fresh water onboard each trawl vessel. When tow catches were very large (>250 fish), some white sturgeon were not counted and immediately released at the capture site. Other fish species were not counted (except salmonids) and released

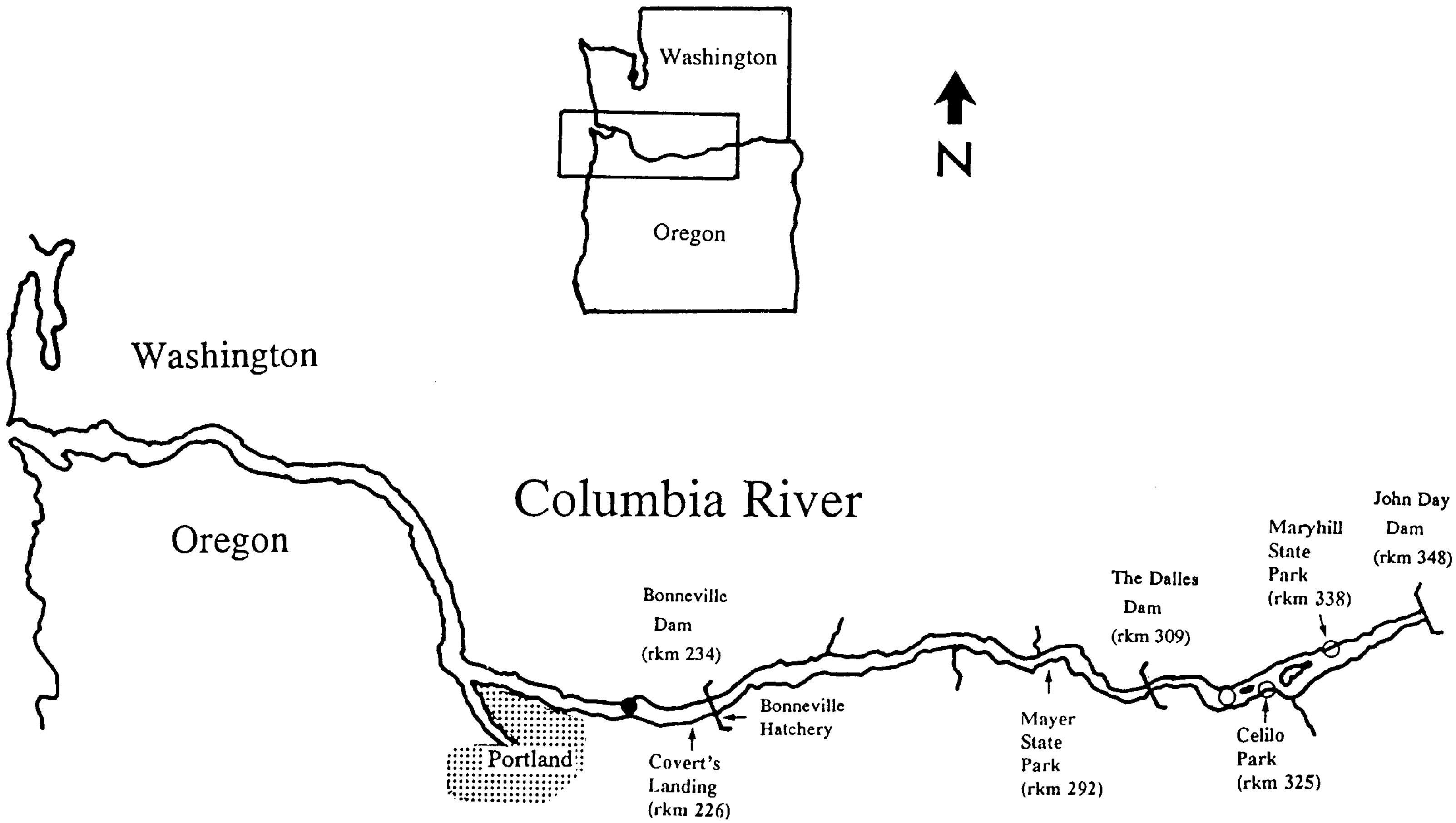

Figure 1. The Columbia River downstream from John Day Dam. Sites of white sturgeon collection (● ; river kilometers (rkm) 209-212) and release (○ ; river kilometers 317, 325, and 338) during October 1993 and October-November, 1994-1995 are indicated. This map is not drawn to scale.

as the trawl was emptied. If few white sturgeon were captured during a tow, they were held onboard the capture vessel while additional trawls were completed. White sturgeon were transferred between the trawl and transport vessels with dip nets or plastic baskets. Large catches were occasionally unloaded from the trawl directly onto the transport vessel to reduce handling.

In 1993 most fish were processed onboard a 7.5-m ODFW research vessel anchored at rkm 210 and released on-site. In 1994 we processed fish onboard a contracted 9.1-m vessel and the ODFW research vessel. In 1995 we processed fish onboard a contracted 7.3 x 21.9-m barge propelled by a 15.2-m tugboat. The barge was equipped with six 520-L plastic totes for holding fish. Each tote received a minimum of 37.8 L/minute of pumped fresh river water. This inflow provided for the total water volume of each container to be exchanged 7.6 times each hour (exchange rate).

We measured fork length (cm) and weight (0.1 kg) of most white sturgeon captured in 1993 and from transported fish in 1994 and 1995. We selected white sturgeon 35-80 cm for processing and transport in 1993 and 1994 (fish outside this length interval were released at the capture site). In 1995 we selected white sturgeon 30-92 cm for processing and transport. Each transported fish received an AVID[1] 125 MHz passive integrated transponder (PIT) tag. In 1993 we injected PIT tags through the ventral body wall into the body cavity. In 1994 and 1995 we injected PIT tags into the musculature beneath the armor of the head near the dorsal midline. Tags and applicators were disinfected with chlorhexidine before each injection. To identify PIT-tag-injected fish at recapture, the second left lateral scute was removed (Rien et al. 1994).

We injected white sturgeon during 1993 and 1995 with oxytetracycline (OTC) to help validate age determinations from fin-ray sections of recaptured fish. We injected 25 mg/kg of 100 mg/ml OTC into the red muscle under the dorsal scutes immediately posterior to the head (McFarlane and Beamish 1987; Rien and Beamesderfer 1994). To identify fish injected with OTC we removed the second right lateral scute.

We removed a lateral scute as a secondary mark to identify year of capture if transponder tags fail or are lost. Secondary marks were the fifth right scute in 1993, the fifth left scute in 1994, and the sixth left scute in 1995 (Table 1).

Transportation

1993

In 1993 we transported a subsample of fish collected on three different days to the ODFW Bonneville Fish Hatchery. These fish were held in a raceway and evaluated for post-handling mortality. Fish were transported from the capture site to Covert's Landing boat ramp (rkm 226) in either 300-L plastic totes or a 450-L live-well onboard the ODFW research vessel. The boat and fish were then transported to Bonneville Hatchery. No fish were transplanted upstream from Bonneville Dam in 1993.

[1] Use of trade names does not imply endorsement by Oregon Department of Fish and Wildlife.

Table 1. Number of subadult white sturgeon processed each year by handling procedure during October 1993 and October-November, 1994-1995. Hyphens (--) indicate the procedure was not conducted.

	Year			
Procedure	1993	1994	1995	Total
Fork length	710	3,044	5,613	9,367
Weight	158	3,028	5,609	8,795
OTC[a] injection	699	--	5,609	6,308
PIT[b] tag placement:				
Intramuscular	--	2,934	5,612	8,546
Abdominal cavity	144	--	--	144
Scutes removed:				
2nd left	151	2,948	5,612	8,711
2nd right	698	--	5,614	6,312
5th left	--	2,948	--	2,948
5th right	902	--	--	902
6th left	--	--	5,611	5,611

[a] Oxytetracycline.

[b] AVID 125 MHz passive integrated transponder.

The transport tank water was aerated by manually exchanging river water on the first day and with compressed oxygen and air stones thereafter. Beginning on the second transport day we added a synthetic fish protectant (Slime-Kote[1]) at 1:7560 to help offset loss of mucus during handling.

1994

In 1994 we transported fish from the capture site to The Dalles Reservoir by boat. We contracted with a private firm that provided a 9.1-m vessel and operator to complete this task. The boat was outfitted with two 300-L plastic totes and two 267-L live-wells; each receiving pumped river water at approximately 30 L/minute (exchange rate ≥6.0). Constant exchange of water prohibited use of additives such as Slime-Kote[1]. We monitored temperature (°C) and dissolved oxygen levels (ppm) of the river and tanks throughout transport (Table 2). Supplemental oxygen was added to the transport tanks beginning on the third day to increase dissolved oxygen concentrations. We attempted to maintain loading density of fish in the transport tanks at 0.09 kg/L or less. Most transported fish were released into the navigation channel at or upstream from rkm 317. Due to boat breakdowns some fish were transported by truck from Covert's Landing to a back-water release site at Celilo Park (rkm 325).

1995

In 1995 we transported all white sturgeon in either a 9,462-L or 13,247-L fish transport truck. The same barge used as the floating platform for fish processing served to ferry these vehicles between the fishing area and Covert's Landing where they were driven off the barge. The fish were then transported to Maryhill State Park (rkm 338) for release into The Dalles Reservoir. Supplemental oxygen was added and monitored throughout transfer. Target loading density of fish in the transport tanker was the same as 1994 (<0.09 kg/L). Beginning on the third transport day, we added a synthetic fish protectant (Poly Aqua[1]) at 1:7570 to help offset loss of mucus during handling.

Holding Experiments

To estimate the effects of capture and handling we held 159 white sturgeon at Bonneville Hatchery from 25 October through 9 November 1993. Duration of holding was 14-16 days depending on capture date. All fish were held in a single-pass standard concrete raceway measuring 0.9 x 6.1 x 24.4 m with a constant water flow of approximately 1,893 L/minute. Floating panels shaded approximately 20% of the raceway. Hatchery staff provided dead juvenile salmonids as a source of food.

We continued our short-term mortality evaluation of trawled, processed, and transported wild white sturgeon during 1994. To minimize unnatural holding conditions, we held one group of fish in a blockaded cove and a second group in a floating net pen at a site within Mayer State Park lagoon (rkm 292) in Bonneville Reservoir. This site was selected because 1) it is sheltered

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[1] Use of trade names does not imply endorsement by Oregon Department of Fish and Wildlife.

from the wind but has free water exchange with the mainstem Columbia River, 2) a boat ramp is available, and 3) fish used in the holding experiment would experience similar (although shorter) transport conditions to the fish released in The Dalles Reservoir.

We blocked the cove with a 1.3-cm mesh net weighted with concrete blocks at 1.2-m intervals to prevent fish from escaping under the leadline. We also raised the corkline above the surface of the water to avoid loss of fish over the net. Dimensions of the cove were approximately 18 x 38 m. Depths graduated from 0.0 m at the terminus to about 0.9-1.5 m at the net. Area and depth of the cove varied with reservoir elevation. Plastic tarps suspended across the cove provided approximately 10% shade cover.

We anchored the net pen in about 4.0 m of water within 100 m of the cove site. Dimensions of the net were 6.1 x 6.1 x 2.4 m with a stretched mesh of 1.3 cm. We suspended approximately 0.6-m of net above the water to prevent escapement and covered the pen with a 5.0-cm (stretched measure) mesh net to inhibit bird predation.

We used the previously described 9.1-m vessel to transport white sturgeon to Mayer State Park. On 3 November 1994 we placed 101 fish into the cove and 104 into the net pen and evaluated survival through 14 December 1994. On 14 November we immersed 50 of the fish from the net pen into 3.0% NaCl solution for 45 seconds to inhibit growth of observed external fungi. We monitored water temperatures and dissolved oxygen levels throughout the retention period and removed mortalities weekly. We did not provide supplemental feed at either site. Removal of dead fish was easily accomplished in the cove, but required lifting the net pen which agitated the enclosed fish.

In 1995 we evaluated the short-term mortality of two groups of non-transported white sturgeon: trawled-only and trawled-processed. On 24 October we placed 44 unprocessed fish into a net pen anchored in 11 m of water along the lower Columbia River Washington shore at rkm 210. We added 6 unprocessed fish on 25 October. On 26 October we added 50 processed fish to the pen. We subjected all processed fish to 1995 handling procedures (Table 1) except fish were punctured with a PIT tag applicator, but no tag was applied. We did not inspect the net and enclosed fish until 14 November. No supplemental feed was provided during this evaluation.

Stress Evaluation

We collected blood plasma samples from three groups of 10-11 captive juvenile white sturgeon on two occasions to determine if blood cortisol measurements are correlated with relative levels of stress experienced by white sturgeon (Strange et al. 1978; Thomas 1990). The three test groups included fish that were unstressed, stressed, and stressed but allowed to recover (Table 3). All fish were less than 50 cm long. Plasma was separated from raw blood with a centrifuge. Personnel at Oregon State University measured blood cortisol levels (ng/ml). Mean blood cortisol levels were examined for significant differences ($P < 0.05$) between groups and tests using analysis of variance (ANOVA; SAS 1988a; SAS 1988b).

During 1995 sampling, we collected blood plasma samples from seven groups of 10 fish each to identify sources of stress experienced by wild white sturgeon during capture, processing,

Table 2. Transport conditions of subadult white sturgeon collected during October 1993 and October-November, 1994-1995. Hyphens (--) indicate missing data.

Year, month/ day	Number of fish transported	Transport duration[a] (hh:mm)	Release location[b]	River DO(ppm)[c] (min/max)	Tank DO(ppm) (min/max)	River temp.(°C) (min/max)	Tank temp.(°C) (min/max)	Vessel[d]	Total fish wt.(kg)	Water volume (L)	Loading density (kg/L)	Water treatment[e]/ oxygen added
1993												
10/25	46	1:55	A	--/--	3.7/6.4	--/--	15.3/15.3	A	36.4	598	0.06	No/No
10/26	69	2:00	A	--/--	7.1/25.0	--/--	14.7/15.3	A	52.4	450	0.12	Yes/Yes
10/27	44	1:20	A	--/--	5.7/9.3	--/--	13.8/14.2	A	28.0	450	0.06	Yes/Yes
1994												
10/18	189	7:17	B	9.1/9.6	5.3/11.0	15.1/15.6	15.1/16.1	B	133.9	1,579	0.08	No/No
10/19	181	7:30	B	9.1/9.1	6.2/8.1	15.9/15.9	15.9/17.1	B	136.5	1,579	0.09	No/No
10/20	202	6:15	B	9.0/10.0	6.3/26.9	15.0/15.7	15.1/16.4	B	158.2	1,579	0.10	No/Yes
10/24	206	5:20	B	9.3/12.2	7.0/15.0	14.6/15.4	14.8/15.9	B	151.7	1,579	0.10	No/Yes
10/25	207	8:30	B	9.3/13.3	6.2/16.1	14.4/15.2	14.4/15.7	B	171.2	1,579	0.11	No/Yes
10/26	202	6:30	B	8.6/9.4	6.0/10.7	14.4/15.6	14.5/15.6	B	152.2	1,579	0.10	No/Yes
10/27	206	5:25	B	8.4/9.0	6.2/13.1	14.0/14.5	14.2/16.1	B	165.0	1,579	0.10	No/Yes
10/31	101	--	C	--/--	--/--	--/--	--/--	C	86.0	680	0.13	No/Yes
11/01	205	4:51	B	7.8/8.3	6.1/7.5	12.7/13.8	12.9/13.9	B	167.6	1,579	0.11	No/Yes
11/02	215	8:31	B	10.1/10.5	6.9/9.2	11.9/12.8	11.6/13.1	B	182.0	1,579	0.12	No/Yes
11/03	205	7:18	D	10.3/13.4	5.7/21.2	9.7/11.9	11.0/12.4	B	180.2	1,579	0.11	No/Yes
11/07	208	7:04	B	10.4/13.4	6.7/35.4	10.7/12.6	10.3/11.8	B	158.0	1,579	0.10	No/Yes
11/08	197	--	C	--/--	--/--	--/--	--/--	C	159.5	680	0.23	No/Yes
11/09	198	--	C	10.4/10.4	7.8/22.6	12.2/12.2	10.3/11.8	C	147.2	680	0.22	No/Yes
11/10	213	--	C	--/--	--/--	--/--	--/--	C	167.4	680	0.25	No/Yes
1995												
10/23	560	2:15	E	10.3/10.4	17.5/---	14.1/14.2	13.9/--	D	430.6	13,247	0.03	No/Yes
10/24	485	2:30	E	9.5/---	15.8/22.0	13.9/-----	13.8/13.9	D	446.3	13,247	0.03	No/Yes
10/25	341	3:20	E	9.9/10.6	--/--	13.8/13.8	--/--	D	296.2	13,247	0.02	Yes/Yes
10/26	478	3:15	E	10.4/-- --	20.0/25.0	13.9/-----	14.4/14.4	D	409.0	13,247	0.03	Yes/Yes
10/27	475	3:45	E	10.4/11.0	20.0/-----	13.7/13.8	14.4/-----	D	429.5	13,247	0.03	Yes/Yes
10/31	108	3:20	E	10.8/-- --	9.9/10.6	11.0/-----	11.8/12.3	E	94.8	9,462	0.01	Yes/Yes
11/02	321	3:00	E	9.8/10.4	9.8/----	10.1/11.3	11.4/-----	E	363.7	9,462	0.04	Yes/Yes
11/03	347	4:15	E	11.1/11.9	11.2/17.0	10.0/10.8	9.9/10.6	E	380.0	9,462	0.04	Yes/Yes
11/06	425	3:35	E	10.7/1.0	10.7/10.9	10.6/10.9	11.1/12.1	E	493.8	9,462	0.05	Yes/Yes
11/07	701	3:00	E	10.7/10.8	11.0/11.7	11.1/11.2	11.7/12.3	E	715.2	9,462	0.08	Yes/Yes
11/08	701	3:00	E	10.4/10.6	10.3/12.9	11.1/11.4	11.0/12.5	E	740.4	9,462	0.08	Yes/Yes
11/09	669	--	E	10.8/11.2	10.3/12.2	10.5/10.9	10.5/11.3	E	716.8	9,462	0.08	Yes/Yes

[a] Estimated time of boat transport during 1993-1994 and combined barge and fish liberation truck transport during 1995.

[b] Release locations were A) Bonneville Hatchery (holding experiment); B) The Dalles Reservoir (river kilometer (rkm) 317); C) The Dalles Reservoir at Celilo Park (rkm 325); D) Bonneville Reservoir at Mayer State Park (rkm 292, holding experiment); and E) The Dalles Reservoir at Maryhill State Park (rkm 338).

[c] Dissolved oxygen levels as measured during daily sampling.

[d] Transport vessels were A) plastic totes and live-wells onboard a 7.5-m research vessel and truck; B) plastic totes and live-wells onboard a 9.1-m contracted boat; C) same as B but fish were transferred to plastic totes onboard a truck for a majority of the transfer; D) Oregon Department of Fish and Wildlife fish liberation tanker; and E) U. S. Fish and Wildlife Service Wildlife fish liberation tanker.

[e] Water treatments were Slime-Kote in 1993 and Poly Aqua in 1995.

and transportation. Each group was exposed to various handling procedures and recovery periods (Table 3).

RESULTS

Fish Collection and Processing

During 1993-95 we caught an estimated 10,689 white sturgeon in 216 trawl tows (49.5 fish per tow; Table 4). Mean duration of each trawl was 10.4 minutes. Mean tow depth was 19.8 m. All sizes of white sturgeon including young-of-the-year and adults were captured (Figure 2). White sturgeon were the most common fish species captured. The following fish species were also observed in the catch: American shad *Alosa sapidissima*, peamouth *Mylocheilus caurinus*, northern squawfish *Ptychocheilus oregonensis*, leopard dace *Rhinichthys falcatus*, redshine shiner *Richardsonius balteatus*, largescale sucker *Catostomus macrocheilus*, chinook salmon *Oncorhynchus tshawytscha* (two juveniles), sand roller *Percopsis transmontana,* prickly sculpin *Cottus asper,* walleye *Stizostedion vitreum, and* starry flounder *Platichthys stellatus.* Numbers of white sturgeon measured, weighed, tagged, marked, and injected with OTC each year are presented (Table 1).

Transportation

Prior to transplanting fish in 1995, we conducted an experiment to determine if white sturgeon could be released from a liberation truck designed for salmonid transport efficiently and without causing external injuries. We released 28 white sturgeon (<90 cm) from a 4,542-L ODFW liberation truck into a net pen and immediately assessed each fish for wounds or abrasions. We did not identify any injuries and concluded that liberation trucks provide a reasonable means of transporting white sturgeon.

We transported 159 fish in 1993; 2,935 in 1994; and 5,611 in 1995. A total of 8,449 fish (7,747.7 kg) were transplanted and released into The Dalles Reservoir. Mean length of transported fish was 45.7 cm in 1993, 48.2 cm in 1994, and 50.7 cm in 1995. Mean weight of transported fish was 0.71 kg in 1993, 0.79 kg in 1994, and 0.98 kg in 1995.

Transportation conditions varied daily and annually (Table 2). Transport tank dissolved oxygen (DO) levels averaged 114% of river DO levels in 1994 and 133% in 1995, although daily extremes were reduced in 1995. Differences between mean river and transport tank temperatures in 1994 and 1995 did not exceed 0.3°C. Mean duration of transport was 6.8 h per trip in 1994 and 3.2 h in 1995. Mean duration of processing was 3.0 h per day in 1994 and 4.4 h in 1995.

Holding Experiments

Mortality of white sturgeon held for short-term evaluation after capture, processing, and transport (in most instances), varied each year (Figure 3). Mortality in 1993 remained below 5.0% during the first 7 days of retention, but increased rapidly to 52.8% after 16 days of holding. Two moribund fish examined in 1993 by an ODFW pathologist exhibited severe external and internal hemorrhaging with fungus present on gill and fin tissues. Cell cultures of liver and kidney

Table 3. Description of white sturgeon stress evaluation experiments conducted during July 1995 and February 1996.

Origin, test group	Test description
Captive[a]	
A	Removed from tank; blood collected immediately.
B	Transferred from tank to a 57-L container of water; deprived of supplemental oxygen for approximately 1 h; blood collected.
C	Same as group B but transferred back to resident tank and allowed to recover for 23 h; blood collected.
Wild[b]	
A	Removed from trawl vessel; blood collected; fish released on-site.
B	Transferred from trawl vessel to net pen; blood collected after 24 h; fish released on-site.
C	Removed from trawl vessel; measured, weighed, two scutes removed, oxytetracycline (OTC) injected, mock tagged with a passive integrated transponder (PIT) tag; blood collected; fish released on-site.
D	Same as group C but transferred to net pen; blood collected after 24 h; fish released on-site.
E	Removed from trawl vessel; measured, weighed, three scutes removed, OTC injected, PIT tagged; transferred to liberation truck for <2 h; removed from truck; blood collected; fish released on-site.
F	Same as group E but transferred to net pen; blood collected after 24 h.
G	Removed from trawl vessel; measured, weighed, three scutes removed, OTC injected, PIT tagged; transferred to a liberation truck and transported for 3.0 h; blood collected; fish released at Maryhill State Park boat ramp, The Dalles Reservoir.

[a] Juvenile white sturgeon obtained from artificially spawned Columbia River stock. This test was conducted 14 July 1995 and repeated 14 February 1996.

[b] Juvenile white sturgeon collected during 1995 transportation evaluation field work. These tests were conducted between 23 October 1995 and 7 November 1995.

Table 4. Effort and catch of subadult white sturgeon captured in the Columbia River (river kilometers 209-212) during October 1993 and October-November, 1994-1995. Hyphens (--) indicate missing data.

Year, agency	Sampling Days	Trawl efforts	Total catch[a]	Mean catch	Mean trawl time (minutes)	Mean depth (m)
1993						
NMFS[b]	3	19	564	29.7	10.0	18.6
NBS[c]	3	14	358	25.6	14.0	--
1994						
NMFS[b]	15	59	3,428	58.1	9.9	19.5
NBS[c]	5	22	365	16.6	10.0	--
1995						
NMFS[b]	12	102	5,974	58.6	10.4	20.3
Combined	38	216	10,689	49.5	10.4	19.8

[a] Approximate number since some white sturgeon were not counted and immediately released at the capture site when tow catches were very large.

[b] National Marine Fisheries Service.

[c] National Biological Service.

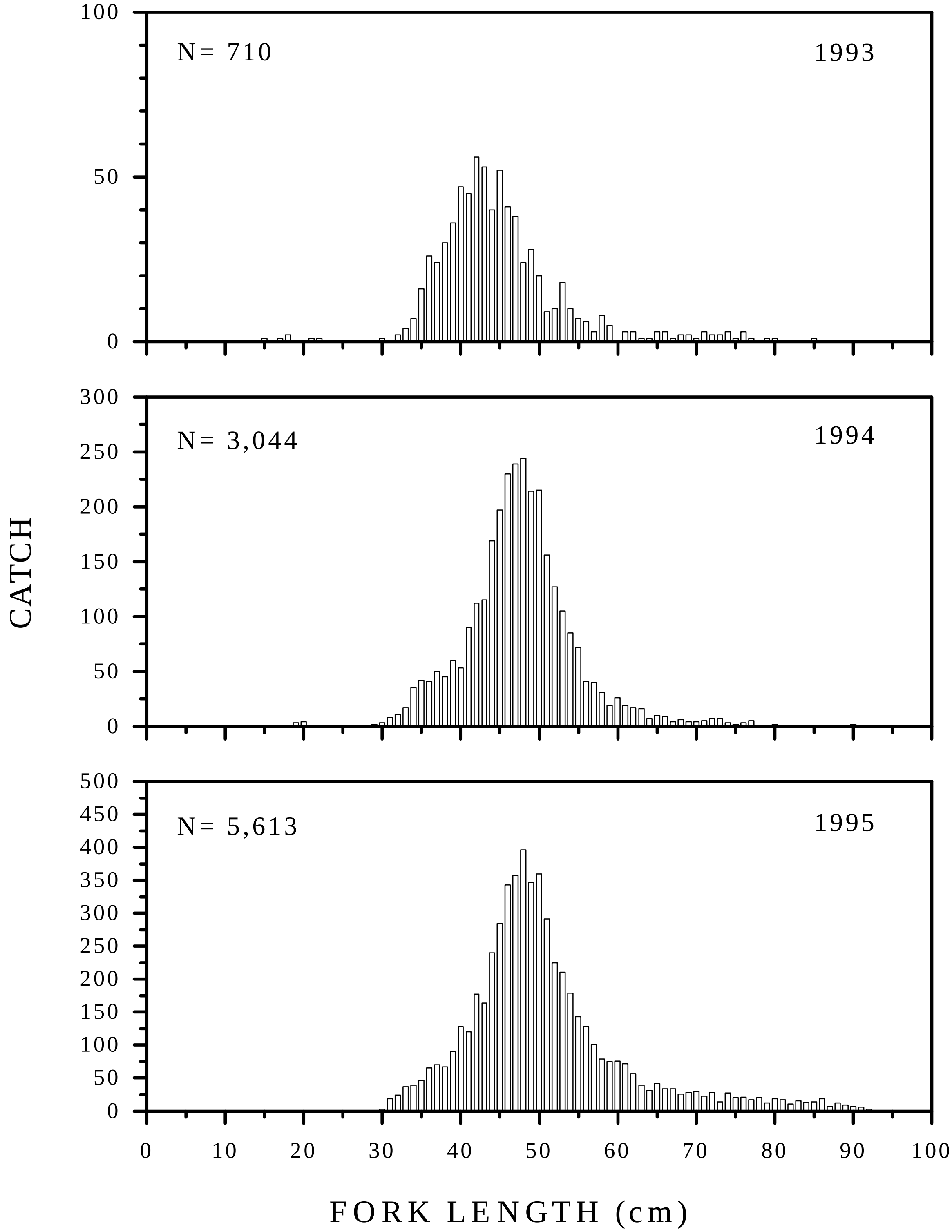

Figure 2. Length frequencies of white sturgeon collected downstream from Bonneville Dam (river kilometers 209-212) during October 1993 and October-November, 1994-1995.

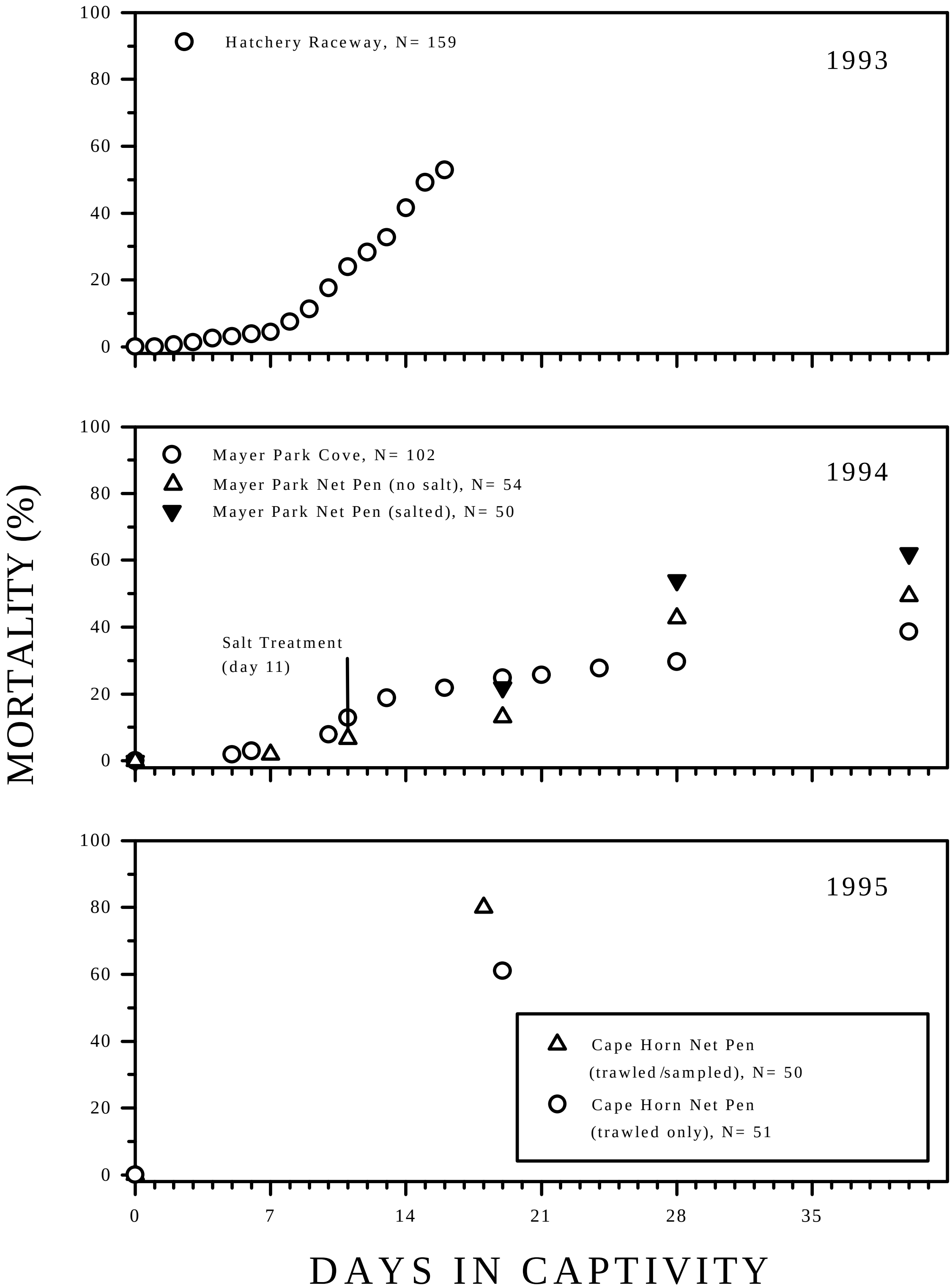

Figure 3. Short-term cumulative mortality of retained juvenile white sturgeon collected downstream from Bonneville Dam during October 1993 and October-November, 1994-1995.

tissue indicated presence of *Aeromonas* spp. and *Pseudomonas* spp. bacteria, which are not typically found in organs of healthy fish.

Mortality of retained fish was less in 1994. During the first 7 days of holding, observed mortality was ≤3.0% in the cove and net pen. After 40 days of retention, mortality increased to 38.6% (37 mortalities and 2 fish not recovered) for fish in the cove and 49.3% (27 mortalities) for untreated fish held in the net pen. White sturgeon treated with salt experienced higher mortality than untreated groups. Mortality after 40 days of retention (29 days post-treatment) for salt treated fish was 62.0% (31 mortalities). We visually inspected each live fish at release to evaluate physical condition. Of the 62 fish released from the cove, we classified 35 (56.5%) fish in fair or good condition, 22 (35.5%) with some degree of fin erosion, and 5 (8.0%) with visible fungus. Of the 46 fish released from the net pen, 18 (39.1%) were in good condition, 18 (39.1%) had fin erosion, and 10 (21.8%) were infected with fungus.

Mortality of retained white sturgeon in 1995 was 80.0% after 19 days in captivity for fish trawled and processed and 61.0% for trawled but unprocessed fish after 21 days of retention. Several anchors that held the net under water were lost during the evaluation which allowed the net to collapse and probably invalidated results. Of the 20 unprocessed fish released, we classified 4 (20.0%) fish in fair condition, 8 (40.0%) with fin erosion, and 8 (40.0%) infected with fungus. We classified the 10 surviving trawled and processed fish as 3 (30.0%) with fin erosion and 7 (70.0%) infected with fungus.

Stress Evaluation

Blood cortisol concentration appears to be a suitable indicator of relative stress experienced by juvenile white sturgeon (Figure 4). Mean cortisol levels of stressed fish (Group B) were significantly different between tests and from both repetitions of unstressed fish (Group A) and fish stressed but allowed to recover (Group C).

Results of blood cortisol sampling conducted during October and November 1995 on wild white sturgeon to identify sources of stress will be presented in our 1996 annual report.

DISCUSSION

Our efforts during 1993-1995 provided estimates of catch rates, maximum mortality rates, and amount of time required to sample and transport large numbers of wild white sturgeon. Distributing our sampling efforts throughout several years allowed us to annually modify elements of the project to improve processing and transportation efficiency. This information coupled with recapture data (to be collected in 1997) will allow us to evaluate if transplantation is a feasible means of supplementing white sturgeon populations within the Columbia River basin.

The use of the barge and fish liberation truck combination greatly facilitated our ability to transport white sturgeon and resolved many of the problems we encountered when transporting fish by boat in 1994. The ample room on the barge simplified movements of personnel and fish and allowed us to increase the number of tanks available for holding fish prior to processing. This increased capacity, combined with an improved water distribution system, allowed large catches

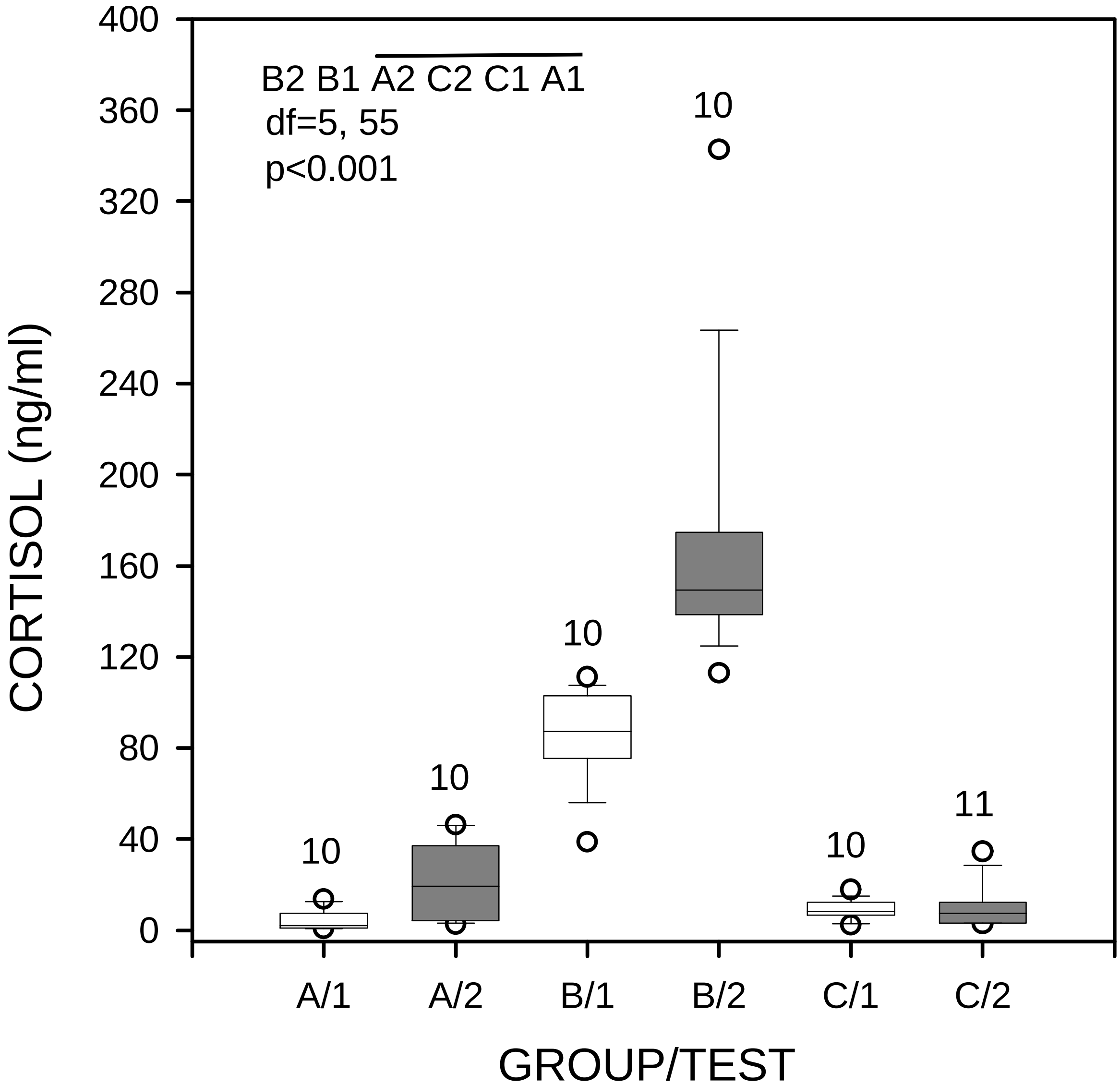

Figure 4. Mean blood cortisol levels of three test groups of captive juvenile white sturgeon. Test groups were A) unstressed; blood collected from fish immediately after removal from rearing tank, B) stressed; blood collected from fish after approximately one h of exposure to reduced dissolved oxygen, and C) stressed with recovery period; fish exposed to same conditions as Group B but returned to culture tank for a 23-h recovery period after which blood was collected. Test 1 was conducted 23 August 1995. Test 2 was conducted 14 February 1996. Sample size and percentiles for each group and test are indicated. Lines represent percentiles of 10, 25, 50, 75, and 90 (the box encompasses the 25th through 75th percentiles). The 5th and 95th percentiles are indicated below and above the 10th and 90th percentile caps. Results of general linear modeling, degrees of freedom (df1, df2), and observed probability level (p) are indicated. Test groups, indicated in the upper left corner, have significantly different means if not covered by the same line.

of fish to be transferred from the trawl vessel to the barge at one time, which increased efficiency. The tugboat and barge operated reliably and served as a stable and safe working platform. We handled fish less often with the liberation truck located on the barge. The large capacity of the liberation truck allowed us to transport more fish each day while maintaining low loading densities. Dissolved oxygen concentrations in the truck tanks were easily monitored and adjusted. Hauling duration was substantially reduced using this combination rather than transporting by boat. The use of a second truck, which could be driven onto the barge each day to replace the departing vehicle, might reduce personnel hours since the driver would not need to remain on the barge all day while the truck was being loaded.

Several factors remain which should be considered during any future white sturgeon transplantation efforts. Sampling schedules should allow for daily fluctuations in catch, mechanical breakdown, and severe weather. Catch rates fluctuate due to patchy distribution of white sturgeon. Severe wind, common along the lower Columbia River during October and November, seemed to reduce catch rates and overall efficiency of personnel and equipment. Since catch rates were generally higher when trawling with the current (i.e., downstream), a relatively large trawl vessel (≥12.2 m) is recommended to reduce the risk of the vessel capsizing if the trawl-net snags the river bottom. Fish handling, loading densities, and duration of transport should be minimized to increase survival. The spring scales we used to measure fish weights had graduations which were too large to accurately weigh small white sturgeon (< 40 cm fork length). Scales with finer graduations and periodic calibration should increase the accuracy of weight data.

The mortality of wild white sturgeon held for evaluation may not represent actual mortality of fish transported and released. Natural conditions and habitat of white sturgeon are difficult to approximate over the extended period necessary to determine delayed effects of treatment. Hatchery raceways, net pens, and small embayments expose fish to unnatural conditions including increased sunlight, abrasion, shallow depths, and overcrowding. These conditions may maintain or elevate stress beyond that experienced during handling and transportation, and may increase mortality rates.

We believe mortality of white sturgeon released into The Dalles Reservoir will not exceed mortality rates of fish retained in the blockaded cove. Natural substrates, potential feed, and fish densities resembled natural conditions more closely than the other holding environments. Fish held in the cove had less fin abrasion and corresponding fungal infections, which reduced mortality. Selection of a deeper cove for holding experiments may reduce exposure to sunlight and further improve survival but recapturing fish would be more difficult.

Analysis of blood cortisol samples collected from white sturgeon during 1995 may allow us to determine which procedures (capture, processing, or transport) cause the most stress and may help us identify where improvements can be made to achieve optimum survival. An evaluation of the short-term survival of white sturgeon captured by trawl versus other less aggressive gear types (e.g., setlines, traps, and angling) may help identify minimum rates of mortality attributable to each capture technique. A repeat of the comparison of short-term survival of trawled and unprocessed versus trawled and processed fish would help determine the percentage of total mortality attributable to handling.

PLANS FOR EVALUATION OF TRANSPORTED STURGEON

Personnel from CRITFC will contract with commercial fishers and begin sampling in The Dalles Reservoir in December 1996 with a primary objective of marking and tagging indigenous and transplanted white sturgeon. We will sample in The Dalles Reservoir beginning April 1997 with primary objectives of recapturing white sturgeon transplanted during 1994 and 1995 and similar-sized indigenous white sturgeon tagged by CRITFC. An estimate of the abundance of transplanted fish will be the product of the estimated total population size and the observed fraction of transplanted white sturgeon in the sample. Survival of transplanted fish will be calculated as the estimated abundance divided by the number transported with corrections for fishing and natural mortality rates. Mortality in excess of expected fishing and natural mortality will be attributed to effects of capture, handling, and transport. Recapture data will also allow us to estimate growth, and condition of transplanted white sturgeon.

We will use setlines and gill nets described by Rien et al. (1991) for fish collection. We may make modifications to our setlines to increase the likelihood of capturing fish ≤80 cm (e.g., longer ground lines, more hooks per line, more hooks of smaller sizes, and different baits). We intend to complete five passes through the reservoir to increase sample size and increase precision of estimates.

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report B

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

and

Describe the life history and population dynamics of subadult and adult white sturgeon upstream of McNary Dam and downstream from Bonneville Dam

This report includes: A survey of the 1995 recreational and commercial fisheries for white sturgeon between Bonneville and McNary dams

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ABSTRACT

The Washington Department of Fish and Wildlife (WDFW) conducted a census of the 1995 recreational fisheries on the Columbia River from Bonneville Dam upstream to McNary Dam to estimate white sturgeon *Acipenser transmontanus* harvest. Harvest and biological data were collected as a component of white sturgeon stock assessment work conducted by the Oregon Department of Fish and Wildlife (ODFW). Harvest monitoring was also used to evaluate the success of managing fisheries to protect and enhance white sturgeon populations between Bonneville and McNary dams (Zone 6 management unit of the Columbia River).

Zone 6 recreational fisheries are managed by WDFW and ODFW with the direction of the Sturgeon Management Task Force (SMTF). The SMTF recommended for 1995 to continue using the recreational fishery harvest guidelines in effect since 1991 of 1,350 fish for Bonneville Reservoir, 100 fish for The Dalles Reservoir, and 100 fish for John Day Reservoir. Harvest exceeded these guidelines in 1994; therefore, WDFW and ODFW adopted a set season for retention of sturgeon (1 January through 30 June 1995) and allowed catch and release during the remainder of the year.

The Washington Department of Fish and Wildlife and ODFW closed the Bonneville Reservoir recreational fishery to the retention of white sturgeon on 24 April and The Dalles and John Day recreational fisheries on 1 June when harvest was projected to exceed the guidelines. We estimated 1,370 white sturgeon were harvested in 1995 from Bonneville Reservoir by anglers making an estimated 5,900 trips for sturgeon (1,330 fish during the February through September census). Thirty percent of angler trips during the census in Bonneville Reservoir were for white sturgeon. Anglers harvested an estimated 50 white sturgeon in 1995 from The Dalles Reservoir during an estimated 1,900 trips for sturgeon (46 fish during the March through September census). Seven percent of angler trips during the census in The Dalles Reservoir were for white sturgeon. We estimated anglers harvested 80 white sturgeon in 1995 from John Day Reservoir during 7,000 trips (77 fish during the March through September census). Sixteen percent of angler trips during the census in John Day Reservoir were for white sturgeon.

Treaty Indian commercial fishers landed 1,421 white sturgeon from Bonneville Reservoir (1,250 fish guideline) during winter gillnet and setline fisheries, 312 from The Dalles Reservoir (300 fish guideline), and 308 from John Day Reservoir (100 fish guideline). The Columbia River Inter-Tribal Fish Commission (CRITFC) and the Yakama Indian Nation estimated an additional 1,150 fish were harvested during subsistence fisheries.

INTRODUCTION

This annual report describes work completed by the Washington Department of Fish and Wildlife (WDFW) as part of the Bonneville Power Administration (BPA) white sturgeon *Acipenser transmontanus* research project 86-50. The WDFW is 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. These tasks include surveying the recreational fishery between Bonneville and McNary dams to estimate annual white sturgeon harvest and to evaluate management plans intended to regulate sturgeon fisheries at optimum sustainable exploitation rates.

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. We intend to describe population characteristics and to estimate productivity of white sturgeon populations in the lower three reservoirs on the Snake River. Our sampling closely follows the methods developed and used since 1987 by ODFW on the Columbia River reservoirs (Rien et al. 1993). At the time of this report we are refining procedures and securing sampling equipment and supplies.

Specific activities reported for the period March 1995 through March 1996 include: 1) surveying the February through September recreational fishery between Bonneville and McNary dams (Zone 6 management unit of the Columbia River), and 2) monitoring Zone 6 treaty Indian commercial fishery landings of white sturgeon.

METHODS

Recreational Fishery Census

The 1995 recreational fishery census was conducted in Bonneville, The Dalles, and John Day reservoirs from February through September (Figure 1). Only the area from McNary Dam downstream to Arlington, Oregon (Rkm 390), was censused in John Day Reservoir. Methods were similar to those used in 1994 (James et al. 1996) and relied on angling pressure distribution data collected during censuses of Bonneville Reservoir from 1988-1990, The Dalles Reservoir from 1987-1989, and John Day Reservoir from 1989-1991 (Hale and James 1993). Sampling was conducted by two full-time creel samplers hired by ODFW, three full-time samplers hired by WDFW, and two staff from the WDFW Columbia River Anadromous Fish Division office.

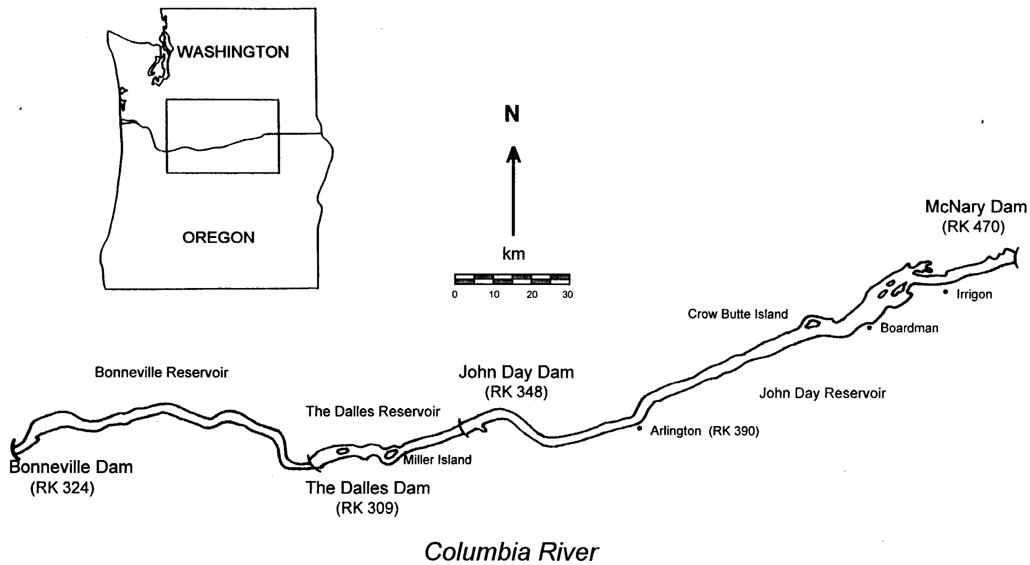

Figure 1. Location of the 1995 recreational fishery census on the Columbia River: Bonneville and The Dalles reservoirs and from Arlington upstream to McNary Dam on John Day Reservoir.

The census was limited to legal angling hours for sturgeon (one hour before sunrise to one hour after sunset). Therefore, estimates of angling effort for and harvest of steelhead *Oncorhynchus mykiss*, walleye *Stizostedion vitreum*, smallmouth and largemouth bass *Micropterus dolomieui* and *Micropterus salmoides*, and northern squawfish *Ptychocheilus oregonensis*, which were allowed to be harvested at night, are considered minimum estimates.

Angling effort (angler hours and angler trips) was estimated by periodically counting anglers within representative index areas and expanding those counts to the entire reservoir using 1987-1991 aerial counts of angling pressure. Catch per effort data were collected by interviewing anglers and examining catches.

Indices of angler pressure were established at popular fishing locations and vantage points in each reservoir. These index areas were the same as those used in 1994. Counts were made of all bank anglers and recreational fishing boats within each index area. Average numbers of anglers per boat were determined from angler interviews.

Angling pressure within index areas was counted once a day between 1000 and 1300 hours (Appendix B-1). Total daily angling effort was then calculated by comparing these counts to prior years' data where systematic counts were made throughout the day. Index to non-index pressure distribution patterns were obtained from prior aerial survey data.

Samplers 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. Samplers collected data from both incomplete and complete angler trips. Interview data collected included: angling method (bank or boat), target species, hours fished, number of anglers in the party, fishing location, state of residence, species, number of fish caught, number released, total length of all retained fish, and mark sample data for white sturgeon, salmonids, and walleye. Samplers did not differentiate between smallmouth and largemouth bass. Anglers were also asked if they had registered with the northern squawfish sport reward program and, if so, the station where they registered.

Personnel from ODFW's District Office in The Dalles, Oregon sampled mainstem Columbia River salmonid anglers exiting the Heritage Park ramp at the mouth of the Deschutes River. They provided sampling summaries and harvest estimates which we incorporated into our harvest estimates for The Dalles Reservoir. Anglers participating in walleye and bass tournaments were not sampled. Summaries of catch and effort provided by tournament operators were used instead.

Effort and catch data were stratified by angling method (bank/boat), reservoir subsection, and weekend and weekday type to account for differential catch and sampling rates. Harvest and angling effort estimates were derived monthly. Harvest estimates for bank anglers fishing Bonneville Reservoir and for all boat anglers 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. Annual harvest estimates were calculated from census period estimates by applying monthly harvest proportions based on 1987-1994 Oregon and Washington sturgeon catch record card reports.

White sturgeon harvest by bank anglers in The Dalles and John Day reservoirs was calculated in a different manner since successful bank anglers may have been missed due to the one fish daily bag limit. The ratio of bank vs. boat harvest per angler hour was determined for years when the daily limit was two fish. This ratio was applied to the 1995 boat harvest per angler hour rate to estimate 1995 bank harvest per angler hour. The 1995 bank harvest rate was then applied to the 1995 estimate of bank angling effort for sturgeon.

Treaty Indian Commercial and Subsistence Harvest

Numbers of white sturgeon harvested in Zone 6 treaty Indian commercial fisheries were estimated from poundages reported on fish receiving tickets for each gear type. Poundages of white sturgeon were converted to numbers of fish by dividing by an average fish weight obtained during random biological sampling of treaty Indian commercial landings by field crews. Landings by reservoir were estimated from the catch area reported on fish receiving tickets. The legal size slot for treaty Indian commercial fisheries was 122-183 cm (48-72 in). Treaty Indian subsistence harvest of white sturgeon was estimated by the CRITFC and the Yakama Indian Nation (YIN) from interviews with treaty Indian fishers.

RESULTS

Recreational Fishery Census

Bonneville Reservoir

Anglers fished an estimated 109,599 hours (18,072 trips) in Bonneville Reservoir from February through September (Table 1). Angling effort for sturgeon comprised 30% (5,480 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 5,179 (29%) for anadromous salmonids, 338 (2%) for American shad *Alosa sapidissima*, 1,231 (7%) for walleye, 2,330 (13%) for bass, 2,710 (15%) for northern squawfish, 659 (4%) for other resident fish, and 145 ($<$ 1%) for anglers participating in tournaments.

Anglers harvested an estimated 1,330 white sturgeon in Bonneville Reservoir from February through April 23 and no sturgeon from April 24 through September when the fishery was closed to retention (Table 2). The fishery for white sturgeon encompassed the entire reservoir with slightly more bank anglers than boat anglers. Harvest per angler trip improved each month prior to closure, peaking in April at 0.39 fish/trip and averaged 0.19 fish per trip for bank anglers

Table 1. Combined Washington and Oregon recreational fishery angling effort estimates for Bonneville Reservoir, February through September 1995, and The Dalles and John Day reservoirs, March through September 1995.

Species, Bank/Boat	Bonneville		The Dalles		John Day	
	Hours	Trips	Hours	Trips	Hours	Trips
Sturgeon						
Bank	17,449	3,139	9,488	1,039	12,151	2,394
Boat	14,238	2,341	3,562	643	21,517	3,853
Total	31,687	5,480	13,050	1,682	33,668	6,247
Salmonid						
Bank	23,699	2,509	9,709	796	11,380	2,338
Boat	15,307	2,670	37,370	5,316	2,645	514
Total	39,006	5,179	47,079	6,112	14,025	2,852
Shad						
Bank	1,148	338	9,345	1,409	1,813	631
Boat	0	0	182	33	169	29
Total	1,148	338	9,527	1,442	1,982	660
Walleye						
Bank	0	0	768	121	966	187
Boat	5,673	1,231	53,189	8,244	63,607	12,446
Total	5,673	1,231	53,957	8,365	64,573	12,633
Bass						
Bank	1,531	486	3,906	780	11,717	3,048
Boat	9,773	1,844	7,114	1,285	40,261	8,131
Total	11,304	2,330	11,020	2,065	51,978	11,179
Squawfish						
Bank	9,074	1,471	19,431	2,023	572	65
Boat	6,964	1,239	16,080	2,458	1,881	263
Total	16,038	2,710	35,511	4,481	2,453	328
Other						
Bank	1,557	418	2,370	396	12,527	2,811
Boat	1,335	241	1,644	324	5,186	1,209
Total	2,892	659	4,014	720	17,713	4,020
Tournament						
Bank	0	0	0	0	0	0
Boat	1,851	145	180	18	13,775	1,562
Total	1,851	145	180	18	13,775	1,562
Combined total						
Bank	54,458	8,361	55,017	6,564	51,126	11,474
Boat	55,141	9,711	119,321	18,321	149,041	28,007
Total	109,599	18,072	174,338	24,885	200,167	39,481

Table 2. Combined Washington and Oregon recreational fishery harvest, and catch and release estimates for Bonneville Reservoir, February through September 1995, and The Dalles and Joh Day reservoirs, March through September 1995.

Species	Bonneville	The Dalles	John Day
White sturgeon			
Legals kept	1,330	46	77
Sublegals released	12,031	2,012	4,726
Legals released	1,145	63	246
Oversize released	156	11	143
Total	14,662	2,132	5,192
Chinook salmon			
Adults kept	558	361	0
Jacks kept	52	53	0
Total kept	610	414	0
Released	203	197	0
Coho salmon			
Adults kept	25	0	11
Jacks kept	0	0	0
Total	25	0	11
Steelhead			
Kept	515	1,191	468
Released	192	832	265
American shad			
Kept	1,663	6,881	298
Released	205	1,495	379
Walleye			
Kept	852	7,491	3,275
Released	445	6,184	1,717
Bass			
Kept	1,227	3,197	7,628
Released	9,557	5,311	21,638
Northern squawfish kept	15,187	33,754	1,996
Other resident fish kept	67	194	4,917

and 0.51 fish per trip for boat anglers during the retention fishery (Table 3). Angling effort for white sturgeon decreased by more than 80% from early April levels during the late April through September catch and release fishery. Approximately 24% of the estimated bank effort (angler hours) and 19% of the estimated boat effort for white sturgeon during the census period were accounted for by the 1,646 sturgeon anglers interviewed (Table 4).

Anglers fished February through 23 April with a daily bag limit regulation allowing one fish 107 to < 122 cm (42 to < 48 in) and one fish 122-168 cm (48-66 in) which contributed to anglers releasing 27% of the reported catch of legal-sized fish (Table 4). The percentage sublegal (< 107 cm, < 42 in), legal (107-168 cm, 42-66 in, both kept and released), and oversize (> 168 cm, > 66 in) sturgeon in the February through September sampled catch was 82%, 17%, and 1%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5.

Approximately 25% of the estimated recreational fishery harvest of white sturgeon from Bonneville Reservoir was examined for marked fish (Table 6). Sixteen white sturgeon marked by ODFW during previous studies were observed in the creel.

The census period estimate expanded to an annual estimate of 1,370 white sturgeon (Table 7). Harvest per trip of 107-168 cm (42-66 in) fish has increased each year since 1992 (Table 8).

The Dalles Reservoir

Anglers fished an estimated 174,338 hours (24,885 trips) in The Dalles Reservoir from March through September 1995 (Table 1). Angling effort for sturgeon comprised 7% (1,682 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 6,112 (24%) for anadromous salmonids, 1,442 (5%) for American shad, 8,365 (34%) for walleye, 2,065 (8%) for bass, 4,481 (18%) for northern squawfish, 720 (3%) for other resident fish, and 18 (< 1%) for anglers participating in tournaments.

The primary recreational fishery for white sturgeon extended from the John Day Dam tailrace downstream to Miller Island (Rkm 327). More sturgeon anglers fished from the bank than from boats. An estimated 46 white sturgeon were harvested March through May with effort and harvest greatest in May, prior to the fishery closing 1 June to the retention of sturgeon (Table 3). The census period estimate expanded to an annual harvest estimate of 50 white sturgeon with the additional harvest coming in January and February. The average harvest per trip was 0.03 for bank anglers and 0.04 for boat anglers targeting sturgeon during the retention fishery. Angling effort for sturgeon decreased by more than 90% from May levels during the June through September catch and release fishery. Approximately 20% of the estimated bank effort (angler hours) and 15% of the estimated boat effort for sturgeon was accounted for by the 545 sturgeon anglers interviewed (Table 4).

Table 3. Estimates of recreational fishery angler trips for white sturgeon, white sturgeon harvest, and harvest per angler trip (HPUE) for Bonneville Reservoir, February through September 1995, and The Dalles and John Day reservoirs, March through September 1995.

Month	Bonneville			The Dalles			John Day		
Method	Trips	HPUE	Harvest	Trips	HPUE	Harvest	Trips	HPUE	Harvest
February									
Bank	262	0.15	38						
Boat	221	0.34	76						
Total	483	0.24	114						
March									
Bank	1,265	0.13	170	166	0.00	0	434	0.00	2
Boat	646	0.52	338	136	0.02	3	611	0.01	6
Total	1,911	0.27	508	302	0.01	3	1,045	0.01	8
April									
Bank	1,014	0.26 [a]	254	292	0.04	12	762	0.01	11
Boat	883	0.54 [a]	454	110	0.00	0	754	0.03	23
Total	1,897	0.39 [a]	708	402	0.03	12	1,516	0.02	34
May									
Bank	136	0.00	0	499	0.03	16	695	0.01	9
Boat	46	0.00	0	264	0.06	15	1,042	0.02	26
Total	182	0.00	0	763	0.04	31	1,737	0.02	35
June									
Bank	108	0.00	0	33	0.00	0	192	0.00	0
Boat	262	0.00	0	66	0.00	0	311	0.00	0
Total	370	0.00	0	99	0.00	0	503	0.00	0
July									
Bank	174	0.00	0	37	0.00	0	71	0.00	0
Boat	105	0.00	0	11	0.00	0	523	0.00	0
Total	279	0.00	0	48	0.00	0	594	0.00	0
August									
Bank	147	0.00	0	1	0.00	0	116	0.00	0
Boat	32	0.00	0	56	0.00	0	371	0.00	0
Total	179	0.00	0	57	0.00	0	487	0.00	0
September									
Bank	33	0.00	0	11	0.00	0	124	0.00	0
Boat	146	0.00	0	0	0.00	0	241	0.00	0
Total	179	0.00	0	11	0.00	0	365	0.00	0
Combined									
Bank	3,139	0.19 [a]	462	1,039	0.03 [a]	28	2,394	0.01 [a]	22
Boat	2,341	0.51 [a]	868	643	0.04 [a]	18	3,853	0.02 [a]	55
Total	5,480	0.32 [a]	1,330	1,682	0.03 [a]	46	6,247	0.02 [a]	77

[a] *Harvest per angler trip calculated for the period when retention was allowed.*

Table 4. Numbers of sturgeon anglers interviewed and numbers of white sturgeon kept and released reported during sampling of recreational fisheries in Bonneville Reservoir, February-September 1995, and The Dalles and John Day reservoirs, March-September 1995

Reservoir, Method/Month	Anglers checked	Hours fished	Sublegal	Legal released	Legal kept	Oversiz
Bonneville						
Bank						
February	113	380	142	3	13	0
March	483	1,658	444	4	42	1
April	458	1,766	415	8	76	0
May	47	136	57	15	0	0
June	30	78	43	10	0	0
July	40	85	103	14	0	0
August	24	76	17	3	0	0
September	3	5	3	0	0	0
Boat						
February	39	258	125	8	15	0
March	169	1,004	628	69	99	0
April	161	998	375	33	86	0
May	7	41	29	1	0	0
June	30	175	81	17	0	12
July	27	198	87	12	0	15
August	3	6	23	1	0	0
September	12	67	66	16	0	0
Combined total	1,646	6,931	2,638	214	331	28
The Dalles						
Bank						
March	64	195	9	0	0	0
April	154	630	26	0	3	0
May	189	996	69	0	3	0
June	11	25	13	1	0	0
July	14	76	37	1	0	1
August	1	1	5	0	0	0
September	7	19	4	3	0	0
Boat						
March	38	192	20	0	1	1
April	23	128	9	0	0	0
May	32	168	32	1	1	0
June	5	29	28	1	0	0
July	2	3	13	0	0	0
August	5	31	7	1	0	0
September	0	0	1	2	0	0
Combined total	545	2,493	273	10	8	2

continued

Table 4. Continued

Reservoir, Method/Month	Anglers checked	Hours fished	Sublegal	Legal released	Legal kept	Oversize
John Day						
Bank						
March	56	113	4	0	0	0
April	97	224	9	0	0	0
May	61	161	15	0	1	0
June	17	52	0	0	0	1
July	8	12	1	0	0	0
August	9	32	7	0	0	0
September	5	22	2	1	0	1
Boat						
March	161	897	119	1	3	4
April	278	1,530	434	1	11	4
May	174	985	238	2	5	5
June	57	345	56	2	0	7
July	82	464	145	24	0	4
August	34	169	35	4	0	0
September	23	133	32	4	0	0
Combined total	1,062	5,139	1,097	39	20	26

Table 5. Length frequencies of harvested white sturgeon measured during sampling o recreational fisheries in Bonneville Reservoir, February through September 1995, and in The Dalles and John Day reservoirs, March through September 1995. Not all sampled fish were measured. Includes prior days catch excluded from Table 3.

Fork length (cm)	Bonneville	The Dalles	John Day	Fork length (cm)	Bonneville	The Dalles	John Day
90				130			
91				131			
92				132	3	1	
93				133			
94	4			134			
95	14			135	1		
96	18			136			2
97	32		1	137			
98	35			138	1		
99	23		1	139			
100	23			140	1		
101	17			141			
102	19			142			
103	15			143			
104	16			144			
105	12		1	145	1		1
106	16		1	146			
107	11		2	147			
108	10	1	2	148			
109	7		1	149			
110	6	2		150			1
111	8		2	151			
112	9	1	3	152			
113	2			153			
114	2		1	154			
115	4			155			
116	3			156			
117	4		1	157			
118	2			158			
119	1			159			
120				160			
121				161			
122	1	3		162			
123	3			163			
124				164			
125				165			
126	1	1		166			
127				167			
128							
129				Total	325	9	20

Table 6. Tag numbers of harvested marked white sturgeon and numbers of unmarked white sturgeon observed by samplers examining the recreational fishery creel (in-sample information) for Bonneville, The Dalles, and John Day reservoirs, 1995. Also presented are the tag numbers of caught and released marked white sturgeon reported during interviews and tag numbers of harvested marked white sturgeon not part of the sampled creel (tags voluntarily returned to WDFW by anglers).

Reservoir, Period Released	Recovery method	Proportion of harvest examined	Non-marked	1995 mark Kept	Kept	Pre-1995 mark Released	Kept
Bonneville							
2/1 - 4/23	In-sample	0.249	315	0	0	JD 70435	JD 72017
						JD 75250	TD 53128
						JD 72149	a
						JD 71704	
						JD 71695	
						JD 71756	
						TD 53025	
						TD 530?1	
						BO 60488	
						BO 60392	
						scar/scute	
						scar/scute	
						scar/scute	
						b	
	Volunteer			0	0	JD 70474	JD 50944
The Dalles							
3/1 - 6/30	In-sample	0.174	8	0	0	0	c
	Volunteer			0	0	JD 73474	TD 53141
John Day							
3/1 - 6/30	In-sample	0.260	20	0	0	0	d
	Volunteer			0	0	0	JD 71112

[a] *Another fifteen marked white sturgeon were reported caught and released without the interviewed anglers recording tag numbers or scute mark patterns.*

[b] *Three secondary marked sturgeon without tags or tag scars were examined with these scute mark patterns (2nd, 3rd, and 4th right; 2nd right and 3rd left; 2nd right and 4th left).*

[c] *One marked white sturgeon was reported caught and released without the interviewed angler recording the tag number or scute mark pattern.*

[d] *Two marked white sturgeon were reported caught and released without the interviewed anglers recording tag numbers or scute mark patterns.*

Table 7. Estimated census period and annual recreational fishery harvest of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1987 through 1995.

	Census period estimates			Annual estimates		
Reservoir, Year	Period	Angler trips	Harvest	Period	Angler trips	Harvest
Bonneville						
1987	-- a			Jan-Dec	N/A	3,300
1988	Mar-Oct	10,429	1,532	Jan-Dec	12,700	1,870
1989	Mar-Oct	13,820	2,798	Jan-Dec	14,700	2,982
1990	Mar-Oct	14,562	2,114	Jan-Dec	15,500	2,249
1991	Mar-Oct	N/A	1,410	Jan-Dec	N/A	2,270
1992	Apr-Oct	8,550	880	Jan-Dec	16,700	1,717
1993	Mar-Oct	14,347	2,145	Jan-Dec	15,400	2,307
1994	Mar-Oct	13,150	2,169	Jan-Dec	13,700	2,223
1995	Feb-Sep	5,480	1,330	Jan-Dec	5,900	1,370
The Dalles						
1987	Jun-Oct	8,637	1,990	Jan-Dec	10,700	2,462
1988	Mar-Oct	7,609	907	Jan-Dec	9,100	1,083
1989	Mar-Oct	5,419	499	Jan-Dec	7,500	693
1990	-- a			Jan-Dec	N/A	482
1991	Mar-Oct	N/A	100	Jan-Dec	N/A	199
1992	Apr-Oct	2,590	110	Jan-Dec	3,300	139
1993	Mar-Oct	3,960	128	Jan-Dec	4,900	158
1994	Mar-Oct	4,987	151	Jan-Dec	5,300	154
1995	Mar-Sep	1,682	46	Jan-Dec	1,900	50
John Day						
1987	-- a			Jan-Dec	N/A	960
1988	-- a			Jan-Dec	N/A	384
1989	May-Jul	6,973	283	Jan-Dec	7,500	304
1990	Mar-Dec	6,869	314	Jan-Dec	7,200	331
1991	Apr-Sep	4,440	143	Jan-Dec	4,700	150
1992	May-Oct	2,740	90	Jan-Dec	4,500	147
1993	Mar-Oct	7,674	134	Jan-Dec	8,200	144
1994	Mar-Oct	10,081	231	Jan-Dec	10,200	234
1995	Mar-Sep	6,247	77	Jan-Dec	7,000	80
Combined						
1987			1,990	Jan-Dec	N/A	6,722
1988			2,439	Jan-Dec	N/A	3,337
1989			3,580	Jan-Dec	29,700	3,979
1990			2,428	Jan-Dec	N/A	3,062
1991			1,653	Jan-Dec	N/A	2,619
1992			1,080	Jan-Dec	24,500	2,003
1993			2,407	Jan-Dec	28,500	2,609
1994			2,551	Jan-Dec	29,200	2,611
1995			1,453	Jan-Dec	14,800	1,500

a *No sampling conducted.*

Table 8. Estimated angling effort, harvest, and harvest per angler trip (HPUE) of 42-66 inch white sturgeon from Bonneville Reservoir and 48-66 inch white sturgeon from The Dalles and John Day reservoirs, 1987 through 1995.

Reservoir, Year	Period	Bank anglers Trips	Harvest	HPUE	Boat anglers Trips	Harvest	HPUE
Bonneville (42 - 66 inches)							
1987	-- a						
1988	Mar-Oct	5,653	532	0.094	4,776	688	0.144
1989	Mar-Oct	8,028	1,316	0.164	5,792	1,099	0.190
1990	Mar-Oct	7,213	719	0.100	7,349	1,055	0.144
1991	-- a						
1992	-- a						
1993	Mar-Oct	7,599	678	0.089	6,747	736	0.109
1994	Mar-Oct	7,821	1,024	0.131	5,329	1,089	0.204
1995	Feb-Apr	3,139	456	0.145	2,341	857	0.366
The Dalles (48 - 66 inches)							
1987	Jun-Oct	5,019	465	0.093	3,618	339	0.094
1988	Mar-Oct	5,043	257	0.051	2,566	170	0.066
1989	Mar-Oct	3,659	119	0.033	1,760	99	0.056
1990	-- a						
1991	-- a						
1992	-- a						
1993	Mar-Oct	2,058	46	0.023	1,902	61	0.032
1994	Mar-Oct	3,124	75	0.024	1,863	68	0.037
1995	Mar-May	957	28	0.029	510	18	0.035
John Day (48 - 66 inches							
1987	-- a						
1988	-- a						
1989	May-Jul	3,572	22	0.006	3,401	34	0.010
1990	Mar-Dec	3,806	33	0.009	3,063	82	0.027
1991	Apr-Sep	1,977	36	0.018	2,463	73	0.030
1992	-- a						
1993	Mar-Oct	3,208	56	0.018	4,466	111	0.025
1994	Mar-Oct	3,221	42	0.013	6,860	164	0.024
1995	Mar-May	1,891	12	0.006	2,407	30	0.013

a *Minimal or no sampling.*

The percentage sublegal (< 122 cm, < 48 in), legal (122-168 cm, 48-66 in), and oversize (> 168 cm, > 66 in) sturgeon in the sampled catch was 93%, 6%, and 1%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5.

Approximately 17% of the estimated recreational harvest of white sturgeon from The Dalles Reservoir was examined for marked fish (Table 6). No ODFW marked white sturgeon were observed in the creel.

John Day Reservoir

Anglers fished an estimated 200,167 hours (39,481 trips) in John Day Reservoir from March through September (Table 1). Angling effort for sturgeon comprised 16% (6,247 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 2,852 (7%) for anadromous salmonids, 660 (2%) for American shad, 12,633 (32%) for walleye, 11,179 (28%) for bass, 328 (8%) for northern squawfish, 4,020 (10%) for other resident fish, and 1,562 (4%) for tournament anglers.

The recreational fishery for white sturgeon was concentrated from McNary Dam downstream past Irrigon, Oregon (Rkm 449) with some additional boat effort out of Boardman, Oregon (Rkm 434), and at Crow Butte Island (Rkm 426). Anglers harvested an estimated 77 white sturgeon during March through May with effort and harvest greatest in April and May (Table 3). The census period estimate expanded to an annual harvest estimate of 80 white sturgeon with the additional harvest coming in January and February. The average harvest per trip was 0.01 for bank anglers and 0.02 for boat anglers during the retention fishery. Angling effort for sturgeon decreased by more than 70% from May levels during the June through September catch and release fishery. Approximately 5% of the estimated bank effort (angler hours) and 21% of the estimated boat effort for sturgeon was accounted for by the 1,062 sturgeon anglers interviewed (Table 4).

The percentage sublegal (< 122 cm, < 48 in), legal (122-168 cm, 48-66 in), and oversize (> 168 cm, > 66 in) sturgeon in the reported catch was 93%, 5%, and 2%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5.

Approximately 26% of the estimated recreational harvest of white sturgeon from John Day Reservoir was examined for marked fish (Table 6). No ODFW marked white sturgeon were observed in the creel.

Treaty Indian Commercial and Subsistence Harvest

The 1995 treaty Indian commercial harvest estimates for Zone 6 were 1,421 white sturgeon from Bonneville Reservoir, 312 white sturgeon from The Dalles Reservoir, and 308 white sturgeon from John Day Reservoir (Table 9). Most of the harvest was landed in the winter gillnet fishery (1,950 fish) with 90 fish harvested in the January setline fishery and 10 fish harvested in the fall gillnet fishery. The treaty Indian Zone 6 subsistence white sturgeon harvest estimated by CRITFC and YIN was 570 fish from Bonneville Reservoir, 260 fish from The Dalles Reservoir, and 320 fish from John Day Reservoir (Table 9) (ODFW and WDFW 1996).

DISCUSSION

Recreational Fishery Census

Harvest management of Columbia River white sturgeon fisheries during 1995 was coordinated through the Sturgeon Management Task Force (SMTF), consisting of representatives from WDFW, ODFW, and the Columbia River treaty Indian tribes. The SMTF recommended 1995 harvest guidelines of 1,350 recreational and 1,250 commercial white sturgeon from Bonneville Reservoir, 100 recreational and 300 commercial from The Dalles Reservoir, and 100 recreational and 100 commercial from John Day Reservoir (ODFW and WDFW 1995). Recreational white sturgeon harvest had exceeded the guidelines in all years since 1991 despite a series of regulatory harvest reduction actions implemented from 1988 through 1994 (Appendix B-2). The WDFW and ODFW further restricted the 1995 fishery by adopting a 1 January through 30 June season for retention of sturgeon and allowing catch and release angling opportunity during the remainder of the year. We projected that this season would maintain recreational harvest within SMTF guidelines and minimize the possibility of emergency in-season closures.

We were asked by fishery managers to provide periodic updates of estimated 1995 white sturgeon harvest and to project future weekly harvest. Using February through mid-April data, we projected that the recreational sturgeon harvest in Bonneville Reservoir would exceed the pool guideline by the end of April. We also projected that harvest from The Dalles and John Day reservoirs would approach their guidelines by the end of May. As a result WDFW and ODFW closed the Bonneville Reservoir recreational fishery to the retention of sturgeon from 24 April through 31 December 1995 and The Dalles and John Day recreational fisheries from 1 June through 31 December 1995. Catch and release fishing for sturgeon was allowed to continue during the closure. Annual harvest ended up exceeding the Bonneville Reservoir guideline by 20 fish while annual harvest stayed within the guidelines for The Dalles and John Day reservoirs. From 1991 through 1995 recreational harvest had exceeded the guidelines by an average of 63% each year.

Managers were unsure of how angling effort would be affected once the sport fishery was closed to retention. The Zone 6 sturgeon fishery has traditionally had a very high catch and release component with 90% of the catch since 1987 being released sublegal, legal, and oversize fish. We observed declines in sturgeon angling effort ranging from 70% to over 90% once

Table 9. Sturgeon Management Task Force (SMTF) harvest guidelines and estimated harvest of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1991 through 1995.

Fishery, Guideline/Harvest Year	Bonneville Reservoir	The Dalles Reservoir	John Day Reservoir	Unspecified reservoir	Total
Recreational					
Guideline	1,350	100	100		1,550
Harvest					
1991	2,270	199	150	0	2,619
1992	1,717	139	147	0	2,003
1993	2,307	158	144	0	2,609
1994	2,223	154	234	0	2,611
1995	1,370	50	80	0	1,500
Indian commercial					
Guideline	1,250	300	100		1,650
Harvest					
1991	999	457	39	0	1,495
1992	1,146	431	23	0	1,600
1993	1,415	579	12	0	2,006
1994	1,176	309	117	0	1,602
1995	1,421	312	308	0	2,041
Combined fisheries					
Guideline	2,600	400	200		3,200
Harvest					
1991	3,269	656	189	0	4,114
1992	2,863	570	170	0	3,603
1993	3,722	737	156	0	4,615
1994	3,399	463	351	0	4,213
1995	2,791	362	388	0	3,541
Indian subsistence					
Expectation [a]	--	--	--	--	300
Harvest					
1991	-- [b]	-- [b]	-- [b]	-- [b]	-- [b]
1992	89	-- [b]	-- [b]	119	208
1993	146	31	30	56	263
1994	290	197	163	0	650
1995	570	260	320	0	1,150

a *The SMTF did not established harvest guidelines for the subsistence fishery, however, the expected annual subsistence harvest was 300 white sturgeon for 1994 and 1995.*

b *Not available.*

retention was prohibited. The estimated total number of angler trips for white sturgeon in 1995 declined to 54% of the 1992-1994 average.

Treaty Indian Commercial and Subsistence Harvest

The treaty Indian commercial harvest exceeded the combined pool guideline for the first time since it was established in 1991. However, even with greater harvest in 1995, treaty Indian commercial harvest has averaged only six percent over the combined pool guideline since 1991. In 1995 harvest guidelines for each pool were attained prior to the end of the winter gillnet season and the tribes elected not to extend the setline fishery beyond January or open the fall gillnet fishery to sturgeon sales. The estimated treaty Indian subsistence harvest of 1,150 fish was also greater than in previous years. This reported increase in subsistence harvest may be due in part to more intensive accounting efforts and to harvest of sturgeon during gillnet seasons open for other species but closed to sturgeon sales.

Plans for 1996

We plan to participate in the October trial transport program conducted by ODFW, finalize our sampling plan for Snake River stock assessment, establish a field station in the Tri-Cities area, prepare sampling equipment and supplies, and conduct stock assessment setline sampling in Ice Harbor Reservoir. We will continue monitoring 1996-1997 Zone 6 recreational and treaty Indian commercial fisheries. Finalization of a comprehensive strategic framework plan for management and enhancement of Zone 6 white sturgeon populations is also scheduled.

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APPENDIX B-1

Angler Pressure Count Index Areas and Reservoir Subsection Stratifications

Index Areas

Bonneville Reservoir

Boat

Bridge of the Gods at Cascade Locks, OR [Rkm 239.0 (RM 148.4)] upstream to marker buoy just past Stevenson, WA [Rkm 244.3 (RM 151.7)].

West of Cooks Landing [Rkm 257.5 (RM 160.0)] upstream to Drano Lake [Rkm 262.3 (RM 163.0)].

West of Spring Creek Hatchery [Rkm 267.3 (RM 166.0)] upstream to Mosier, OR (Rkm 282.6 [RM 175.5]).

The mouth of the Klickitat River [Rkm 289.6 (RM 180.0) to Rkm 290.0 (RM 180.8)].

West end of The Dalles, OR [Rkm 303.7 (RM 188.6)] upstream to Hwy. 197 bridge at The Dalles [Rkm 308.4 (RM 191.5)].

Bank

The old lock structure on the Oregon shore at Cascade Locks [Rkm 239.9 (RM 149.0)].

Four access points along the Washington shore between Thirteenmile Point and the Hood River bridge [Rkm 258.5 (RM 160.5), Rkm 261.5 (RM(162.5), Rkm 266.0 (RM 165.2), and Rkm 271.0 (RM 168.4)].

Two access points along the Oregon shore across from Drano Lake [Rkm 261.0 (RM 162.2), Rkm 263.7 (RM 163.9)]

The Highway pullout on the Oregon shore just west of Mosier [Rkm 280.0 (RM 173.9)].

The Oregon and Washington shore at The Dalles [Rkm 303.7 to Rkm 305.2 (RM 188.6 to RM 189.5)].

The Dalles Reservoir

Boat

The lower end of Miller Island [Rkm 327.2 (RM 203.2)] upstream to John Day Dam [Rkm 347.2 (RM 215.6)].

Bank

The Washington shore east of Maryhill, WA [Rkm 340.7 (RM 211.6)] upstream to the base of John Day Dam [Rkm 347.0 (RM 215.5)].
The Oregon shore east of Rufus, OR [Rkm 344.9 (RM 214.2)] upstream to John Day Dam [Rkm 347.2 (RM 215.6)].

John Day Reservoir

Boat

West of Boardman, OR [Rkm 431.6 (RM 268.0)] upstream past Glade Creek on the Washington shore [Rkm 439.6 (RM 273.0)].

Irrigon, OR [Rkm 455.7 (RM 283.0)] upstream to McNary Dam [Rkm 471.0 (RM 292.5)].

Bank

The Oregon shore just east of Boardman [Rkm 438.0 (RM 272.2)].

Three access points along the Oregon shore just west of Irrigon [Rkm 449.2 (RM 279.2), Rkm 451.3 (RM 280.5), Rkm 453.7 (RM 282.0)].

The Washington and Oregon shore just upstream of Hwy. 82 bridge at Umatilla, OR [Rkm 468.6 (RM 291.0)].

The Washington and Oregon shore just downstream of McNary Dam [Rkm 470.4 (RM 292.1)].

McNary Reservoir

Boat

McNary Dam [Rkm 470.4 (RM 292.1)] upstream to the Wallula pulp mill [Rkm 513.3 (RM 319.0)].

The railroad bridge [Rkm 520.5 (RM 323.5)] upstream to the red marker [Rkm 524.5 (RM 326.0)] on the Columbia River and upstream to the Hwy bridge on the Snake River (Rkm 3.5 (RM 2.2)].

Ice Harbor Dam [Rkm 15.6 (RM 9.7)] on the Snake River downstream 4.8 km (3.0 miles).

Trailers

Ringold ramp [Rkm 571.2 (RM 355.0)].

Vernita Bridge ramp [Rkm 624.3 (RM 388.0)].

Bank

The Oregon/Washington shore past Cold Springs Junction [Rkm 484.6 (RM 301.2)] upstream to the mouth of the Walla Walla River [Rkm 506.2 (RM 314.6)].

Both shores of the Snake River from Rkm 13.8 (RM 8.6) upstream to Ice Harbor Dam [Rkm 15.6 (RM 9.7)].

The east shore at Ringold [Rkm 571.2 (RM 355.0)].
The northeast shore from Vernita Bridge [Rkm 624.3 (RM 388.0)] upstream to Priest Rapids Dam [Rkm 639.1 (RM 397.2)].

Reservoir Subsections

Bonneville Reservoir

Boat

Sect-3 Bonneville Dam [Rkm 233.5 (RM 145.0)] upstream past Stevenson [Rkm 244.3 (RM 151.7)].

Sect-2 East of Stevenson [Rkm 244.3 (RM 151.7)] upstream to Mosier [Rkm 282.6 (RM 175.5)].

Sect-1 Mosier [Rkm 282.6 (RM 175.5)] upstream to The Dalles Dam [Rkm 308.4 (RM 191.5)].

Bank

Sect-3 The Oregon shore from Bonneville Dam [Rkm 233.5 (RM 145.0)] upstream to Cascade Locks [Rkm 239.9 (RM 149.0)].

Sect-2 The Oregon shore east of Cascade Locks [Rkm 239.9 (RM 149.0)] upstream to Mosier [Rkm 282.6 (RM 175.5)] and the Washington shore from Bonneville Dam [Rkm 233.5 (RM 145.0)] upstream to a point across from Mosier [Rkm 282.6 (RM 175.5)].

Sect-1 The Oregon and Washington shores from Mosier [Rkm 233.5 (RM 175.5)] upstream to The Dalles Dam [Rkm 308.4 (RM 191.5)].

The Dalles Reservoir

Boat and Bank

Sect-3 The Dalles Dam [Rkm 308.4 (RM 191.5)] upstream to the railroad bridge at Celilo [Rkm 323.8 (RM 201.1)].

Sect-2 The railroad bridge [Rkm 323.8 (RM 201.1)] upstream to the Hwy. 97 bridge at Biggs [Rkm 336.7 (RM 209.1)].

Sect-1 Hwy. 97 bridge [Rkm 336.7 (RM 209.1)] upstream to John Day Dam [Rkm 347.2 (RM 215.6)].

John Day Reservoir

Boat and Bank

Sect-3 Arlington [Rkm 390.2 (RM 242.5)] upstream past Patterson [Rkm 449.3 (RM 279.0)].

Sect-2 East of Patterson [Rkm 449.3 (RM 279.0)] upstream to the Hwy. 82 bridge [Rkm 468.4 (RM 290.9)].

Sect-1 Hwy. 82 bridge [Rkm 468.4 (RM 290.9)] upstream to McNary Dam [Rkm 471.0 (RM 292.5)].

McNary Reservoir

Boat

Sect-5 McNary Dam [Rkm 470.4 (292.1)] upstream to approximately Hat Rock State Park [Rkm 475.5 (RM 295.5)].

Sect-4 Hat Rock State Park [Rkm 475.5 (RM 295.5)] upstream to the red marked past the mouth of the Snake River [Rkm 525.3 (RM 326.5)]

Sect-3 The Snake River upstream to Ice Harbor Dam.

Sect-2 The red marker [Rkm 525.3 (RM 326.5)] upstream past Richland to Rkm 550.3 (RM 342.0).

Sect-1 Rkm 550.3 (RM 342.0) upstream to Priest Rapids Dam [Rkm 639.1 (RM 397.2)].

Bank

Sect-5 McNary Dam [Rkm 470.4 (RM 292.1)] upstream to the mouth of the Walla Walla River [Rkm 506.2 (RM 314.6)].

Sect-4 From the Walla Walla River [Rkm 506.2 (RM 314.6)] upstream to the red marker [Rkm 525.3 (RM 326.5)] and up the Snake River 10.8 km (6.7 miles).

Sect-3 Rkm 10.8 (RM 6.7) on the Snake River upstream to Ice Harbor Dam.

Sect-2 The red marker [Rkm 525.3 (RM 326.5)] upstream past Richland to Rkm 550.3 (RM 342.0).

Sect-1 Rkm 550.3 (RM 342.0) on the Columbia River upstream to Priest Rapids Dam [Rkm 639.1 (RM 397.2)].

APPENDIX B-2

Recreational sturgeon fishery regulations for Bonneville, The Dalles, and John Day reservoirs, 1991-1995.

Year	Daily bag limit	Size limit	Other
1991	1/1	40-72"	Oregon and Washington - Bag limit changed to 1 fish less than 48" and 1 fish ≥ 48" (1/1 regulation) for waters downstream of The Dalles Dam.
	1	48-66"	Oregon and Washington - Size limit change effective April 16, 1991 for waters upstream of The Dalles Dam.
1992	1/1	40-72"	Oregon - No change from 1991 regulations for waters downstream of The Dalles Dam.
	1	48-66"	Oregon - No change from 1991 regulations for waters upstream of The Dalles Dam.
	1/1	40-60"	Washington - Size limit change effective April 16, 1992 for waters downstream of The Dalles Dam.
	1	48-60"	Washington - Size limit change effective April 16, 1992 for waters upstream of The Dalles Dam.
1993	1/1	40-72"	Oregon - No change from 1991 regulations for waters downstream of The Dalles Dam.
	1	48-66"	Oregon - No change from 1991 regulations for waters upstream of The Dalles Dam.
	1/1	40-72"	Washington - Size limit change effective April 16, 1993 for waters downstream of The Dalles Dam.
	1	48-66"	Washington - Size limit change effective April 16, 1993 for waters upstream of The Dalles Dam.
1994	1/1	42-66"	Oregon and Washington - Size limit effective January 1, 1994 for waters downstream of The Dalles Dam. Annual limit 10 fish. Closed to the retention of sturgeon September 16 - December 31.
	1	48-66"	Oregon and Washington - No size limit change from 1993 regulations for waters upstream of The Dalles Dam. Annual limit 10 fish. Closed to the retention of sturgeon September 16 - December 31.
1995	1/1	42-66"	Oregon and Washington - No size or bag limit change from 1994 for waters downstream of The Dalles Dam. Closed to the retention of sturgeon April 24 - December 31.
	1	48-66"	Oregon and Washington - No size or bag limit change from 1994 for waters upstream of The Dalles Dam. Closed to the retention of sturgeon June 1 - December 31.

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report C

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

and

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

This report includes: Investigations on white sturgeon spawning and availability of spawning habitat in McNary Reservoir, the Hanford Reach, and downstream from lower Columbia River dams, and recruitment to young of year in McNary and Bonneville reservoirs

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ABSTRACT

White sturgeons spawned during 3-17 June 1995 in the Snake river downstream from Ice Harbor Dam, during 7 June - 15 July in the Columbia River downstream from Priest Rapids Dam, and during 23 May - 6 July in the Columbia River downstream from The Dalles Dam. We collected 201 white sturgeon eggs from the Snake River, 81 eggs from the Columbia River downstream from Priest Rapids Dam, and 235 eggs from the Columbia River downstream from The Dalles Dam. Indices of spawning habitat from four known spawning areas downstream from the McNary, John Day, The Dalles, and Bonneville dams indicate that environmental conditions were favorable for spawning in 1995.

The Bonneville and McNary pools were sampled with bottom trawls to determine if recruitment to young of year occurred. We captured 72 young of year white sturgeon from the Bonneville Pool and six young of year from the McNary Pool. In addition, 50 juvenile white sturgeons older than young of year were captured from the Bonneville Pool, but no white sturgeons older than young of year were captured from the McNary Pool.

INTRODUCTION

This annual report describes the progress of the National Biological Service's Columbia River Research Laboratory from 1 April 1995 through 31 March 1996 toward meeting the objectives of Bonneville Power Administration's Project 86-50. The primary goals of the National Biological Service under this project are to investigate the reproduction and early life history of white sturgeon in the Columbia River downstream from Priest Rapids Dam and in the Snake River downstream from Ice Harbor Dam (Figure 1). Our tasks for this period were to:

> Estimate the timing of white sturgeon spawning in the Columbia River between McNary and Priest Rapids dams and in the Snake River downstream from Ice Harbor Dam.
>
> Evaluate the effects of river flows and hydropower operations on the spawning of white sturgeon downstream from The Dalles Dam.
>
> Determine if recruitment of white sturgeon young of year occurred in the McNary and Bonneville pools.
>
> Continue to quantify spawning and rearing habitat for white sturgeon in McNary Pool.
>
> Estimate the availability of spawning habitat for white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams.

METHODS

We used artificial substrates (McCabe and Beckman 1990) and D-shaped plankton nets (Parsley et al. 1993) to sample for white sturgeon eggs that we used to estimate the timing of spawning. Seven artificial substrates were placed at five locations in the Snake River (Figure 2) on 17 May. The substrates were checked weekly until they were removed on 11 July after the water temperature reached 19 C. D-shaped plankton nets were fished for 30 min weekly from 24 May to 5 July downstream from one artificial substrate (Figure 2) to collect additional eggs and to compare the two gears abilities to detect spawning events. We sampled the Columbia River at six sites (Figure 3) with artificial substrates. These substrates were deployed on 2 June and checked once weekly for white sturgeon eggs until they were removed on 24 July after the water temperature reached 19.2 C. To further compare the abilities of the two gears to detect spawning events, we fished D-shaped plankton nets for 30 min weekly from 2 June to 18 July downstream from one artificial substrate in the Columbia River (Figure 3).

Sample sites were designated with a code indicating statute river mile and relative position across the river channel. The last digit of the site designation represents position in the channel, with 0 and 5 designating backwater areas and 1 through 4 designating 1/4 channel width

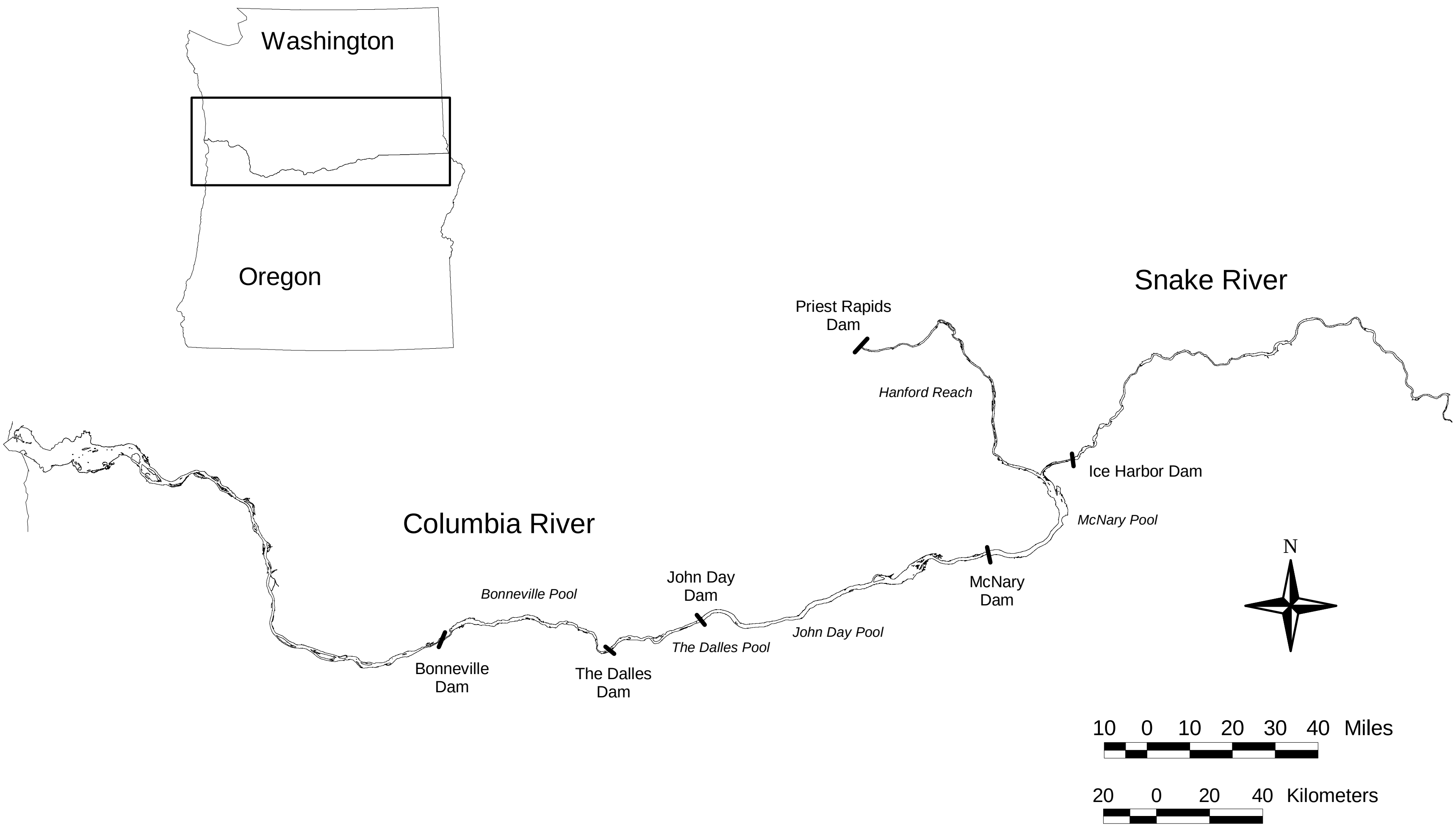

Figure 1. Location of the study areas on the Columbia and Snake rivers.

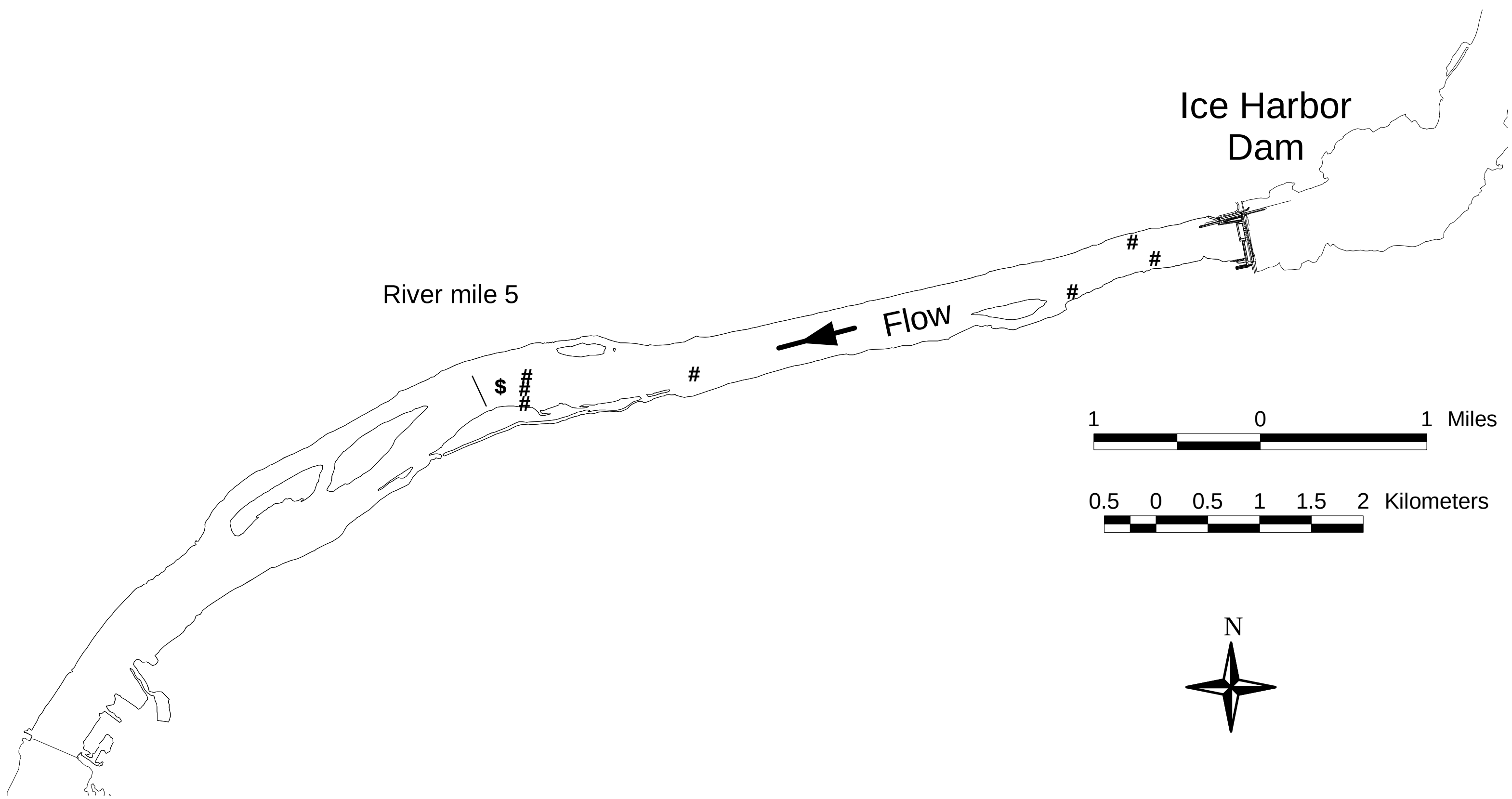

Figure 2. Locations sampled with artificial substrates (circles) and plankton nets (triangles) in the Snake River during 1995.

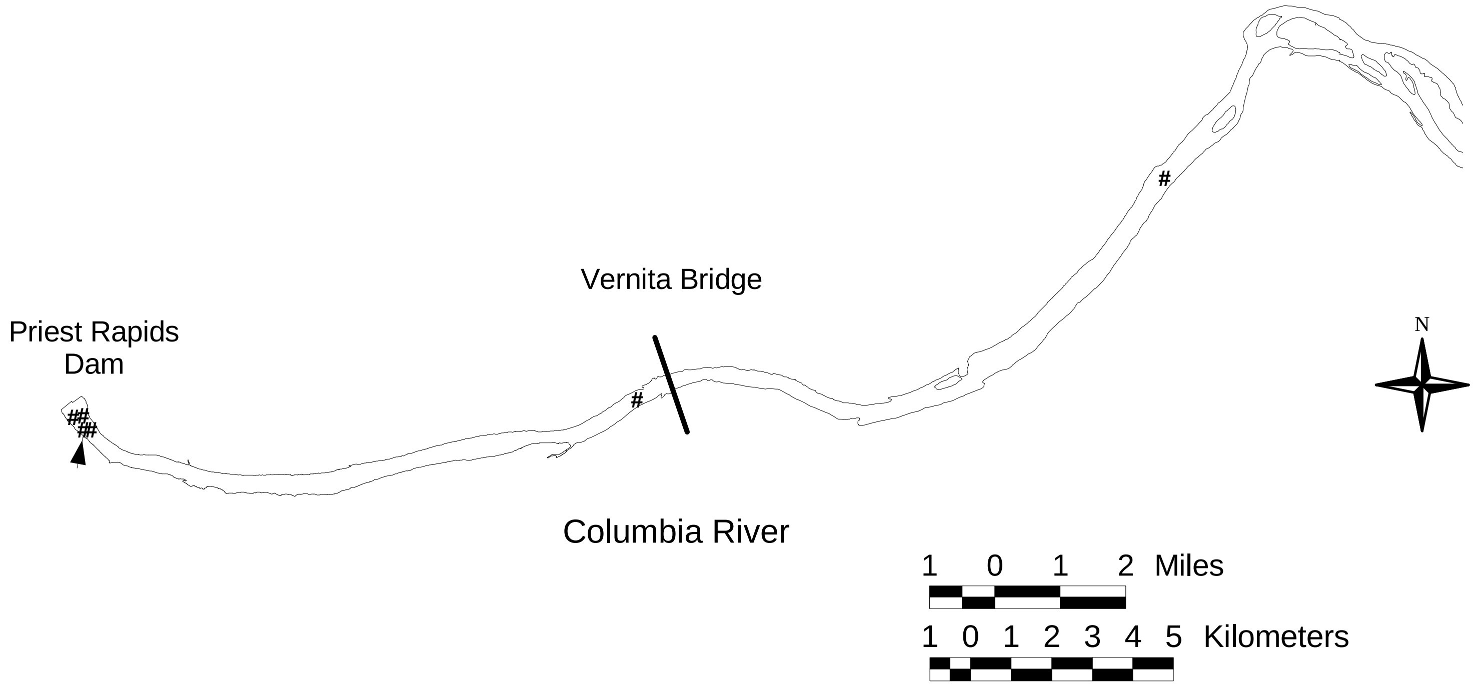

Figure 3. Locations sampled with artificial substrates (circles) and plankton nets (arrow) in the Columbia River during 1995.

increments from left to right while facing upstream. Digits preceding the last number represent river mile (RM) to the nearest 0.1 mile from the mouth of the Columbia or Snake rivers. For example, a site coded as 34753 indicates that the location is near river mile 347.5 and in the third quadrant of the river from the left bank (looking upstream). We also noted the latitude and longitude of sample sites by using a Rockwell[1] PLGR+ Global Positioning System (GPS) receiver using Precise Positioning Service[2], with a specified accuracy of about 10 m horizontally.

To address the task of evaluating the effects of river flow and hydropower operation on the spawning of white sturgeon downstream from The Dalles Dam we examined hourly patterns of discharge from 1988-1994. We found that mean hourly discharges were generally lowest around 0500 hours, increased from 0500 hours to 1300 hours, were relatively constant from 1300 hours to 2100 hours, then decreased until 0500 hours the next day.

We established a sampling program around this pattern. Each weekday was divided into three 8-hr time periods (0500-1300 hours, 1300-2100 hours, and 2100-0500 hours). We randomly chose three days within each week to sample one of these time periods, then randomly selected a fourth time period from the remaining 12 (Appendix C-1). We did not sample during weekends. We sampled with D-shaped plankton nets at two sites where we could expect to collect white sturgeon eggs if they were present because we were interested in the temporal distribution of spawning rather than the spatial distribution of spawning locations. We typically conducted eight efforts with paired nets each sampling period and alternated efforts between the two sites to the extent weather and commercial barge traffic allowed. The National Marine Fisheries Service provided assistance with this work by sampling two of the four time periods weekly from 9 May until 15 June.

Most samples were presorted in the field to separate white sturgeon eggs and larvae from the detritus. All white sturgeon eggs or larvae that were found and samples too large to be sorted in the field were preserved in a solution of 10% formalin. Many of the samples were then transferred to the Washington Department of Fish and Wildlife (WDFW) for processing (see Report B). White sturgeon eggs and larvae were assigned developmental stages based on criteria described by Beer (1981), and dates on which spawning occurred were estimated by back-calculating the time of fertilization from the relationships developed from Wang et al. (1985).

We fished a 6.2-m high-rise shrimp trawl on the bottom to capture juvenile white sturgeon (Palmer et al. 1988; Parsley et al. 1989) to determine if recruitment of white sturgeon to young of year occurred in the McNary and Bonneville pools. We fished this gear twice weekly on consecutive days from 28 August to 7 September at five sites in the McNary Pool. In the Bonneville Pool, we fished the high-rise trawl on 12 consecutive days (excluding weekends) from

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[1] Mention of trade names does not imply endorsement by the National Biological Service.

[2] Precise Positioning Service (PPS) is available to the military and certain Federal civilian agencies. This service differs from the Standard Positioning Service available to civilian users; PPS provides an accurate position (currently about 10 m) without performing differential corrections.

15 September to 3 October. We trawled at 11 sites where young-of-year white sturgeon had been collected during previous years of this study. Logistically, the 11 sites could not be trawled in one day, therefore, six sites upstream from the bridge at Hood River, Oregon, were trawled on one day and the remaining five sites downstream from the bridge on the next day. On any given day, the direction that sampling proceeded (i.e., the furthest upstream site first, then moving downstream, or vice versa) was randomly chosen. Catch per unit effort (CPUE) of white sturgeon was expressed as the number of fish caught per hectare sampled with the high-rise trawl. A Vemco Minilog digital depth recorder was attached to one of the trawl doors to record the depth of the trawl during tows. The depth track from this recorder was compared to the bottom track from the chart recorder on the towing vessel to determine if the trawl doors were following the bottom contours. We measured fork length (FL) and total length (TL) to the nearest mm on all young-of-year and other juvenile white sturgeons and weighed each on a Pesola hanging scale. In general, young-of-year white sturgeons were weighed to the nearest 1 or 5 g, and larger juveniles were weighed to the nearest 10 g.

Habitat descriptors calculated, measured, or obtained were river discharge, water temperature, water depth, and weighted usable spawning habitat. Mean daily discharge records for The Dalles, Priest Rapids, and Ice Harbor dams were obtained for May through July 1995 from the Fish Passage Center. Water temperatures were automatically recorded every two h with Ryan Tempmentor thermographs placed on the river bottom at RMs 190.8 and 290.6 in the Columbia River, and at RM 6.3 in the Snake River. Water temperatures were also measured with a digital thermometer prior to most sampling efforts.

The methods and data described in Parsley and Beckman (1994) were used to model the availability of spawning habitat for white sturgeons downstream from McNary, John Day, The Dalles, and Bonneville dams. In that paper, the authors presented the results of hydraulic simulations of the physical habitat downstream from these dams in response to river discharges. The results from that paper were used with river discharges and water temperatures that occurred during 1995 to create a daily index of spawning habitat for the four areas.

RESULTS

Timing of Spawning in McNary Reservoir

White sturgeon spawned in the Snake River downstream from Ice Harbor Dam and in the Columbia River downstream from Priest Rapids Dam. We collected 201 eggs in the Snake River downstream from Ice Harbor Dam, and 81 eggs in the Columbia River downstream from Priest Rapids Dam with plankton nets and artificial substrates.

Snake River

The 152 viable eggs collected from the Snake River ranged in development from the small-yolk-plug to pre-hatch stages, as described by Beer (1981). Forty-nine (24.4%) of the eggs collected were not viable. Thirty-three of these 49 eggs were collected on one day from one artificial substrate at site 523. All the eggs were collected between 7 June and 19 June. The eggs were collected at three sites (Table 1) where water depths ranged from 3.4 to 5.2 m. These sites were all on the south side of the navigation channel (Figure 2). We had collected eggs in previous years from one site (523), but had not previously sampled at the other sites[3]. We did not sample within the navigation channel this year because the buoys marking the unattended substrates would have been a hindrance to commercial navigation.

We estimated that spawning in the Snake River occurred on at least eight days between 3 June and 17 June by back-calculating spawning dates from the viable eggs collected (Figure 4). Water temperatures in the Snake River first became optimal for white sturgeon spawning (14 - 17 C; Wang et al. 1985) on 25 May, but the temperatures varied considerably during the estimated spawning period. The water temperature rose from 14.7 C on 3 June to 15.5 C on 5 June, then fell to 13.3 C on 14 June (Figure 4). River discharges during this period were variable; the onset of spawning occurred just prior to the peak in the annual hydrograph (Figure 4).

Columbia River

The 72 viable white sturgeon eggs we collected from the Columbia River ranged in development from newly spawned to pre-hatch.. Nine (11 %) of the 81 eggs collected were not viable. All of the eggs were collected between 8 June and 18 July. The eggs were collected at four of the six sites we sampled (Table 1). Water depths where the eggs were collected rangedfrom 2.7 to 5.2 m. We had collected eggs at these sites in previous years. However, we collected no white sturgeon eggs in 1995 at sites near Vernita Bridge (RM 388), Coyote Rapids (RM 381), or White Bluffs (RM 370); we collected eggs in previous years with beam trawls at these sites.

We estimated that spawning in the Columbia River occurred on at least 15 days between 7 June and 15 July by back-calculating spawning dates from the viable eggs collected (Figure 5). Water temperatures in the Columbia River were optimal for white sturgeon spawning (14 - 17 C; Wang et al. 1985) by 9 June, but were variable during the estimated spawning period. Temperatures dropped to less than optimal twice during the estimated spawning period (Figure 5). River discharges also varied considerably during this time period. The peak of the annual hydrograph occurred on 26 June, well after water temperatures became optimal for spawning.

Comparison of Gears used to Detect Spawning

We collected no white sturgeon eggs during six efforts with the plankton nets in the Snake River. However, the artificial substrate fished at the same site collected 133 white sturgeon eggs. From these eggs, we estimated that spawning occurred on six days (Table 2). We

[3]The jet boat we used this year allowed us to sample in areas that were inaccessible to our stern-drive boats used previously.

Table 1. Locations sampled with artificial substrates in the Snake and Columbia rivers and the number of white sturgeon eggs collected. Six 30-min efforts with paired D-shaped plankton nets were also made at site 523 in the Snake River and at site 39651 in the Columbia River. The number of white sturgeon eggs collected with plankton nets are given in parenthesis.

		Number of Eggs Collected		
	Site	Viable	Dead or fungused	% Dead or fungused
Snake River	523[a]	136 (0)	43 (0)	24.0
	612	0	0	0.0
	874	16	5	23.8
	902	0	0	0.0
	914	0	1	100.0
	Total	152 (0)	49 (0)	24.4
Columbia River	38191	0	0	0.0
	38854	0	0	0.0
	39624	1	0	0.0
	39651	18 (3)	5 (0)	21.7
	39672	33	3	8.3
	39673	17	1	5.6
	Total	69 (3)	9 (0)	11.1

[a]Three substrates were fished at this site.

Table 2. The number of white sturgeon eggs collected and the estimated number of days on which spawning by white sturgeon occurred, based on fishing two sampling gears, artificial substrates (McCabe and Beckman 1990) and D-shaped plankton nets, in the same locations. The artificial substrates were fished continuously and checked weekly. Paired D-shaped plankton nets were fished for 30 min weekly immediately downstream from the artificial substrates. Comparisons were made in the Snake River downstream from Ice Harbor Dam (site 523) and in the Columbia River downstream from Priest Rapids Dam (site 39651) during June 1995.

	Snake River		Columbia River	
	Plankton net	Substrate	Plankton net	Substrate
Number of efforts	6	6	7	7
Number of eggs collected	0	133	3	23
Estimated number of days on which spawning occurred	0	6	2	4

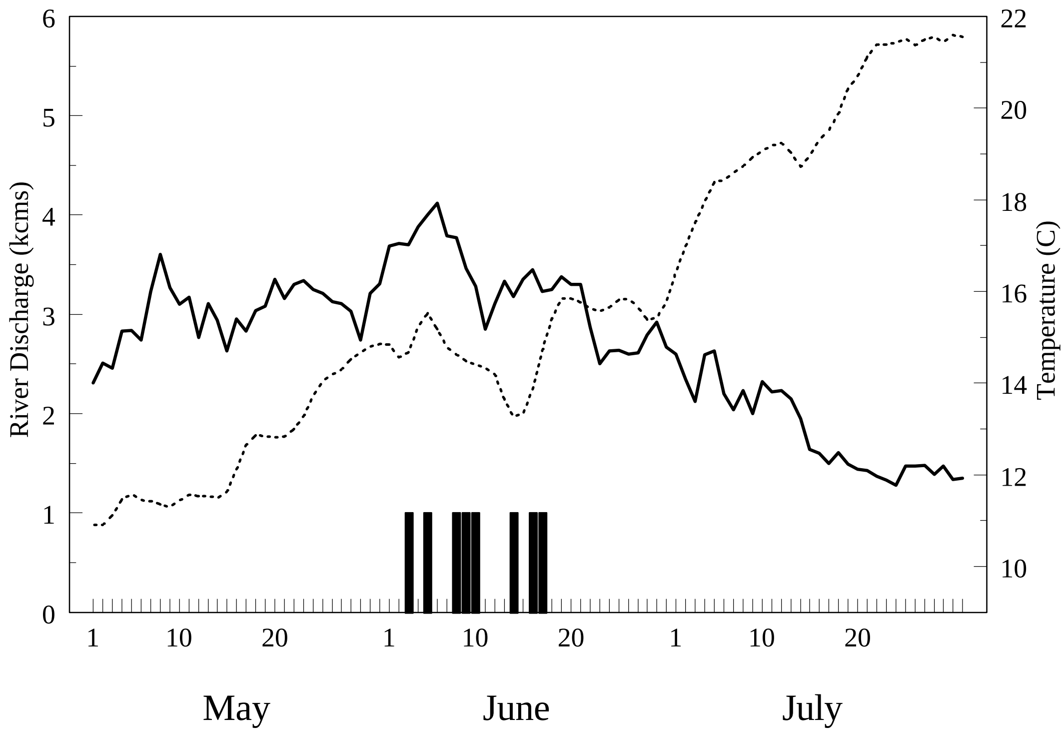

Figure 4. Mean daily discharges (x 1,000; solid line), water temperatures (C; dashed line), and dates on which spawning by white sturgeon occurred (vertical bars) downstream from Ice Harbor Dam during 1995. Sampling began on 17 May and was discontinued on 11 July.

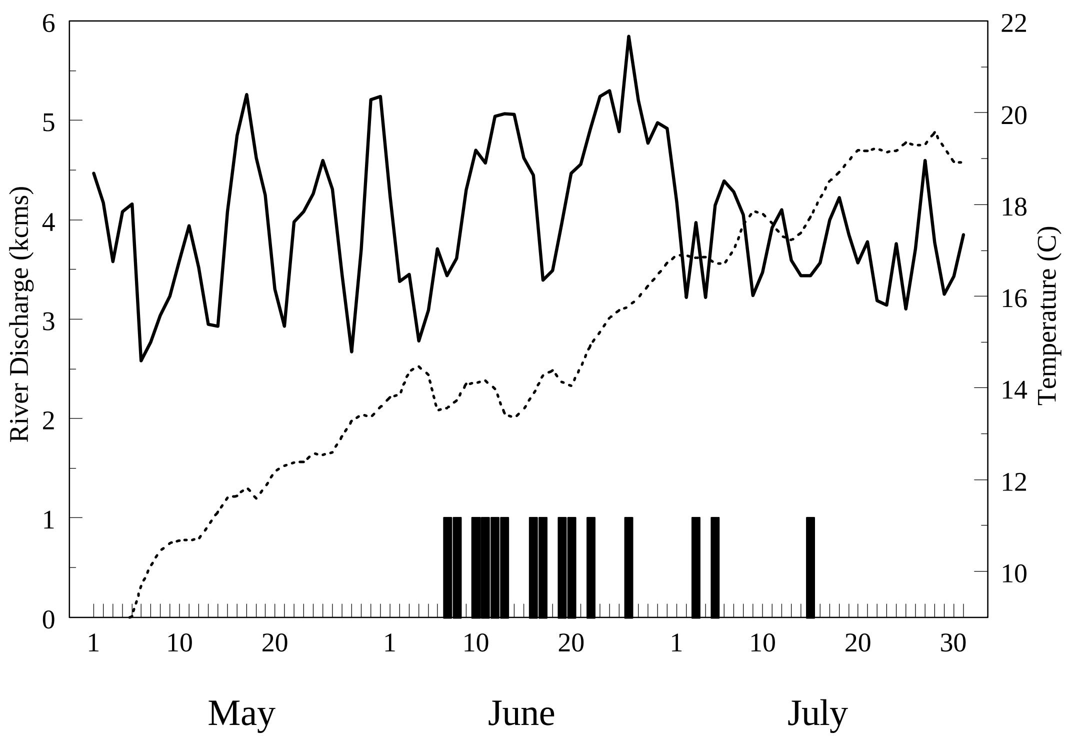

Figure 5. Mean daily discharges (x 1,000; solid line), water temperatures (C; dashed line), and dates on which spawning by white sturgeon occurred (vertical bars) downstream from Priest Rapids Dam during 1995. Sampling began on 2 June and was discontinued on 24 July.

collected three eggs in the plankton nets we fished in the Columbia River, and from these eggs we estimated that spawning occurred on two days. The artificial substrate fished at the same site collected 23 eggs, which we estimated were spawned on four days (Table 2).

Effects of Hydropower Operations on Spawning in The Dalles Dam Tailrace

The sampling in The Dalles Dam tailrace yielded 235 white sturgeon eggs, ranging in stage from newly-spawned to pre-hatch, and 258 white sturgeon larvae (Table 3). Twenty three (10%) of these eggs were newly-spawned and 75 (32%) were not viable. By back-calculating the date of spawning from each viable egg, we estimated that spawning began on 23 May and lasted until 6 July. Spawning was estimated to have occurred on 35 of the 45 days during this period (Figure 6). Catch per effort of white sturgeon eggs and larvae was greatest during efforts conducted in the morning time period (0500 hours to 1300 hours; Table 4).

Water temperatures downstream from The Dalles Dam during the estimated spawning period ranged from 14.2 to 18.6 C. However, temperatures were variable during this time, rising to 16.2 C on 2 June, falling to 14.7 C on 20 June, then again rising to 18.1 C on 30 June (Figure 6). River discharges also varied somewhat during the estimated spawning period, and ranged from a high of 8,370 m^3/s to a low of 5,989 m^3/s (Figure 6). There was no discernable peak to the annual hydrograph as has been evident in previous years. Characteristics of the river discharge that occurred through The Dalles Dam during the 21 time periods we sampled are shown in Appendix C-2.

Juvenile Sampling

All scheduled trawling was completed. Bottom tracks from the digital depth recorder attached to a trawl door and the analog chart recorder mounted on the trawling vessel generally showed agreement, indicating that the trawl doors followed the bottom contours. The two bottom tracks differed only in areas with steep relief (4-5 m) occurring over short distances. We believe these areas are characterized by large sand dunes. Here, the trawl doors remained in contact with the bottom along the sides and crest of the individual dunes, but appeared to ride above the bottom in the troughs of the dunes. This type of habitat was only encountered at one sampling site in the Bonneville Pool.

McNary Pool

There was evidence of recruitment of white sturgeons to young of year in the McNary Pool. The trawling efforts at the five sites in the McNary Pool yielded six young-of-year white sturgeons. No yearling or older juvenile white sturgeons were captured with the high-rise bottom trawl. The six young of year were collected from three sites (Table 5), and ranged in length from 93 to 200 mm TL and weighed 5 to 44 g.

Bonneville Pool

Table 3. Egg developmental stage (Beer 1981) and number of white sturgeon eggs and larvae collected with D-shaped plankton nets in The Dalles Dam tailrace from 9 May to 11 July 1995.

Eggs		Larvae	
Stage	Number	Stage	Number
Unidentifiable	1	Unidentifiable	12
Fertilized egg	23	Post-hatch	70
First cleavage	1	1-day post-hatch	128
Second cleavage	5	2-day post-hatch	15
Third cleavage	4	3-day post-hatch	22
Fourth through sixth cleavage	9	Post-larvae	11
Late cleavage	8		
Early epithelial	13		
Late epithelial	8		
Involution	4		
Large yolk plug	8		
Small yolk plug	4		
Early neurulation	16		
Closure of the neural tube	10		
Elongation of the pronephros	9		
Formation of the heart	20		
Pre-hatch	15		
Hatch in progress	2		
Non-viable/dead	75		
Totals	235		258

Table 4. Numbers of white sturgeon eggs and larvae and catches per 500 m^3 of water sampled downstream from The Dalles Dam during three time periods. Sampling was conducted from 9 May through 11 July 1995.

	Time period sampled						
	0500h - 1300h		1300h - 2100h		2100h - 0500h		
	n	Catch/500m^3	n	Catch/500m^3	n	Catch/500m^3	Totals
Newly-spawned eggs	19	0.015	2	0.009	2	0.005	23
All egg stages	156	0.580	44	0.210	35	0.200	235
Larvae	158	0.590	71	0.330	29	0.170	258

Table 5. Effort expended and catch of white sturgeons with a high-rise trawl at five sites in the McNary Pool between 28 August and 7 September 1995. No juvenile white sturgeons older than young of year were captured.

Site	Time trawled (min)	Area sampled (ha)	Number of Young of year collected	Catch/ha sampled
30712	40	1.04	0	0.00
30934	40	0.95	1	1.05
31193	45	1.21	4	3.31
31254	40	0.95	0	0.00
31432	40	0.96	1	1.04
Totals	205	5.11	6	1.17

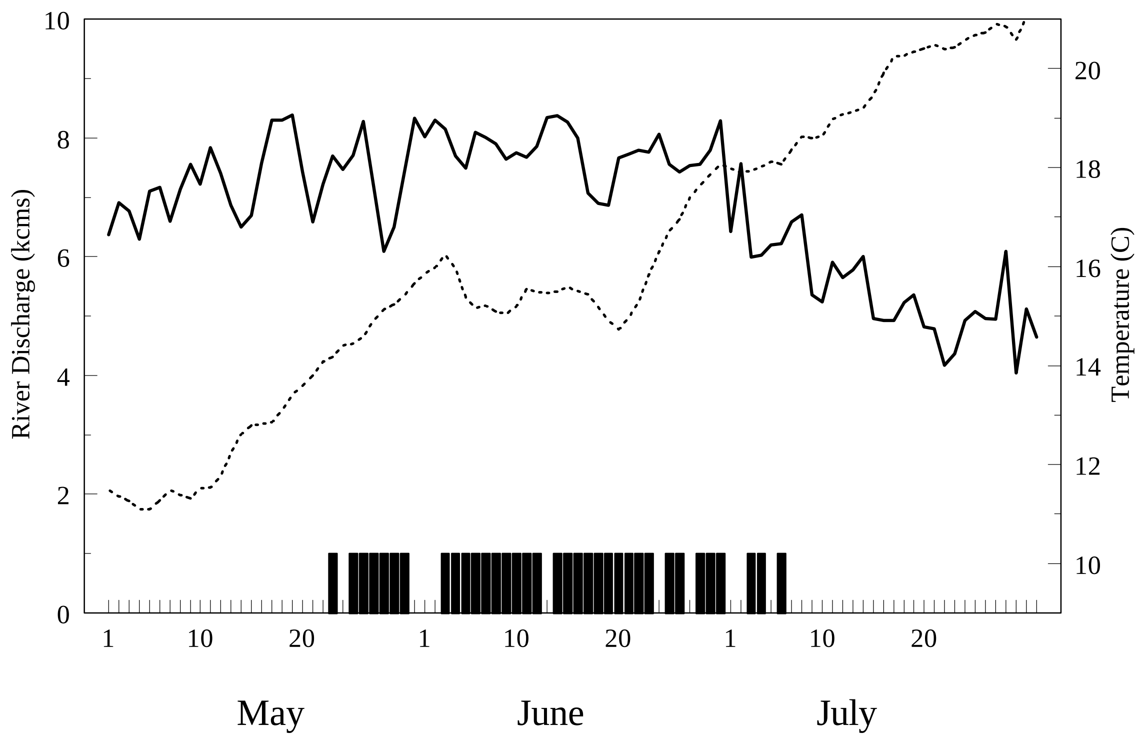

Figure 6. Mean daily discharges (x 1,000; solid line), water temperatures (C; dashed line), and dates on which spawning by white sturgeon occurred (vertical bars) downstream from The Dalles Dam during 1995. Sampling began on 9 May and was discontinued on 13 July.

Recruitment to young of year occurred in the Bonneville Pool in 1995. We captured 122 juvenile white sturgeon with the high-rise trawl during our sampling in the Bonneville Pool, 72 of these fish were young of year. Young-of-year and older white sturgeons were captured at all eleven sites (Table 6). The young of year ranged in length from 119 to 258 mm FL and weighed 7 to 113 g. The older juvenile white sturgeons captured were 326 to 895 mm FL and weighed 257 to 4,700 g.

Densities of white sturgeon estimated from catches with the bottom trawl varied from 0.71 to 12.5 young of year per hectare sampled at the eleven sites and densities for all juveniles ranged from 1.34 to 24.3 fish per hectare sampled (Table 6). The density for all sites combined was 4.58 young of year per hectare sampled and 7.75 fish per hectare sampled for all juvenile white sturgeon.

Catch of Other Fish Species

The pooled data for all sites in Bonneville Pool showed that prickly sculpins were most abundant in our catches, followed by sandrollers, peamouths, American shad, and redside shiners (Table 7). In the McNary Pool, prickly sculpins were most abundant in our pooled catches, followed by channel catfish, sandrollers, and largescale suckers. As during 1994, no redside shiners were captured in McNary Pool, but they were abundant in the Bonneville Pool; and no common carp were captured in the Bonneville Pool, but they were abundant in McNary Pool.

Availability of Spawning Habitat

Phase 1 Study Area

Monthly estimates of the index of white sturgeon spawning habitat (temperature conditioned weighted usable area) for 1995 were generally above the 11-year average for each spawning area (Figure 7, Appendix C-3). The Bonneville Dam tailrace was the exception, with a lower than average index of spawning habitat for June 1995. The availability of spawning habitat was greatest during May downstream from Bonneville Dam, but was greatest during June downstream from The Dalles, John Day, and McNary dams. The annual mean composite index of spawning habitat for 1995 (Figure 8) was within one standard deviation of the average for the Bonneville Dam tailrace, but the index for 1995 was outside of one standard deviation of the average annual mean composite index for The Dalles, John Day, and the McNary dam spawning areas (Figure 8, Appendix C-3).

McNary Pool

We determined the substrate composition at 144 locations within the McNary Pool. These data will be used to create a map of the substrates present within this area for input into a geographic information system (GIS). Bathymetry of the impounded portion of this pool was entered into a GIS during 1994.

Table 6. Effort expended and catch of white sturgeons with a high-rise trawl at 11 sites in the Bonneville Pool between 15 September and 3 October 1995.

Site	Time trawled (min)	Area sampled (ha)	Number of white sturgeon captured		Catch/ha sampled	
			All ages	Young of year	All ages	Young of year
15052 15734	60	1.41 1.4912	5	1	3.55	0.71
15734	60	1.49	2	2	1.34	1.34
15951	60	1.49	8	6	5.37	4.02
16522	60	1.20	2	1	1.67	0.83
16851	60	1.48	7	6	4.73	4.04
17063	60	1.56	15	13	9.62	8.31
17374	60	1.48	21	12	14.19	8.14
17652	60	1.38	8	5	5.80	3.63
17911	60	1.45	12	4	8.28	2.76
18351	60	1.36	33	17	24.26	12.50
18523	60	1.44	9	5	6.25	3.40
Totals	660	15.74	122	72	7.75	4.58

Table 7. Number and catch per hectare (CPHA) of fishes other than white sturgeon captured with the high-rise bottom trawl from 28 August through 3 October 1995 at trawling sites in Bonneville and McNary pools.

		Bonneville Pool		McNary Pool	
Species		No.	CPHA	No.	CPHA
American shad	*Alosa sapidissima*	125	7.9	9	1.8
Common carp	*Cyprinus carpio*	0	0	66	12.9
Redside shiner	*Richardsonius balteatus*	78	5.0	0	0
Peamouth	*Mylocheilus caurinus*	146	9.3	23	4.5
Largescale sucker	*Catostomus macrocheilus*	21	1.3	109	21.4
Bridgelip sucker	*Catostomus columbianus*	1	0.1	2	0.4
Channel catfish	*Ictalurus punctatus*	2	0.1	188	36.9
Sandroller	*Percopsis transmontana*	242	15.4	145	28.4
Threespine stickleback	*Gasterosteus aculeatus*	1	0.1	0	0
Walleye	*Stizostedion vitreum*	1	0.1	0	0
Yellow perch	*Perca flavescens*	0	0	8	1.6
Prickly sculpin	*Cottus asper*	441	28.0	484	94.9
Unidentified		0	0	1	0.2

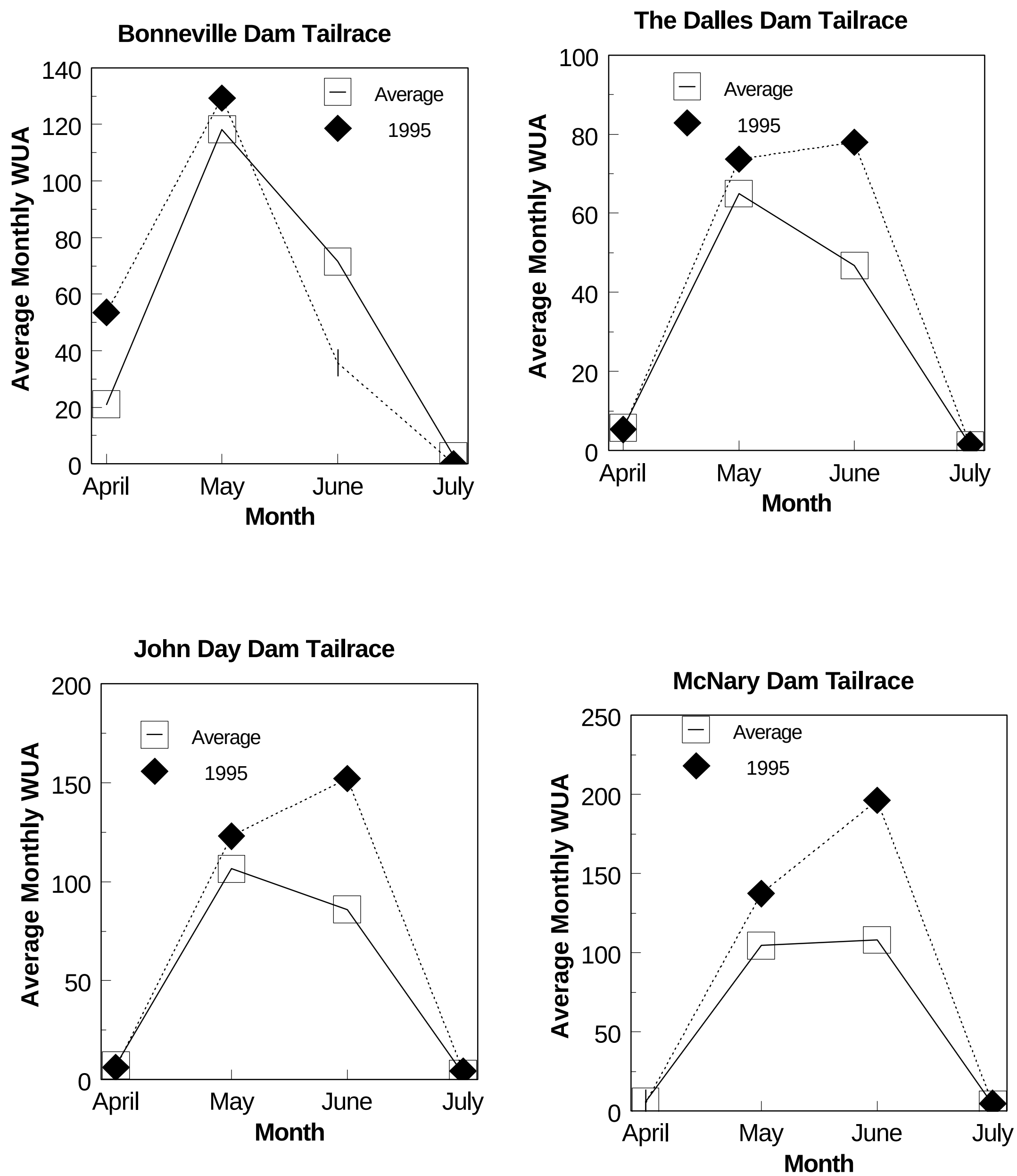

Figure 7. Mean monthly indices of spawning habitat (temperature weighted usable area (WUA)) for white sturgeon during 1995 and the average since 1985 for the four spawning areas that have been modeled.

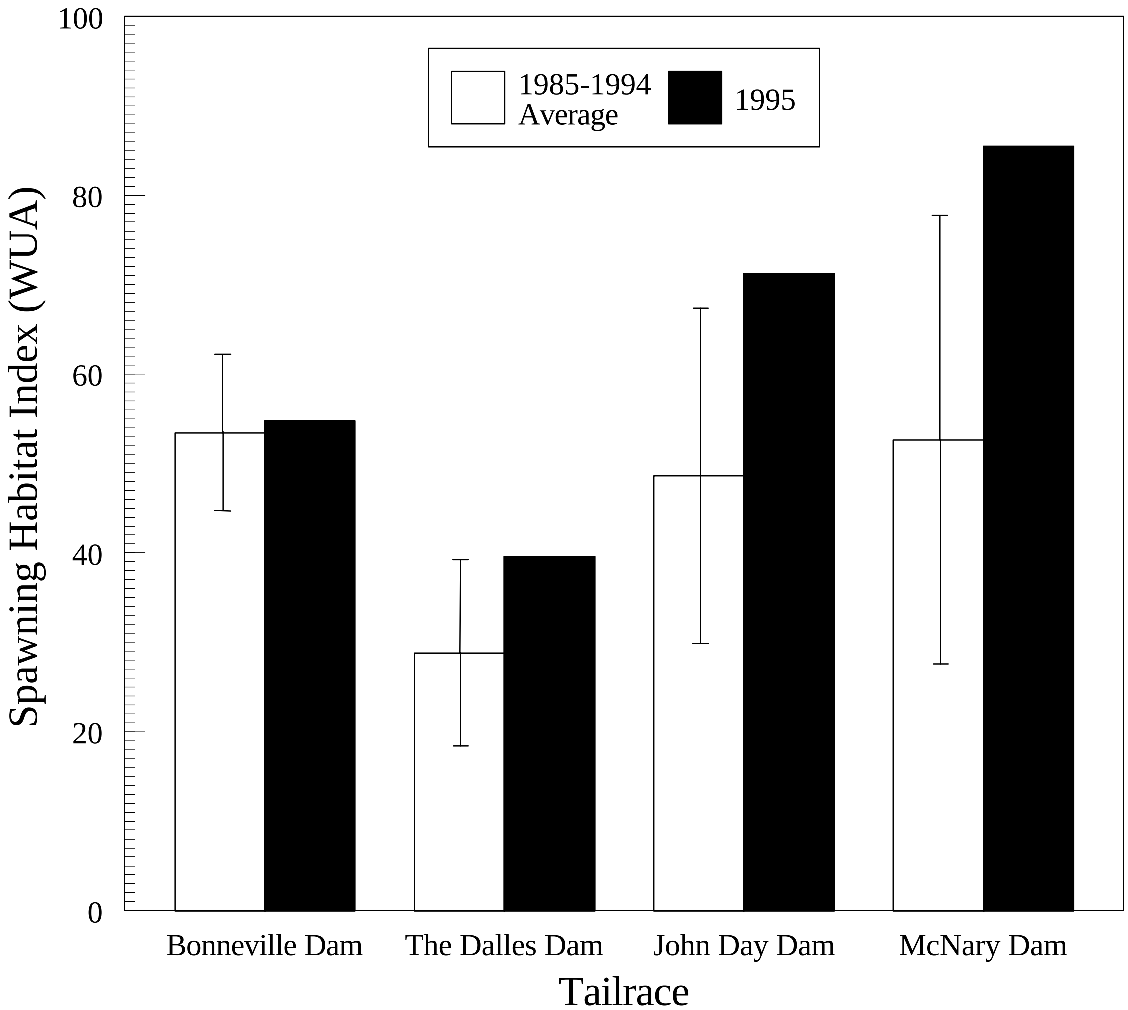

Figure 8. Annual mean composite index of spawning habitat (temperature conditioned weighted usable area; WUA) for white sturgeon for each of the four river tailraces that have been modeled (Parsley and Beckman 1994). Shown are the indices for 1995 and the average for 1985 through 1994. The vertical lines within the bars for the averages depict one standard deviation.

We continued to assist the USFWS in its efforts to quantify spawning habitat in the free-flowing reach of the Columbia River downstream from McNary Dam and in the Snake River downstream from Ice Harbor Dam. We provided personnel, boats, and survey equipment during field efforts. See Report E (USFWS) within this volume for further information.

DISCUSSION

Sampling for eggs enabled us to estimate the timing and duration of spawning by white sturgeons in the McNary Pool study area. Environmental conditions during 1995 appeared to be favorable for spawning fish in both the Snake and Columbia rivers. In the Snake River, discharges were higher during the spawning period in 1995 than in 1994 (Parsley et al. 1996), and water temperatures were favorable for an extended period. Mean daily river discharges in the Columbia River fluctuated widely during 1995. The peak mean daily discharge during the spawning period in 1995 exceeded the peak that occurred during 1994. River discharges during July 1995 were higher than those during July of 1993 and 1994.

The artificial substrates were superior in several ways to the paired plankton nets used in previous years to collect white sturgeon eggs. The substrates were easily deployed and retrieved, and provided a method of unattended continuous sampling. This continuous sampling resulted in greater collections of eggs than the sampling done with paired plankton nets, which enabled better estimates of the timing and duration of spawning. The substrates were safely fished in high water velocities that may have precluded sampling with the plankton nets. However, the substrates do not generally collect white sturgeon larvae as the plankton nets do, and we did not sample with artificial substrates in commercial navigation channels because the marker floats would have obstructed navigation.

The preliminary analyses of the data collected downstream from The Dalles Dam indicate that there is a relation between dam operations and catches of white sturgeon eggs and larvae. However, the analyses of the relations of short-term dam operations to white sturgeon spawning activity may be hindered by the inability to accurately determine the time of spawning from advanced stages of eggs. Because of the uncertainty in the results of Wang et al. (1985) we will limit our analyses to using only newly spawned eggs. This results in a substantial reduction in the number of eggs that we can use in our analysis. There is also evidence that the numbers of newly spawned eggs collected during a time period may not be indicative of the magnitude of spawning by white sturgeons. Catches of all egg stages and larvae were highest during the morning time period (0500-1300 hours), indicating that hydraulic conditions may have scoured eggs and larvae from the substrate during this time period. Catches of advanced eggs from the drift should have been similar among time periods if scouring was not occurring.

The bottom trawling for juvenile white sturgeons revealed that recruitment to young of year occurred in the McNary and Bonneville pools. In the McNary Pool, we captured no white sturgeons older than young of year. We have not captured a white sturgeon older than young of year from this pool with the bottom trawl since we began our efforts in 1993. In the Bonneville

Pool, the majority (59%) of the white sturgeons captured were young of year. Results from trawling in 1994 in August and September (Parsley et al. 1996) led us to believe that the selectivity of the trawl used would be improved and thus our efforts would more represent the relative year-class strength if the work was done later in the year when more of the young of year were large enough to be vulnerable to the gear. The sampling in 1995 occurred in the latter part of September and young of year were captured on the first day of efforts. Analyses are underway to estimate the number of efforts needed to provide a reliable index of trends in young of year abundance in this pool.

The indices of spawning habitat indicated that environmental conditions were favorable for spawning during 1995 when compared to the average of the yearly indices (Figure 8). Estimates of an index of spawning habitat have been calculated for each year since 1985. The averages should not be construed as indicative of a longer time period. The index for each area provides information on the effects of hydropower operations on the habitat for white sturgeons because it incorporates backwater effects caused by the dams and changes to the river hydrograph and water temperatures caused by the storage and release of water in upriver impoundments. Analyses are underway to determine if these indices of spawning habitat are correlated with recruitment to young of year. However, other factors such as brood stock abundance, periodicity of spawning, and environmental conditions prior to vitellogenesis and after hatch may also affect recruitment.

Plans for 1996

The National Biological Service will initiate two new studies during 1996. We will begin a study that will use sonic telemetry to investigate the movements and habitat use of white sturgeons in the McNary Pool, and we will conduct laboratory experiments to describe the effects of gas supersaturation on post-hatch white sturgeon larvae.

We will describe the habitat used by spawning and rearing white sturgeon by conducting an analysis of water depth, velocity, and substrate at sites where white sturgeons are located through telemetry studies. Criteria will be stratified by winter, spring, and summer time periods. Habitat suitability criteria curves will be developed by using non-parametric tolerance limits applied to measurements of water column depth measured with a recording fathometer, water column velocities measured with mechanical meters or an acoustic Doppler current profiler, and substrates determined with either an underwater video camera or with a dredge.

The studies of habitat use will be used to estimate the availability of habitat within the McNary Pool. We will provide assistance to the USFWS's Columbia River Fisheries Program Office to estimate spawning and rearing habitat in the free-flowing Columbia River downstream from Priest Rapids Dam and in the Snake River downstream from Ice Harbor Dam. We will quantify habitat available for rearing within the impounded waters upstream from McNary Dam through cartographic modeling with a geographic information system.

Spilling at the dams creates gas-supersaturated water within areas used by spawning white sturgeon. Private aquaculturists have acknowledged problems with rearing larval white sturgeon in supersaturated water, but there are no published studies on the physiological or behavioral consequences of prolonged exposure of white sturgeon larvae to supersaturated conditions. Laboratory studies will provide vital information on the effects of supersaturated water resulting from hydropower operations on recruitment of white sturgeons. This work will provide a description of the physiological and behavioral consequences to larval sturgeons exposed to supersaturated conditions, and should provide managers with information to address questions on the effects of increased gas levels caused by spilling water at some dams on recruitment of white sturgeons.

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APPENDIX C-1

Schedule of sampling that occurred in The Dalles Dam tailrace during 1995. Sampling was done by the National Marine Fisheries Service (NMFS) and the National Biological Service (NBS).

Date	Time Period Sampled (hrs)	Agency that performed the sampling
9 May	1300-2100	NMFS
10 May	0500-1300	NBS
10/11 May	2100-0500	NMFS
11 May	1300-2100	NBS
15/16 May	2100-0500	NBS
16/17 May	2100-0500	NMFS
17 May	1300-2100	NBS
18 May	0500-1300	NMFS
22 May	0500-1300	NBS
23 May	1300-2100	NMFS
23/24 May	2100-0500	NMFS
24 May	0500-1300	NBS
30 May	0500-1300	NMFS
30/31 May	2100-0500	NBS
31 May	1300-2100	NMFS
1 June	1300-2100	NBS
6/7 June	2100-0500	NBS
6 June	0500-1300	NMFS
7 June	1300-2100	NMFS
8 June	0500-1300	NBS
13/14 June	2100-0500	NMFS
14 June	1300-2100	NBS

Appendix C-1 Continued.

Date	Time Period Sampled (hrs)	Agency that performed the sampling
15 June	0500-1300	NMFS
16 June	0500-1300	NBS
20 June	0500-1300	NBS
21 June	1300-2100	NBS
22/23 June	2100-0500	NBS
23 June	0500-1300	NBS
27 June	1300-2100	NBS
28/29 June	2100-0500	NBS
29 June	0500-1300	NBS
30 June	0500-1300	NBS
5/6 July	2100-0500	NBS
6 July	1300-2100	NBS
7 July	0500-1300	NBS
10 July	0500-1300	NBS
11 July	0500-1300	NBS

APPENDIX C-2

Mean hourly discharge (m^3/s x 1,000), coefficient of variation (CV) of discharge, spill (m^3/s x 1,000), and CV of spill for sampling efforts conducted below The Dalles Dam from 22 May 1995 to 7 July 1995.

Time period sampled	Date	Mean discharge (m^3/s x 1,000)	CV discharge	Spill (m^3/s x 1,000)	CV Spill
0500 h - 1300 h	22 May	7.190	4.73	4.441	2.73
	24 May	8.418	3.08	4.530	0
	30 May	7.330	17.4	4.228	10.7
	6 June	8.249	5.61	4.483	3.16
	8 June	7.871	6.56	4.729	7.34
	15 June	8.232	1.89	5.209	0
	16 June	8.131	2.88	2.885	4.00
	20 June	7.814	5.19	4.992	3.94
	23 June	7.840	2.86	4.990	2.00
	29 June	7.815	5.85	4.967	4.96
	30 June	8.305	1.95	5.208	1.74
	7 July	6.607	1.80	4.156	0.30
1300 h - 2100 h	23 May	8.119	2.96	4.530	0
	31 May	8.438	2.75	4.530	0
	1 June	8.030	1.96	4.480	0
	7 June	8.218	3.48	5.096	0
	14 June	8.250	3.18	5.294	2.12
	21 June	7.694	0.87	4.898	0
	27 June	7.466	2.03	4.775	1.19
	6 July	6.401	1.62	4.121	1.14

Appendix C-2 continued.

Time period sampled	Date	Mean discharge (m^3/s x 1,000)	CV discharge	Spill (m^3/s x 1,000)	CV Spill
2100 h - 0500 h	23/24 May	5.789	15.3	3.646	15.7
	30/31 May	7.911	4.8	4.530	0
	6/7 June	7.717	11.7	4.725	8.06
	13/14 June	8.117	0.57	5.238	0
	22/23 June	7.647	5.06	4.851	4.70
	28/29 June	7.261	1.99	4.637	1.29
	5/6 July	5.843	13.1	3.743	12.8

APPENDIX C-3

Monthly and annual indices of white sturgeon spawning habitat. The indices are temperature conditioned weighted usable areas (hectares) and were derived following the methodology used by Parsley and Beckman (1994).

Bonneville Dam Tailrace

Month	Year										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
April	10.35	5.77	17.19	14.42	30.64	22.76	7.02	29.17	9.03	32.33	53.55
May	105.83	77.42	140.80	113.42	149.39	99.85	83.87	128.05	143.04	129.67	129.31
June	65.09	51.40	48.36	74.90	46.23	138.61	156.17	19.82	97.70	53.24	35.74
July	0.12	0.34	0.00	2.28	1.09	9.04	3.77	0.00	11.41	3.20	0.00
Sum	181.39	134.93	206.35	205.02	227.35	270.26	250.83	177.04	261.18	218.44	218.60
Annual mean	45.47	33.82	51.90	51.36	57.14	67.35	62.40	44.58	65.49	54.81	54.81
Standard deviation	57.92	47.73	62.07	56.39	63.63	64.39	69.69	52.61	69.55	53.61	58.50
Coef. var	1.27	1.41	1.20	1.10	1.11	0.96	1.12	1.18	1.06	0.98	1.07

APPENDIX C-3 continued.

The Dalles Dam Tailrace

Month	Year										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
April	6.70	4.97	4.32	2.06	11.98	10.89	1.85	7.07	1.65	6.77	5.35
May	54.77	58.36	72.81	42.60	89.10	46.63	61.90	51.49	109.77	53.49	73.66
June	22.76	30.94	17.18	26.49	26.83	112.71	107.84	6.13	55.80	30.20	77.98
July	0.05	0.14	0.01	0.11	0.28	4.48	5.92	0.00	2.45	0.48	1.52
Sum	84.28	94.41	94.32	71.26	128.19	174.71	177.51	64.69	169.67	90.94	158.51
Annual mean	21.17	23.69	23.79	17.87	32.25	43.38	44.20	16.33	42.64	22.81	39.59
Standard deviation	27.74	37.45	34.19	24.32	40.24	52.24	51.39	22.64	58.23	24.23	44.11
Coef. var	1.31	1.58	1.44	1.36	1.25	1.20	1.16	1.39	1.37	1.06	1.11

APPENDIX C-3 continued.

John Day Dam Tailrace

Month	Year										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
April	9.25	1.44	4.63	1.16	14.43	16.38	3.14	8.81	1.84	11.35	6.09
May	93.29	75.43	118.25	65.26	127.92	76.66	108.81	88.28	195.73	99.08	123.00
June	41.60	79.12	28.75	41.10	50.63	200.49	188.32	10.79	96.93	55.55	152.23
July	0.20	1.40	0.17	0.24	0.15	9.16	11.98	0.00	3.53	0.64	4.25
Sum	144.34	157.39	151.80	107.76	193.13	302.69	312.25	107.88	298.03	166.62	285.57
Annual mean	36.26	39.33	38.30	27.04	48.54	75.13	77.77	27.25	74.92	41.79	71.27
Standard deviation	49.57	66.44	57.77	41.28	61.80	92.72	90.21	39.10	104.12	45.36	80.21
Coef. var	1.37	1.69	1.51	1.53	1.27	1.23	1.16	1.43	1.39	1.09	1.13

APPENDIX C-3 continued.

McNary Dam Tailrace

Month	Year										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
April	12.70	3.36	3.57	0.91	9.99	11.26	2.07	6.23	1.48	8.22	4.83
May	92.46	99.49	102.39	43.73	114.66	81.20	105.19	81.37	205.26	86.00	137.37
June	56.47	138.72	27.46	25.00	59.62	247.90	228.91	16.47	124.67	67.54	196.16
July	0.06	0.17	0.00	0.00	0.05	15.73	20.77	0.00	4.87	0.72	4.67
Sum	161.69	241.74	133.42	69.64	184.32	356.09	356.94	104.07	336.28	162.48	343.03
Annual mean	40.52	60.26	33.65	17.48	46.27	88.36	88.80	26.26	84.42	40.67	85.52
Standard deviation	54.48	103.89	55.68	29.85	59.60	115.08	104.21	38.94	117.56	45.51	101.22
Coef. var	1.34	1.72	1.65	1.71	1.29	1.30	1.17	1.48	1.39	1.12	1.18

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report D

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,

Evaluate white sturgeon spawning and recruitment downstream from McNary Dam under recommended flows and project operations

and

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

This report includes: Investigations on juvenile and young-of-year white sturgeon downstream from The Dalles and Bonneville dams

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July 1997

CONTENTS

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ABSTRACT

During 1995, the National Marine Fisheries Service (NMFS) sampled juvenile white sturgeon (*Acipenser transmontanus*) in the Columbia River downstream from Bonneville Dam (River Mile (RM) 145). In September 1995, 310 juvenile white sturgeon were collected with a 7.9-m (headrope length) semiballoon shrimp trawl between RM 28 and 132. Distribution of juvenile white sturgeon was patchy; catches differed among areas of the river and between parallel transects within the same area. We collected 111 young-of-the-year (YOY) white sturgeon between RM 28 and 132; YOY comprised about 38% of the total catch of juvenile white sturgeon that was measured. Densities of YOY white sturgeon at 13 index sampling stations averaged 14.6 fish/hectare during the first survey (1-8 September) and 11.0 fish/hectare during the second survey (18-21 September); the mean for both surveys combined was 12.8 fish/hectare.

The NMFS assisted both the National Biological Service (NBS) and the Oregon Department of Fish and Wildlife (ODFW) in collecting white sturgeon in 1995. During May-June, NMFS assisted NBS in sampling for white sturgeon eggs and larvae with plankton nets in the Columbia River downstream from The Dalles Dam (RM 192). In late October and early November, NMFS collected juvenile white sturgeon with a 7.9-m semiballoon shrimp trawl in the vicinity of RM 131-132 for ODFW. The ODFW is evaluating transplanting juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam into The Dalles Reservoir.

INTRODUCTION

Under an agreement with the Oregon Department of Fish and Wildlife (ODFW), the National Marine Fisheries Service (NMFS) was responsible for segments of three objectives of the White Sturgeon Study in 1995. The first objective was 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 second objective was to evaluate white sturgeon spawning and recruitment downstream from McNary Dam under recommended flows and project operations. The ODFW and the National Biological Service (NBS) had the primary responsibilities for the first and second objectives, respectively. The third objective was to describe reproductive and early life history characteristics of white sturgeon in McNary Reservoir and downstream from Bonneville Dam. The NMFS research for the third objective was 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 is being 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 hydroelectric system on white sturgeon spawning and recruitment in the impoundments upstream from Bonneville Dam.

Specific research goals for 1995 were 1) to collect juvenile white sturgeon in selected areas of the Columbia River downstream from Bonneville Dam for an ODFW evaluation 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; 2) to assist NBS in sampling for white sturgeon eggs and larvae with plankton nets in the Columbia River downstream from The Dalles Dam; and 3) to estimate the success of young-of-the-year (YOY) white sturgeon recruitment in 1995 in the Columbia River downstream from Bonneville Dam. This report describes progress on NMFS studies from March 1995 to March 1996.

METHODS

Egg and Larval Sampling

From 9 May through 15 June 1995, NMFS assisted NBS in sampling for white sturgeon eggs and larvae at two sampling stations in the Columbia River downstream from The Dalles Dam. A D-ring plankton net was used to collect white sturgeon eggs and larvae. The 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); the open area of the net was about 0.3 m^2. Depending upon the water velocity, two 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 30 min from an anchored 12.2-m research vessel.

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

White sturgeon eggs and larvae were fixed in an approximately 4% buffered formaldehyde solution and transferred to NBS for processing (see Report C for further details and results of the NBS study).

Juvenile Sampling

A 7.9-m (headrope length) semiballoon shrimp trawl, identical to that used from 1987 through 1994, 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 to 7 min in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable were deployed, and the effort was considered ended when 5 to 7 min had 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. The sampling stations were originally selected primarily to determine habitat use by juvenile white sturgeon; no attempt was made to randomly select the stations. In 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 river sections where only two transects were established, Transect 3 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 shrimp trawls were identified and counted. White sturgeon from each sampling effort were generally measured (total and fork lengths (mm)) and weighed (g). Small YOY sturgeon do not have a distinct fork in their tails; therefore I 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), I 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. I routinely examined juvenile white sturgeon longer than 174 mm fork length for the nematode parasite *Cystoopsis acipenseri* (Chitwood and McIntosh 1950; McCabe 1993). When present, the parasite is encased in blister-like cysts under the skin.

From 23 October to 9 November, NMFS collected juvenile white sturgeon between RM 131 and 132 for ODFW with the 7.9-m shrimp trawl described above. The ODFW is evaluating transplanting juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam into The Dalles Reservoir (see Report A for further details and results of the ODFW study).

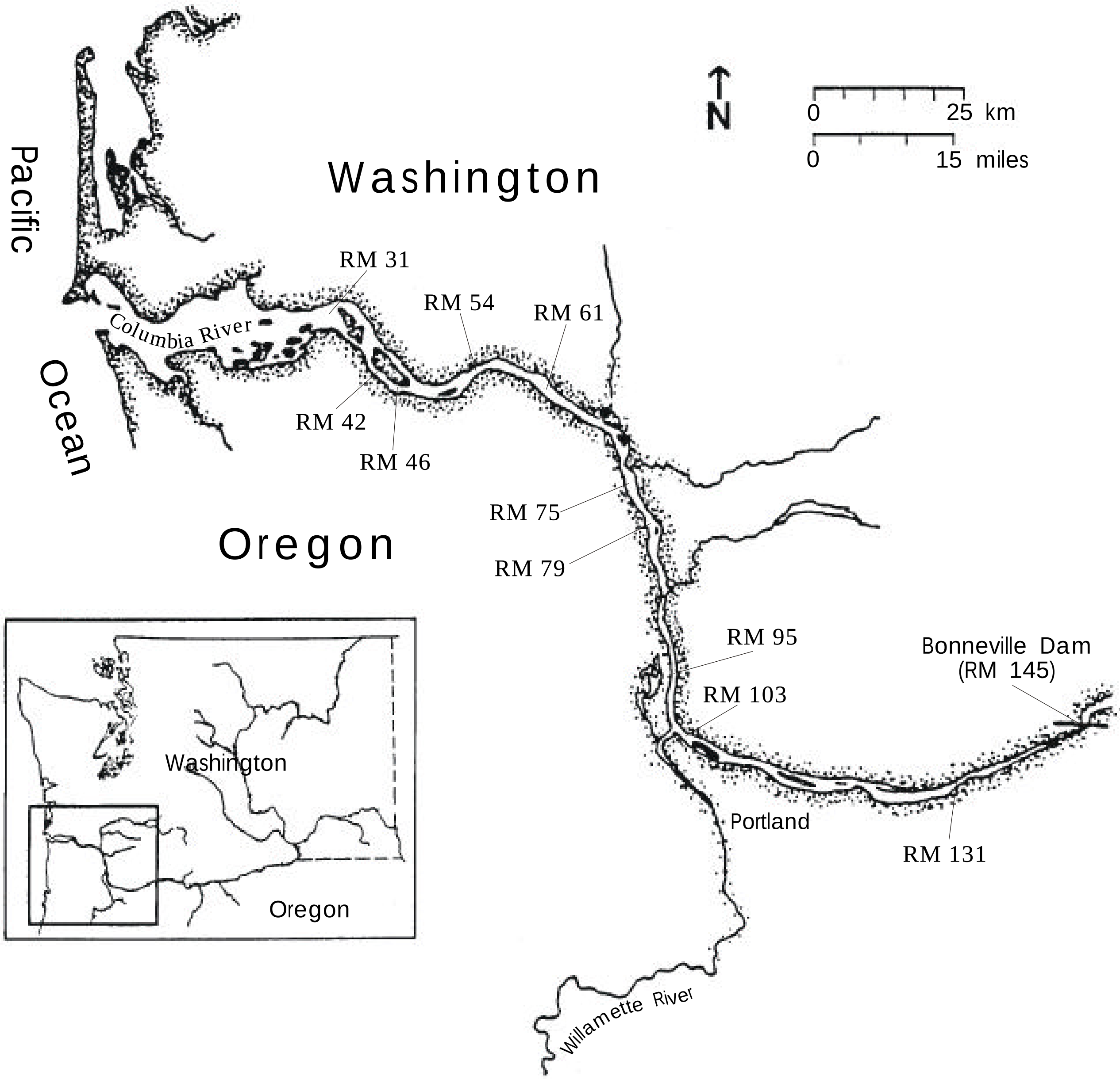

Figure 1. Location of the white sturgeon study area in the Columbia River downstream from Bonneville Dam. The specific locations of the thirteen index trawling stations are shown; at RMs 79, 95, and 131 two stations were sampled. No sampling was done at RM 145.

Physical Conditions

The following physical parameters were measured in conjunction with juvenile sturgeon sampling in September 1995: bottom depth (m) (minimum and maximum), bottom-water temperature (°C), and bottom-water turbidity (NTU). Depth was measured with an electronic depth sounder. 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. All physical and accompanying fish catch data are available upon request from NMFS, Northwest Fisheries Science Center, Point Adams Biological Field Station, P.O. Box 155, Hammond, Oregon 97121.

Data Analyses

Physical and biological data collected during September 1995 were entered into computer files following formats agreed to by the original cooperating agencies involved in the White Sturgeon Study: NBS, ODFW, NMFS, and the Washington Department of Fish and Wildlife.

Using the distance fished during a shrimp trawl effort and the estimated fishing width of the net (5.3 m), I 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

In September 1995, 310 juvenile white sturgeon were collected between RM 28 and 132. Distribution of juvenile white sturgeon in this section of the river was patchy. There were differences in catch among different areas of the river and between 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 2). The mean fork length ($\pm$ SD) and weight ($\pm$ SD) of 111 YOY white sturgeon collected were 177 mm ($\pm$ 32 mm) and 42 g ($\pm$ 19 g), respectively. Variations in the lengths and weights of YOY were considerable--lengths ranged from 63 to 224 mm and weights ranged from 1 to 84 g.

In 1995, 111 YOY white sturgeon were collected between RM 28 and 132; YOY comprised about 38% of the total catch of juvenile white sturgeon that was measured. Densities of YOY white sturgeon at 13 index sampling stations averaged 14.6 fish/hectare during the first survey (1-8 September) and 11.0 fish/hectare during the second survey (18-21 September); the mean for both surveys combined was 12.8 fish/hectare (Table 1).

Fourteen (6%) of 251 juvenile white sturgeon were infected with the nematode parasite

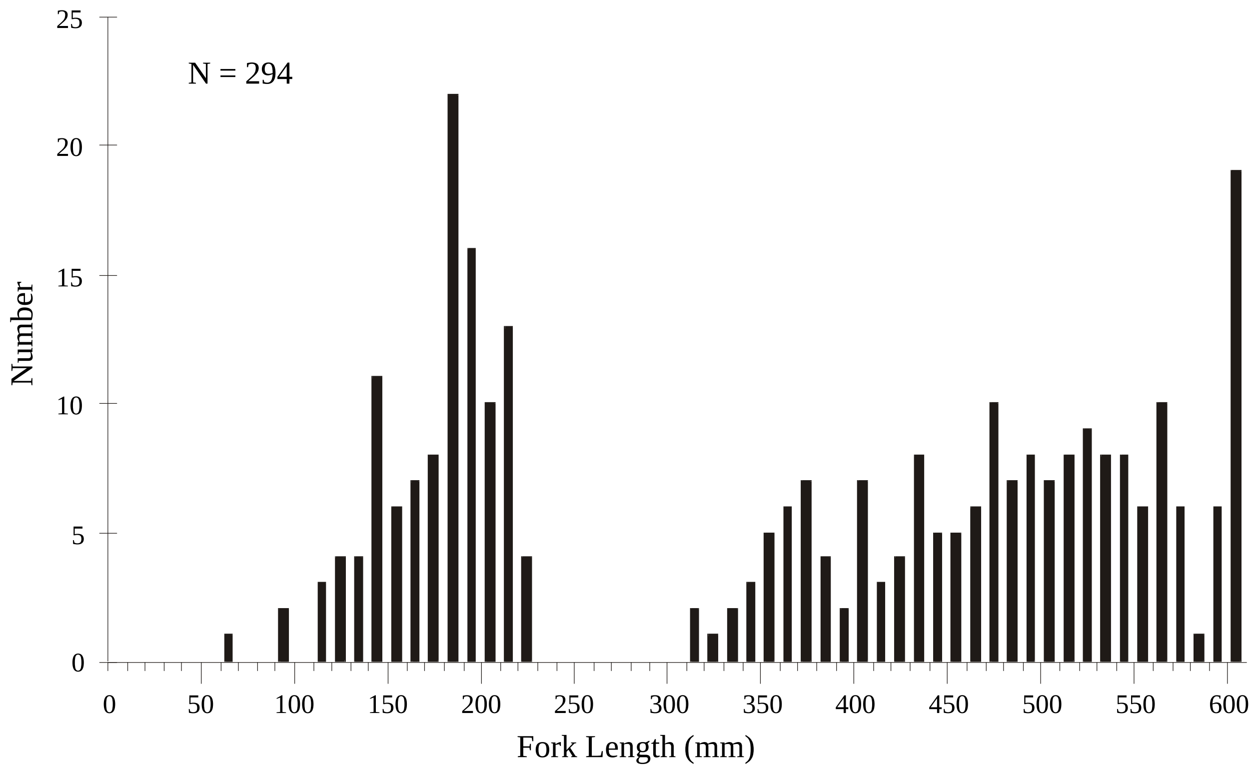

Figure 2. Length-frequency histogram for juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam, 1995. White sturgeon longer than 600 mm are included in the 600-mm interval.

Table 1. Catches of young-of-the-year white sturgeon in September 1995 at 13 sampling stations in the Columbia River downstream from Bonneville Dam. Location is shown in River Miles (RM) and in some instances a transect number is shown when parallel trawling efforts were done at the same RM.

Location (RM)	1-8 September		18-21 September	
	Number	Number/hectare	Number	Number/hectare
31	2	6.8	3	9.9
42	0	0.0	0	0.0
46	3	7.6	1	4.1
54	5	17.0	0	0.0
61	6	23.5	3	13.9
75	10	48.5	12	76.5
79-1	6	22.6	2	8.5
79-2	2	6.6	1	4.1
95-1	1	4.1	0	0.0
95-2	1	3.9	0	0.0
103	11	44.8	6	25.5
131-1	0	0.0	0	0.0
131-2	1	4.2	0	0.0
Mean	3.7	14.6	2.2	11.0

Cystoopsis acipenseri. The mean fork length of infected fish was 353 mm, with a range from 311 to 391 mm.

DISCUSSION

Young-of-the-Year

Catches (number/hectare) of YOY white sturgeon at 13 index trawling stations in late September 1995 (second survey) were not significantly different (Kruskal-Wallis, $P = 0.19$) than catches at the same sites in late September of 1991, 1993, and 1994. No sampling was conducted in September 1992. Catches at the 13 sites averaged 6.7, 9.0, 2.3, and 11.0 YOY/hectare in 1991, 1993, 1994, and 1995, respectively. In all years, catches at 31% or more of the stations were zero. Young-of-the-year white sturgeon were collected over a larger geographic area in September 1995 than in September 1994 (includes all sampling data from September of both years). In 1994, YOY white sturgeon were collected between RM 61 and 132; whereas in 1995, YOY white sturgeon were collected between RM 28 and 132. In September of 1991 and 1993, YOY white sturgeon were collected between RM 28 and 131. In 1995, as in 1991 and 1993, the side channel near Goble, Oregon (RM 75), was a productive sampling site for YOY white sturgeon. No YOY white sturgeon were captured at this site in September 1994. The lower catches of YOY white sturgeon in late September and the smaller area of capture in 1994 (all September sampling) compared to 1991, 1993, and 1995 may have been due to lower river flows in 1994 during the larval life stage. After hatching, white sturgeon larvae are dispersed out of the spawning and egg incubation areas by river currents. In the Sacramento-San Joaquin Delta, California, Stevens and Miller (1970) observed a direct relationship between river flow into the Delta and catches of white or green sturgeon (*Acipenser medirostris*) larvae, or both.

Plans for 1996

In 1996, NMFS will estimate the success of YOY-white sturgeon recruitment by bottom trawling at previously established sampling stations in the Columbia River downstream from Bonneville Dam.

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report E

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

This report includes: Physical habitat measurements at various river discharges in free-flowing portions of the lower Columbia and Snake rivers

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ACKNOWLEDGEMENTS

We would like to thank Alan Ecklund and Pat Kemper, U.S. Fish and Wildlife Service (USFWS), and Darren Gallion, National Biological Service (NBS) for their assistance with field sampling. Mike Parsley and Dennis Rondorf (NBS) provided an Acoustic Doppler Current Profiler (ADCP) for field data collection and Greg Ruppert with the Pasco Field Office of the U.S. Geological Survey (USGS) provided Columbia River and Snake River discharge information and McNary Pool elevation data. Walt Skalicky provided expertise and assistance with development of design blueprints for fabrication of the ADCP deployment hardware. We would also like to thank the cooperating agencies of this study and Rick Westerhof of the Bonneville Power Administration for comments on earlier drafts of this report. Funding for this work was provided by the Bonneville Power Administration.

ABSTRACT

The U.S. Fish and Wildlife Service established 55 new main channel cross sections during 1995 in the Columbia River between Vernita Bridge and Priest Rapids Dam for white sturgeon (*Acipenser transmontanus*) habitat quantification. Cross section profiles and velocity distributions were collected for the new cross sections at river discharges ranging from 3,325 m^3/s to 5,546 m^3/s. Additional field data were collected on 51 existing cross sections in the Columbia River between White Bluffs and Vernita Bridge and in the lower Snake River between McNary Reservoir and Ice Harbor Dam. Stage-discharge work included collection of 56 data pairs for 56 cross sections in the Columbia River at discharges ranging from 2,080 m^3/s to 4,849 m^3/s, and three stage-discharge pairs for three cross sections in the Snake River at discharges ranging from 827 m^3/s to 1,067 m^3/s. Global Positioning System (GPS) coordinates were collected for 81 cross section headpins.

Cross section profiles and velocity distribution data files for all 129 cross sections were reduced and imported into hydraulic and habitat modeling software. All stage-discharge data pairs were entered into the programs and preliminary rating curve analysis was begun.

INTRODUCTION

This report describes work conducted by the U.S. Fish and Wildlife Service (USFWS) from 1 April 1995 to 31 March 1996 as part of white sturgeon (*Acipenser transmontanus)* studies under the Bonneville Power Administration's Project 86-50 on the mainstem Columbia and Snake rivers. The U.S. Fish and Wildlife Service is cooperating with the National Biological Service (NBS) on studies designated under Goal 3, Objective 3 of the program. The purpose of Goal 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. Under Objective 3, USFWS is responsible for quantification of white sturgeon spawning and rearing habitat in the free-flowing portion of the Columbia River between McNary and Priest Rapids dams and the free-flowing portion of the Snake River between the confluence with the Columbia River and Ice Harbor Dam. Studies being conducted by NBS under this objective consist of determining habitat used by spawning and rearing white sturgeon and quantification of spawning and rearing habitat in the impounded portion of the study area (NBS REPORT C in this volume).

Funding for work under this Objective resumed on about 1 April 1995 following a six-month lapse in the contract. Most work conducted during this reporting period actually occurred between 1 August 1995 and 31 March 1996 following personnel and equipment reacquisition and mobilization. Specific study tasks during this period were:

1) Completion of cross section headpin placement for hydraulic data collection;

2) Completion of horizontal and vertical cross section profiles and velocity distributions;

3) Measurement of cross section water surface elevation (stage)-discharge data pairs;

4) Collection of Global Positioning System (GPS) coordinates for cross section headpins and reference marks;

5) Reduction of Acoustic Doppler Current Profiler (ADCP) raw data files, integration of survey data, and import of data into hydraulic modeling programs.

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). Within the PHABSIM, field measurements of depth, water column velocity, river elevation, and river discharge are used to calibrate hydraulic models for simulation of depths and velocities at unmeasured discharges (Bovee and Milhous 1978; Milhous et al. 1989). Output from the hydraulic models along with substrate or cover data is then compared to habitat suitability criteria for the species of interest to predict habitat quality and quantity over a range of river discharges. Hydraulic and habitat modeling algorithms and other data processing functions have been re-programmed into a user-friendly, menu driven software package known as Riverine Habitat Simulation (RHABSIM)[1]. RHABSIM is fully compatible with PHABSIM and provides the same capabilities in addition to many enhancements, particularly graphics (Payne 1994). The RHABSIM system was used in place of PHABSIM for data entry and initial hydraulic model calibration, and will continue to be used throughout the remainder of this analysis.

Hydraulic data collection, which began in 1994 (Anglin 1995), continued in 1995 in the Columbia River between White Bluffs near river mile (RM) 368 and Priest Rapids Dam (RM 397), and in the lower Snake River between RM 4.5 and Ice Harbor Dam at RM 9.8 (Figure 1). River segmentation and cross section placement were based on a sensitivity analysis conducted in early 1994 (Anglin 1995) and are discussed in greater detail in the 1994 Annual Report (Anglin in press). Cross sections were marked on each riverbank above the high water mark with painted lath and rebar capped with labeled plastic surveying markers. A reference mark was established near each cross section on a stationary object (usually a large boulder) to be used as a relative datum for profile and water surface elevation surveys.

A Precision Lightweight GPS Receiver (PLGR) was used to determine locations for all cross section headpins and a subset of reference marks. The PLGR's were purchased under a U.S. Air Force military contract and have the ability to utilize the Precise Positioning Service (PPS) of the NAVSTAR Global Positioning System. The PPS enables horizontal positions to be determined within $\pm$10 m autonomously, in real-time without the need for post-processing.

An electronic total station was used to measure riverbank profiles and water surface elevations, and an ADCP on loan from NBS was used to measure depths, water column velocities, and discharge on each cross section. An electronic total station uses laser technology to measure distance while electronically compensating for atmospheric conditions and curvature of the earth. Horizontal and vertical angles are measured electronically and combined with distance measurements to provide slope distance, horizontal distance, and vertical difference (elevation). The ADCP uses the Doppler effect (the apparent change in the frequency of a wave resulting from relative motion of the source and the receiver) to measure the motion, direction, and depth of water from the returning echoes of four acoustic beams (RD Instruments 1989). River bank profiles consisted of horizontal distance (from headpin) and elevation (relative to reference mark) for a variable number of points down to the water's edge for description of the bank contour. Velocity distributions were collected for a single discharge on each cross section and relative water surface elevations (stages) were collected for up to four discharges (stage-discharge pairs) on each cross section. Velocity distributions were comprised of measurements of water column velocity for 50 cm bins from approximately 1 m below the water surface to approximately 1 m above the river bottom. Horizontal distance, relative elevation, depth, and water column velocities were measured at 50-100 points along each cross section. Portable electromagnetic flowmeters were used to collect velocity data from inshore areas that were too shallow for ADCP data collection.

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[1] Reference to trade names does not imply endorsement by the U.S. Fish and Wildlife Service, DOI.

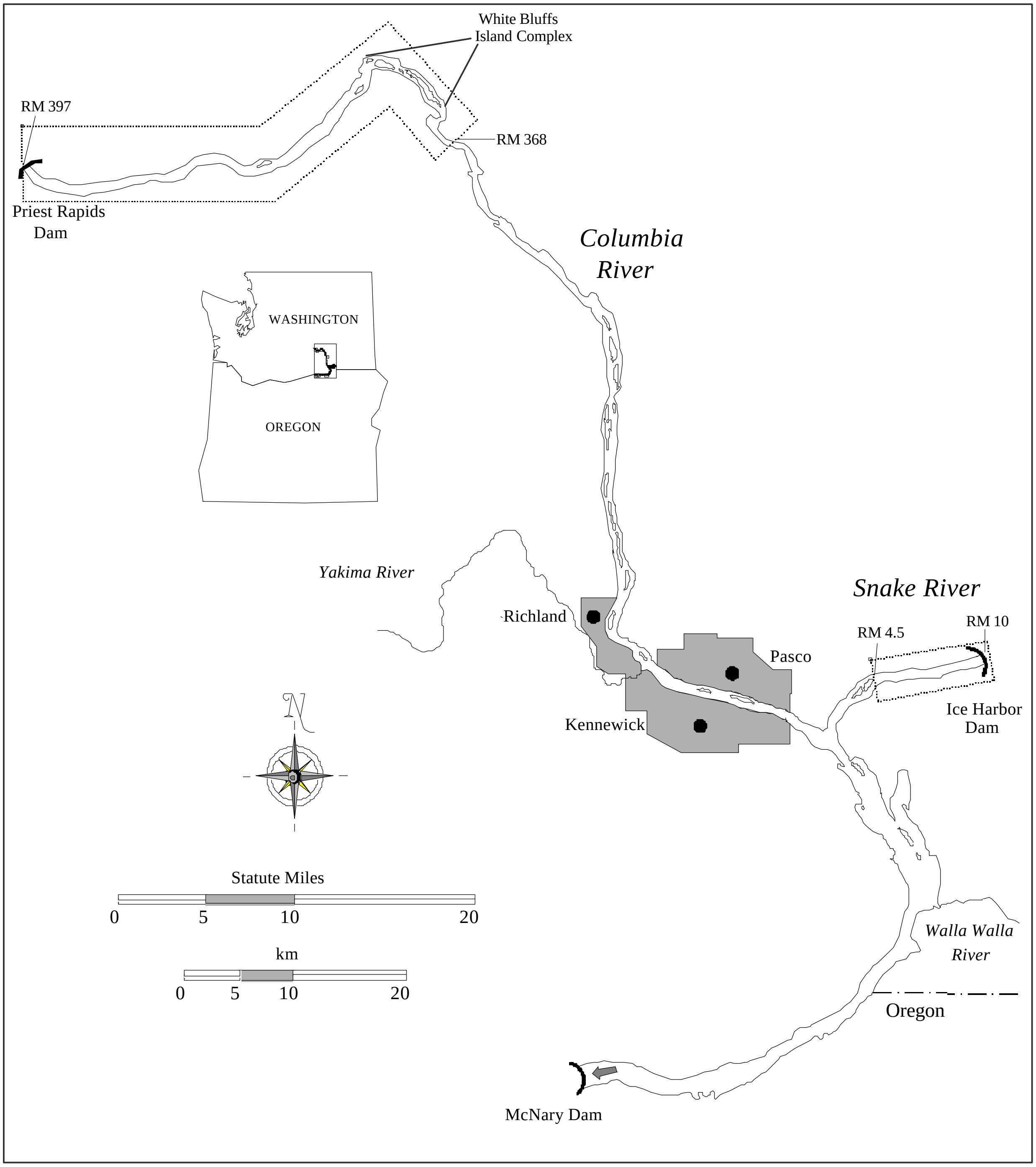

Figure 1. Location of study area between White Bluffs and Priest Rapids Dam on the Columbia River and downstream from Ice Harbor Dam on the Snake River.

Hydraulic field data collected by the ADCP were converted from binary format to ASCII format and imported into the RHABSIM field data spreadsheet. Horizontal distance, depth, and mean column velocity are calculated from the appropriate ADCP data fields and combined with horizontal distance and elevation for surveyed bank points, the water's edge, and water surface in the field data spreadsheet. Inshore depths and velocities were then entered at the correct distances from the water's edge. Water surface elevation and the corresponding discharge were entered into the spreadsheet as the data pairs were collected. Cross section profiles, water surface elevations, and velocity distributions were then viewed graphically and scanned for errors.

We assisted NBS with the maintenance of digital thermographs for collection of continuous water temperature data in the Columbia River near Richland, Washington (RM 340.3) and near Ringold Flat (RM 353), and in the Snake River below Ice Harbor Dam (RM 6.3).

RESULTS

Field Sampling

Cross sections were distributed between five hydraulically controlled (pool/run), four uncontrolled (riffle), and one tailrace section in the Columbia River between RM 368 and the Priest Rapids Dam tailrace (Figure 2). Controlled sections ranged from 3,000 to 6,500 m in length and uncontrolled sections ranged from 1,500 to 3,200 m in length. The tailrace section was approximately 1,600 m in length. We installed headpins and reference marks for 55 new cross sections between Vernita Bridge and Priest Rapids Dam to complete cross section placement for the study area. Controlled sections between Vernita Bridge and Priest Rapids Dam (C6, C7) were characterized with 37 cross sections, and uncontrolled sections (R5, R6) and the tailrace (TR) were characterized with 18 cross sections. Snake River cross sections were selected at various locations to characterize observed habitat conditions. Cross section widths ranged from 402 to 919 m in the Columbia River and 402 to 641 m in the Snake River.

Measurement of cross section profiles and velocity distributions was completed for both the Columbia and Snake River study areas. Velocity distributions were measured at river discharges ranging from 3,325 to 5,546 m^3/s for the newly established cross sections in the Columbia River.

Fifty-one stage-discharge pairs were collected for the newly established cross sections in the Columbia River at river flows ranging from 2,080 to 3,324 m^3/s. Additional stage-discharge data (5 points) were collected for other Columbia River cross sections at river flows ranging from 4,372 to 4,849 m^3/s. Stage-discharge data points were collected for three Snake River cross sections at river flows ranging from 827 to 1,067 m^3/s. Locations were determined with the PLGR-GPS receiver for a total of 81 cross section headpins in the Columbia and Snake rivers.

In some areas, Columbia River water surface elevations increased over 4.9 vertical meters from the lowest to the highest calibration flow. Maximum water surface elevation change associated

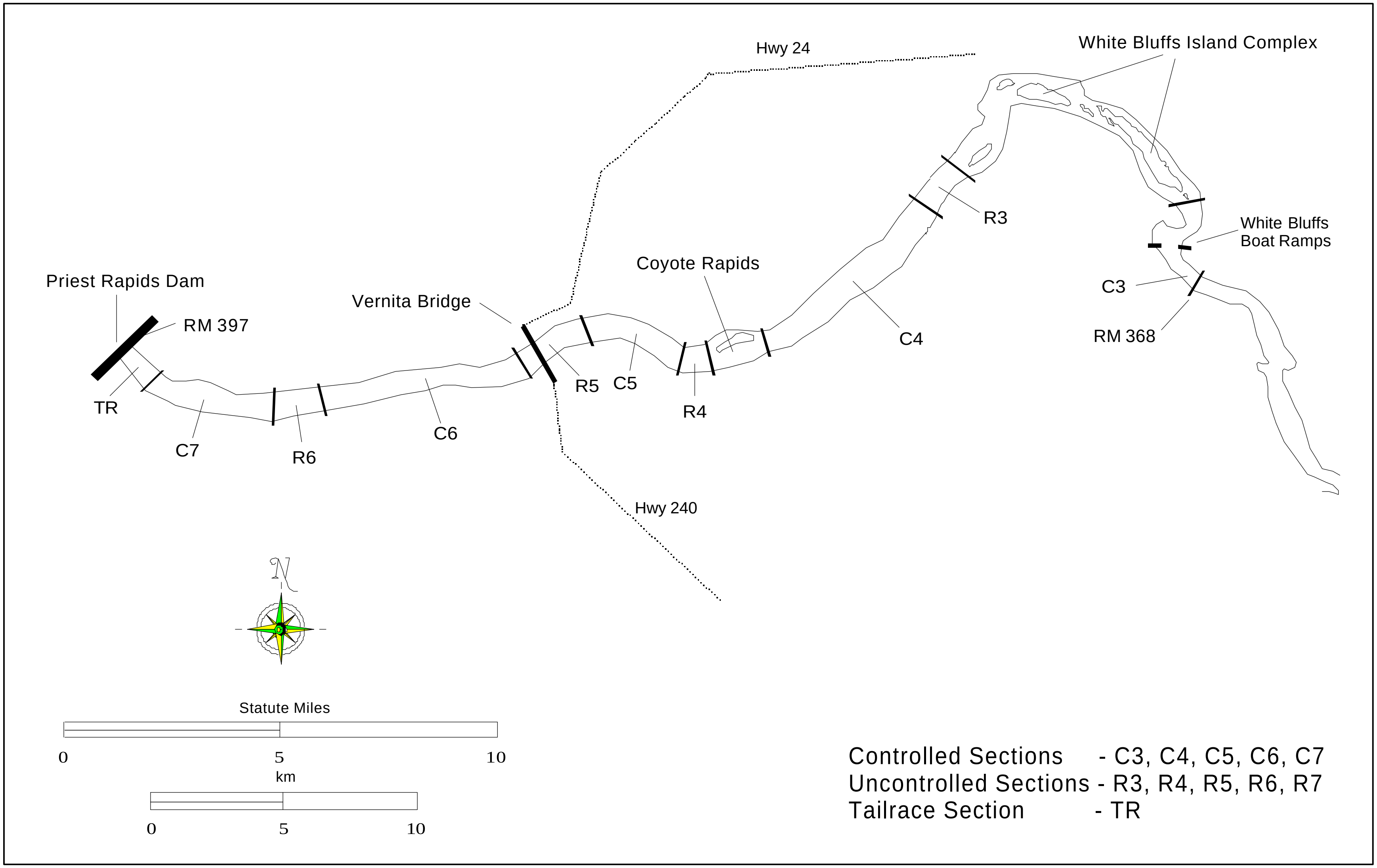

Figure 2. Habitat unit location for the Columbia River portion of the study area.

with calibration data within a 24-hour period was 1.9 meters. Cross section depth and velocity ranged to maximums of 22 meters and 3.35 m/s respectively, for calibration data sets.

Elevations relative to a USGS benchmark near the Highway 12 bridge were determined for all Snake River cross section headpins. Cross section water surface elevations along with the elevation of McNary Pool were then compiled for river flows ranging from 318 m^3/s to 3,059 m^3/s to characterize the backwater effect from McNary Pool. We will continue to compile cross section and McNary Pool elevations along with river flows to determine the appropriate modeling and analytical approach considering the variable backwater effect.

Analysis

Data sets for hydraulic simulation were compiled using hydraulic data measured with the ADCP, and bank profile data and water surface elevations measured with the electronic total station. All ADCP raw data files for velocity distributions (129 cross sections total) were converted to ASCII files, reduced, and imported into the RHABSIM hydraulic and habitat modeling programs. Survey data for bank profiles and edge depths and velocities were then integrated with the hydraulic data files. All stage-discharge data files were reviewed, and the discharges along with corresponding water surface elevations were entered into the hydraulic modeling programs. Cross section plots and summary rating curve statistics were produced (Figure 3) and reviewed for errors. Three-dimensional plots of cross section profiles were produced to review the channel patterns for each controlled and uncontrolled section. The three-dimensional plot for the lower Snake River is shown in Figure 4 and the plots for the Columbia River sections are shown in Appendix E.

Preliminary calibration of hydraulic models has indicated that cross-sectional area and water column velocity simulation can reasonably be conducted for the range of Columbia River discharges between 707.8 m^3/s - 14,156 m^3/s. This will allow us to include hydrographs for nearly all years, including extremely low and high years, from the period of record for the eventual time-series analysis of pre- and post-hydrosystem habitat conditions for white sturgeon.

We began compiling and examining historical water temperature and streamflow data for the formulation of a time series analysis of spawning and rearing habitat. Comparisons of various temporal segments of the Columbia River hydrograph were initiated to determine when hydrosystem development produced a change over historic conditions.

C:\RHABSIM\DATA\IFG-REG.TXT

Stage/Flow Regression Statistics

XS	Name	N	A	B	MeanErr(%)	Variance	Std.Dev
1	C412VELD.000	4	0.8737	3.5050	3.8949	8.0899	2.84428

REGRESSION RESULTS:

XSEC # 1 C412VELD.000
SZF = 62.615

Log/log Functions (Given Flows):
FLOW = 0.87371 * (Stage - 62.6150) ** 3.50497
STAGE = 1.03927 * Flow ** 0.28531 + 62.6150

GivenFlow	Predicted	Ratio
162402.100	163777.300	0.9916
103806.000	95946.200	1.0819
49047.000	51192.990	0.9581
210896.000	216771.600	0.9729

Control 4 - Cross Section 12

CROSS-SECTION C412VELD.000

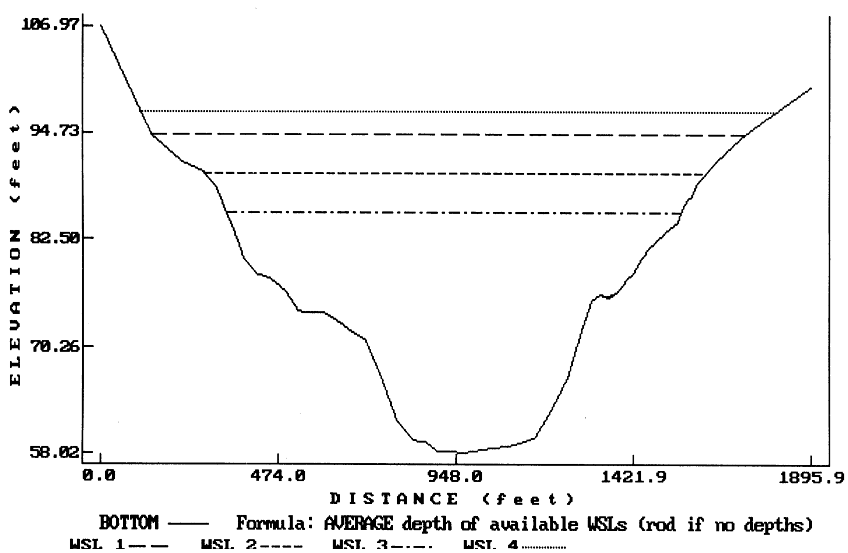

Figure 3. Rating curve statistics and cross section plot showing water surface elevations for habitat unit C4, cross section 12.

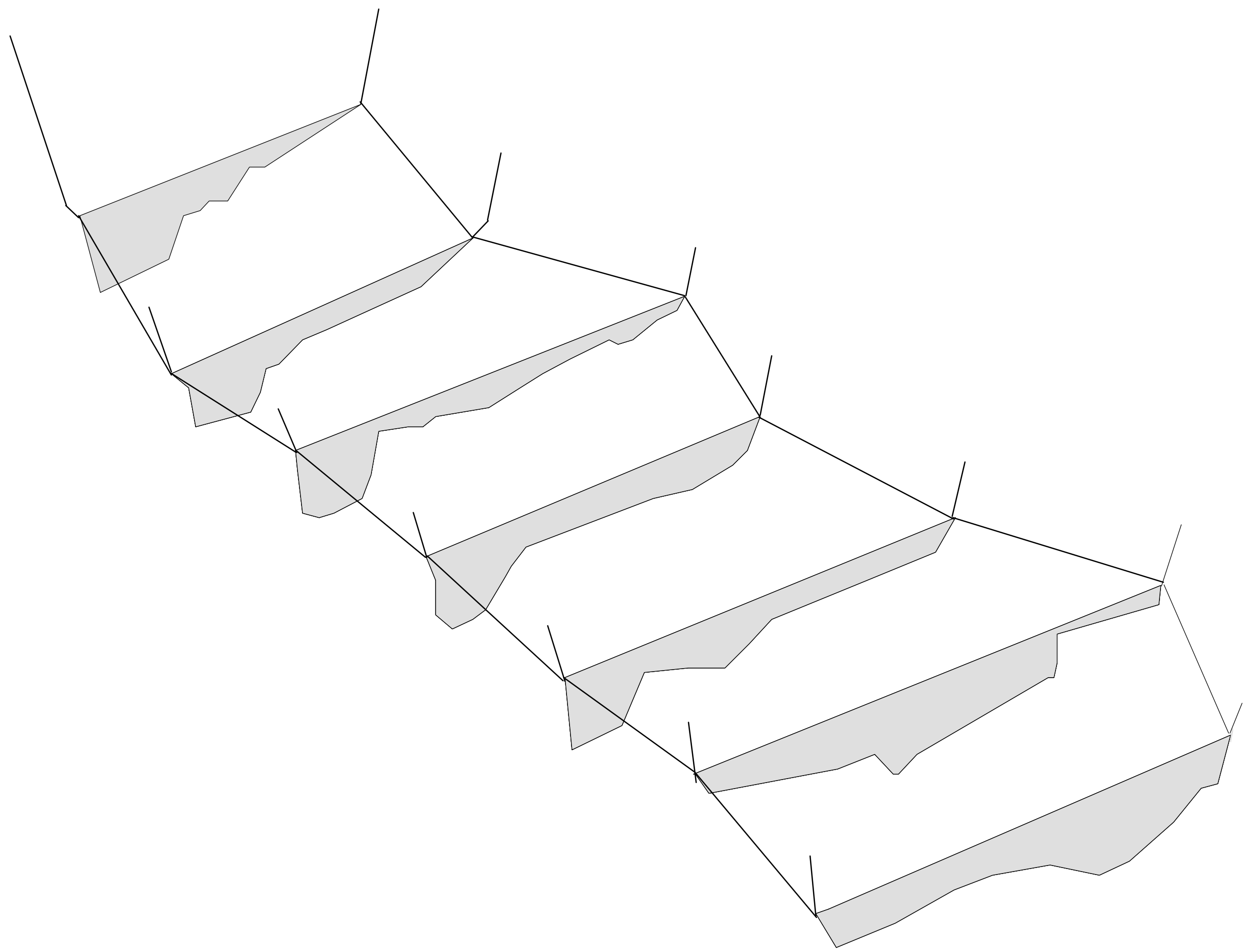

Figure 4. Three-dimensional cross section of the Snake River uncontrolled habitat unit, Ice Harbor Dam Tailrace, showing the most downstream cross section in the lower right with an x to y scale of 1 to 10.

DISCUSSION

The winter of 1995/96 was characterized by medium-high flow conditions in the Columbia and Snake rivers. We were able to take advantage of the extended time period these flows were available by using an ADCP provided by NBS. As a result, velocity distribution data collection was completed prior to the spring runoff. High flows in May and June 1996 will provide an opportunity to collect a relatively high stage-discharge data point, enhancing our hydraulic simulation capabilities. We expect to take delivery on our own ADCP in May 1996, which will give us the flexibility to take full advantage of these conditions. We were not able to collect substrate data for either the Columbia or Snake river cross sections because of the high flow conditions that persisted all winter.

Our accumulation of hydraulic data for the lower Snake River is allowing us to sort out the characteristics of the variable backwater effect from McNary Pool. We will continue to accumulate data to examine the backwater effect over a range of river flows and reservoir elevations to determine the appropriate hydraulic simulation technique.

We assisted Thomas R. Payne & Associates in the development of a software routine that allows direct import of ADCP ASCII files into RHABSIM. This new capability has allowed us to substantially increase the efficiency of data input over the methods required for data input into the PHABSIM programs. Many hours were spent deriving equations for the routine, testing the routine, and making the necessary changes. The time was well spent and this project, as well as other ADCP and RHABSIM users, will continue to enjoy the cost savings associated with the increased efficiency of data input.

Plans for 1996

We plan to complete hydraulic data collection during 1996. The type of water year and hydrograph will ultimately determine to what extent we are able to complete data collection. Given the water supply forecast, we do not anticipate any problem with completion of data collection. We plan to complete substrate characterization where needed during summer/fall low flows. We will also develop a sampling plan for individual islands and the island complexes within the Columbia and Snake river study areas and initiate data collection.

Acquisition of water temperature and streamflow data for use in the habitat analysis will be completed, and we will define the hydrographs to be used in the time series analysis. Integration of new stage-discharge data points and substrate characteristics with existing data files will be the primary analytical task, followed by calibration of the hydraulic models. Habitat analysis will begin as hydraulic model calibration is completed.

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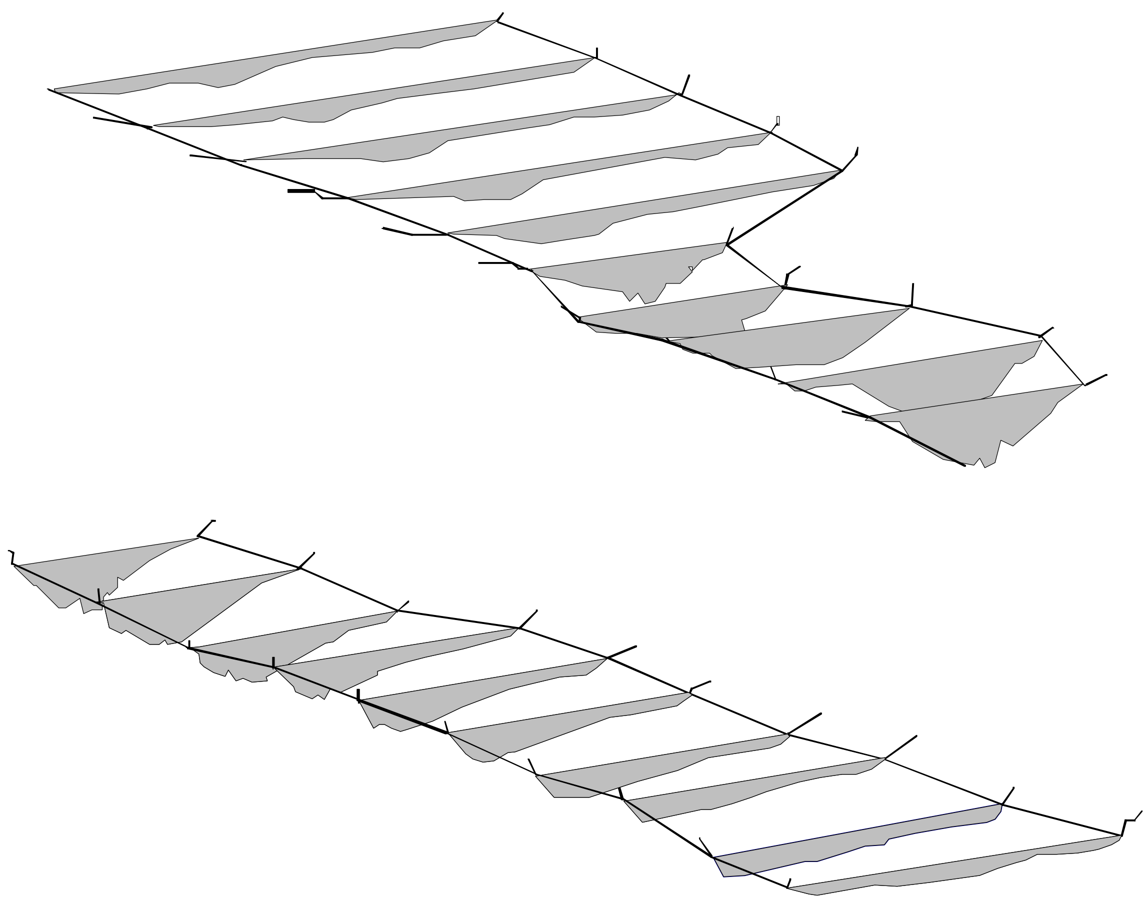
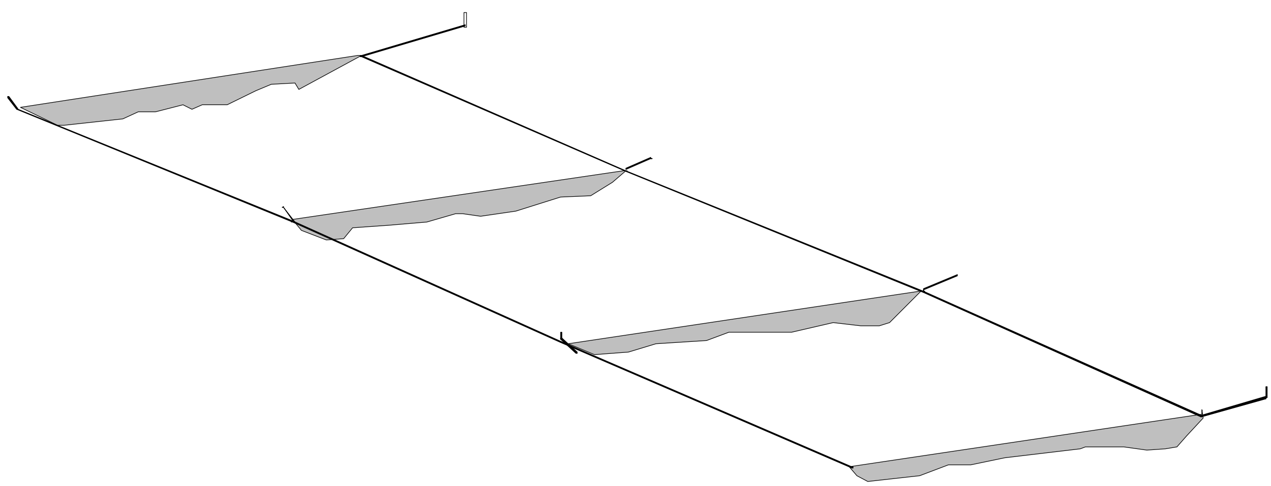
APPENDIX E-1

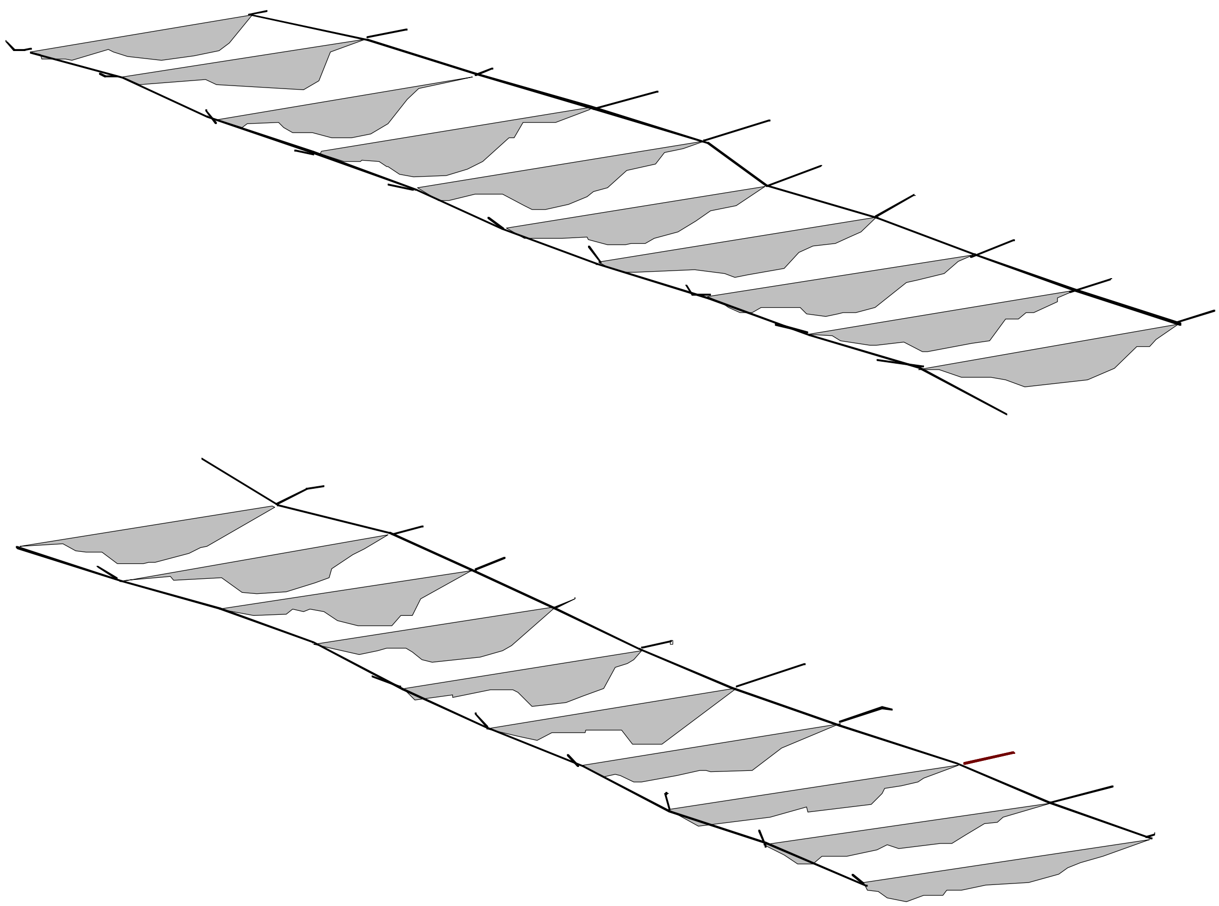
Three-dimensional plots of controlled and uncontrolled habitat unit cross sections in the Columbia River, with the most downstream cross section on the lower right and the most upstream cross section on the upper left. (X to Y scale of 1:10). Locations of the habitat units within the study area are shown in Figure 2 under **RESULTS**.



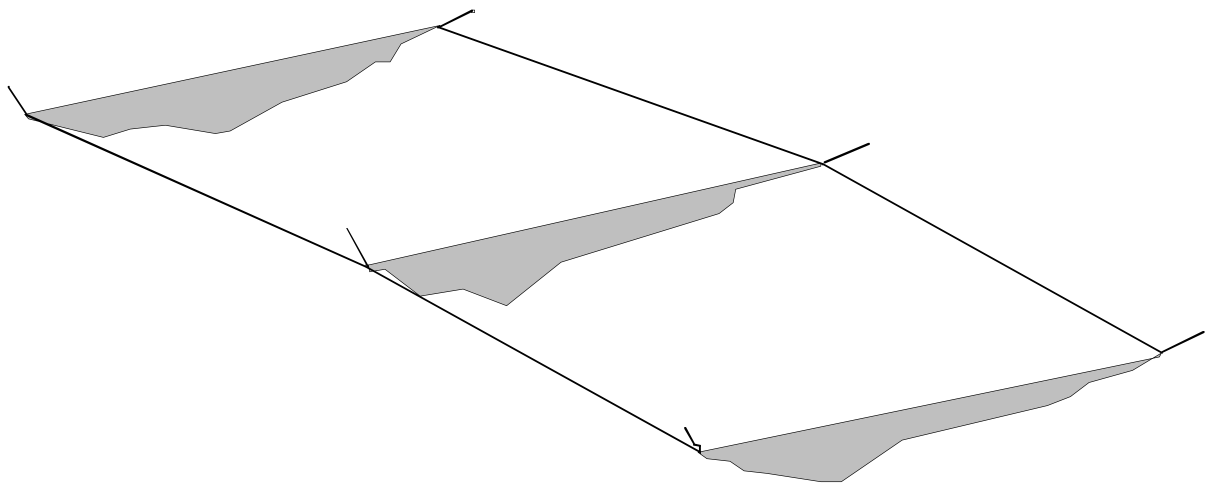
Appendix Figure E1. Columbia River controlled habitat unit three (C3).



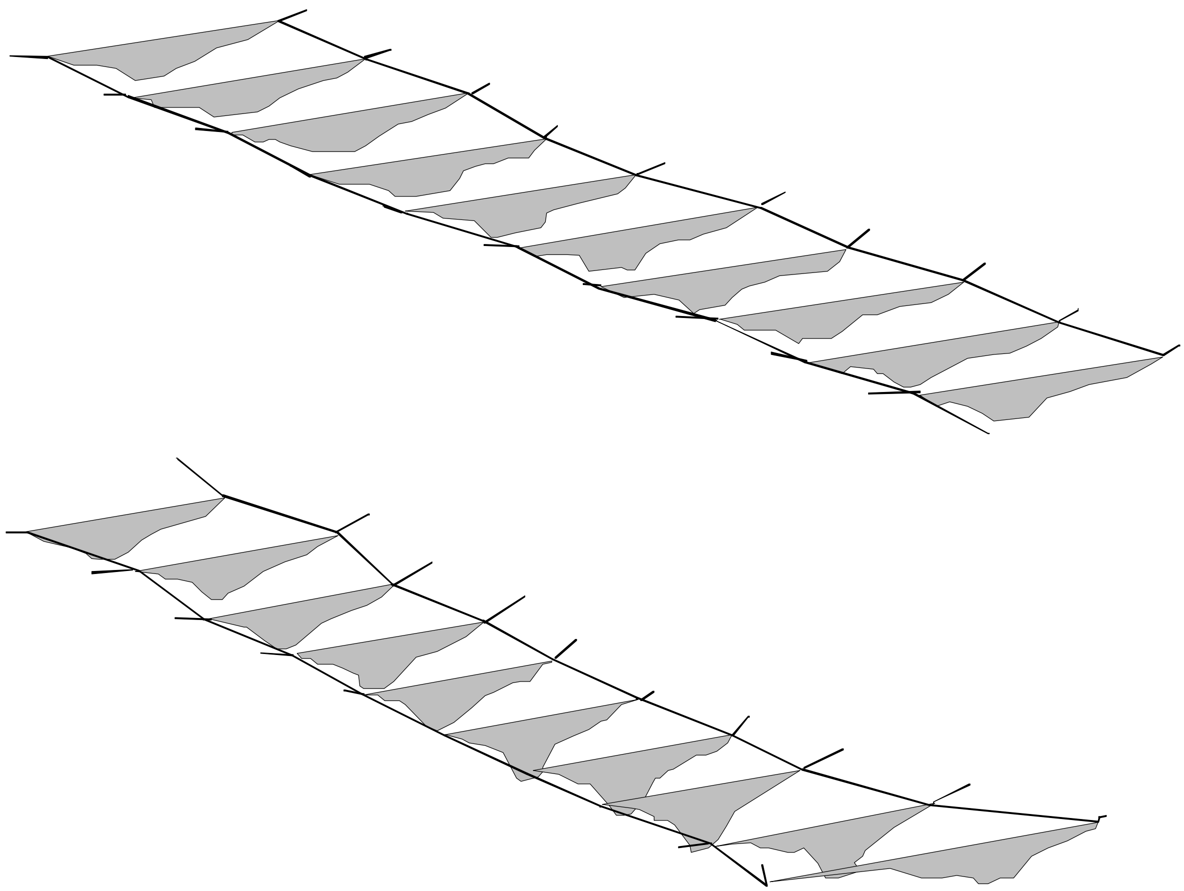
Appendix Figure E2. Columbia River uncontrolled habitat unit three (R3).



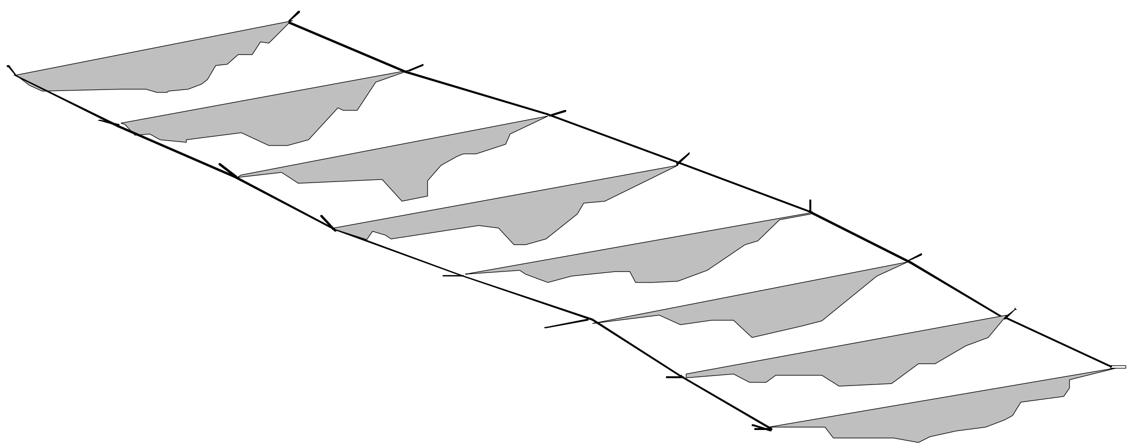
Appendix Figure E3. Columbia River controlled habitat unit four (C4).



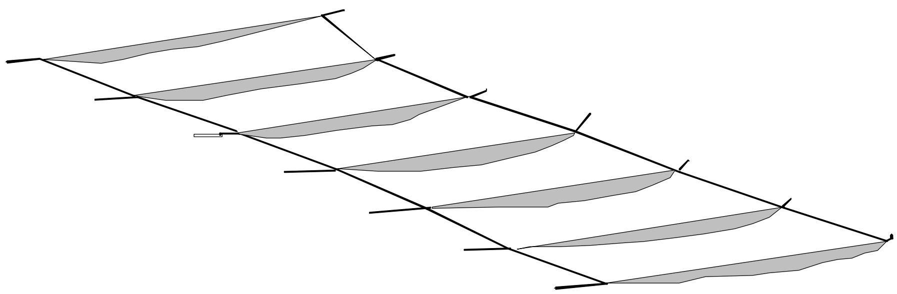
Appendix Figure E4. Columbia River uncontrolled habitat unit four (R4).

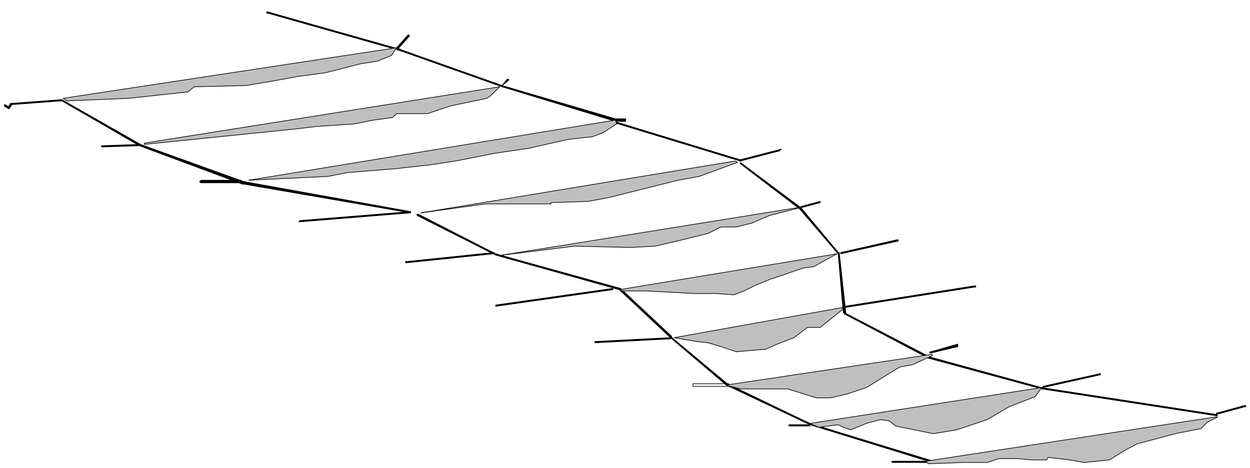


Appendix Figure E5. Columbia River controlled habitat unit five (C5).

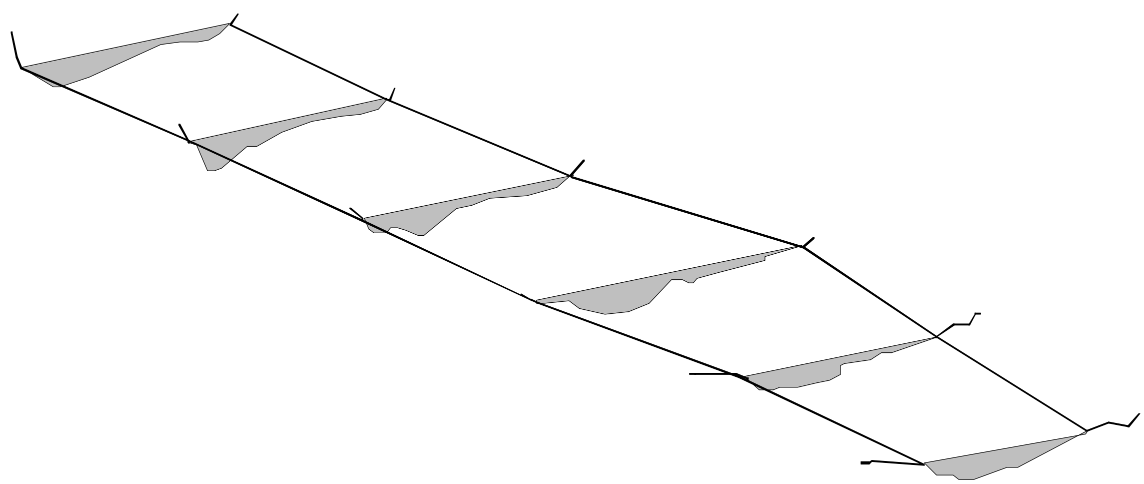


Appendix Figure E6. Columbia River uncontrolled habitat unit five (R5).

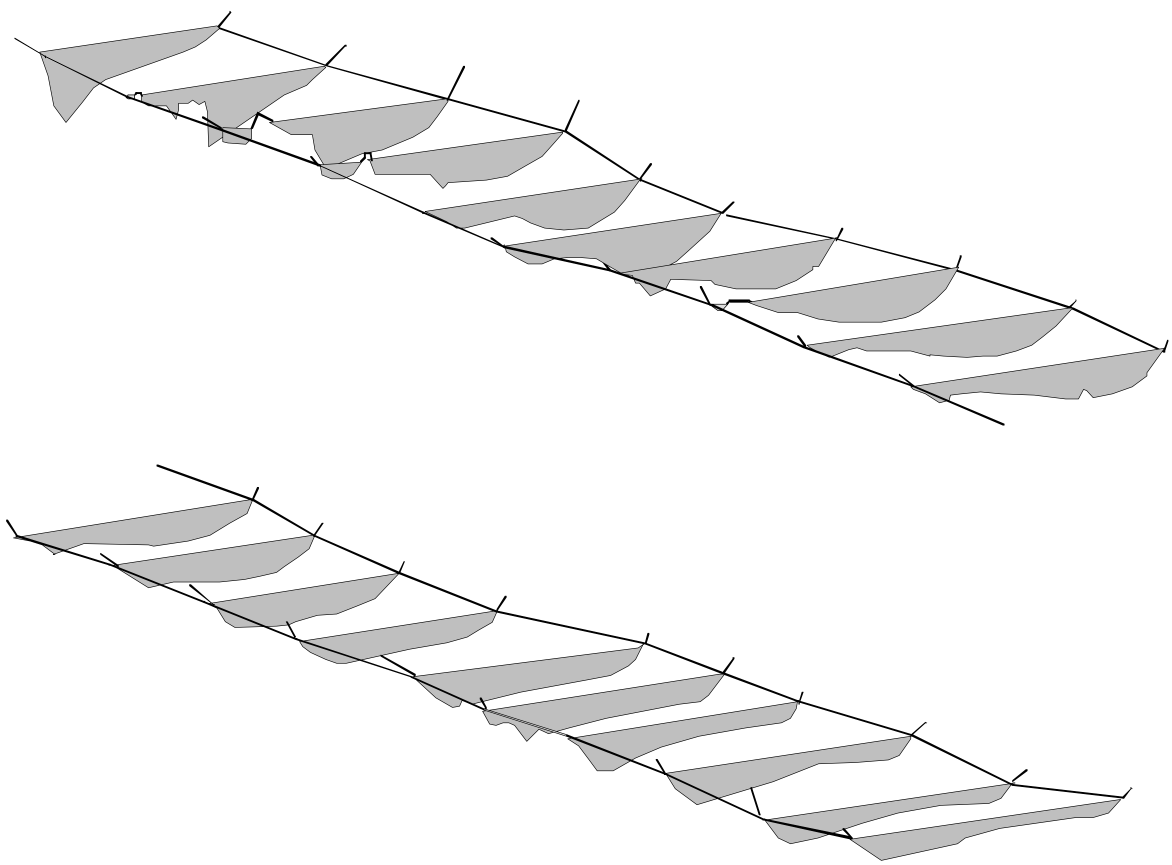




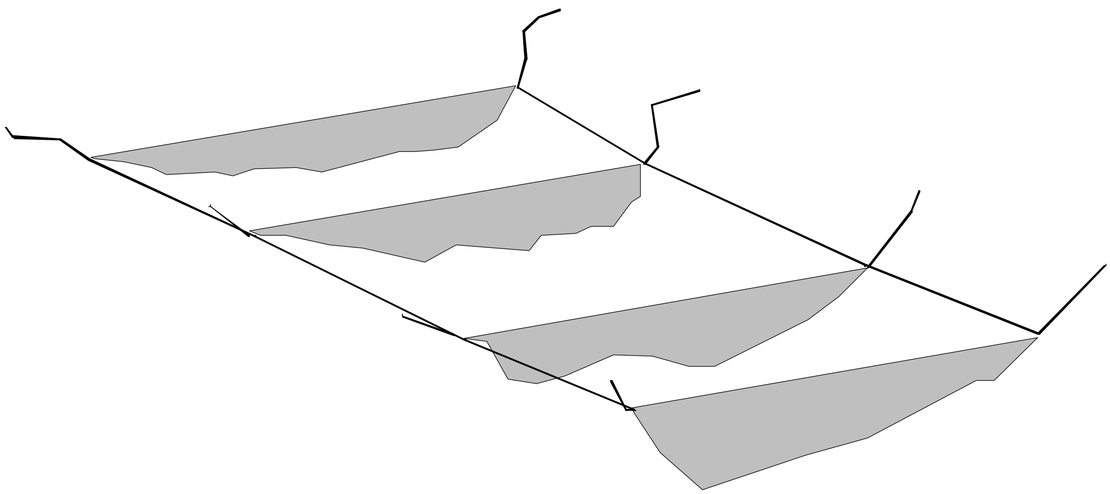
Appendix Figure E7. Columbia River controlled habitat unit six (C6).



Appendix Figure E8. Columbia River uncontrolled habitat unit six (R6).



Appendix Figure E9. Columbia River controlled habitat unit seven (C7).



Appendix Figure E10. Columbia River uncontrolled habitat unit, Priest Rapids Tailrace (TR).

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

ANNUAL PROGRESS REPORT

APRIL 1995 - MARCH 1996

Report F

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

This report includes: Monitoring efforts in Bonneville, The Dalles, and John Day reservoirs to assess potential mortality of juvenile white sturgeon during the winter commercial fishing season

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My appreciation goes to Yakama Indian Nation (YIN) fisheries technicians, James Kiona and Evans Lewis, Jr., for their untiring efforts in data collection during the 1995 Zone 6 winter commercial fishery. In addition, my sincere thanks to the many tribal fishers who participated in the monitoring effort by allowing access to their boats, gear, and catch. Their cooperation was critical for the success of this project. I thank Tim Counihan, George McCabe, Jr., John North, Mike Parsley, and Tom Rien for their comments on the draft report.

ABSTRACT

I report on monitoring efforts conducted on Zone 6 reservoirs from February 1995 through March 1995 (winter commercial fishing season) to assess potential mortality of juvenile white sturgeon during this fishery. Yakama Indian Nation (YIN) fishery technicians sampled 375 net days of effort in Bonneville, The Dalles, and John Day reservoirs. The majority of white sturgeon were captured with diver gillnets with stretched meshes ranging from 20.3 cm to 25.4 cm. Data were collected on 857 white sturgeon, with fork lengths that ranged from 47 cm to 305 cm. No direct mortalities of white sturgeon were observed during the monitoring effort. Approximately 93% of the sampled sturgeon were sublegal, less than 110 cm fork length. Floating gillnets were also sampled, although only seven sturgeon were recorded and sampled. Steelhead trout *Oncorhynchus mykiss*, walleye *Stizostedion vitreum*, and common carp *Cyprinus carpio* were the primary catch in floating gillnets. Technicians recorded more sublegal subsistence sturgeon being retained (N=126) for subsistence compared to the numbers of legal fish (N=49) retained during the monitoring period.

INTRODUCTION

This report documents the task completed by the Columbia River Inter-Tribal Fish Commission (CRITFC) from field operations conducted in February and March of Fiscal Year 1995. This tasks is a component of Objective 1 of from the Bonneville Power Administration Project 86-50. Deliverables associated with the task for Objective 1 are detailed below.

The CRITFC was responsible for portions of Objective 1; which is to evaluate the success of developing and implementing a management plan for white sturgeon in the reservoirs between Bonneville and McNary dams to enhance production. The tasks for this objective included monitoring the sturgeon catch and incidental mortality during Zone 6 tribal commercial fisheries and to assist the ODFW and WDFW in the development a comprehensive enhancement plan that describes how sturgeon production in Zone 6 may be increased. This report will be completed separately in 1997.

METHODS

Monitoring of the 1995 Zone 6 Commercial Fishery

Monitoring of the 1995 Zone 6 commercial fishery was conducted by Yakama Indian Nation (YIN) fisheries technicians in Bonneville, The Dalles, and John Day reservoirs from February through March 1995 (Figure 1). The distribution of sampling efforts throughout the reservoirs were determined by fisher contact and availability. Eight different fishing crews were monitored during the project. Generally, technicians spent the entire day on the fishers boat, although the technicians also used a YIN fisheries research boat during foul weather or if the fishers boat was too small to safely handle the additional personal. Monitoring trips were coordinated in advance from interested fishers. Fishers participation was completely voluntary, although we estimate that over half of the active commercial fishers of white sturgeon participated in the monitoring effort (S. Parker, Harvest Manager, Yakama Indian Nation Fisheries, personal communication). Contact with the fishers was coordinated by the technicians, who as former commercial fishers themselves, knew nearly all the active commercial sturgeon fishers in Zone 6. No night work was done. Monitoring efforts generally occurred every day that nets were pulled during the fishing season. A Sunday closure rule was in effect during the fishery, which meant that nets were pulled by Saturday afternoon and set again after Monday noon.

Data collection procedures and data sheet format were similar to those developed by Rien et al. (1991). Additional data collected included net length, stretched mesh dimensions and whether it was floating or a diver net. White sturgeon were measured to the nearest cm fork length and examined for tags and marks. This examination included the use of a hand held detector for Passive Integrated Transponders (PIT), commonly referred to as PIT tags. Weights were generally not recorded, except for tagged fish.

Zone 6 commercial fishery management recognizes three size classes of white sturgeon. Sublegal sturgeon have a fork length of less than 110 cm. These are not legal for commercial sale. White

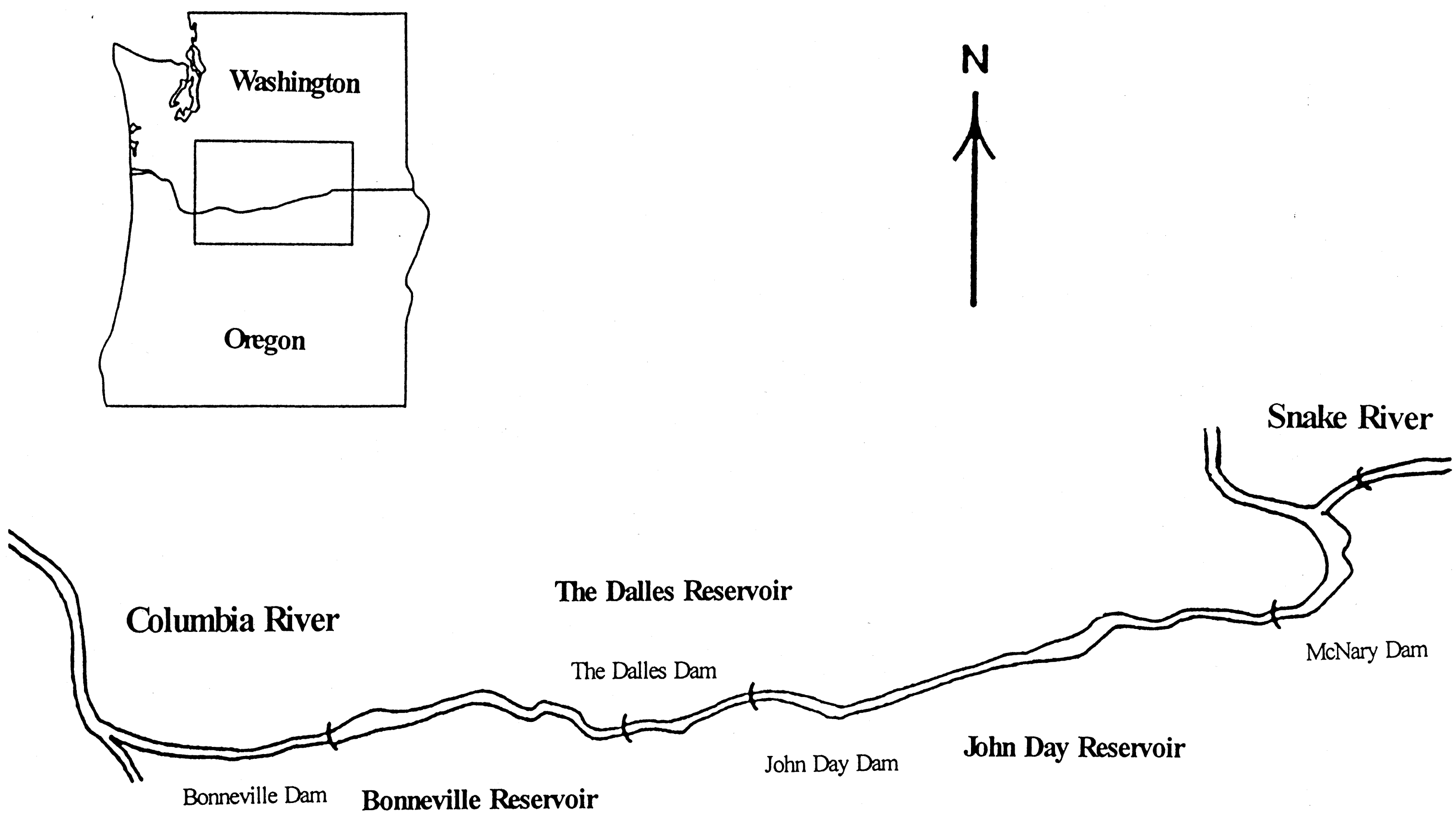

Figure 1. The Columbia and Snake rivers showing the Zone 6 sampling area between Bonneville Dam and McNary Dam. The map is not drawn to scale.

sturgeon equal to or greater than 110 cm but less than 167 cm fork length were legal for retention and commercial sale. Oversized white sturgeon were fish that exceeded 166 cm fork length and were not legal for sale or subsistence. Oversized white sturgeon were generally left in the water since the crews and technicians were not equipped to safely bring such large fish onboard. In addition, treaty Indian fishers can also retain white sturgeon from 82 to 166 cm fork length for subsistence, although most fish retained for subsistence were between 82 and 109 cm fork length. Fish of legal commercial size were generally sold.

After the first week of monitoring, we marked all released white sturgeon by punching a predetermined pattern of holes in a pelvic or anal fin. This was done to determine if individual white sturgeon were being recaptured during the single commercial season. A different punch pattern was used each week.

Data were entered into a database and summarized. Summaries were primarily qualitative and described white sturgeon catch, fishing effort, direct mortality, and incidental species captured. Five white sturgeon caught were not included in the catch and effort analysis since no set data or pull data were recorded for those fish. Catch per effort was calculated as the number of sublegal, legal, oversized, and total number of white sturgeon per day per net. The day was used as the standard of measure for time in catch per effort summaries, since set times were not available for all monitored nets. I calculated a mean number of hours for those 1, 2, and 3 d sets which contained both set and pull times. I multiplied the mean number of hours for the respective number of set days by the total number of nets set for that same number of days (e.g. the 2 d mean by the total number of 2 d sets) for each specific reservoir. I converted the total hours into days by dividing the total by 24 hours.

RESULTS

Monitoring of the 1995 Zone 6 Commercial Fishery

Effort

Commercial tribal fisher efforts in Zone 6 during the 1995 winter commercial season were monitored for a total of 375 set days. John Day Reservoir received the greatest level of monitoring effort at 177 set days, with effort in The Dalles and John Day reservoirs at lower levels (Table 1). Bottom set gillnets, commonly referred to as "diver" gillnets, accounted for 91.5 % of the nets sampled and captured 99.2% of the total sampled white sturgeon catch. Floating gillnets were also sampled (32 set days) and captured 0.8% of the white sturgeon catch.

Since technicians often worked with different fishers on successive days, specific set time data were often unavailable for monitored nets. We attempted to have the fishers record the set times for the technicians, but this effort was not always unsuccessful and was discontinued. Technicians recorded set and pull times for 32% of all sampled nets. The mean set times for 1 d, 2 d, and 3 d sets were 21.8, 46.4, and 75.9 h respectively. Fishers characterized their effort by set days (e.g. 1 set day equals 24 h) rather than set hours. Of the 375 days of effort monitored, 67% of the sets monitored were 2 d sets.

Table 1. Catch and effort summaries for winter gillnet season monitoring effort in Bonneville, The Dalles, and John Day reservoirs, February through March 1995. All net types and mesh sizes are combined by pool and includes all sets. Catch per unit effort (CPUE) is defined as the number of fish caught per 24 h period (e.g. day).

Sites and totals	Hours fished	Days fished	Total sturgeon catch	Total sturgeon catch CPUE (d)
Bonneville	2,288	95	232	2.434
The Dalles	2,469	103	237	2.304
John Day	4,242	177	407	2.303
Total	8,998	375	876	2.337

Daily catch rates for all sets combined was 2.337 fish per hour. There was little variation between daily catch rates per reservoir (Table 1). Pooled data (i.e., all mesh sizes and net types) were substantially less than values some for individual mesh sizes. Mean catches of all sturgeon for a specific size of mesh varied from less than one fish per day to nearly six fish per day (Table 2). Diver nets with 20.3 cm and 22.9 cm stretched mesh were used most frequently and were the most effective (Table 2).

White Sturgeon Catch

The monitoring effort sampled a total of 876 sturgeon, although length data were not collected for all fish (Figure 2). We documented no direct mortality of sturgeon during the monitoring effort, but did note some fish with a reddish coloration on fins and ventral surface of body. Minor injuries including torn fins and lost scutes were noted on some white sturgeon, probably from the capture gear. Sets with a 2 d soak time accounted for 79% of the sampled catch, with 1 d sets contributing 18% and 3 d sets the remaining 3%. Nearly all sampled sturgeon were less than 110 cm fork length. Only 6% of the total sampled catch was comprised of legal or oversized white sturgeon (Figure 2). Sampled white sturgeon ranged from 47 cm fork length to approximately 305 cm fork length. The largest legal white sturgeon we sampled was 134 cm fork length. The mean fork length of legal fish harvested during our monitoring effort was 114 cm, slightly longer than the 110 cm minimum fork length. In addition, monitoring efforts revealed a greater number of white sturgeon were harvested as subsistence fish (N= 126) than for commercial sale (N=49). The mean fork length of harvested subsistence fish was 105 cm, slightly under the legal minimum fork length for commercial sale. The legal catch was highest in John Day Reservoir (N=24) and lowest in The Dalles Reservoir (Table 2).

Technicians sampled 10 white sturgeon that had been previously caught and marked by other researchers. Of the 10 fish, 1 was from Bonneville Reservoir, 1 from John Day Reservoir, and 8

Table 2. Catch and effort summaries for specific mesh sizes with greater than 100 hours of effort per mesh increment for Bonneville, The Dalles, and John Day reservoirs, in February and March 1995. Data in this table are for diver gillnets only and includes all sampled sets.

Site and stretched mesh size (cm)	No. of sets	Hours fished	Fork lengths (cm)			Total catch	Total sturgeon catch CPUE (d)
			<100	110-116	>166		
Bonneville							
21.6	6	179	9	1	0	10	1.345
22.9	43	1,626	185	12	0	197	2.909
25.4	9	321	4	2	0	6	0.449
The Dalles							
20.3	26	1,032	168	2	0	170	3.953
22.9	25	1,100	48	2	0	50	1.091
23.5	3	144	3	0	0	3	0.500
John Day							
20.3	8	342	83	0	0	83	5.824
22.9	62	2,532	268	24	1	293	2.778
23.5	5	360	3	0	0	3	0.200

were from The Dalles Reservoir. Six of the eight fish from The Dalles Reservoir had PIT tags. The remaining four fish for all three reservoirs had external tags (Table 3). All tagged fish sampled were released.

Incidental Catch

We considered fish species other than white sturgeon caught in diver nets to be incidental, since white sturgeon are the target species for this gear. A total of five incidental gamefish were caught in diver gillnets; one walleye *Stizostedion vitreum*, one channel catfish *Ictalurus punctatus*, and three steelhead trout *Onchorynchus mykiss*. The converse was true for floating gillnets, which caught primarily steelhead trout, walleye, and common carp *Cyprinus carpio*, not white sturgeon. A total of seven white sturgeon were caught in floating gillnets that contained 163 common carp, 102 steelhead trout, and 48 walleye from floating gillnets.

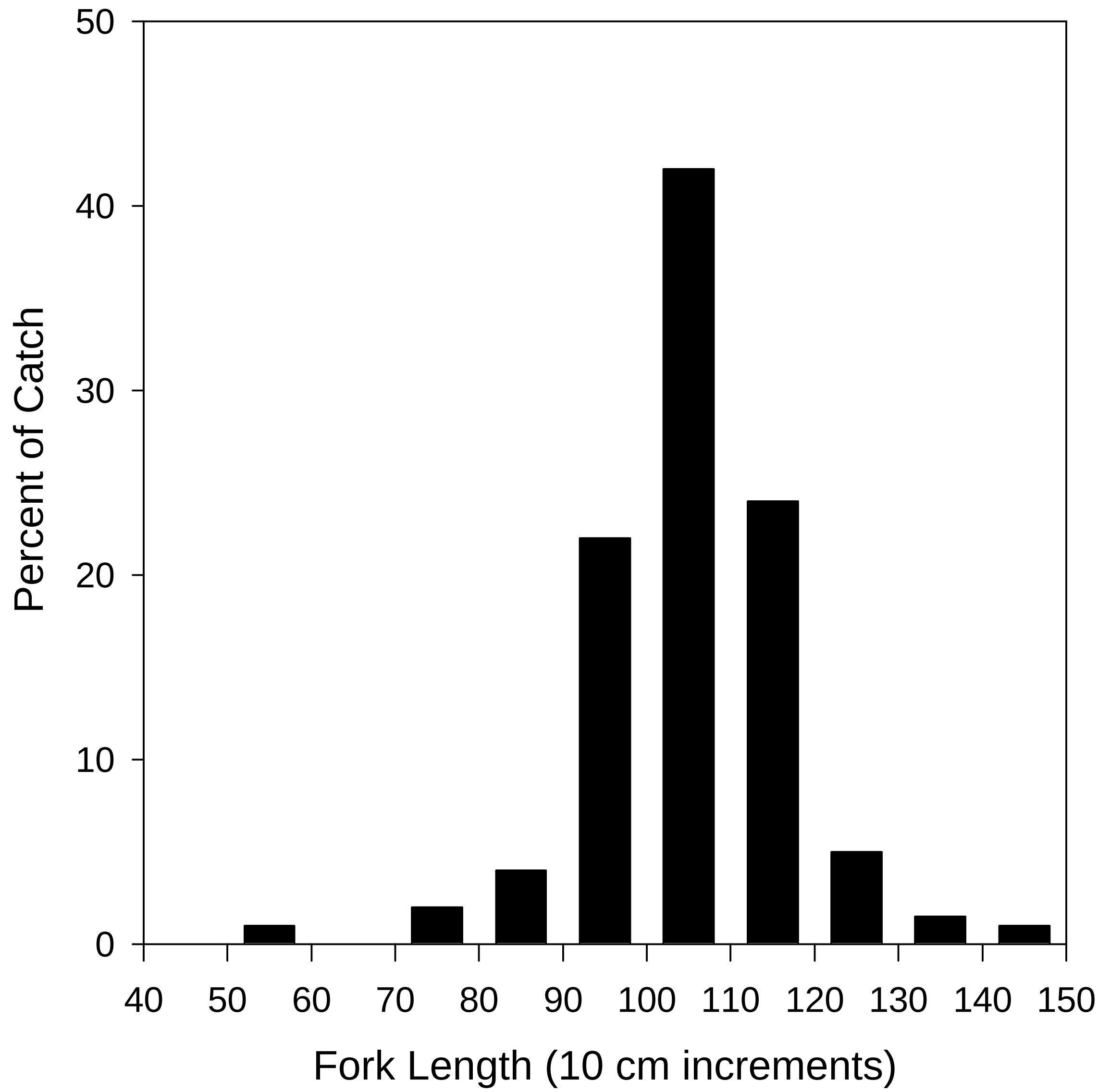

Figure 2. Length-frequency distribution for white sturgeon sampled during the monitoring of the winter commercial gillnet fishery in Bonneville, The Dalles, and John Day reservoirs, February through March 1995.

Table 3. Biological and tag information from white sturgeon sampled during the 1995 Zone 6 winter commercial season monitoring effort. Note: An underlined space within a tag number indicate that a letter(s) or number(s) may be missing. All fish were released.

Reservoir	Total length (cm)	Scute marks	External Tag No.	PIT tag No.
Bonneville	99	2 right, 3 left	B061479	None
The Dalles	104	3 right, 5 left	TD53601	None
The Dalles	111	2 right, 2 & 5 left	__74676	_10297862
The Dalles	100	2 & 5 left	None	__5107612
The Dalles	98	2 right, 3 left	TD52463	None
The Dalles	92	2 right, 2 & 5 left	None	_11104022
The Dalles	92	None	None	_10801847
The Dalles	89	None	None	__6619284
The Dalles	99	2 right, 2 & 5 left	None	__7570325
John Day	110	2 right, 3 left	JD70002	None

DISCUSSION

Monitoring of the 1995 Zone 6 Commercial Fishery

Aside from subsistence and commercial harvest we determined that tribal fishers using diver nets during the winter commercial season did not directly result in juvenile white sturgeon mortality. We did not see any direct mortalities as a result of this gear being deployed, although it is likely that some mortalities do occur. We also determined that diver nets are highly selective for sturgeon, generally catching very few other fish species. This effectiveness on white sturgeon was somewhat surprising since previous research efforts using gillnets to capture white sturgeon for research purposes were not found to be as effective as setlines (Elliott and Beamesderfer 1990). The time of year, mesh size, and set duration were substantially different for the research efforts than for the tribal fishing efforts.

Plans for 1996

We will coordinate with the ODFW and other 86-50 cooperators to use contract tribal fishers and trained technicians to capture, tag, and release white sturgeon in John Day Reservoir in 1996. Moderate to good CPUE, combined with low direct mortality and minimal incidental catch revealed a unique opportunity to use tribal fishers and their crews in ongoing sturgeon population studies in Zone 6. Sturgeon tagged by trained tribal technicians and the associated population data may help to increase the accuracy of population estimates and population dynamics data. In addition, I will assist with completion of the comprehensive strategic framework plan for the management and enhancement of white sturgeon in Zone 6.

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