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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

APRIL 1998 - MARCH 1999

Annual Progress Report 1998

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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM.

ANNUAL PROGRESS REPORT

APRIL 1998 - MARCH 1999

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EXECUTIVE SUMMARY

We report on our progress from April 1998 through March 1999 on determining the effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and on determining the status and habitat requirements of white sturgeon populations in the Columbia and Snake rivers upstream from McNary Dam. The study is a cooperative effort by the Oregon Department of Fish and Wildlife (ODFW; Report A), Washington Department of Fish and Wildlife (WDFW; Report B), U.S. Geological Survey Biological Resources Division (USGS; Report C), U.S. Fish and Wildlife Service (USFWS; Report D), Columbia River Inter-Tribal Fish Commission (CRITFC; Report E), and the University of Idaho (UI; Report F).

This is a multi-year study with many objectives requiring more than one year to complete. Therefore, findings from a given year may be part of more significant findings yet to be reported. Highlights of results of our work from April 1998 through March 1999 are:

Report A

(1) During this reporting period Oregon Department of Fish and Wildlife worked jointly with cooperating agencies to assess distribution and size structure of white sturgeon in Rock Island, Chief Joseph, and Grand Coulee reservoirs, determine feasibility of indexing recruitment using gill nets, and transplant white sturgeon into The Dalles and John Day reservoirs.

(2) In late 1997, 38% of 105 white sturgeon caught with index gill nets in The Dalles Reservoir were classified as young-of-year (YOY) based on length frequency interpretation, and 38% of 219 were classified as YOY in John Day Reservoir. These data suggest recruitment to YOY was achieved in these reservoirs in 1997. Several years of data collection are planned to allow comparison of gill nets and trawls as index gears and to correlate river conditions with recruitment.

(3) In late 1998, 24% of 702 white sturgeon caught with index gill nets in The Dalles Reservoir were YOY based on length frequency interpretation, 5% of 107 were YOY in John Day Reservoir, and 13% of 312 were YOY in Little Goose Reservoir. These data suggest recruitment to YOY was achieved in these reservoirs in 1998.

(4) In late 1998 we transplanted 3,257 white sturgeon (30-90 cm fork length) to The Dalles Reservoir and 5,534 to John Day Reservoir. All transplants were 30-90 cm fork length.

(5) We summarized 1994 - 1998 tag Passive Integrated Transponder (PIT) tag data to estimate re-detection rate. Among 1,504 white sturgeon recaptured after 1 - 1,219 days at large (mean = 435 days), recapture data correctly matched tagging data for 1,474 fish (98.0%). Of the 30 fish recovered that had lost the PIT tag, 21 (70%) resulted from an inability to locate the tag with the scanner and 9 (30%) could not be verified because they were recorded incorrectly at the time of tagging or recapture. (Appendix A-1).

(6) To assist with requests for information on our setline gear and methodologies we summarized detailed gear specifications and procedures in Appendix A-2.Abundance of white sturgeon in The Dalles Reservoir was estimated to be 59,800 fish 70-166 cm fork length, of which 8,100 were within the legal harvest slot (110-137 cm). This is a six-fold increase over the 1994 estimate of 9,700 white sturgeon 70-166 cm. This difference is attributed to possible underestimation in 1994, and to inherent uncertainty with mark and recapture estimates.

Report B

(1) Fishery managers used our projections of estimated harvest to close the retention season in Bonneville Reservoir on April 20th, on June 6th in The Dalles Reservoir, and on November 22nd in John Day Reservoir. An estimated 1,630, 860, and 600 white sturgeon were harvested from each reservoir respectively.

(2) Two hundred and four white sturgeon were caught during a single pass through Lake Roosevelt. We captured seven white sturgeon in Lake Rufus Woods and four white sturgeon in Rock Island Reservoir. The catch was dominated by fish over 20 years of age. The lack of younger fish in all three reservoirs indicated that these populations were severely recruitment limited.

Report C

(1) Habitat suitability curves depicting the suitability of water depths, mean column velocities, and substrates were constructed from telemetry data.

(2) Bottom trawling for juvenile white sturgeon during September and October revealed that recruitment to young of the year occurred in Bonneville, The Dalles, and John Day reservoirs. Modeled estimates of the availability of spawning habitat for 1998 show that conditions were good for spawning.

(3) A manuscript describing the location, timing, and duration of spawning by white sturgeon downstream from Ice Harbor, Little Goose, Lower Monumental, and Lower Granite dams was published in *Northwest Science.*

Report D

(1) Field data collection for white sturgeon spawning and rearing habitat quantification in the Hanford Reach of the Columbia River and the lower Snake River downstream from Lower Granite Dam was essentially completed.

(2) A new underwater video equipment system was used to collect approximately 500 substrate data points and geographic locations in the Hanford Reach.

(3) Hydraulic model calibration for main channel portions of the Hanford Reach neared completion. Tailwater rating curves which will be used to calibrate hydraulic models for the lower Snake River were received from the Corps of Engineers.

(4) Habitat modeling for main channel portions of the Hanford Reach indicated large areas of high quality white sturgeon spawning habitat at low to intermediate flows in uncontrolled or "riffle" areas, particularly in the Priest Rapids Dam tailrace.

Report E

(1) A creel survey of the tribal subsistence hook-and-line sturgeon fishery was initiated to quantify the annual harvest of white sturgeon. Yakama Nation technicians surveyed nine index sites 102 times, counting six fishers at four index sites over the summer and fall sampling season. Anecdotal comments received from local fishers indicated that a recent restriction of the legal size (from a 3-5 ft size range down to a 4-5 ft size range) for subsistence sturgeon fisheries had greatly reduced the incentive of tribal fisheries to participate. Additionally, some confusion existed among fishers regarding which pools were open, due to recent closures of some commercial sturgeon fisheries.

Report F

(1) Genetic analysis of 211 white sturgeon identified five mtDNA haplotypes present upstream from Bonneville Dam, and a sixth haplotype represented by two individuals from the Columbia River downstream from Bonneville Dam. Of five mtDNA haplotypes observed upstream from Bonneville Dam, the most common accounted for 44% of overall D-loop length variation in fish from all sample locations; and the second most common accounted for an additional 30%. The prevalence and relatively wide distribution of haplotypes in this study thus far suggest historical migration and gene flow among larger areas of the Columbia River Basin than currently probable following hydroelectric development.

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 1998 - MARCH 1999

Report A

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

This report includes: Investigations on white sturgeon recruitment to young-of-year in Columbia and Snake River reservoirs and results of full-scale transplant supplementation efforts in The Dalles and John Day reservoirs.

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February 2000

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We thank Susan Hinton, Dennis Umphfres, Lawrence Davis, and Rick Nelson of the National Marine Fisheries Service for coordinating and conducting trawling efforts needed to supplement Zone 6 white sturgeon populations. Recognition is due Bob Becker and Randy Lewis who maintained liberation trucks and transported juvenile white sturgeon to designated release sites in The Dalles and John Day reservoirs. We appreciate the following staff and volunteers who assisted with fish processing during trawl-and-haul: Roy Clark, Matt Howell, Ron Reeves, Bryant Spellman, Jimmy Watts, Susan Beilke, Jim Davies, Doc Hickman, Jim Liddell, Doug Tombelson, Brian Sagmiller, Randy Whitten, Ray Warner, Richard Henningsen, Marilyn Lum, Bert Hoffman, Dennis O'Brien, Steve Sexton, and Wally Nelson. Some white sturgeon tissue samples for toxin analyses were collected by Brad James of Washington Department of Fish and Wildlife and Robert Brooks, Kevleen Melcher, and Jimmy Watts of the Interjurisdictional Fisheries Unit of Oregon Department of Fish and Wildlife. Credit is extended to the United States Geological Survey for providing the digital representation of river shoreline used in Figure 1.

ABSTRACT

This report summarizes data collected on white sturgeon *Acipenser transmontanus* in the Columbia and Snake Rivers to document young-of-year (YOY) recruitment and implement transplant supplementation from fully-seeded to under-seeded habitats. The Dalles, John Day, and Ice Harbor reservoirs were fished with gill nets in 1997 to determine if recruitment to YOY occurred. In John Day Reservoir 84 of 219 (38%) white sturgeon were classified as YOY based on fork length (FL; ≤ 35 cm). In The Dalles Reservoir 40 of 105 (38%) white sturgeon measured ≤ 35 cm FL. These catches suggest successful recruitment in these reservoirs in 1997. Low catches (N=20) of white sturgeon in Ice Harbor Reservoir precluded accurate YOY determination. The Dalles, John Day, and Little Goose reservoirs were sampled with gill nets in 1998. We explored different deployment configurations but focused our effort on nets set singularly. Single net sets resulted in white sturgeon catches where 167 of 702 (24%) measured ≤ 35 cm FL in The Dalles Reservoir, 5 of 107 (5%) in John Day Reservoir, and 42 of 312 (13%) in Little Goose Reservoir suggesting recruitment to YOY was achieved in these reservoirs in 1998.

Full-scale transplant supplementation was implemented by transplanting juvenile white sturgeon captured in the Columbia River downstream of Bonneville Dam into The Dalles and John Day reservoirs to enhance these populations. Using trawl gear, a total of 10,362 white sturgeon were captured in 118 tows. White sturgeon measuring 35-90 cm FL were targeted for transplantation and given an external mark for future identification. Of the 8,799 white sturgeon (≤90 cm FL) transplanted, 3,257 (37%) were released into The Dalles Reservoir and 5,534 (63%) were released into John Day Reservoir.

INTRODUCTION

This annual report summarizes work performed by the Oregon Department of Fish and Wildlife (ODFW) during the period April 1998 through March 1999 in accordance with tasks outlined in the Bonneville Power Administration funded Project 86-50 Performance Work Statement. We report white sturgeon *Acipenser transmontanus* catch data obtained in 1998 during gill-net sampling for young of year (YOY) in The Dalles, John Day, and Little Goose reservoirs. A summary of 1997 YOY gill-net activities in The Dalles, John Day, and Ice Harbor reservoirs is also included in this report to ensure documentation. Trends in recruitment estimates from 1997 and 1998 YOY data will be compared with trends obtained from trawl catch data collected by the U. S. Geological Survey (USGS) to determine the most suitable index of recruitment. Recruitment indices have been correlated with physical conditions including water temperature, total discharge, and available spawning habitat (Parsley and Beckman 1994). Continued monitoring of effects associated with hydropower operations and annual recruitment will augment existing data.

We also describe activities and results of work conducted during this contract period to implement full-scale transplant supplementation of juvenile white sturgeon from high- to low-recruitment populations. This work is based on results identified during a feasibility evaluation conducted from 1993-1997 that documented positive growth, improved condition, and high survival rates of white sturgeon transplanted from the fully-recruited population downstream of Bonneville Dam into The Dalles Reservoir.

Additional tasks performed during this reporting period are included as appendices to this progress report. Results summarizing the long-term retention rate of passive integrated transponder (PIT) tags are presented in Appendix A-1. Appendix A-2 describes current methodology employed by project personnel to capture white sturgeon using setline gear. Periodic inquiries from other agencies have demonstrated the need for an updated summary of our capture techniques. Future requests for documentation will be directed to this reference.

METHODS

Young-of-Year Indexing

Two Columbia River reservoirs and one Snake River reservoir were sampled in 1997 and 1998 with gill nets to determine white sturgeon recruitment to YOY. Each reservoir was subdivided into linearly equal quarters (Table 1). Sampling effort in Columbia River reservoirs was distributed among reservoir quarters at locations near trawl sites sampled by USGS to facilitate statistical comparisons of trends in relative abundance between gill nets and bottom trawls. A summary of this work is provided by Kappenman et al. (this report). Sampling effort and areas sampled in Snake River reservoirs were selected by Washington Department of Fish and Wildlife (WDFW) based upon knowledge of channel morphology and white sturgeon catch data obtained during setline sampling.

In 1997 we sampled The Dalles, John Day, and Ice Harbor reservoirs (Figure 1). Three days of fishing occurred during 10-12 November in Ice Harbor Reservoir, 4 days during 1-4 December in The Dalles Reservoir, and 5 days during 8-12 December in John Day Reservoir.

Table 1. Sampling effort (number of gill-net sets) by linear reservoir quarter for white sturgeon (all lengths) in The Dalles, John Day, and Ice Harbor reservoirs, November-December, 1997 and in The Dalles, John Day, and Little Goose reservoirs, October-November, 1998. A '--' indicates sampling was not conducted.

Set Type Year:Net Type Reservoir	Reservoir Quarter 1	2	3	4	Total
Single Sets					
1997:Standard					
The Dalles	8	6	14	7	35
John Day	9	9	12	10	40
Ice Harbor	6	3	8	4	21
1998:Standard					
The Dalles	7	9	16	5	37
John Day	9	9	12	10	40
Little Goose	3	4	5	4	16
1998:Experimental					
The Dalles	2	3	3	3	11
John Day	1	1	--	--	2
Little Goose	3	3	2	4	12
Paired Sets					
1998:Standard					
The Dalles	1	1	2	--	4
John Day	1	1	2	1	5
1998:Experimental					
The Dalles	1	1	2	--	4
John Day	1	1	2	1	5

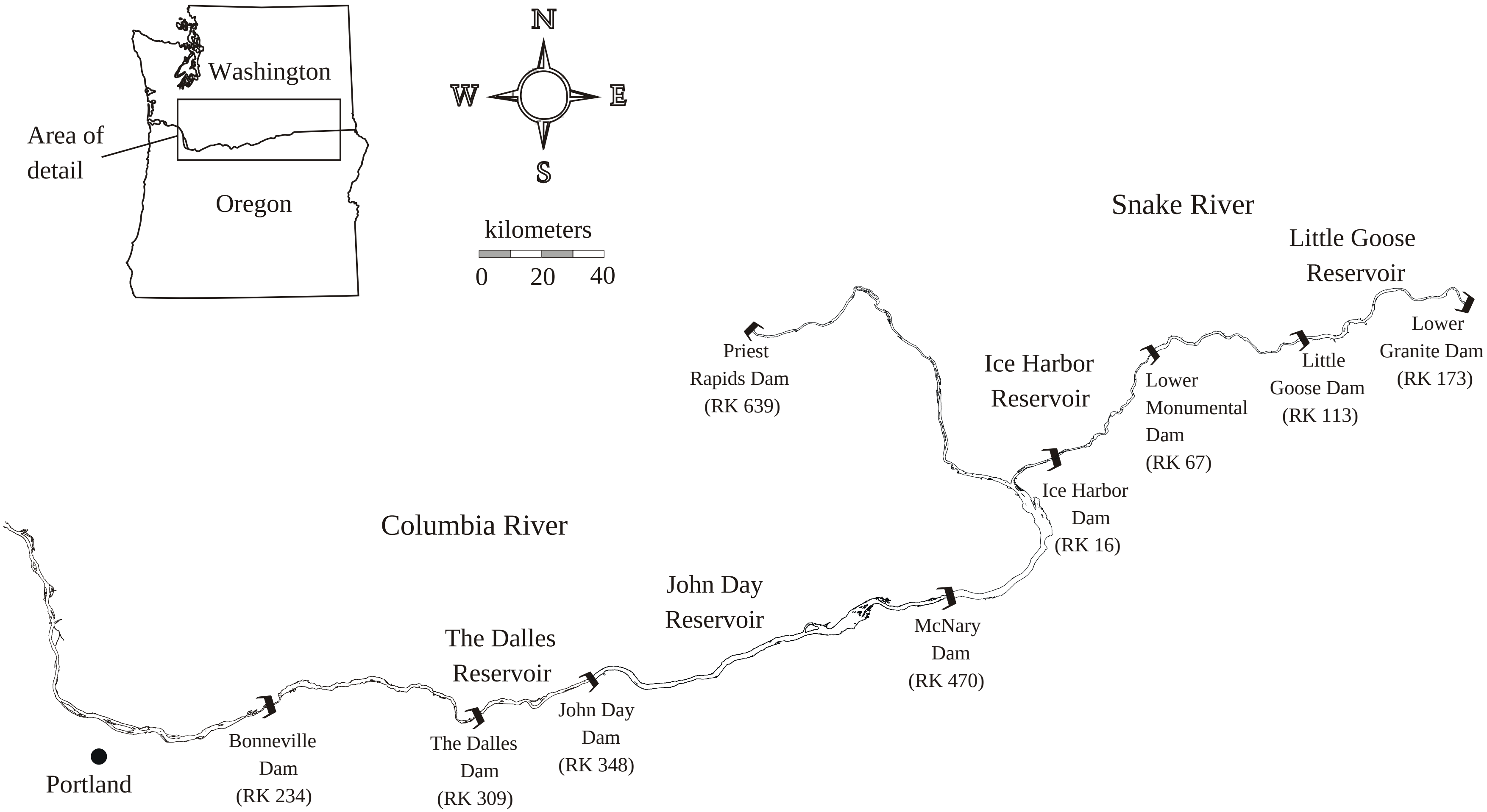

Figure 1. The Columbia River upstream to Priest Rapids Dam and the Snake River upstream to Lower Granite Dam. The scale is approximate. RK = river kilometer.

White sturgeon were captured using multifilament nylon gill nets measuring 91.4 m in length by 3.7 m in depth. Standard nets consisted of six 15.2 m sections of alternating 8.9-cm and 10.2-cm stretched mesh panels. Nets were fished on the river bottom overnight for 18.9 h to 26.2 h (average 22.9 h) in The Dalles Reservoir, 19.2 h to 23.8 h (average 21.7 h) in John Day Reservoir, and 19.8 h to 28.6 h (average 23.3 h) in Ice Harbor Reservoir.

In 1998 we sampled The Dalles, John Day, and Little Goose reservoirs (Figure 1). Four days of fishing occurred during 19-22 October in Little Goose Reservoir, 5 days during 2-6 November in The Dalles Reservoir, and 6 days during 16-21 November in John Day Reservoir. We supplemented the standard nets used in 1997 with experimental nets made entirely of 5.1-cm stretched mesh netting in an effort to capture more YOY white sturgeon. Sampling effort focused on standard nets set singly to permit comparison with 1997 data, however, several paired sets consisting of an standard net set adjacent to an experimental net were fished in The Dalles and John Day reservoirs. We speculated that smaller mesh (experimental nets) would capture greater numbers of YOY white sturgeon. Small sample sizes did not permit statistical comparisons of paired net catches. Overall, nets were fished on the river bottom overnight for 18.2 h to 25.8 h (average 22.8 h) in The Dalles Reservoir, 17.6 h to 23.9 h (average 21.5 h) in John Day, and 16.3 h to 29.8 h (average 21.7 h) in Little Goose Reservoir.

We measured fork length (FL) and total length, and looked for tags, tag scars, and scute marks on every captured white sturgeon. Gear specifications, particularly mesh size (8.9 cm or 10.2 cm) in 1997 or net type (standard or experimental) and set type (single or paired) in 1998, were recorded. Incidentally captured species were enumerated (Appendix A-3).

We classified juvenile white sturgeon as YOY when FL measured ≤ 35.0 cm. Though YOY white sturgeon can not be defined by an absolute fork length interval, a 35.0 cm upper limit provided a convenient classification scheme until USGS can complete interpretation of the length-frequency distributions.

We calculated mean catch per unit effort (CPUE) for each reservoir quarter as the ratio of white sturgeon catch (all lengths) per gill net set. Positive sets were calculated as the ratio of sets where at least one YOY white sturgeon (FL≤ 35 cm) was captured to the total number of sets. The derivation of this value is similar to positive tows (*Ep*) described by Counihan et al. (in press).

Trawl-and-Haul Supplementation

During late October and November, we transplanted juvenile white sturgeon captured in the Columbia River downstream of Bonneville Dam into The Dalles and John Day reservoirs to supplement these populations (Figure 1). Equipment and techniques used for fish collection and transportation were virtually identical to work conducted in 1995 (North et al. in press). Trawling was conducted by staff of the National Marine Fisheries Service (NMFS), which provided the trawling vessel (12.5 m) and gear (McCabe in press). Fish processing and transportation was conducted primarily by staff of ODFW with assistance from many volunteers.

Trawling was conducted in the navigation channel of the Columbia River between river kilometers (RK) 209-212 because this area consistently produced high catches of white sturgeon during earlier phases of this study (Table 2). Trawl mesh size was the same as that used during previous work; 38.0 mm (stretched measure) with a 10.0-mm liner inserted in the cod end of the net (McCabe in press). The number and duration of tows conducted each day varied with catch rate and the amount of time available. Adverse weather conditions and mechanical difficulties with the trawl occasionally decreased the number of trawls completed.

White sturgeon were removed from the trawl after completion of each tow and placed into two 520-L containers with circulating fresh water onboard the trawl vessel. White sturgeon obviously smaller or larger than the target size (35-90 cm FL) were typically released as each trawl was emptied. Fish species other than white sturgeon were identified, counted and released. If few white sturgeon were caught in a net tow, they were held onboard the capture vessel while additional trawls were completed. Retained fish were delivered to the processing crew stationed onboard a contracted 7.3 x 21.9-m barge propelled by a 15.2-m tugboat (the same contractor and equipment were used in 1995). Plastic baskets were used to transfer fish from the trawl vessel to four, 520-L containers on the barge. Each tote received a minimum of 37.8 L/minute of pumped fresh river water.

Although most transported fish were 35-90 cm FL, some fish <35 cm FL were transported on days when catches of larger fish were low. To decrease handling and increase efficiency, we only measured FL (cm) of approximately 100 fish daily to estimate the length frequency of transported fish. All transported fish received an external mark (removal of the eighth right lateral scute) for future identification.

After processing, white sturgeon were loaded into either a 10,598-L or 13,247-L ODFW fish transportation truck parked on the processing barge which also served to ferry these vehicles between the fishing area and a boat ramp at RK 226. The transport trucks were rotated daily with the loaded vehicle being replaced by the empty truck which remained on the barge overnight. These vehicles were equipped with supplemental oxygen systems and water circulating pumps to maintain adequate dissolved oxygen levels. The target tank-loading density was ≤0.09 kg/L (approximately 1,000 fish). A synthetic fish protectant (Poly Aqua[1]) was added to the transport water at 1:7,570 to help offset loss of mucus during transportation. River and transport vessel water temperatures (°C) and dissolved oxygen levels (ppm) were monitored irregularly (Table 3).

Release sites in The Dalles Reservoir were Celilo Park (RK 325) in Oregon and Maryhill State Park (RK 338) in Washington. In John Day Reservoir, all fish were released from the Oregon side of the Columbia River at either the Arlington Boat Ramp (RK 390), the Boardman Boat Ramp (RK 434), an unimproved ramp near the ODFW Irrigon Fish Hatchery (RK 450), the Irrigon Boat Ramp (RK 455), or the Umatilla Boat Ramp (RK 468).

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

Table 2. Effort and catch of juvenile and sub-adult white sturgeon captured in the Columbia River downstream of Bonneville Dam (river kilometers 209-212) during October and November, 1998. Data for other years are included for comparison. 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
USGS[c]	3	14	358	25.6	14.0	--
1994						
NMFS[b]	15	59	3,428	58.1	9.9	19.5
USGS[c]	5	22	365	16.6	10.0	--
1995						
NMFS[b]	12	102	5,974	58.6	10.4	20.3
1998						
NMFS[b]	14	118	10,362	87.8	8.6	17.8

[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] U. S. Geological Survey-Biological Resources Division.

Table 3. Transport conditions of subadult white sturgeon collected in the Columbia River downstream of Bonneville Dam and transplanted to The Dalles and John Day reservoirs by Oregon Department of Fish and Wildlife during October and November, 1998. Hyphens (--) indicate missing data.

Month And Day	Number of fish transported	Number of mortalities	Number of fish released	Maximum time in tanker[a] (h:min)	Release reservoir and (location)[b]	River temp. (°C) (min/max)	Tank temp. (°C) (min/max)	Tank DO (ppm)[c] (min/max)	Transport tank volume (L)	Loading density[d] (kg/L)
Oct. 13	299	0	299	5:30	The Dalles (A)	--/--	16.8/16.8	14.8/30.7	10,598	0.02
Oct. 14	460	0	460	8:30	John Day (A)	--/--	--/--	9.4/21.0	13,247	0.03
Oct. 15	951	0	951	10:00	John Day (B)	15.9/--	15.6/16.1	15.3/20.8	10,598	0.09
Oct. 19	935	1	934	8:50	The Dalles (A)	--/--	12.2/13.9	12.7/14.6	13,247	0.06
Oct. 20	598	0	598	10:20	John Day (C)	14.3/15.5	14.3/14.3	17.9/20.9	10,598	0.05
Oct. 21	548	1	547	10:45	John Day (D)	--/--	12.8/15.5	12.3/15.2	13,247	0.04
Oct. 22	971	0	971	7:55	John Day (E)	14.1/14.6	14.0/14.2	11.3/19.9	10,598	0.08
Oct. 26	456	0	456	9:10	The Dalles (A)	15.5/--	15.3/16.0	12.5/17.2	13,247	0.03
Oct. 27	164	0	164	9:00	The Dalles (B)	14.3/--	14.5/15.0	24.0/31.2	10,598	0.01
Oct. 28	615	0	615	8:45	The Dalles (A)	14.2/--	14.0/14.7	15.0/19.5	10,598	0.05
Oct. 29	596	0	596	10:30	John Day (E)	15.0/--	14.9/14.9	15.5/19.0	13,247	0.04
Nov. 02	739	1	738	9:00	John Day (A)	13.2/--	12.9/13.8	14.8/20.2	10,598	0.06
Nov. 03	793	4	789	10:30	The Dalles (B)	14.0/--	14.0/--	12.4/18.1	13,247	0.05
Nov. 04	674	1	673	11:00	John Day (D)	14.0/--	14.0/--	13.4/27.0	13,247	0.04
Sum	8,799	8	8,791							
Mean	628	<1	628	9:16		14.6	14.6	17.7		0.05

[a] This value represents the elapsed time between placement of the first sturgeon into the tanker until the time of release.

[b] Release locations in The Dalles Reservoir were: A) Celilo Park Boat Ramp (river kilometer (RK) 325); and B) Maryhill State Park Boat Ramp (RK 338). Release locations in John Day Reservoir were: A) Arlington Boat Ramp (RK 390); B) Boardman Boat Ramp (RK 434); C) an unimproved boat ramp near the Oregon Department of Fish and Wildlife Irrigon Fish Hatchery (RK 450); D) Irrigon Boat Ramp (RK 455); and E) Umatilla Boat Ramp (RK 468).

[c] Daily measurements were taken irregularly.

[d] Loading densities were based on an estimated average weight (0.86 kg) of the mean length of fish transported (50.2 cm fork length).

RESULTS

Young-of-Year Indexing

1997

In The Dalles Reservoir standard gill nets captured 219 white sturgeon of which 138 (63%) were caught in 8.9-cm mesh and 81 (37%) were caught in 10.2-cm mesh (Table 4). Fork lengths for white sturgeon captured in 8.9-cm mesh ranged from 19.7-115.0 cm whereas the 10.2-cm mesh captured white sturgeon with FL ranging from 22.8-107.0 cm (Figure 2). Approximately 42% (58) of the white sturgeon captured in the 8.9-cm mesh were ≤ 35.0 cm FL compared to 32% (26) of the white sturgeon captured in the 10.2-cm mesh. Catch per unit effort was 7.9 fish per set in the smaller mesh, 4.6 fish per set in the larger mesh, and 6.3 fish per set overall (Table 5). The proportion of positive sets for YOY white sturgeon using standard gill nets was 0.74 in The Dalles Reservoir.

In John Day Reservoir standard gill nets caught 105 white sturgeon; 59 (56%) fish in 8.9-cm mesh and 46 (44%) fish in 10.2-cm mesh. The smaller mesh captured white sturgeon measuring 20.3-114.0 cm FL but 48% (28) were ≤ 35.0 cm FL. The larger mesh caught white sturgeon measuring 24.5-76.5 cm FL of which 26% (12) measured ≤ 35.0 cm. Total CPUE was 2.6 fish per set overall, 3.0 fish per set in 8.9-cm mesh and 2.3 fish per set in 10.2-cm mesh. The proportion of positive sets for YOY white sturgeon using standard gill nets was 0.53 in John Day Reservoir.

Standard gill nets set in Ice Harbor Reservoir captured 12 white sturgeon in 8.9-cm mesh and 8 white sturgeon in 10.2-cm mesh. Fork length intervals of white sturgeon ranged from 39.0-142.0 cm for the smaller mesh and 40.0-111.0 cm for the larger mesh. The CPUE was 1.1 fish per set for 8.9-cm mesh, 0.8 fish per set for 10.2-cm mesh, and 1.0 fish per set overall.

1998

In The Dalles Reservoir 567 white sturgeon were captured using single standard nets and 135 were captured using single experimental nets. Standard nets captured fish measuring 22.6-105.0 cm FL with 14% (78) measuring ≤ 35.0 cm (Figure 3). The experimental nets captured fish ranging from 18.0-64.2 cm FL with 66% (89) of the catch measuring ≤ 35.0 cm. Mean catch of white sturgeon per gill net set was 15.3 and 12.3 for standard and experimental nets, respectively. The proportion of positive sets for YOY white sturgeon in The Dalles Reservoir was 0.65 using standard gill nets and 1.00 using experimental gill nets.

In John Day Reservoir single standard gill nets captured 107 white sturgeon and single experimental nets captured no white sturgeon. White sturgeon fork lengths ranged from 24.9-103.0 cm but only 5% (5) of the catch measured ≤ 35.0 cm. Catch rate was 2.7 fish per net set with rates highest in the upper half of the reservoir. The proportion of positive sets for YOY white sturgeon was 0.08 in John Day Reservoir.

Table 4. Gill net catches of white sturgeon (all lengths) by linear reservoir quarter in The Dalles, John Day, and Ice Harbor reservoirs, November-December, 1997 and in The Dalles, John Day, and Little Goose reservoirs, October-November, 1998. A '--' indicates sampling was not conducted.

Set Type / Year:Net Type / Reservoir	Reservoir Quarter 1	2	3	4	Total
Single Sets					
1997:Standard (8.9-cm mesh)[a]					
The Dalles	28	38	43	29	138
John Day[b]	1	9	25	24	59
Ice Harbor	4	1	5	2	12
1997:Standard (10.2-cm mesh)[a]					
The Dalles	35	9	20	17	81
John Day	0	9	26	11	46
Ice Harbor	1	1	4	2	8
1998:Standard					
The Dalles	219	129	156	63	567
John Day	1	0	57	49	107
Little Goose	3	10	17	216	246
1998:Experimental					
The Dalles	52	41	16	26	135
John Day	0	0	--	--	0
Little Goose	0	3	0	63	66
Paired Sets					
1998:Standard					
The Dalles	25	15	39	--	79
John Day	0	0	23	5	28
1998:Experimental					
The Dalles	17	18	16	--	51
John Day	0	0	8	1	9

[a] Combined index catch values correspond to one set of effort values.

[b] Totals do not include one white sturgeon captured in quarter 2 because mesh size was not specified.

Table 5. Mean catches of white sturgeon (all lengths) per gill net by linear reservoir quarter in The Dalles, John Day, and Ice Harbor reservoirs, November-December, 1997 and in The Dalles, John Day, and Little Goose reservoirs, October-November, 1998. A '--' indicates sampling was not conducted.

Set Type Year:Net Type Reservoir	Reservoir Quarter 1	2	3	4	All Quarters
Single Sets					
1997:Standard					
The Dalles	7.9	7.8	4.5	6.6	6.3
John Day	0.1	2.1	4.3	3.5	2.7
Ice Harbor	0.8	0.7	1.1	1.0	1.0
1998:Standard					
The Dalles	31.3	14.3	9.8	12.6	15.3
John Day	0.1	0.0	4.8	4.9	2.7
Little Goose	1.0	2.5	3.4	54.0	15.4
1998:Experimental					
The Dalles	26.0	13.7	5.3	8.7	12.3
John Day	0.0	0.0	--	--	0.0
Little Goose	0.0	1.0	0.0	15.8	5.5
Paired Sets					
1998:Standard					
The Dalles	25.0	15.0	19.5	--	19.8
John Day	0.0	0.0	11.5	5.0	5.6
1998:Experimental					
The Dalles	17.0	18.0	8.0	--	12.8
John Day	0.0	0.0	4.0	1.0	1.8

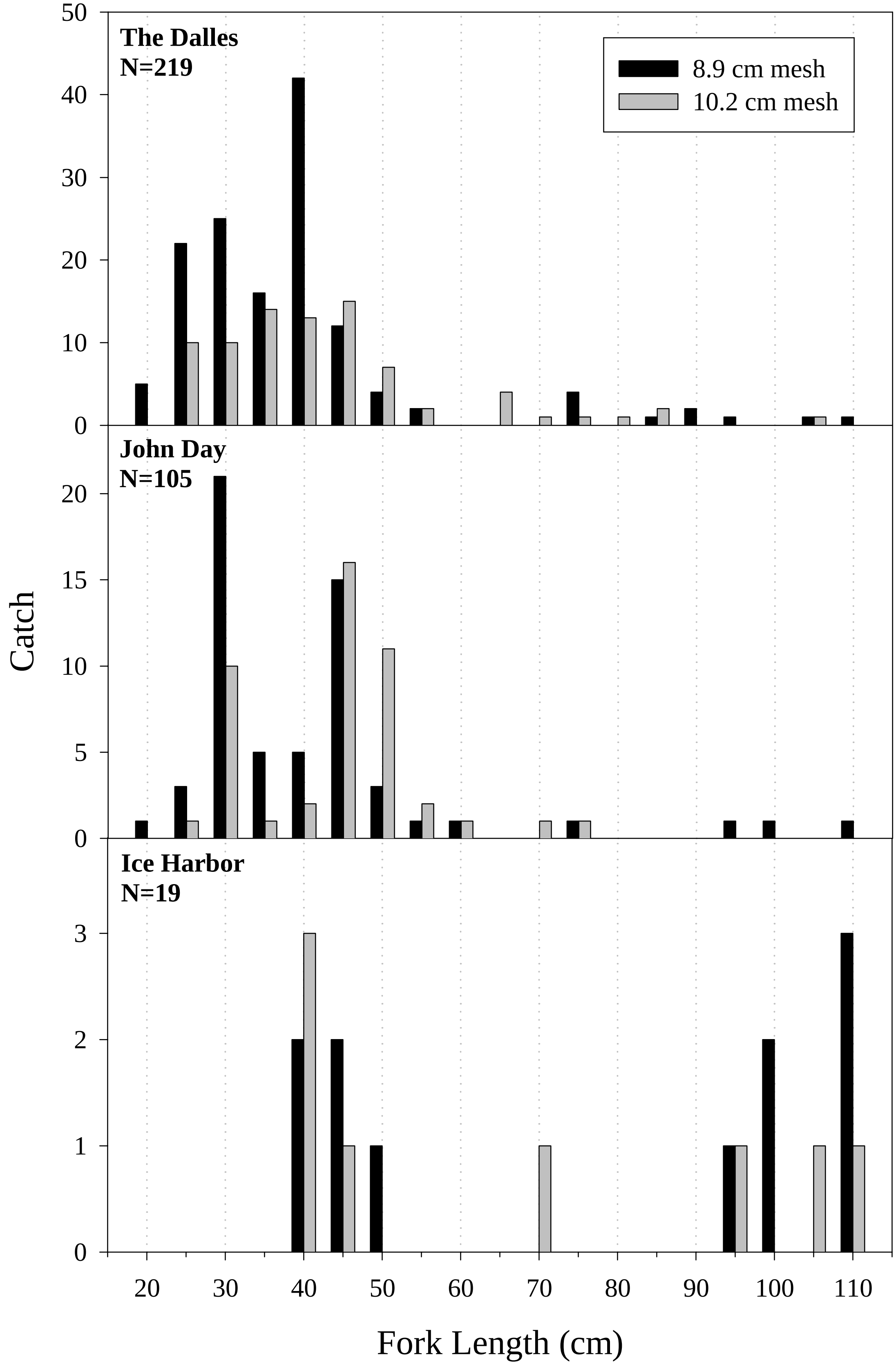

Figure 2. Frequency of white sturgeon collected with standard gill nets in The Dalles, John Day, and Ice Harbor reservoirs, 1997.

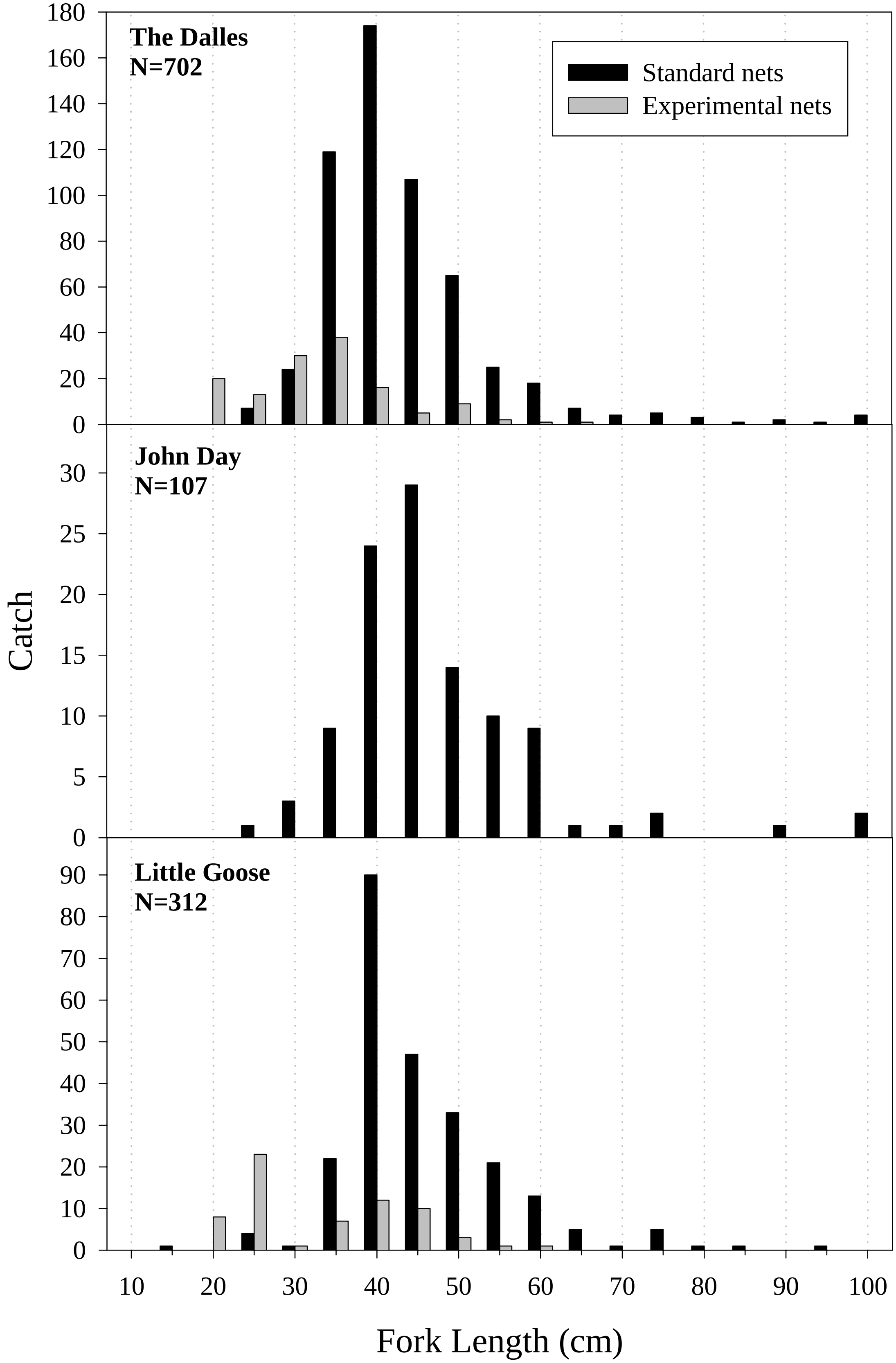

Figure 3. Frequency of white sturgeon collected with single gill net sets in The Dalles, John Day, and Little Goose reservoirs, 1998.

White sturgeon catch in Little Goose Reservoir totaled 246 fish in single standard nets and 66 fish in single experimental nets. Standard nets caught white sturgeon 14.3-94.5 cm FL with 4% (10) measuring ≤ 35.0 cm. Experimental nets caught white sturgeon 19.6-59.0 cm and nearly half (49%) measured ≤ 35.0 cm. Mean catch rate of white sturgeon using standard nets (15.4) was threefold higher than experimental nets (5.5). The proportion of positive sets for YOY white sturgeon in Little Goose Reservoir was 0.31 using standard gill nets and 0.33 using experimental gill nets.

Paired sets resulted in white sturgeon catches of 79 in standard nets and 51 in experimental nets set in The Dalles Reservoir and 28 in standard nets and 9 in experimental nets set in John Day Reservoir. In The Dalles Reservoir 69% (35) of the experimental net catch measured ≤ 35.0 cm FL compared to 11% (9) of the standard catch (Figure 4). In John Day Reservoir 33.3 % (3) of white sturgeon captured in experimental nets measured ≤ 35.0 cm FL compared to 7% (2) in standard nets.

Trawl-and-Haul Supplementation

The NMFS caught 10,362 white sturgeon in 118 trawl tows (87.8 fish per net tow; Table 2). Mean trawl duration was 8.6 minutes at an average depth of 17.8 m. Mean daily catch rates of white sturgeon ranged from 17 to 164 fish/trawl. White sturgeon ≤ 138 cm FL including YOY and adults were captured although fish of the target size group (35-90 cm FL) comprised the majority (85%) of the catch (Figure 5). Although white sturgeon were the most common fish species captured, the following species (and catch) were also observed: American shad *Alosa sapidissima* (1,657), peamouth *Mylocheilus caurinus* (2,499), northern pikeminnow *Ptychocheilus oregonensis* (338), leopard dace *Rhinichthys falcatus* (28), redside shiner *Richardsonius balteatus* (4), largescale sucker *Catostomus macrocheilus* (883), unidentified bullhead *Ameiurus* sp. (1), unidentified catfish *Ictalurus* spp. (4), sand roller *Percopsis transmontana* (460), prickly sculpin *Cottus asper* (83), smallmouth bass *Micropterus dolomieu* (2), yellow perch *Perca flavescens* (3), and starry flounder *Platichthys stellatus* (3).

Of the 8,799 white sturgeon (≤90 cm FL) transplanted, 3,257 (37.0%) were released into The Dalles Reservoir and 5,534 (63.0%) were released into John Day Reservoir. Although no mortalities were observed during capture and processing, eight (0.1%) of the transported fish died as a result of being lodged in oxygen supply lines inside the liberation tank at release. Most (98.8%) of the transplanted fish were 35-90 cm FL although 17 fish were <35 cm FL. The majority of white sturgeon (70.7%) that were transported to The Dalles Reservoir were released at Celilo Boat Ramp. Releases into John Day Reservoir were distributed more evenly among the five release sites with most fish (28.3%) released at the Umatilla Boat Ramp. Mean (±SE) fork length of transplanted fish was 50.2 cm (±0.28) based on measurements of 1,402 (16.0%) of the transplanted fish.

Daily maximum transport tank loading densities ranged from 0.01-0.09 kg/L (mean=0.05 kg/L) in response to fluctuations in catch rate and tank volume (Table 3). Daily maximum holding duration in the transport tanker ranged from 5.5-11.0 hours depending on catch rate and distance to the release site.

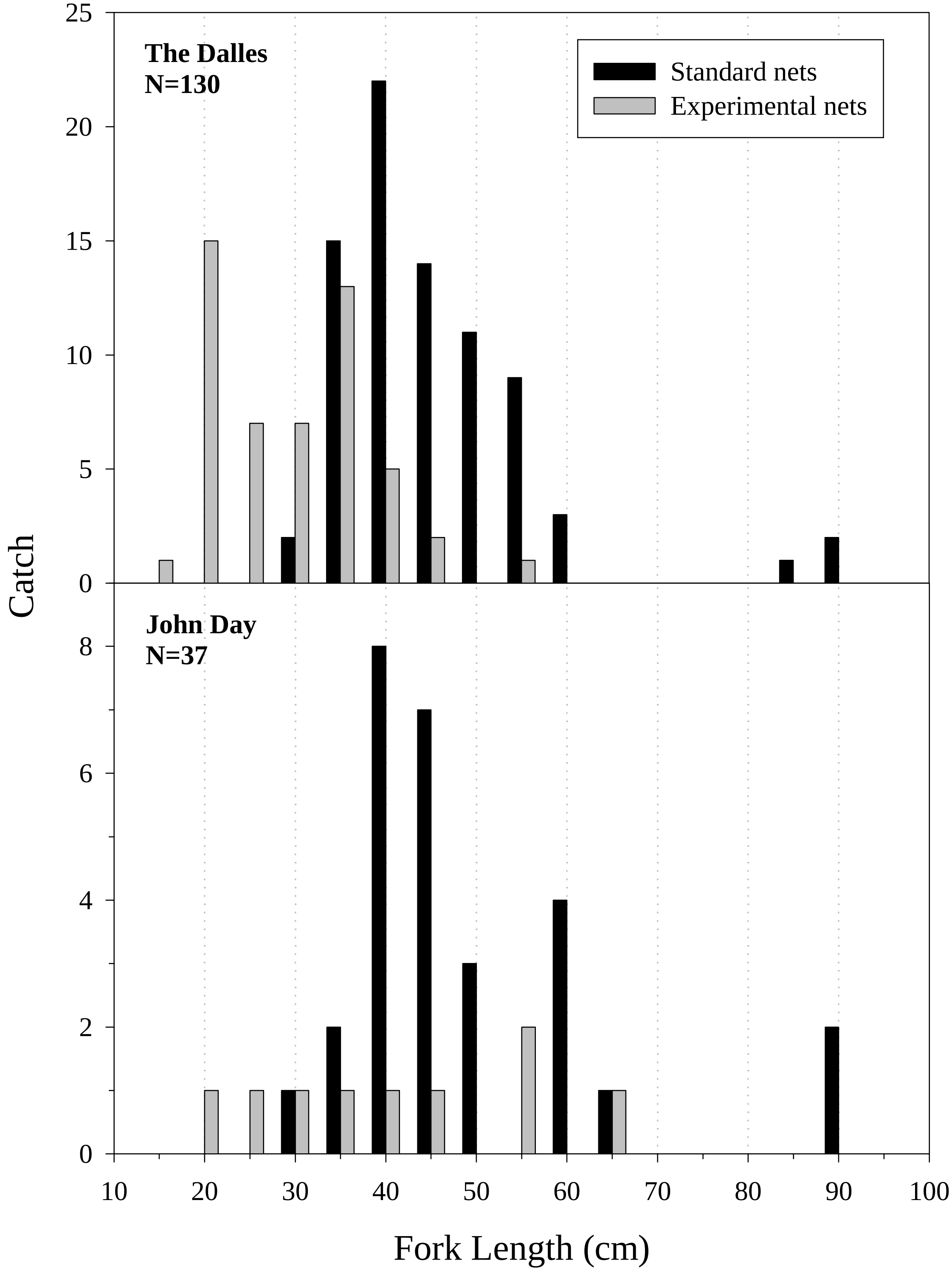

Figure 4. Frequency of white sturgeon collected with paired gill net sets in The Dalles and John Day reservoirs, 1998.

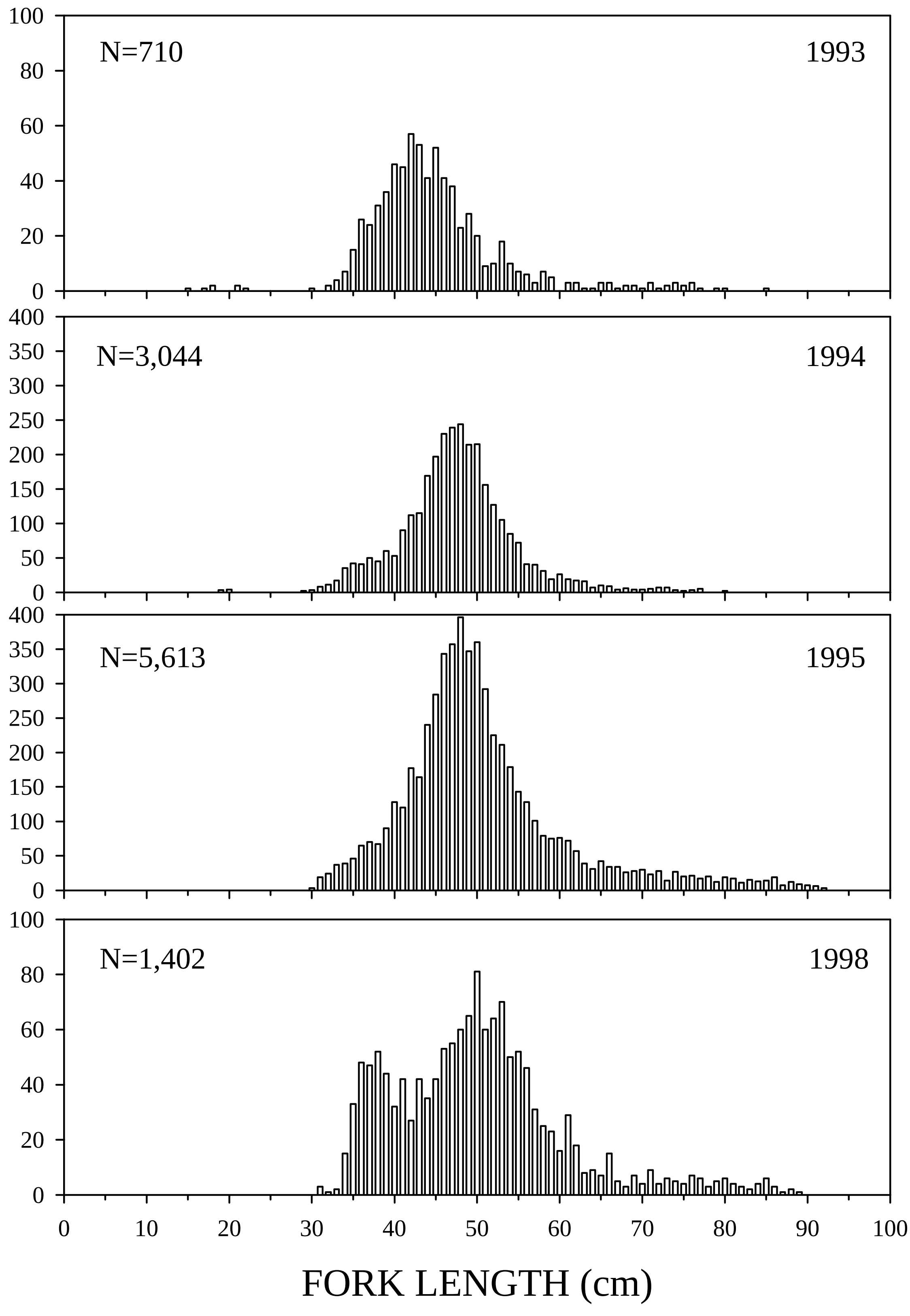

Figure 5. Length frequencies of white sturgeon collected downstream of Bonneville Dam (river kilometers 209-212) during October and November, 1993-1998. Length measurements were only collected from a sub-sample of the catch in 1993 and 1998.

DISCUSSION

Young-of-Year Indexing

Capture of white sturgeon measuring ≤ 35.0 cm FL suggests recruitment to YOY occurred in The Dalles and John Day reservoirs in 1997 and in The Dalles, John Day, and Little Goose reservoirs in 1998. Gill nets captured 5 white sturgeon measuring 39.0-42.0 cm FL in Ice Harbor Reservoir during 1997, however, insufficient length frequency data prohibits classifying these fish as YOY.

Catch data indicate that smaller-mesh nets are more effective at targeting YOY white sturgeon than larger-mesh nets. Evidence includes information collected during 1997 when 8.9-cm mesh caught more white sturgeon and greater numbers of smaller (FL ≤ 35.0 cm) white sturgeon than 10.2-cm mesh. In 1998 larger-mesh nets caught greater numbers of white sturgeon than smaller-mesh nets; however, the smaller-mesh nets captured greater numbers of YOY white sturgeon. Length-frequency distributions of white sturgeon captured in paired nets set in 1998 illustrate that smaller white sturgeon are captured in smaller-sized mesh.

Minimal personnel training, ease of deployment, and adequate white sturgeon catches suggest that gill nets may be suitable gear for documenting the relative abundance of YOY white sturgeon. In some cases, however, bycatch of other fish may limit the use of this gear. Future sampling will utilize 5.1-cm stretch mesh nets exclusively because they appear to better target YOY white sturgeon. An additional benefit of smaller mesh is that it may reduce incidental catch of salmonids (*Onchorhynchus* spp.). This is a particular concern for those salmonid stocks designated as threatened under Endangered Species Act guidelines. Catch data from the smaller-mesh nets will then be compared to trawl catch data from USGS to determine if trends in abundance of YOY are similar. Some habitats preclude the use of certain gear types and it may become apparent that a combination of sampling with gill nets and trawls will prove most practical.

Trawl-and-Haul Supplementation

This season's effort was very successful even though we did not fulfill our pre-season goal of transplanting 10,000 white sturgeon. The daily average catch rate exceeded that of previous sampling in this area and would have been sufficient to reach our goal if we had not voluntarily reduced the number of days fished (North et al. in press). Catch rates were sustained throughout the capture period indicating our removals were not rapidly depleting this size group of fish. Although trawl gear did collect a substantial number of incidental species, no salmonids were handled and most white sturgeon captured were within the desired size range.

The trawl vessel, barge, tugboat, and liberation trucks all operated reliably and in combination, and served as a safe and efficient means of catching and transporting large numbers of fish. Although we have investigated alternative transport methods (North et al. in press), we feel our current approach is the best method for transporting large numbers of white sturgeon. Reductions in the size of either the trawl vessel or barge would likely increase cancellations due to inclement weather. Smaller capacity transport trucks would result in increased loading densities or limit the number of fish that could be transported each day.

Some changes instituted this year improved overall efficiency of the project. By incorporating two transport vehicles, we were able to prepare for the following day and therefore begin fishing earlier. This also condensed personnel work schedules because a driver was not required to load a truck onto the barge each morning. Fish processing was less time consuming because we discontinued using PIT tags, oxytetracycline injections, and measuring the weight and length of the entire catch.

We are currently satisfied with this transport system and substantial changes to the process in the future are unlikely. Although we did not experience any lost time or cancellations due to mechanical breakdowns or inclement weather, scheduling additional sampling days should be considered to account for these potential events.

OTHER ACTIVITIES

Toxin Analyses Efforts

In 1994, we initiated a cooperative study with ALTA Analytical Laboratory (ALTA) to examine levels of polychlorinated dibenzo-p-dioxins (PCDD’s), dibenzofurans (PCDF’s), and biphenyls in ovarian tissue samples of Columbia River white sturgeon. From June 1994 through March 1997, 19 tissue samples were obtained and transferred to ALTA. Most samples (12) were collected from commercially-harvested fish, although 5 samples were collected from surgical biopsy of live fish, and 2 samples were obtained from natural mortalities. Preliminary laboratory analyses have been conducted, but results are not yet available. This study has been protracted due to the difficulty of obtaining a sufficient number of samples. We will continue efforts to obtain results of laboratory analyses.

Master Plan

In January 1997 ODFW, WDFW, and Columbia River Inter-Tribal Fish Commission (CRITFC) staff met with Northwest Power Planning Council (NPPC) staff to determine if transplanting white sturgeon from the Columbia River downstream of Bonneville Dam to The Dalles and John Day reservoirs trigger the "3-step process" developed by the NPPC to ensure compliance with the National Environmental Policy Act (NEPA). The first of the 3 steps in the process is to develop a "master plan" as outlined in NPPC measure 7.4B.1 (NPPC 1994). The master plan would summarize environmental impacts and production goals associated with transplanting white sturgeon. Those in attendance determined that transplanting fewer than 12,000 juvenile white sturgeon annually a distance less than 200 km does not trigger the 3-step process. Instead, it warrants a Categorical Exclusion under NEPA (letter dated February 20, 1998 from John Brigotti, Chair, Fish and Wildlife Committee, NPPC -- "Re: White Sturgeon Restoration and Enhancement in the Columbia and Snake Rivers Upstream from Bonneville Dam"). Since that finding we have not worked on preparing a master plan. However, we will consult with NPPC staff before substantial increases in the number of fish transplanted annually are called for.

Genetics Sample Collection

To date ODFW and WDFW have provided over 700 samples, collected from ten Columbia and Snake River reaches, to University of Idaho staff (Table 6). The samples will be used by BPA-funded project number 9902200 -- "Assessing Genetic Variation Among Columbia Basin White Sturgeon Populations."

Table 6. Tissue samples collected by Oregon and Washington departments of fish and wildlife for laboratory analyses of DNA through September 1999. All tissue samples, except John Day blood and 1999 Bonneville fin tissue, have been transferred to the Aquaculture Research Institute at the University of Idaho (BPA project 9902200).

		Number of Samples	
Reservoir or Reach	Year	Blood	Fin tissue
Columbia River			
Estuary	97-99	100+	60
Bonneville Reservoir	1999	0	390
The Dalles Reservoir	1997	0	60
John Day Reservoir	1996	100+	60
McNary Reservoir/Hanford Reach	1995	100+	0
Rock Island Reservoir	1998	0	4
Lake Rufus Woods	1998	0	7
Lake Roosevelt	1998	0	60
Snake River			
Ice Harbor Reservoir	1996	100+	0
Lower Monumental Reservoir	1997	0	100+
Little Goose Reservoir	1997	0	100+
Oregon Coast tributaries	97-99	0	29

Fisheries Monitoring and Management

The ODFW worked cooperatively with WDFW in coordinating and implementing recreational fishery sampling between Bonneville and McNary dams to monitor white sturgeon catch and ensure harvest remained within guidelines recommended by the Sturgeon Management Task Force (SMTF). In December 1997 and January 1998 we worked with WDFW and CRITFC staffs to recommend sport and commercial harvest guidelines for white sturgeon in Bonneville, The Dalles, and John Day reservoirs using past stock assessment data and harvest estimates from 1997 fisheries. The SMTF agreed to use 1997 recreational harvest guidelines in Bonneville and John Day reservoirs and adopted a new recreational guideline for The Dalles Reservoir based on updated abundance estimates (Table 7). Final estimates of white sturgeon sport catch and effort by reservoir are reported by DeVore et al. (this report).

Sampling in Rock Island, Chief Joseph, and Grand Coulee Reservoirs

Oregon Department of Fish and Wildlife staff worked with WDFW staff sampling for white sturgeon in Chief Joseph, and Grand Coulee reservoirs (lakes Rufus Woods and Roosevelt) during mid May through August, 1998, and in Rock Island Reservoir during September, 1998. Setlines baited with squid were fished throughout the reservoirs and gill nets were fished at selected sites to describe distribution and length frequency of white sturgeon in these areas. Details of sampling and results of this work are reported by DeVore et al. (this report).

PLANS FOR NEXT YEAR

From May through August 1999 we will work jointly with WDFW in Bonneville Reservoir where we will conduct mark and recapture sampling to update size structured estimates of white sturgeon abundance. We intend to continue supplementing white sturgeon populations in The Dalles and John Day reservoirs in 1999 by transplanting up to 10,000 juvenile fish from below Bonneville Dam. Working cooperatively with WDFW, we will use small-mesh gill nets to document the abundance of YOY white sturgeon in The Dalles, John Day, McNary, Ice Harbor, and Little Goose reservoirs during October-November.

Table 7. Harvest guidelines for sport and treaty white sturgeon fisheries in Bonneville, The Dalles, and John Day reservoirs, 1998.

Reservoir	Sport	Treaty	
		Commercial	Subsistence
Bonneville	1,520	1,300	--
The Dalles	600 - 800	1,000 - 1,200	--
John Day	560	1,160	--
Sum	2,680 - 2,880	3,460 - 3,660	300

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APPENDIX A-1

Retention of passive integrated transponder tags applied to white sturgeon in Columbia River reservoirs

INTRODUCTION

Since 1994, the Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and Columbia River Inter-Tribal Fish Commission (CRITFC) have utilized AVID[1] 125-Mhz Passive Integrated Transponder (PIT) tags in addition to a variety of external tags to uniquely mark individual white sturgeon for population-monitoring and supplementation studies in the Columbia River. This tag can be applied quickly and is not subject to gill-net entanglement that can occur with external tags. The greatest advantage of PIT tags may be a superior long-term retention rate because retention of external spaghetti tags decreases steadily over time (Rien et al. 1994). Although previous estimates of within-year PIT tag retention have ranged from 97-100% (North et al. in press-a; North et al. in press-b; North et al. in press-c), these values are based on relatively small numbers of recovered fish (79-202 annually), limited time at-large between tagging and recapture (<257 days), and only slightly exceed the estimated with-in year rate (96%) reported for white sturgeon tagged with external spaghetti tags (Rien et al. 1994).

METHODS

To estimate the overall within and between year retention rate of PIT tags, we examined most white sturgeon recaptured in The Dalles and John Day reservoirs from 1994-1998. All fish were originally tagged, and later recaptured by experienced staff of ODFW and CRITFC. Because all white sturgeon that receive a PIT tag should also be externally marked by removing the second left lateral scute, this was the primary mark used to verify tag loss. External tags were used to verify PIT tag losses whenever original tagging data indicated that both tag types were applied. The retention rate of PIT tags was estimated as the percent of recaptured fish with readable PIT tags that correctly matched the original tag number applied. Tags were considered lost if they could not be detected or the number could not be verified. Differences in mean retention rates by time at-large were evaluated with a general linear model program (PROC GLM) of the Statistical Analysis System (SAS 1988a; SAS 1988b). Comparisons between sample means were made using Tukey's studentized range test ($P<0.05$).

RESULTS

We recaptured 1,504 white sturgeon (45-184 cm fork length) after 1-1,219 days at-large (mean=435 days) which should have been previously PIT-tagged at initial capture, based on the external tag present at recapture. Recapture data correctly matched tagging data for 1,474 (98.0%) of these fish. Of the 30 fish recovered that had lost the PIT tag, 21 (70%) resulted from an inability to locate the tag with the scanner and 9 (30%) could not be verified because they

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

were recorded incorrectly at the time of tagging or recapture. We did not attempt to surgically examine fish that appeared to have a missing PIT tag to determine if tags were damaged during application, had not actually been applied, or had failed. Retention rates were not significantly different for PIT-tagged white sturgeon at large <1, 1-2, and 2 or more years (PROC GLM; P=0.470).

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APPENDIX A-2

Setline Gear and Techniques Used to Monitor White Sturgeon Populations in Lower Columbia River Reservoirs

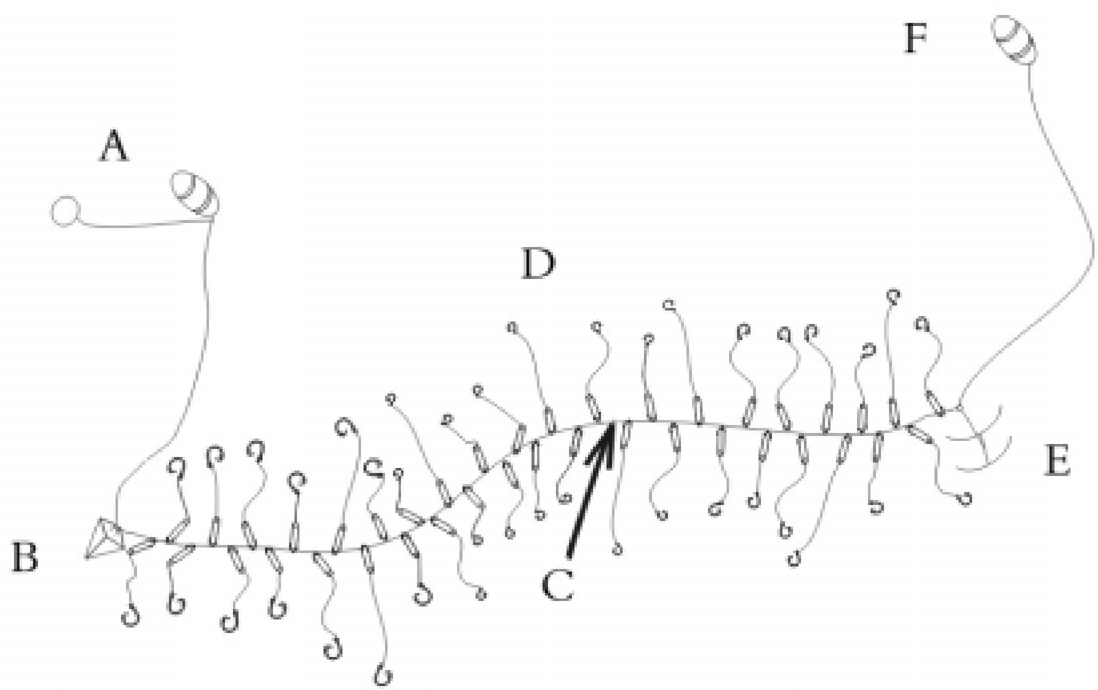
This document was prepared to address numerous requests for information on our setlines and is intended to provide enough detail to enable others to replicate our gear and to assist in procuring gear components. While specific vendors, manufacturers, and brands of components are referenced this should not be construed as an endorsement of those over other vendors or products.

Since 1987, we have used setlines as our primary means of capturing sub-adult and adult white sturgeon in Columbia River reservoirs. Based on a comparison of setlines, gill nets and angling (Elliott and Beamesderfer 1990) we chose setlines because they provide the greatest catch rates, capture the widest range of fish sizes, select almost exclusively for sturgeon, and seldom harm fish. In a typical 8-10 hour day we can fish 8-12 lines depending on catch rates.

Refinements and innovations in the commercial fisheries and fisheries research have improved the gear, and we have incorporated changes that simplify deployment or increase catch rates.

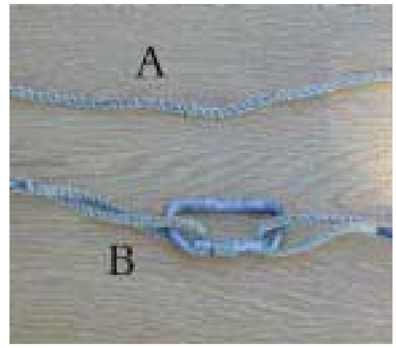
GEAR DESCRIPTION

Our typical setline consists of a 600-foot mainline (C), anchored on the upstream-end with a rocker anchor (E) and the downstream-end with a pyramid anchor (B). Forty baited hooks (D) of three sizes are clipped to the mainline at 15-foot intervals. A floatline and float are attached to the upstream-end (F) anchor and a floatline and float with a trailer buoy (A) are attached to the downstream-end anchor to facilitate location and retrieval of the set.



Mainline

The mainline consists of 600 feet of 0.25-inch soft-to-medium lay twisted strand rope which is marked every 15 feet with brightly colored yarn or vinyl (waste from spaghetti tags) woven through the rope to mark hook set placement (A). Eyes are (B) spliced into both ends. The mainlines are stored in plastic, 32 gallon garbage cans drilled for drainage. Several lines (5-6) are stored in each can connected together end-to-end with snap hooks or carabiners.

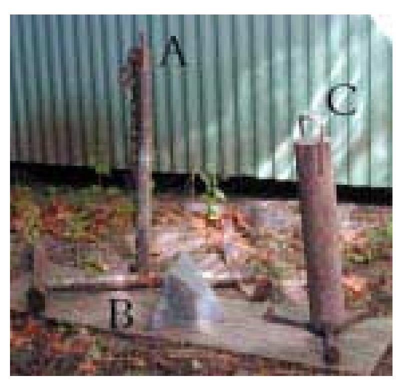


Hooks Sets

Hook sets contain 40 hooks of three sizes assembled in the following manner: a five-inch stainless steel or galvanized longline snap (A) is attached to a 6/0 500 lb. swivel (C) with a large (~167 to the pound) stainless steel hog ring (B). The hog ring can be omitted by purchasing "halibut" clips fitted with swivels. An 18-24-inch length of no. 42 gangion line (used for hooks 12/0 and smaller) or no. 72 gangion line (used for hooks larger than 12/0; D) is tied to the swivel with a bowline knot and a 2-3 inch loop is tied into the loose end, again with a bowline knot. The looped end is threaded though the eye of either a 12/0, 14/0, or 16/0 circle hook (E) and then the hook is passed through the eye of the loop. This enables the easy replacement of the hook at a later time. Thirteen hooks of two of the sizes and 14 hooks of the third size (randomly chosen) are bundled together and stored in a heavy-duty plastic bag. About six bundles of these hook sets can be stored in a 5-gallon bucket.

Anchors

We use a variety of anchors depending on water velocity. The anchors weigh 30-45 pounds each. For fast-water sets we use rocker-type anchors (A) on the up-stream end with a 30-pound lead pyramid-type anchor (B) on the down-stream end. The rockers hold better in fast water and if they do break loose in current or from a large fish the pyramid at the downstream end will "walk" with the current and keep tangles to a minimum. In lower velocities we use pyramid-type and home-made anchors (C) constructed of 14-16-inch lengths of 3-3.5-inch diameter steel shaft with railroad spikes welded to one end and a 3/8 inch steel handle welded to the other.

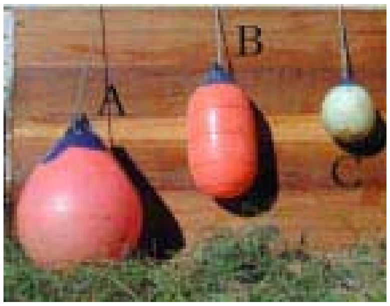


Floatline

We use 50, 75, 100, 125, and 150 foot lengths of 0.25-inch soft to medium lay twisted strand rope with a loop spliced into the ends, and marked on both ends with stripe patterns to indicate length. The floatlines are connected end-to-end with snap hooks and stored in 5-gallon buckets by length. The buckets are drilled to provide drainage.

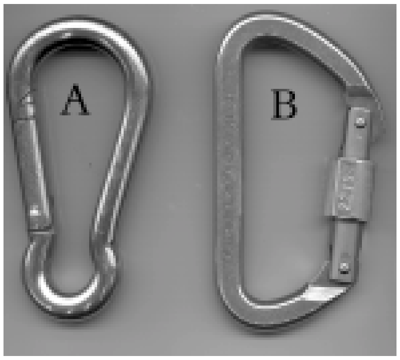
Floats

We use Polyform brand A2 type (A) or LD (low drag) type (B) floats with a Polyform A0 trailer buoy (C) on the downstream buoy to assist with retrieval. In higher velocities the lower buoy is occasionally pulled down low in the water and the trailer will float freely on the surface. We individually number the buoys and record the numbers when the lines are set. This helps identify the set if a different crew pulls the lines.



Snap Hooks and Carabiners

We use four-inch snap hooks (A) between floatlines for storage and to attach floats to the floatline. We use four-inch locking type carabiners (B) to attach the mainline and floatline to the anchor as twisting of the rope can cause non-locking types to separate and lose the anchor and/or the float line.



Bait

Each line is baited entirely with pickled squid because catch per unit effort with this bait type is far superior to Pacific lamprey and salted American shad (Appendix Table A-2.1). Lines ordinarily need to be re-baited daily due to poor bait retention.

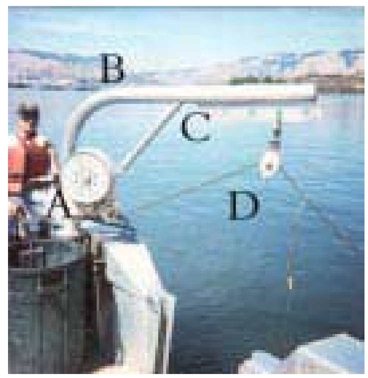
Appendix Table A-2.1. Mean catch of white sturgeon (all lengths) per setline-day by month in John Day Reservoir, April through September, 1990 and 1996; (North et al. in press)

Year: bait type	No. Sets	Month: April	May	June	July	August	September	All months
1990: Pacific lamprey	1188	0.3	0.4	0.3	0.8	0.6	0.9	0.5
1996: Pacific lamprey	448	0.7	0.6	1.4	2.1	1.3	1.5	1.2
1996: salted American shad	460	0.4	1.2	1.2	3.8	1.3	1.4	1.6
1996: pickled squid [a]	216				10.3	6.2	10.8	8.7

[a] Pickled squid was not used until July 1996.

BOAT SETUP

We use a 25-foot aluminum skiff equipped with a 7.5 gpm Vickers hydraulic pump run from a power take off on the inboard engine. We also use a 22-foot Boston Whaler hull equipped with a hydraulic power unit consisting of an 8 hp Briggs and Stratton engine, a Vickers hydraulic pump, and a fluid reservoir and filter. We use Hydro-slave and Kolstrand pot haulers (hydraulically operated hoist; A) controlled with a three position valve. Pot haulers are mounted on davits (B) attached to the gunwale and floor of the boats. The davits have a series of holes (C) to attach a snatch block (D). Placement of the snatch block is dependent on comfortable reaching length. We use the hydraulics to pull in the gear. Sometimes the crew will pull the line in by hand and use the hydraulics for retrieving the anchors.



TECHNIQUE

Setlines are typically deployed parallel to flow and/or wind to facilitate retrieval but can be angled. Generally we start deploying at the upstream end. Depth of the set is determined with a fathometer and float lines of the appropriate length are selected. We generally try to keep the float line length at least 15-feet longer than the depth. If we are setting in high velocity water we will use a float line that is about twice the water depth. A float is attached to one end of the selected float line and the other end is connected to an anchor and mainline with a locking carabiner. The float is tossed away from the boat and the anchor is lowered overboard using the mainline. One person pays out the mainline while another person attaches the pre-baited hook sets at marks on the mainline. When the first anchor reaches bottom, the third crewmember (the boat driver) backs the boat in the direction of the current or the wind. The pace is matched to the line setters to keep the line straight, but to avoid dragging the anchor. The second anchor, float line, and buoy (with a trailer buoy clipped on) are attached to the opposite end of the mainline with a locking carabiner and lowered to the bottom. The boat driver (data recorder) records start time when the second buoy is tossed.

Setlines are normally retrieved from the downstream float. The trailer buoy and float line is snagged with a boat hook. The line is pulled in by hand until there is sufficient slack to thread the floatline though the pot hauler. The stop time is recorded when the buoy is snagged.

The hydraulic control lever is depressed to begin retrieving the float line, which is coiled into a bucket. The boat operator moves the boat forward as the anchor and main line are lifted off the bottom, lessening the force needed to pull the line. Whenever possible the boat is used to do the work and to reduce the strain on personnel and the hydraulic assembly. When the anchor comes up, it is lowered to the deck by reversing the control lever. The mainline is then lifted over the snatch block and repositioned on the hauler. The control lever is then depressed again to retrieve the mainline. The hook sets are removed before they reach the snatch block. The second anchor and float line are then retrieved.

GEAR SPECIFICATIONS

Mainline/ Floatline

0.25-inch soft/medium tarred Aqualine rope - 1800-foot spool (Englund)

Hooks Sets

Hooks - Mustad brand circle hooks (12/0, 14/0, and 16/0 sizes) - box of 100 (Englund)

Halibut snaps - 5-inch galvanized - bag of 100 (Englund)

Hog rings - stainless steel, large size (~167 to the pound) - by the pound (Englund)

Swivels - Berkley McMahon brand 6/0 500 lb - box of 100 (Englund)

No.42 braided gangion twine - Powers brand - by the one-pound spool (Englund)

No.72 braided gangion twine - Powers brand - by the one-pound spool (Englund)

Anchors

30-pound lead pyramid anchor (FMSI)

30-pound rocker-style break-away anchor (FMSI)

Floats

Float - Polyform brand LD-2 (Englund)

Float - Polyform brand A-2 (Englund)

Float - Polyform brand A-0 (Englund)

Snap Hooks and Carabiners

Snap hook - stainless steel, 5/16-inch diameter stock, 3 15/16-inch length, 7/16-inch jaw open opening (Englund)

Carabiners - locking D carabiner (REI)

Bait

Pickled squid - 5-gallon buckets (Gilmore)

Pot Hauler and Snatch Block

12-inch multi-purpose hauler (Kolstrand/Marine Hydraulic)

Aluminum snatch block - Baywood brand for up to 0.5-inch line (Kolstrand)

VENDORS

Englund Marine Supply

PO Box 296
Astoria, Oregon 97103
1-800-452-6746
http://www.pagecreator.com/home/icint009/index.html

FMSI Marine Goods Distributors

901 N Columbia Blvd
Portland, Oregon 97217
1-800-333-3674

Gilmore Fish and Smokehouse

PO Box 184
Dallesport, Washington 98617
(509) 767-1650

Kolstrand Marine Supply

PO Box 70348
4733 Ballard Ave. NW
Seattle, Washington 98107
1-800-334-3224

Marine Hydraulic Engineering
    17 Gordon Drive
    Rockland, Maine
    1-800-747-7750
    http://www.midcoast.com/~marinhyd/

REI-Recreational Equipment, Inc
    7410 SW Bridgeport Road
    Tigard, Oregon 97224
    (503) 624-8600
    http://www.rei.com/

ACKNOWLEDGEMENTS

Over the years a number of people have helped to refine our gear and techniques. We would like to acknowledge them for their creative help. Specifically we wish to thank John Elliot, Doug Engle, Ray Hartlerode, Brad Cady, and current staff for major contributions.

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North, J. A., T. A. Rien, and R. A. Farr. In Press. Report A *in* D. L. Ward, editor. Effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and the status and habitat requirements of white sturgeon populations in the Columbia and Snake rivers upstream from McNary Dam. Annual Progress Report to Bonneville Power Administration, Portland, Oregon, USA. Project 86-50. April 1996-March 1997.

APPENDIX A-3

Number and disposition of all fishes caught during young-of-year sampling, 1997-1998

Appendix Table A-3.1. Number and disposition of all fishes caught during young-of-year sampling in The Dalles, John Day, and Ice Harbor reservoirs, 1997.

	The Dalles[1]			John Day			Ice Harbor		
Species	Live	Kept[2]	Dead	**Live**	Kept[2]	Dead	Live	Kept[2]	Dead
White sturgeon (*Acipenser transmontanus*)	191	27	1	88	16	2	20	0	0
American shad (*Alosa sapidissima*)	0	0	3	0	0	11	0	0	7
Black crappie (*Pomoxis nigromaculatus*)	0	0	0	0	0	0	3	0	1
Bridgelip sucker (*Catostomus columbianus*)	20	0	0	15	0	1	2	0	0
Brown bullhead (*Ictalurus nebulosus*)	0	0	0	0	0	0	1	0	0
Channel catfish (*Ictalurus punctatus*)	2	5	1	19	40	0	963	0	31
Chinook salmon (*Oncorhynchus tshawytshcha*)	0	0	0	0	0	0	1	0	0
Chiselmouth chub (*Acrocheilus alutaceus*)	8	0	0	0	0	0	1	0	0
Common carp (*Cyprinus carpio*)	1	0	0	2	0	0	5	2	0
Largescale sucker (*Catostomus macrocheilus*)	123	0	8	2	16	0	28	0	3
Mountain whitefish (*Prosopium williamsoni*)	0	0	0	1	1	0	0	0	0
Northern pikeminnow (*Ptychocheilus oregonensis*)	7	228	34	0	20	13	0	3	3
Peamouth chub (*Mylocheilus caurinus*)	42	0	21	0	0	0	0	0	0
Smallmouth bass (*Micropterus dolomieui*)	0	0	0	0	0	0	1	0	0
Steelhead (*Oncorhynchus mykiss*)	1	0	0	0	0	0	0	0	2
Walleye (*Stizostedion vitreum*)	0	8	0	1	1	0	1	0	0
Yellow perch (*Perca flavescens*)	2	0	0	0	0	0	0	0	0

[1] Disposition not specified for 4 largescale suckers and 2 northern pikeminnow.

[2] Fish were euthanized and transferred to other researchers: David Terpening, U.S. Environmental Protection Agency-Region 10, Seattle, Washington (for contaminant analysis), or Scott LaPatra, Clear Springs Foods, Inc., Buhl, Idaho (for viral analysis).

Appendix Table A-3.2. Number and disposition of all fishes caught during young-of-year sampling in The Dalles, John Day, and Little Goose reservoirs, 1998.

	The Dalles			John Day			Little Goose		
Species	Live	Kept[1]	Dead	Live	Kept[1]	Dead	Live	Kept[1]	Dead
White sturgeon (*Acipenser transmontanus*)	821	0	11	141	0	4	304	0	8
American shad (*Alosa sapidissima*)	0	0	1	1	0	23	0	0	0
Bridgelip sucker (*Catostomus columbianus*)	39	0	7	10	0	0	7	0	2
Channel catfish (*Ictalurus punctatus*)	8	0	1	141	0	2	728	0	84
Chiselmouth chub (*Acrocheilus alutaceus*)	16	0	2	2	0	1	3	0	0
Common carp (*Cyprinus carpio*)	0	0	0	8	0	0	0	0	0
Crappies (*Pomoxis* spp.)	0	0	0	9	0	0	2	0	0
Largescale sucker (*Catostomus macrocheilus*)	189	0	24	113	0	25	198	0	42
Mountain whitefish (*Prosopium williamsoni*)	1	0	0	0	0	1	0	0	0
Northern pikeminnow (*Ptychocheilus oregonensis*)	59	271	27	49	55	23	2	40	1
Peamouth chub (*Mylocheilus caurinus*)	25	0	12	5	0	0	76	0	134
Sculpins (*Cottus* spp.)	0	0	2	0	0	0	0	0	0
Smallmouth bass (*Micropterus dolomieui*)	3	0	0	9	0	0	1	0	0
Steelhead (*Oncorhynchus mykiss*)	0	0	1	0	0	0	0	0	0
Walleye (*Stizostedion vitreum*)	10	0	15	4	0	5	0	0	0
Yellow perch (*Perca flavescens*)	39	0	14	14	0	14	3	0	4

[1] Sacrificed.

WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM.

ANNUAL PROGRESS REPORT

APRIL 1998 - MARCH 1999

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 1998 recreational and commercial fisheries for white sturgeon between Bonneville and McNary dams, and a stock assessment of white sturgeon in Rock Island, Chief Joseph, and Grand Coulee reservoirs

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We could not have carried out our activities without the assistance of staff from the numerous agencies who provided both reconnaissance opportunities and sites to store our boats and equipment. We would like to thank Bob Fisher and Jim Habermehl of the United States Army Corps of Engineers' Chief Joseph Project, Dan Guptill and Steve Sauer of the United States Bureau of Reclamation's Grand Coulee Project, and Karen Taylor Goodrich, Scott Hebner, and Gig LeBret of the National Park Service's Lake Roosevelt National Recreation Area for help with logistics in sampling Lake Rufus Woods and Lake Roosevelt. We would also like to thank Dewayne Standerford of the Washington State Department of Transportation for providing field facilities while sampling Rock Island Reservoir.

ABSTRACT

The Washington Department of Fish and Wildlife (WDFW) conducted a census of the 1998 sport fisheries on the Columbia River from Bonneville Dam upstream to McNary Dam to estimate white sturgeon *Acipenser transmontanus* harvest. Harvest monitoring was 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 sport fisheries are managed by WDFW and ODFW within the purview of the Sturgeon Management Task Force (SMTF). In 1998, the SMTF recommended the following fishery harvest guidelines: 1,520 sport and 1,300 treaty Indian commercial in Bonneville Reservoir, 600-800 sport and 1,000-1,200 treaty Indian commercial in The Dalles Reservoir, and 560 sport and 1,160 treaty Indian commercial in John Day Reservoir. The SMTF agreed to a total allowable harvest in The Dalles Reservoir of 1,800, but failed to reach agreement on harvest allocation. Therefore, the states' guideline was 600-800 fish while the treaty commercial guideline was 1,000-1,200 fish.

The WDFW and ODFW closed the sport fishery to the retention of white sturgeon in Bonneville Reservoir on April 20, The Dalles Reservoir on June 8, and John Day Reservoir on November 23 when harvest was projected to reach respective guidelines. We estimated 1,630, 860, and 600 white sturgeon were harvested in 1998 sport fisheries in Bonneville, The Dalles, and John Day reservoirs, respectively. Harvest in all three reservoirs was slightly greater than SMTF guidelines. The states intend to manage 1999 fisheries more conservatively to make up for this overharvest.

The treaty Indian commercial fishers landed 1,460 white sturgeon from Bonneville Reservoir, 1,100 from The Dalles Reservoir, and 1,100 from John Day Reservoir during gill net and setline fisheries. The Columbia River Inter-Tribal Fish Commission (CRITFC) and the Yakama Indian Nation estimated an additional 240 fish were harvested during 1998 subsistence fisheries (110, 90, and 40 white sturgeon in Bonneville, The Dalles and John Day reservoirs, respectively).

White sturgeon stock assessment was done in Rock Island (n = 4), Chief Joseph (Lake Rufus Woods) (n = 7), and Grand Coulee (Lake Roosevelt) (n = 204) reservoirs using setlines and gill nets. The focus of 1998 work was to index these reservoirs with a single pass sampling effort to determine relative density and age composition of these impounded sturgeon populations to assess past recruitment. These reservoirs were also being assessed as candidate areas for experimental sturgeon hatchery supplementation. The lack of younger fish in all three reservoirs led investigators to characterize these populations as severely recruitment-limited. Future research may shed light on what factors are limiting recruitment in these areas. Based on these findings and the isolation of these populations from healthier populations in the basin, we recommend the Rock Island and Chief Joseph impoundments as good areas for experimental hatchery supplementation.

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 sport fishery between Bonneville and McNary dams to estimate annual white sturgeon harvest and evaluation of management plans intended to regulate sturgeon fisheries at optimum sustainable exploitation rates.

The WDFW also shares responsibility for tasks relating to Objective 3: *monitor and evaluate actions to mitigate for lost white sturgeon production due to development, operation, and configuration of the hydropower system*. We describe population characteristics and estimate productivity of white sturgeon populations in the three mid- and upper Columbia reservoirs sampled in 1998. Our sampling closely follows the methods developed and used since 1987 by the Oregon Department of Fish and Wildlife (ODFW) on other Columbia River reservoirs (Rien et al. 1993). In this report we will describe our 1998 stock assessment effort in Rock Island, Chief Joseph (Lake Rufus Woods), and Grand Coulee (Lake Roosevelt) reservoirs of the upper Columbia River and present our results and conclusions regarding the productivity of these populations.

Specific activities reported include: 1) surveying the sport fisheries between Bonneville and McNary dams (Zone 6 management unit of the Columbia River), 2) monitoring Zone 6 treaty Indian commercial fishery landings of white sturgeon, and 3) assessing the dynamics and productivity of the white sturgeon populations residing in Rock Island, Chief Joseph (Lake Rufus Woods), and Grand Coulee (Lake Roosevelt) reservoirs of the upper Columbia River. The WDFW also provided the vessels and some of the crew for young-of-year white sturgeon sampling (see ODFW Report A).

METHODS

Sport Fishery Census

The 1998 sport fishery survey was conducted in Bonneville and The Dalles reservoirs, and that portion of the John Day Reservoir downstream from McNary Dam to Arlington, Oregon (river kilometer (rkm) 390) (Figure 1). Methods were similar to those used since 1995 (James et al. 1996) and relied on angling pressure distribution data collected during surveys 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, one staff person from the ODFW Columbia River Management office, and two staff people from the WDFW Southwest Regional office.

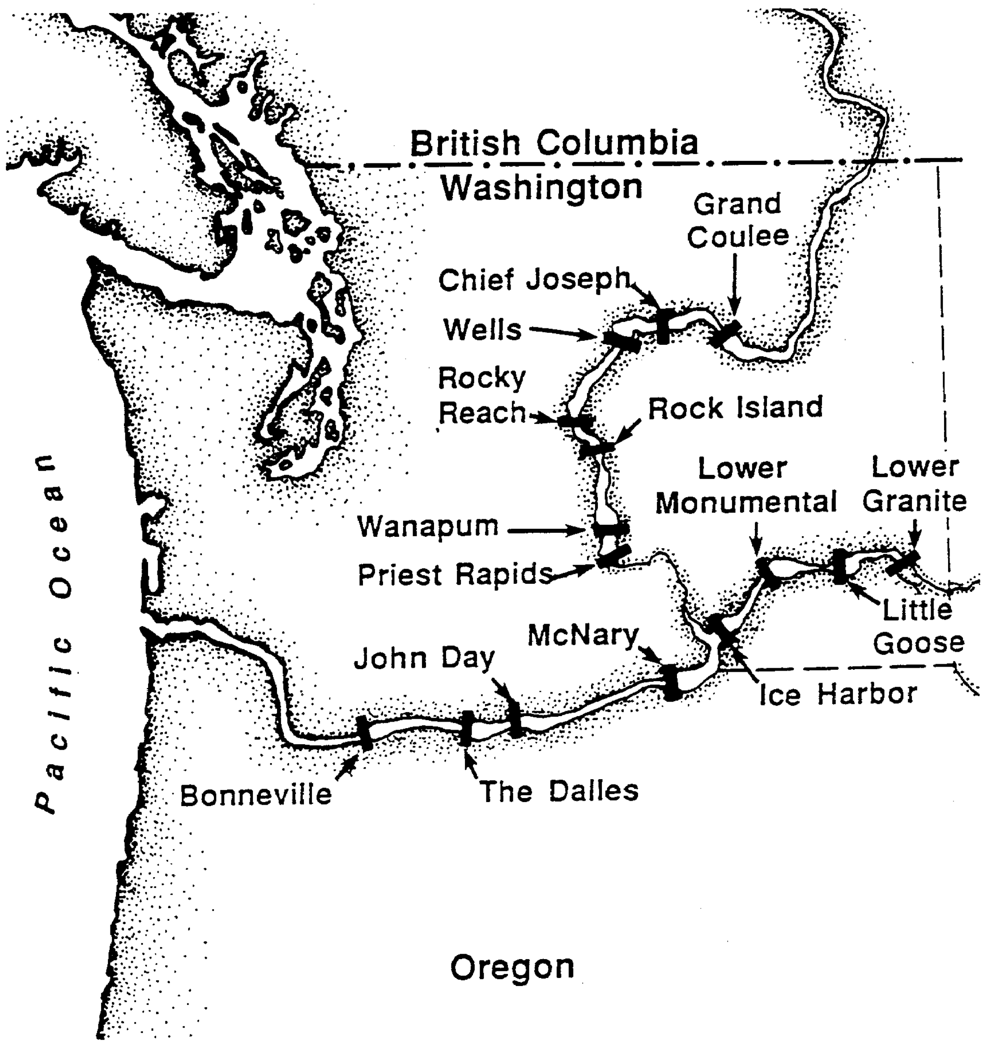

Figure 1. The Columbia River, including impoundments studied in 1998: angler survey (Bonneville Dam upstream to McNary Dam); white sturgeon stock index- Rock Island Reservoir (Rock Island Dam upstream to Rocky Reach Dam), Lake Rufus Woods (Chief Joseph Dam upstream to Grand Coulee Dam), and Lake Roosevelt (Grand Coulee Dam upstream to the U.S./Canada border).

The survey was limited to legal angling hours for sturgeon (one hour before sunrise to one hour after sunset). Therefore, estimates of angling effort and harvest for steelhead *Oncorhynchus mykiss*, walleye *Stizostedion vitreum*, smallmouth and largemouth bass *Micropterus dolomieui* and *M. salmoides*, and northern pikeminnow *Ptychocheilus oregonensis*, that are allowed to be harvested at night in Washington, 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. 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 since 1995. Counts were made of all bank anglers and sport 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. 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.

Catch per effort data were collected by interviewing anglers and examining catches. 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, fork length (FL) 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 pikeminnow sport reward program (Winther et al. 1996) and, if so, the station where they registered. Anglers participating in walleye and bass tournaments were not sampled, however, summaries of catch and effort provided by tournament operators were used.

Harvest estimates for 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. White sturgeon harvest by bank anglers was calculated in a different manner. The one fish daily bag limit, which was enacted in 1991 for The Dalles and John Day reservoirs and in April 1996 for Bonneville Reservoir, made it more likely that successful bank anglers would leave the river before we could interview them, thus biasing our estimate of harvest per hour of bank angling effort downward. Boat angler catch per hour of effort was not biased by the one fish daily bag limit since we only interviewed boat anglers after they had completed their trip. Therefore, we calculated reservoir specific ratios of boat angler HPUE vs. bank angler HPUE for years prior to the one fish bag limit (1988-90 and 1993-96 for Bonneville Reservoir, 1988-89 for The Dalles Reservoir, and 1989-90 for John Day Reservoir). Then, for each reservoir, we used 1998 boat angler HPUE to adjust 1998 bank angling HPUE to match 1998 boat HPUE vs. bank HPUE with the pre-one fish daily limit ratios.

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 weekly and reported monthly.

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 122-152 cm (48-60 in) total length (TL). Treaty Indian subsistence harvest of white sturgeon was estimated by the Columbia River Inter-Tribal Fish Commission (CRITFC) and the Yakama Indian Nation (YIN) from interviews with treaty Indian fishers.

Upper Columbia River Sturgeon Stock Assessment

Sampling closely followed the methods developed and used since 1987 by ODFW on the Columbia River reservoirs (Rien et al. 1993). Impounded white sturgeon residing in Rock Island, Chief Joseph (Lake Rufus Woods), and Grand Coulee (Lake Roosevelt) reservoirs of the upper Columbia River (Figure 1) were captured for stock assessment using 600 foot setlines consisting of 1/4 inch nylon mainline with 40 detachable gangions snapped on every 15 feet. Gangions were 2 feet long and consisted of a 5/16 inch stainless steel snap attached to a 6/0 swivel and a #42 or #72 300 lb test braided nylon gangion line attached to a circle halibut hook. Hook sizes were 12/0, 14/0, and 16/0. Each setline had 13 hooks of two sizes and 14 hooks of the third size. The size with 14 hooks was chosen randomly when setlines were deployed. Hooks were baited with chunks of pickled squid *Loligo sp*. Setlines were deployed parallel to the current and set two per mile. Small mesh gill nets (3½-4 in stretch mesh) were also deployed in an effort to survey smaller sturgeon that are not commonly recruited to setline gear. All reservoirs were systematically fished with just one pass to index relative density and age structure.

Captured sturgeon were immediately placed in a live well or, for fish > 183 cm (> 72 in) TL, tied alongside the boat. Stressed fish and large fish were sampled first and stressed fish were recovered in a live well prior to release. All captured sturgeon were examined for tags, tag scars, pectoral fin marks, and lateral scute marks. Sturgeon were measured using FL to the nearest centimeter and weights to the nearest 0.1 kg. All sturgeon were injected with oxy-tetracycline (OTC) for ageing verification (Leaman and Nagtegaal 1987) and externally marked by removal of the second right lateral scute. Passive Integrated Transponder (PIT) tags were injected behind and beneath the bony plates of the head of captured sturgeon. The second left lateral scute was removed on all fish receiving PIT tags. PIT tag injection needles were sterilized in a solution of chlorhexidine prior to each PIT tag injection. Sequentially coded, wire core spaghetti tags were applied to all captured fish in the dorsal musculature ventral to the dorsal fin rays. All fish captured in 1998 upper Columbia River stock assessment efforts were also marked by removal of the eighth right lateral scute.

A section of the leading right pectoral fin ray was removed for ageing purposes. Fin ray sections were removed using a hacksaw blade. A left pectoral fin ray sample was taken when fish had a damaged or deformed right pectoral fin ray. A one-cm section was removed from approximately 0.5 cm distal to the articulation of the leading pectoral fin ray with particular care to avoid the vein under the ray. Nexaband, an antiseptic surgical adhesive, was used with a sterile cotton ball to stem bleeding in those instances where bleeding occurred. Thirty pectoral fin ray samples per 20 cm length interval was the target sample for characterizing the age structure of each population studied. Age at length data were fitted to a von Bertalanffy growth function. Parameters were estimated using nonlinear least squares regression (SAS 1988).

Length at weight data were fitted to an exponential function using nonlinear least squares regression. Relative condition was determined by estimating mean relative weight of the population and comparing to a standard weight determined for white sturgeon (Beamesderfer 1993).

Sex and stage of maturity was determined by assaying blood plasma sex steroid and calcium levels in blood plasma samples collected from captured white sturgeon. Blood samples were collected from the caudal vein using sterile syringes and vacutainers. Blood plasma was separated with a centrifuge within one hour of collection. Blood tissue was collected for genetic analysis. Blood and plasma samples were preserved by freezing. Blood plasma levels of testosterone (T), 11-ketotestosterone (KT), estradiol (E2), and calcium (Ca) were measured by researchers from Oregon State University. Sturgeon were considered immature if they had low levels of T, KT, and E2. Immature males were categorized when T and KT were greater than 3 ng/ml; immature females had levels of T and KT less than 3 ng/ml. Maturing males were distinguished by high levels of T and KT, but low levels of E2 or Ca. Researchers were uncertain of the maturity of males with intermediate levels of T and KT. Maturing females had high levels of T, KT, E2, and Ca. Calcium levels over 15 mg/dl were diagnostic of maturing females.

RESULTS

Sport Fishery Census

Bonneville Reservoir

The 1998 retention season for white sturgeon in Bonneville Reservoir opened January 1 and was scheduled to run through June 30. We began our survey January 2 and continued through April 19. State fishery managers closed the fishery to retention of white sturgeon on April 20 based on our projection that harvest would reach the guideline by that date.

Anglers fished an estimated 60,158 hours (10,949 trips) in Bonneville Reservoir from January 1 through April 19 (Table 1). Angling effort for sturgeon comprised 91% (9,903 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 61 (1%) for anadromous salmonids, 0 (0%) for American shad *Alosa sapidissima*, 597 (6%) for walleye, 237 (2%) for bass, 0 (0%) for northern pikeminnow, 151 (1%) for other resident fish, and 0 (0%) for anglers participating in tournaments.

Anglers harvested an estimated 1,626 white sturgeon during 9,903 trips for sturgeon between January 1 and April 19, an 11% increase in harvest and 30% increase in angler trips from the 1997 retention period (Tables 2 and 3). The fishery for white sturgeon encompassed the entire reservoir although most of the harvest occurred downstream of Hood River, OR (Rkm 271). Harvest per angler trip peaked in April at 0.22 fish per trip and averaged 0.08 fish per trip for bank anglers and 0.25 fish per trip for boat anglers during the retention fishery (Table 3). Approximately 23% of the estimated bank effort (angler hours) and 14% of the estimated boat effort for white sturgeon during the survey period were accounted for by the 2,710 sturgeon anglers interviewed (Table 4).

Anglers fished January 1 through April 19 with a daily bag limit regulation allowing one fish 107 to 152 cm (42 - 60 in) TL which contributed to anglers releasing 14% of the reported catch of legal-sized fish (Table 4). The percentage sublegal (< 107 cm, < 42 in) TL, legal (107-152 cm, 42-60 in, both kept and released) TL, and oversize (> 152 cm, > 60 in) TL white sturgeon in the January 1 through April 19 reported catch was 87.5%, 12.5%, and < 1%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 95-138 cm FL (42-60 in TL) fish by bank anglers decreased from 1997 levels (Table 6).

Table 1. Combined Washington and Oregon recreational fishery angling effort estimates for Bonneville Reservoir, January 1 through April 19, 1998; The Dalles Reservoir, January 1 through June 7, 1998; and John Day Reservoir, January 1 through November 22, 1998.

	Bonneville		The Dalles		John Day	
Method	Hours	Trips	Hours	Trips	Hours	Trips
Sturgeon						
Bank	28,424	4,913	33,367	4,102	34,219	5,531
Boat	27,638	4,990	7,266	1,319	47,719	8,540
Total	56,062	9,903	40,633	5,421	81,938	14,071
Salmonid						
Bank	187	34	2,922	419	8,835	1,656
Boat	235	27	4,174	627	4,622	1,149
Total	422	61	7,096	1,046	13,457	2,805
Shad						
Bank	0	0	167	36	702	176
Boat	0	0	0	0	121	21
Total	0	0	167	36	823	197
Walleye						
Bank	0	0	417	75	89	38
Boat	2,486	597	20,082	3,616	78,233	14,653
Total	2,486	597	20,499	3,691	78,322	14,691
Bass						
Bank	13	6	593	209	2,530	596
Boat	783	231	869	158	25,464	5,288
Total	796	237	1,462	367	27,994	5,884
Northern Pikeminnow						
Bank	0	0	2,898	335	13	3
Boat	0	0	976	180	118	17
Total	0	0	3,874	515	131	20
Other						
Bank	197	68	1,494	347	4,583	849
Boat	195	83	40	16	2,441	651
Total	392	151	1,534	363	7,024	1,500
Tournament						
Bank	0	0	0	0	0	0
Boat	0	0	0	0	9,449	952
Total	0	0	0	0	9,449	952
Combined total						
Bank	28,821	5,021	41,858	5,523	50,971	8,849
Boat	31,337	5,928	33,407	5,916	168,167	31,271
Total	60,158	10,949	75,265	11,439	219,138	40,120

Table 2. Combined Washington and Oregon recreational fishery harvest, and catch and release estimates for Bonneville Reservoir, January 1 through April 19, 1998; The Dalles Reservoir, January 1 through June 7, 1998; and John Day Reservoir, January 1 through November 22, 1998.

Species	Bonneville	The Dalles	John Day
White sturgeon [1]			
Legals kept	1,626	857	593
Sublegals released	15,868	6,544	8,380
Legals released	592	72	88
Oversize released	11	157	883
Total	18,097	7,630	9,944
Chinook salmon [2]			
Adults kept	0	0	8
Jacks kept	0	0	0
Total kept	0	0	8
Released	0	0	5
Coho salmon [2]			
Adults kept	0	0	0
Jacks kept	0	4	3
Total	0	4	3
Steelhead [3]			
Kept	0	614	130
Released	0	2	142
American shad			
Kept	0	328	537
Released	0	136	215
Walleye			
Kept	219	1,094	2,275
Released	196	594	1,045
Bass			
Kept	9	676	942
Released	189	916	3,780
Northern pikeminnow kept	117	2,280	825
Other resident fish kept	7	36	886

[1] *White sturgeon retention allowed January 1 through April 19 in Bonneville Reservoir, January 1 through June 7 in The Dalles reservoir, and January 1 through November 22 in John Day reservoir.*

[2] *Chinook season was closed to retention January 1 - July 31 and September 21 - October 16, and coho season was closed January 1 - July 31.*

[3] *Steelhead season was closed to retention April 1 - June 15.*

Table 3. Estimates of recreational fishery angler trips for white sturgeon, white sturgeon harvest, and harvest per angler trip (HPUE) for Bonneville Reservoir, January 1 through April 19, 1998; The Dalles Reservoir, January 1 through June 7, 1998; and John Day Reservoir, January 1 through November 22, 1998.

	Bonneville			The Dalles			John Day		
Method	Trips	HPUE	Harvest	Trips	HPUE	Harvest	Trips	HPUE	Harvest
January									
Bank	1,190	0.01	8	352	0.02	6	288	0.02	7
Boat	888	0.26	233	51	0.04	2	253	0.00	0
Total	2,078	0.12	241	403	0.02	8	541	0.01	7
February									
Bank	1,284	0.07	88	267	0.02	6	525	0.01	5
Boat	1,102	0.30	327	58	0.21	12	411	0.02	9
Total	2,386	0.17	415	325	0.06	18	936	0.01	14
March									
Bank	1,619	0.08	131	659	0.04	26	585	0.01	7
Boat	1,649	0.22	363	308	0.11	34	1,036	0.02	25
Total	3,268	0.15	494	967	0.06	60	1,621	0.02	32
April									
Bank	820	0.17 [1]	143	517	0.17	87	710	0.01	9
Boat	1,351	0.25 [1]	333	316	0.53	168	1,337	0.03	37
Total	2,171	0.22 [1]	476	833	0.31	255	2,047	0.02	46
May									
Bank	0	0.00	0	1,951	0.16	312	681	0.01	7
Boat	0	0.00	0	454	0.21	97	875	0.02	14
Total	0	0.00	0	2,405	0.17	409	1,556	0.01	21
June									
Bank	0	0.00	0	356	0.23 [1]	82	695	0.05	32
Boat	0	0.00	0	132	0.19 [1]	25	754	0.06	48
Total	0	0.00	0	488	0.22 [1]	107	1,449	0.06	80
July									
Bank	0	0.00	0	0	0.00	0	944	0.06	55
Boat	0	0.00	0	0	0.00	0	1,329	0.08	103
Total	0	0.00	0	0	0.00	0	2,273	0.07	158
August									
Bank	0	0.00	0	0	0.00	0	398	0.03	13
Boat	0	0.00	0	0	0.00	0	1,267	0.04	53
Total	0	0.00	0	0	0.00	0	1,665	0.04	66
September									
Bank	0	0.00	0	0	0.00	0	262	0.04	10
Boat	0	0.00	0	0	0.00	0	517	0.06	30
Total	0	0.00	0	0	0.00	0	779	0.05	40
October									
Bank	0	0.00	0	0	0.00	0	256	0.08	20
Boat	0	0.00	0	0	0.00	0	439	0.13	57
Total	0	0.00	0	0	0.00	0	695	0.11	77
November									
Bank	0	0.00	0	0	0.00	0	187	0.07 [1]	14
Boat	0	0.00	0	0	0.00	0	322	0.12 [1]	38
Total	0	0.00	0	0	0.00	0	509	0.10 [1]	52
Combined									
Bank	4,913	0.08 [1]	370	4,102	0.13 [1]	519	5,531	0.03 [1]	179
Boat	4,990	0.25 [1]	1,256	1,319	0.26 [1]	338	8,540	0.05 [1]	414
Total	9,903	0.16 [1]	1,626	5,421	0.16 [1]	857	14,071	0.04 [1]	593

[1] *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, January 1 through April 19, 1998; The Dalles Reservoir, January 1 through June 7, 1998; and John Day Reservoir, January 1 through November 22, 1998.

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal released	Legal kept	Oversize released
Bonneville						
Bank						
January	333	798	46	0	1	0
February	569	1,940	189	0	23	0
March	646	2,249	305	4	27	0
April	420	1,536	274	10	38	0
Bank total	1,968	6,523	814	14	89	0
Boat						
January	79	510	324	10	27	1
February	184	1,023	567	24	45	0
March	314	1,619	618	41	70	0
April	165	850	293	9	44	0
Boat total	742	4,002	1,802	84	186	1
Combined total	2,710	10,525	2,616	98	275	1
The Dalles						
Bank						
January	139	560	8	0	2	1
February	168	682	9	0	2	0
March	235	1,133	45	0	6	1
April	234	1,045	144	0	23	1
May	448	2,069	325	0	43	8
June	182	865	239	0	23	11
Bank total	1,406	6,354	770	0	99	22
Boat						
January	4	33	3	0	0	0
February	10	59	10	0	2	0
March	34	203	63	2	6	0
April	50	250	126	9	25	6
May	54	277	123	0	12	0
June	31	194	44	0	6	3
Boat total	183	1,016	369	11	51	9
Combined total	1,589	7,370	1,139	11	150	31

continued

Table 4. Continued.

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal released	Legal kept	Oversize released
John Day						
Bank						
January [1]	50	114	1	0	0	0
February	233	565	7	0	0	0
March	321	1,016	16	0	0	1
April	392	1,148	24	0	1	5
May	314	962	27	0	3	3
June	333	928	45	0	5	13
July	355	1,232	33	0	2	5
August	202	704	11	0	1	0
September	82	251	19	0	1	0
October	19	64	6	0	2	4
November [2]	------	------	------	------	------	------
Bank total	2,301	6,984	189	0	15	31
Boat						
January [1]	46	246	12	0	0	0
February	139	753	49	2	3	2
March	251	1,360	139	1	9	11
April	345	1,985	354	4	11	25
May	124	705	62	1	2	11
June	119	683	92	1	9	19
July	255	1,460	200	3	20	22
August	258	1,400	203	1	14	5
September	102	584	142	0	6	11
October	46	242	57	2	6	3
November [2]	------	------	------	------	------	------
Boat total	1,685	9,418	1,310	15	80	109
Combined total	3,986	16,402	1,499	15	95	140

[1] *No legal kept fish were observed in sample, but anglers out of sample reported 7 legals kept.*

[2] *No sampling was done in November.*

Table 5. Length frequencies of harvested white sturgeon measured during sampling o recreational fisheries in Bonneville Reservoir, January 1 through April 19, 1998; The Dalles Reservoir, January 1 through June 7, 1998; and John Day Reservoir, January 1 throug November 22, 1998.

Fork length (cm)	Bonneville	The Dalles	John Day	Fork length (cm)	Bonneville	The Dalles	John Day
90				130	1		4
91				131		2	2
92	2			132	2	2	5
93	1			133		2	1
94	6			134		2	1
95	11			135		2	1
96	14			136		2	1
97	26			137	1	1	2
98	21			138		3	
99	23			139		2	
100	11			140			1
101	10			141			
102	14			142	1		
103	15			143			1
104	17		1	144			
105	7			145			
106	8	1	1	146			
107	9	4	2	147			
108	6	8	4	148			
109	8	5	2	149			
110	7	15	11	150			
111	6	5	6	151			
112	6	7	9	152			
113	7	8	4	153			
114	4	11	7	154			
115	3	5	3	155			
116	3	8	5	156			
117	1	9	2	157			
118	4	3	4	158			
119	3	2	2	159			
120	1	6	3	160			
121	1	5	3	161			
122	3	3	2	162			
123	2	2		163			
124		3		164			
125	1	6	4	165			
126		2		166			
127	2	5	1	167			
128		4					
129		1	2	Total	268	146	97

Table 6. Estimated angling effort, harvest, and harvest per angler trip (HPUE) of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1987 through 1998.

Reservoir		Bank anglers			Boat anglers		
Year	Period	Trips	Harvest	HPUE	Trips	Harvest	HPUE
Bonneville (95-138 cm fork length interval)							
1987	-- [1]						
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	-- [1]						
1992	-- [1]						
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	2,541	456	0.180	1,750	857	0.490
1996	Jan-Mar	3,341	823	0.246	1,735	463	0.267
1997	Jan-Apr 4	5,093	808	0.159	2,535	632	0.249
1998	Jan-Apr 20	4,913	358	0.073	4,990	1,214	0.243
The Dalles (110-138 cm fork length interval)							
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	-- [1]						
1991	-- [1]						
1992	-- [1]						
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
1996	Mar-Apr	655	21	0.031	251	29	0.115
1997	Jan-May 4	2,278	119	0.052	538	16	0.030
1998	Jan-June 8	4,102	455	0.111	1,319	296	0.225
John Day (110-138 cm fork length interval)							
1987	-- [1]						
1988	-- [1]						
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	-- [1]						
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
1996	Mar-Apr	1,524	17	0.011	1,396	27	0.020
1997	Feb-Aug	4,780	166	0.035	5,968	287	0.048
1998	Jan-Oct	5,531	161	0.029	8,540	371	0.043

[1] *Minimal or no sampling.*

The Dalles Reservoir

The 1998 retention season for white sturgeon in The Dalles Reservoir opened January 1 and was scheduled to run through June 30. We began our survey of the fishery on January 2 and continued sampling through June 6. State fishery managers closed the fishery to retention of white sturgeon on June 8 based on our projection that harvest would reach the guideline by that date.

Anglers fished an estimated 75,265 hours (11,439 trips) in The Dalles Reservoir from January 1 through June 7 (Table 1). Angling effort for white sturgeon comprised 47% (5,421 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 1,046 (9%) for anadromous salmonids, 36 (< 1%) for American shad, 3,691 (32%) for walleye, 367 (3%) for bass, 515 (5%) for northern pikeminnow, 363 (3%) for other resident fish, and 0 (0%) for anglers participating in tournaments.

Anglers harvested an estimated 857 white sturgeon during 5,421 trips for sturgeon between January 1 and June 7, a 2,946% increase in harvest and 93% increase in angler trips from the 1997 retention period (Tables 2 and 3). The primary sport fishery for white sturgeon extended from the John Day Dam tailrace downstream to Miller Island (Rkm 327). More white sturgeon anglers fished from the bank than from boats. The average harvest per trip was 0.13 for bank anglers and 0.26 for boat anglers targeting white sturgeon during the retention fishery (Table 3). Approximately 19% of the estimated bank effort (angler hours) and 14% of the estimated boat effort for white sturgeon were accounted for by the 1,589 white sturgeon anglers interviewed (Table 4).

The percentage sublegal (< 122 cm, < 48 in) TL, legal (122-152 cm, 48-60 in) TL, and oversize (> 152 cm, > 60 in) TL white sturgeon in the January through June sampled catch was 86%, 12%, and 2%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 110-138 cm FL (48-60 in TL) fish by bank anglers has increased each year since 1993 (Table 6). Harvest per trip by boat anglers was the highest observed since the survey was initiated in 1987.

John Day Reservoir

The 1998 retention season for white sturgeon in John Day Reservoir opened January 1 and was scheduled to run through June 30, but was extended through November 22. We began our survey of the fishery on January 3 and continued sampling it through October 31. State fishery managers closed the fishery to retention of white sturgeon on November 23 based on our projection that harvest would reach the guideline by that date.

Anglers fished an estimated 219,138 hours (40,120 trips) in John Day Reservoir from January through November 22 (Table 1). Angling effort for white sturgeon comprised 35% (14,071 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 2,805 (7%) for anadromous salmonids, 197 (< 1%) for American shad, 14,691

(37%) for walleye, 5,884 (15%) for bass, 20 (< 1%) for northern pikeminnow, 1,500 (4%) for other resident fish, and 952 (2%) for tournament anglers.

Anglers harvested an estimated 593 white sturgeon during 14,071 trips for sturgeon between January 1 and November 22, a 28% increase in harvest and 31% increase in angler trips from the 1997 retention period (Tables 2 and 3). The sport 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). Effort for white sturgeon was greatest in July (Table 3). The average harvest per trip was 0.03 for bank anglers and 0.04 for boat anglers during the retention fishery (Table 3). Approximately 20% of the estimated bank effort (angler hours) and 20% of the estimated boat effort for white sturgeon were accounted for by the 3,986 sturgeon anglers interviewed (Table 4).

The percentage sublegal (< 122 cm, < 48 in) TL, legal (122-152 cm, 48-60 in) TL, and oversize (> 152 cm, > 60 in) TL white sturgeon in the reported catch was 86%, 6%, and 8%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 110-138 cm FL (48-60 in TL) fish for bank and boat anglers was 8% and 9% lower, respectively than in 1997 (Table 6).

Treaty Indian Commercial and Subsistence Harvest

The 1998 treaty Indian commercial harvest estimates for Zone 6 were 1,462 white sturgeon from Bonneville Reservoir, 1,108 white sturgeon from The Dalles Reservoir, and 1,100 white sturgeon from John Day Reservoir (Table 7). Most of the harvest (2,825 fish) was landed in the winter gill net fishery (February 1- March 14) with 748 fish harvested in the spring setline fishery (March 23- June 30), 97 fish harvested in the January setline fishery (January 1-31), and 2 fish illegally landed in the fall gill net fishery. The treaty Indian Zone 6 subsistence white sturgeon harvest estimated by CRITFC and YIN was 109 fish from Bonneville Reservoir, 86 fish from The Dalles Reservoir, and 45 fish from John Day Reservoir (Table 7).

Upper Columbia River Sturgeon Stock Assessment

Chief Joseph Reservoir (Lake Rufus Woods)

A total of 204 overnight setline sets were made to assess the white sturgeon population in Lake Rufus Woods (Table 8). Additional sampling effort included 16 multiple-hour gill net sets. Total catch (including all captures and recaptures) of white sturgeon was 7 (Table 8). All the sturgeon were caught on setlines; none were encountered in the small mesh gill nets deployed. Catch rates were greatest in the uppermost sections of the reservoir (Table 8); a result similar to the distribution of sturgeon found in most of the Columbia Basin impoundments studied (Beamesderfer et al. 1995).

Table 7. Sturgeon Management Task Force (SMTF) harvest guidelines and estimated harvest of white sturgeon from Bonneville, The Dalles, and John Day reservoirs, 1991 through 1998.

Fishery	Bonneville		The Dalles		John Day		Unspecified	
Year	Guideline	Harvest	Guideline	Harvest	Guideline	Harvest	Harvest	Total
Recreational								
Harvest								
1991	1,350	2,270	100	199	100	150	0	2,619
1992	1,350	1,717	100	139	100	147	0	2,003
1993	1,350	2,307	100	158	100	144	0	2,609
1994	1,350	2,223	100	154	100	234	0	2,611
1995	1,350	1,370	100	50	100	53	0	1,473
1996	1,350	1,353	100	80	100	62	0	1,495
1997	1,520	1,463	200	178	560	464	0	2,105
1998	1,520	1,626	600-800	857	560	593	0	3,076
Indian commercial								
Harvest								
1991	1,250	999	300	457	100	39	0	1,495
1992	1,250	1,146	300	431	100	23	0	1,600
1993	1,250	1,415	300	579	100	12	0	2,006
1994	1,250	1,176	300	309	100	117	0	1,602
1995	1,250	1,421	300	312	100	308	0	2,041
1996	1,250	1,005	300	230	100	360	0	1,595
1997	1,300	1,852	400	498	1,160	1,260	0	3,610
1998	1,300	1,462	1,000-1,200	1,108	1,160	1,100	0	3,670
Combined fisheries								
Harvest								
1991	2,600	3,269	400	656	200	189	0	4,114
1992	2,600	2,863	400	570	200	170	0	3,603
1993	2,600	3,722	400	737	200	156	0	4,615
1994	2,600	3,399	400	463	200	351	0	4,213
1995	2,600	2,791	400	362	200	361	0	3,514
1996	2,600	2,358	400	310	200	422	0	3,090
1997	2,820	3,315	600	676	1,720	1,724	0	5,715
1998	2,820	3,088	1,800	1,965	1,720	1,693	0	6,746
Indian subsistence [1]								
Harvest								
1991		-- [2]		-- [2]		-- [2]	-- [2]	-- [2]
1992		89		-- [2]		-- [2]	119	208
1993		146		31		30	56	263
1994		290		197		163	0	650
1995		570		260		320	0	1,150
1996		260		120		110	0	490
1997		130		40		63	0	233
1998		109		86		45	0	240

[1] The SMTF did not establish harvest guidelines for the subsistence fishery, however, the expected annual subsistence harvest was 300 white sturgeon for 1994 through 1998.

[2] Not available.

Table 8. Sampling effort for white sturgeon in numbers of overnight setline sets and multiple-hour gillnet sets, numbers of white sturgeon caught, and average catch per set, by reservoir, sample location, and sample period, for Lake Rufus Woods, Lake Roosevelt, and Rock Island Reservoir, 1998.

		Setline			Gill net		
Reservoir, Period	Location (river mile)	Number of sets	Catch	CPUE	Number of sets	Catch	CPUE
Lake Rufus Woods							
5/21-5/26	544-574	130	0	0.00	8	0	0.00
6/04-6/09	575-590	74	7	0.09	8	0	0.00
Total		204	7	0.03	16	0	0.00
Lake Roosevelt							
6/18-6/23	597-617	150	0	0.00	7	0	0.00
7/02-7/07	618-647	150	0	0.00	6	0	0.00
7/16-7/21	Spokane	150	0	0.00	6	0	0.00
7/30-8/04	648-677	150	8	0.05	6	0	0.00
8/13-8/18	678-706	150	139	0.93	7	2	0.29
8/27-9/01	707-731	137	32	0.23	6	1	0.17
9/10-9/15	732-746	40	22	0.55	5	0	0.00
Total		927	201	0.22	43	3	0.07
Rock Island Reservoir							
9/24-9/29	454-473	95	4	0.04	0	0	0.00
Total		95	4	0.04	0	0	0.00

The seven white sturgeon captured were marked with PIT and spaghetti tags, and released back into Lake Rufus Woods. They ranged in length from 139-215 cm FL (mean = 170 cm FL) and in weight from 21.0-85.0 kg (mean = 43.6 kg).

Grand Coulee Reservoir (Lake Roosevelt)

A total of 927 overnight setline sets were made to assess the white sturgeon population in Lake Roosevelt (Table 8). Additional sampling effort included 42 multiple-hour gill net sets. Catch rates were greatest in the uppermost sections of Lake Roosevelt with no sturgeon captured in the lower third of the reservoir (Table 8).

There were 201 white sturgeon captured with setlines and 3 captured with gill nets. Of the 204 white sturgeon captured in Lake Roosevelt, 200 were marked with PIT and spaghetti tags and 4 were recaptured from previous sturgeon studies. All sturgeon captured were released back into the reservoir unharmed. White sturgeon captured in Lake Roosevelt ranged in length from 33-270 cm FL (mean = 177 cm FL). Only 3 (1.5%) sturgeon captured were less than 110 cm FL (4 ft TL).

There were 124 length-at-age assignments made for Lake Roosevelt white sturgeon, ranging from 12 years (92 cm FL) to 96 years (269 cm FL). The von Bertalanffy growth equation, $L_t = 255.2\,(1-e^{-0.035\,(t+3.450)})$, best described these data (Figure 2). The length frequency of captured Lake Roosevelt white sturgeon is presented in Figure 3.

A total of 198 paired length and weight samples that ranged from 33-269 cm FL with weights from 0.1-160.0 kg were taken for Lake Roosevelt white sturgeon. The exponential equation that best fit these data was $W = 1.111 * 10^{-5}\,(FL^{2.9419})$ (Figure 4A). Mean relative weight for the population was 91 (Figure 4B).

Sex and maturity (by size interval) results from blood plasma samples assayed from Lake Roosevelt white sturgeon are presented in Table 9.

Rock Island Reservoir

A total of 95 overnight setline sets were made to assess the white sturgeon population in Rock Island Reservoir (Table 8). No additional sampling effort using gill nets was done. Total catch (including all captures and recaptures) of white sturgeon was 4 (Table 8).

The four white sturgeon captured were marked with PIT and spaghetti tags, and released back into Rock Island Reservoir. They ranged in length from 144-192 cm FL (mean = 170 cm FL) and in weight from 31.0-57.0 kg (mean = 45.3 kg). Age assignments could only be made for two of the sturgeon captured in Rock Island Reservoir: 17 yrs (163 cm FL) and 30 yrs (192 cm FL).

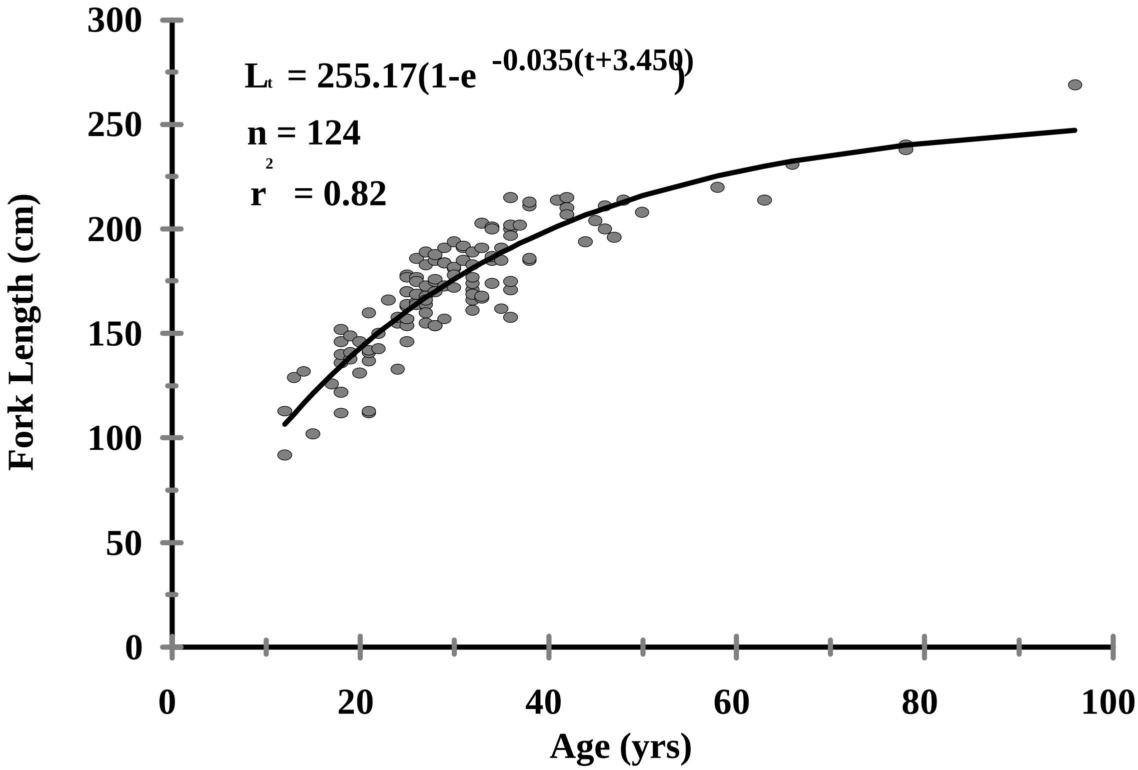

Figure 2. Length-at-age data and von Bertalanffy growth function for Lake Roosevelt white sturgeon, 1998.

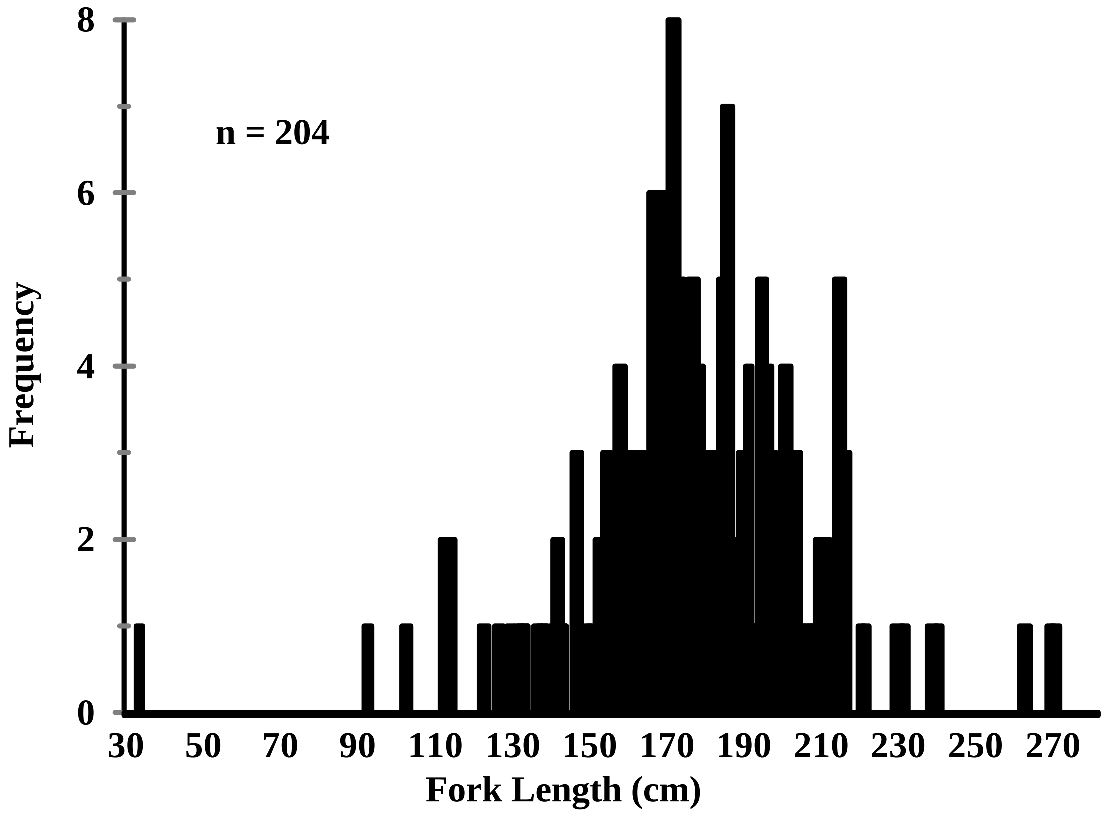

Figure 3. Length frequency of white sturgeon captured in Lake Roosevelt with setline and small mesh gill net gear, 1998.

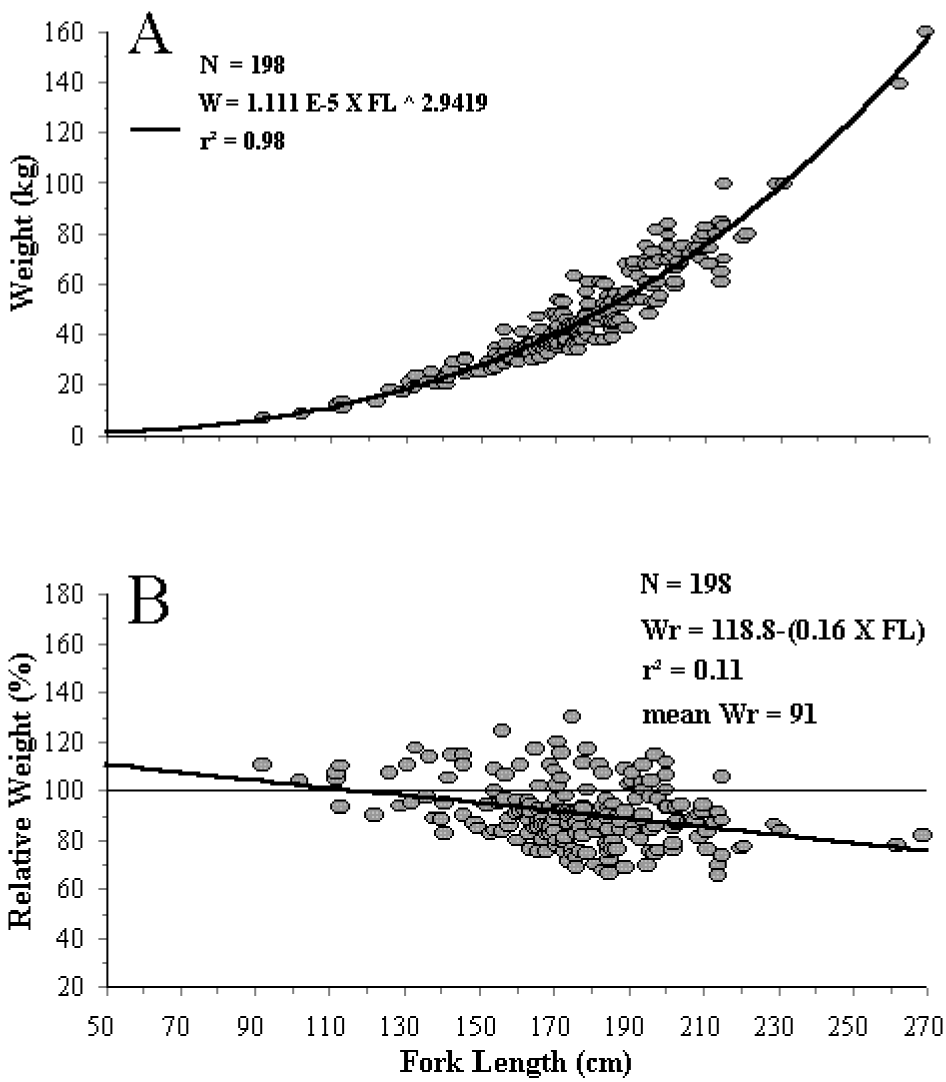

Figure 4. Length-weight relationship (A) and mean relative weight (B) of white sturgeon sampled in Lake Roosevelt, June through September 1998.

Table 9. Gender and maturity by size class of white sturgeon sampled in Lake Roosevelt in 1998 from blood plasma assays of sex steroids. [1]

Fork length interval (cm)	Number sampled	Males immature	Males maturing/mature	Females immature	Females maturing/mature
102 - 159	18	6	3 + 2 possible	7	0
160 - 179	14	4	5 + 2 possible	3	0
180 - 269	20	5	3 + 2 possible	3	7

[1] Blood plasma steroids were assayed by Marty Fitzpatrick and Grant Feist at Oregon State University. Gender and maturity determinations were made based on the relative levels of testosterone, 11-ketotestosterone, estradiol, and calcium.

DISCUSSION

Zone 6 Sturgeon Harvest Management

Harvest management of Zone 6 white sturgeon fisheries during 1998 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 1998 harvest guidelines of 1,520 sport and 1,300 commercial white sturgeon from Bonneville Reservoir, 600-800 sport and 1,000-1,200 commercial from The Dalles Reservoir, and 560 sport and 1,160 commercial from John Day Reservoir. A 1997 stock assessment in The Dalles Reservoir indicated greater abundance of legal-sized white sturgeon which justified the liberalization of harvest guidelines in 1998. The SMTF recommended a total allowable harvest of 1,800 sturgeon in The Dalles Reservoir in 1998, but failed to negotiate the allocation between non-Indian sport and treaty Indian commercial fishers. It is recommended that the SMTF reconcile this difference and allocate the allowable harvest in The Dalles Reservoir within optimal sustainable limits estimated for the population. White sturgeon sport harvest had exceeded the guidelines during 1991-94 despite a series of regulatory harvest reduction actions implemented from 1992 through 1994 (Table 10). The WDFW and ODFW further restricted fisheries beginning in 1995 by adopting a January 1 through June 30 season for retention of sturgeon and allowing catch and release angling opportunity during the remainder of the year. Despite this management action, in-season sport fishery closures prior to June 30 were needed to stay within SMTF guidelines during 1995-98. The 1998 sport guidelines were exceeded in all three reservoirs. Unexpected late season increases in catch rate skewed our in-season harvest projections. It is recommended that sport harvest in 1999 Zone 6 fisheries be managed more conservatively to account for potential late surges in catch rate and to make up for the overharvest in 1998.

Table 10. Recreational sturgeon fishery regulations for Bonneville, The Dalles, and John Day reservoirs, 1994-1998.

Year	Daily bag limit	Size slot	Other
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.
1996	1/1	42-66"	Oregon and Washington - No size or bag limit change from 1995 for waters downstream of The Dalles Dam. Closed to the retention of sturgeon April 1 - December 31.
	1	48-66"	Oregon and Washington - No size or bag limit change from 1995 for waters upstream of The Dalles Dam. Closed to the retention of sturgeon May 1 - December 31.
1997	1	42-60"	Oregon and Washington - Size limit change effective January 1, 1997 for waters downstream of The Dalles Dam. Closed to the retention of sturgeon April 5 - December 31.
	1	48-60"	Oregon and Washington - Size limit change effective January 1, 1997 for waters upstream of The Dalles Dam. Closed to the retention of sturgeon May 5 - December 31 in The Dalles Reservoir and from September 2 - December 31 in John Day Reservoir.
1998	1	42-60"	Oregon and Washington - No size or bag limit change from 1997 for waters downstream of The Dalles Dam. Closed to the retention of sturgeon April 20 - December 31.
	1	48-60"	Oregon and Washington - No size or bag limit change from 1997 for waters upstream of The Dalles Dam. Closed to the retention of sturgeon June 8 - December 31 in The Dalles Reservoir and from November 23 - December 31 in John Day Reservoir.

The 1998 treaty Indian commercial winter gill net season was more productive than the 1997 season, due mainly to the increased allowable harvest in The Dalles Reservoir. A significant increase in commercial catch rate and landings in the last two weeks of the winter gill net fishery in Bonneville Reservoir caused the guideline to be exceeded in this fishery. This increase in late winter season sturgeon landings is a normal pattern for Zone 6 fisheries and is coincident with increased water temperatures and movements of sturgeon. Managers need to recognize this pattern when projecting commercial harvest in order to stay within prescribed harvest guidelines. Like the recommendation offered for managing 1999 Zone 6 sport fisheries, the 1999 Bonneville commercial harvest should be managed more conservatively to mitigate for exceeding the 1998 harvest guideline. Failure to heed harvest constraints will hinder the recovery of Zone 6 sturgeon stocks and result in reduced harvest guidelines in future years.Harvest management mediated restoration of white sturgeon through implementation of harvest guidelines has contributed to the recovery of white sturgeon in Zone 6. A trend of increased catch rates in sturgeon fisheries in Bonneville Reservoir indicates the relatively high productivity of that population. A more significant result is the recovery of white sturgeon in The Dalles and John Day reservoirs. Managers had been concerned about the annual decline in catch rates in these reservoir sturgeon fisheries. However, for the first time since the population crashed in the mid-1980s, catch rates in the 1996-1998 sport fisheries increased relative to previous years. Stock assessments of the John Day Reservoir population in 1996 and The Dalles Reservoir population in 1997 confirmed higher abundance of white sturgeon.

Upper Columbia River Sturgeon Stock Assessment

The stock indexing efforts conducted in Rock Island Reservoir, Lake Rufus Woods, and Lake Roosevelt indicate that the white sturgeon populations in these reservoirs are severely recruitment-limited. The lack of juveniles in these reservoirs implies either elimination of spawning habitat from hydropower development (suspected for Rock Island Reservoir and Lake Rufus Woods) or a critically altered ecosystem where recruitment has been functionally disrupted (suspected for Lake Roosevelt). These conclusions are based on qualitative observations for Rock Island Reservoir and Lake Rufus Woods where spawning habitat appears to be absent. The lack of juveniles, skewed age structure, and low densities of white sturgeon in these populations, especially in Rock Island Reservoir and Lake Rufus Woods, makes these reservoirs ideal locations for experimental supplementation using artificial propagation.

The Lake Roosevelt population does appear to have access to spawning habitat. Canadian researchers have identified at least one active spawning site at the mouth of the Pend d'Oreille River on the U.S./Canada border (R.L.& L. Environmental Services Ltd. 1994, 1996, 1997). This spawning site, known as Waneta Eddy, was found by radiotracking gravid female white sturgeon during the spawning season. Deposition of fertilized eggs was verified by collections on artificial substrate mats as per the methods described by McCabe and Beckman (1990). However, stock assessments conducted since 1992 on the Canadian reach of the Columbia River from the border upstream to Hugh Keenleyside Dam have consistently indicated a lack of juvenile fish in the population. Our stock indexing from Grand Coulee Dam upstream to the border verifies the lack of recruitment for this population. We speculate that recruitment may be disrupted by predation of eggs and/or larvae, unnatural flow regimes, pollution, and/or a less productive ecosystem.

The predation hypothesis is advanced by a number of studies indicating the long term shift in the community assemblage in Lake Roosevelt toward exotic piscivorous predators like walleye and egg predators like common carp, longnose suckers, and largescale suckers (Table 11; Griffith and Scholz 1991). Miller and Beckman (1993) observed sturgeon egg predation by common carp, largescale suckers, and other fish species in Columbia River impoundments. They surmised that sturgeon egg predation may be more intense now with impoundment and the introduction of species such as common carp. Typically, egg predators are not strong swimmers and are generally unable to hold in the high velocity reaches where sturgeon spawning and egg deposition occurs. However, in low runoff years, flow regulation in the Pend d'Oreille River, which shapes the velocities in Waneta Eddy, can be highly variable with the characteristic pattern being high diurnal flows and low nocturnal flows (L. Hildebrand, R.L.& L. Environmental Services Ltd.-personal communication). Significant nocturnal predation on sturgeon eggs at the only known spawning site for this population could be one factor influencing the lack of recruitment.

Hydropower development in the upper Columbia Basin has probably had the most dramatic effect on sturgeon recruitment. Besides creating migration barriers to historical spawning areas upstream from Hugh Keenleyside Dam, these dams have altered the natural hydrograph in this reach. Lower flows during the spawning timeframe, coupled with higher temperatures in the Pend d'Oreille flume where egg deposition occurs, has probably limited successful recruitment (R.L.& L. Environmental Services Ltd. 1996). In many years, a substantial proportion of spawning takes place when Pend d'Oreille water temperatures approach 18°C, the upper level noted for successful sturgeon egg incubation. Survival of eggs to hatch is therefore likely reduced. It is interesting to note from the sampling conducted by R.L.& L. Environmental Services Ltd. and our own stock indexing effort in 1998 that the youngest relatively abundant year classes were produced prior to the completion of Hugh Keenleyside (1968) and Mica (1973) dams.

Pollution may have also contributed to poor recruitment of sturgeon in the Grand Coulee to Hugh Keenleyside reach. Pulp mill, smelter, and municipal wastes affect availability of food, water quality, fish survival, and fish reproduction. Contaminants in the form of elevated dioxin/furan compounds in the biota and high heavy metal concentrations in substrates and biota have been observed in Lake Roosevelt (Mah et al. 1989, Johnson et al. 1991, R.L.& L. Environmental Services Ltd. 1994). However, pollution has been significantly reduced in recent years, yet juvenile recruitment still seems to be lacking.

Growth and condition of Lake Roosevelt white sturgeon is significantly less than for other populations studied. The relative weight of 91% is the l4owest recorded for any Columbia Basin population studied to date. The lack of an anadromous forage base may be largely responsible for this result. Likewise, the large seasonal drawdowns and low water retention times in Lake

Table 11. Numbers of fish caught with 3½-4 inch stretch mesh gillnets and with setlines from Lake Rufus Woods and Lake Roosevelt, May through September 1998.

	Gillnet			Setline	
Reservoir, Taxon	Catch	Catch per set	Catch per hour	Catch	Catch per set
Lake Rufus Woods					
Burbot	1	0.06	0.00	0	0.00
Common carp	2	0.13	0.01	0	0.00
Northern pikeminnow	84	5.25	0.39	20	0.10
Peamouth chub	30	1.88	0.14	0	0.00
Rainbow trout	13	0.81	0.06	0	0.00
Kokanee	0	0.00	0.00	0	0.00
Longnose sucker	53	3.31	0.25	0	0.00
Largescale sucker	5	0.31	0.02	0	0.00
Smallmouth bass	1	0.06	0.00	0	0.00
Walleye	6	0.38	0.03	0	0.00
Yellow perch	2	0.13	0.01	0	0.00
Lake whitefish	9	0.56	0.04	0	0.00
Mountain whitefish	0	0.00	0.00	0	0.00
White sturgeon	0	0.00	0.00	7	0.03
Lake Roosevelt					
Burbot	3	0.07	0.01	0	0.00
Common carp	0	0.00	0.00	0	0.00
Northern pikeminnow	3	0.07	0.01	11	0.01
Peamouth chub	1	0.02	0.00	0	0.00
Rainbow trout	4	0.09	0.01	0	0.00
Kokanee	8	0.19	0.02	0	0.00
Longnose sucker	35	0.81	0.07	0	0.00
Largescale sucker	8	0.19	0.02	0	0.00
Smallmouth bass	0	0.00	0.00	0	0.00
Walleye	29	0.67	0.06	0	0.00
Yellow perch	0	0.00	0.00	0	0.00
Lake whitefish	210	4.88	0.42	0	0.00
Mountain whitefish	7	0.16	0.01	0	0.00
White sturgeon	3	0.07	0.01	201	0.22

Roosevelt tend to decrease densities of benthic invertebrates (Griffith and Scholz 1991) which would decrease sturgeon productivity. Interestingly, these authors observed higher densities of benthic and pelagic invertebrates in the downstream-most portions of Lake Roosevelt where we did not encounter any sturgeon.

Plans for 1999

We plan to conduct young-of-year (YOY) white sturgeon recruitment indexing using small mesh gill nets in Little Goose, John Day, and The Dalles reservoirs in the 1999 fiscal year (October-November 1998). There will be a statistical comparison of catch rates of YOY by the bottom trawl gear used by USGS and small mesh gill net gear from planned sampling in John Day and The Dalles reservoirs. This comparison, which will be done by USGS, will be used to test the efficacy of using small mesh gill net for recruitment indexing. We also plan to conduct stock assessment setline sampling in Bonneville Reservoir. In 1999 we will be assisting the USGS in capturing sturgeon in The Dalles Reservoir for their telemetry studies to identify habitat use and movements of mature white sturgeon. We will also assist the CRITFC in capturing mature white sturgeon in the Columbia River upstream from McNary Dam to provide broodstock for a planned experimental artificial propagation effort. Sturgeon broodstock will be captured on setlines, transferred to Abernathy National Fish Hatchery in a custom tanker trailer, and spawned using standard propagation techniques. Progeny will be reared for eventual release into Rock Island Reservoir as YOY, 1+, and 2+ year fish. We will continue monitoring Zone 6 sport and treaty Indian commercial fisheries in 1999.

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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 1998 – MARCH 1999

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 sturgeon and quantify the extent of habitat available in the Columbia River between Bonneville and Priest Rapids dams

This report includes: Investigations on seasonal habitat use and movements of white sturgeon in McNary Reservoir and the Hanford Reach, the relation of the timing of egg development to water temperature, and spawning, spawning habitat, and recruitment to young-of-the-year in various Columbia and Snake River reservoirs

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ABSTRACT

The USGS conducted investigations using telemetry to study seasonal habitat use and movements of white sturgeon *Acipenser transmontanus* in the Columbia and Snake rivers between Priest Rapids, Ice Harbor, and McNary dams from 1996 through 1998. Habitat suitability curves were constructed from microhabitat descriptor data at fish locations. The information will be used to identify the quality and extent of habitat available to rearing white sturgeon. A comparison of a subset of habitat relative frequency of use data to habitat available data specific to the free-flowing Hanford Reach showed that fish are not selecting habitat based on particular depths or substrates, but are selecting for velocity.

Young-of-the-year (YOY) indexing was performed in Bonneville, The Dalles, and John Day reservoirs with a bottom trawl. Recruitment to YOY occurred in Bonneville, The Dalles, and John Day reservoirs. The number of YOY caught was lower for all three reservoirs compared to 1997 catches.

River discharges and water temperatures that occurred during April through July1998 provided conditions that were favorable to spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams. Monthly estimates of the index of available spawning habitat showed that the available habitat peaked in May and was higher for this month than the average of the estimates made since 1985.

Research continued on laboratory studies investigating the relation of white sturgeon egg development to water temperature and field studies comparing use of gill nets and bottom trawls to index recruitment to YOY.

Two manuscripts that report on results from this project were completed during this performance period. Both have been published in the journal Northwest Science. One manuscript describes the location, timing and duration of white sturgeon spawning in Ice Harbor, Lower Monumental, and Little Goose reservoirs of the Snake River and one describes the food habits of first feeding larval and YOY white sturgeon.

INTRODUCTION

This annual report describes the progress of the U.S. Geological Survey, Columbia River Research Laboratory from 1 April 1998 through 31 March 1999 toward meeting the objectives of Bonneville Power Administration's Project 86-50. The primary goals of the U.S. Geological Survey (USGS) under this project are to investigate the reproduction and early life history of white sturgeon *Acipenser transmontanus*. Our tasks for this period were to:

1) Describe the habitat use and movements of juvenile and adult white sturgeon in the Columbia River between Priest Rapids and McNary dams, and downstream from Ice Harbor Dam on the Snake River and continue to quantify spawning and rearing habitat for white sturgeon in McNary Reservoir.

2) Use trawls to determine if recruitment of white sturgeon to young-of-the-year (YOY) occurred in Bonneville, The Dalles, and John Day reservoirs and Lake Roosevelt.

3) Compare catches of YOY from gill nets and trawls to index the abundance of YOY white sturgeon in The Dalles and John Day reservoirs.

4) Assess the effects of water temperature on the development of white sturgeon eggs obtained from feral sturgeon in the Columbia River Basin.

5) Estimate the availability of spawning habitat for white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams.

6) Describe the potential effect of reservoir drawdowns on white sturgeon productivity in John Day, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs.

7) Use telemetry to monitor the behavior of pre-spawn and spawning white sturgeon in the tailrace of John Day Dam in relation to dam operations.

8) Determine the location and estimate the timing and duration of white sturgeon spawning in Ice Harbor, Lower Monumental, and Little Goose reservoirs of the Snake River.

The latter task, determining the location and estimate the timing and duration of white sturgeon spawning in Ice Harbor, Lower Monumental, and Little Goose reservoirs of the Snake River, has been addressed in paper published in the journal Northwest Science (Parsley and Kappenman 2000) and will not be reported on in this report. In addition, another paper describing food habits of first-feeding and larval and young-of-the-year white sturgeon was also published in the journal Northwest Science (Muir et al.

2000). This paper was developed using information collected during earlier years of this project.

METHODS

Habitat Use and Seasonal Movements

Investigation of the seasonal habitat use and movements of Columbia and Snake River juvenile and adult white sturgeon in McNary Reservoir began in 1996. Acoustic telemetry was used to locate fish from 1996 to 1998. Parsley et al. (1996) and Counihan et al. (1997) provide information on methods and early results from that work. In 1998, we used global positioning system technologies to return to the geographic coordinates where the white sturgeon were found to determine the substrate specific to each fish location. Substrates were categorized by particle size using criteria presented in Parsley et al. (1993) and substrate type was generally determined visually in shallow water or by using an underwater video camera fitted with artificial lighting in deeper water. When visual identification was not possible, we used a ponar dredge to obtain a sample of the substrate. Generally, the underwater camera worked well for substrate identification in deep water when the substrate was composed of larger particles, but it was difficult to visually distinguish between finer substrates composed of sand and silt. In these instances, we used the ponar dredge to collect a sample of the substrate for classification.

In addition to identifying substrates at locations where fish were found, we constructed a substrate map[1] of the study area by aggregating data from a variety of sources. The US Fish and Wildlife Service (USFWS) had collected transect riverbed substrate information from river kilometer 592.2 to 638.9 (Anglin et al. 1996). We collected additional point data from river km 469.9 to 592.2 using the methods previously described. Point samples were taken where bathymetry contours indicated there might be a change in substrate. We combined all these data within a geographic information system and manually interpreted polygons that described the distributions of the substrates present within the study area.

We developed Habitat Suitability Index (HSI) curves for rearing white sturgeon using the information collected at individual fish locations during the 1996-1998 investigations. Habitat use was determined from the weekly locations of the sonic tagged fish. The curves were developed for depth, velocity, and substrate by histogram analysis using the GCURVE program of the Physical Habitat Simulation System (PHABSIM, Bovee 1982). Optimal bin interval sizes for creating histograms were determined using Sturges equation, $C = R/(1/3.322*\log_{10}N)$, where C = the optimal class (interval) size, R = the range of the variable (max-min), and N = the number of observations (Cheslak and Garcia 1988). Depth intervals were rounded to the nearest meter and velocity intervals were rounded to the nearest 0.1 m/s. Habitat suitability index curves were constructed by applying three curve-fitting techniques to the original histograms describing depth and velocity use. Those techniques included the line draw, 3-point, and 5-point running filters that are available through the GCURVE program. Suitability index values for the six-substrate

[1] The substrate map is available from the USGS in an ArcView shape file format.

categories were assigned by normalizing the frequency data to 1.0.

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Young-of-the-Year Indexing

We fished for juvenile white sturgeon with a 6.2-m high-rise bottom trawl (Palmer et al. 1988; Parsley et al. 1989) to determine if recruitment to YOY occurred in Bonneville, The Dalles, and John Day reservoirs and Lake Roosevelt. We fished the bottom trawl on 13 d from 14 September to 1 October 1998 in Bonneville Reservoir, on 4 d from 23 October to 28 October 1998 in The Dalles Reservoir, and on 7 d from 19 October to 12 November 1998 in John Day Reservoir. A total of 66 tows were completed at 11 sites in Bonneville Reservoir. We trawled 12 sites in The Dalles Reservoir, and 19 sites in John Day Reservoir. Each of the sites in The Dalles and John Day reservoirs were trawled two times for a total of 24 tows in The Dalles Reservoir and 38 completed tows in John Day Reservoir. 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 increments from left to right while facing upstream. Digits preceding the last number represent river miles 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 estimated the distance fished during each tow with a Rockwell PLGR+ Global Positioning System (GPS) receiver using the Precise Positioning Service[2] and determined the area fished by multiplying the distance by 4.4 m, the estimated fishing width of our bottom trawl. We also used GPS to navigate the trawling vessel and to maintain a speed-over-ground of approximately 3 km/h during each tow. Trawling was conducted in an upstream direction and was typically 10 min in duration. We measured the total length (TL) to the nearest mm on all young-of-the-year and measured the fork length (FL) and TL to the nearest mm on other juvenile white sturgeon. The fish were each weighed on a Pesola hanging scale. Usually, young-of-the-year white sturgeon were weighed to the nearest 1 g, and larger juveniles were weighed to the nearest 5 or 10 g.

We fished the 6.2-m high-rise bottom trawl described above and a 3-m beam trawl in Lake Roosevelt to determine if juvenile white sturgeon were present in this impoundment. Sampling was done during 4 August through 9 August 1998. Because this sampling was exploratory in nature, the tows varied in duration and speed over ground.

Catch-per-unit-effort (μ_{cpue}) of white sturgeon was expressed as the number of fish caught per 2,500 m^2. The proportion of positive tows (*Ep*) (Counihan et al. 1999) for YOY white sturgeon in

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[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. The GPS receiver incorporates the Wide Area GPS Enhancement (WAGE) system and can achieve less than 4 m of error in horizontal positioning autonomously in real-time without the need for broadcast variables or post-processing. The WAGE also provides position error estimates to indicate the quality of the data.

Bonneville Reservoir was calculated as the ratio of tows where at least one YOY was captured to the total number of tows.

Comparison of Gill Nets and Bottom Trawls to Index Recruitment to Young-of-the-Year

Sampling with bottom trawls to index the recruitment of young-of-the-year white sturgeon is restricted to areas with suitable bottom topography, and requires specialized boats and boat operator experience. The USGS is collaborating with the Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) to determine if indices of recruitment developed from catches of young-of-the-year white sturgeon from small-mesh gillnets follow trends similar to those developed from catches in bottom trawls (Counihan et al.1999). The ODFW conducted sampling in The Dalles and John Day reservoirs (Burner et al. this report), entered and proofed the catch data, and forwarded the data sets to the USGS for analysis.

Counihan et al. 1999 described two indices that can be used to assess the relative abundance of young-of-the-year white sturgeon from highly skewed trawling data; the proportion of positive tows and mean catch per unit of effort. We calculated the proportion of positive tows and mean catch per unit of young-of-the-year from the data sets provided to us by the ODFW.

The Relation of the Timing of White Sturgeon Egg Development to Water Temperature

During June 1998, we incubated white sturgeon eggs obtained from broodstock from the Kootenai and Columbia rivers from fertilization to hatching at the Kootenai Tribal Experimental Hatchery (KTEH) in Bonners Ferry, Idaho, and at the Columbia River Research Laboratory (CRRL) in Cook, Washington. Gamete collection, transportation, insemination, de-adhesion, and incubation followed procedures described in Conte et al. (1988). Females were induced to spawn with injections of luteinizing releasing hormone.

After fertilization and de-adhesion, eggs were incubated in Macdonald jars. The eggs were gradually transitioned from the ambient hatchery water temperature to the experimental incubation temperatures by incremental addition of progressively warmer or cooler (1 C 10 min^{-1}) suspensions of fuller's earth. At the KTEH, approximately 12,000 eggs were stocked into one Macdonald jar and incubated at 12 C, and approximately 3,200 eggs were stocked into another Macdonald jar and incubated at 15 C. At the CRRL, approximately 12,000, 10,000, and 8,000 eggs were stocked into each of three Macdonald jars and incubated at 12, 15, and 18 C. Each Macdonald jar received water from heated recirculation tanks equipped with one or two 1000 W thermostatically controlled heaters, an ultraviolet (UV) sterilizer and a submerged pump. Fresh water flushed through the tank at 0.5 l min^{-1}.

Samples of developing embryos were taken during the de-adhesion process and from the Macdonald jars as they developed. Samples of unfertilized eggs were collected just prior to fertilization, kept at each of the incubation temperatures for one hour and preserved in a solution of 10% unbuffered formalin. Samples were taken from the Macdonald jars every 15 min for the first 8 h, every 30 min between 8 and 24 h, and every 2 h after the first 24 h until most eggs had hatched. Eggs were collected from the Macdonald jars at each prescribed time interval by drawing up ten or more eggs with a large pipette. These samples were also preserved in a solution of 10% unbuffered formalin. Preserved eggs were then examined under a dissecting microscope and assigned a developmental stage using classifications developed by Beer (1981).

Availability of Spawning Habitat

The methods and hydraulic data described in Parsley and Beckman (1994) were used to model the availability of spawning habitat for white sturgeon downstream from McNary, John Day, The Dalles, and Bonneville dams. Parsley and Beckman (1994) presented the results of hydraulic simulations of the physical habitat downstream of these dams in response to river discharges. The results from that paper were used with river discharges and water temperatures that occurred during 1998 as inputs to create a daily index of spawning habitat for the four areas. Mean daily river discharges and water temperatures that occurred at the dams during April through July were obtained from the Data Access in Real Time (DART) web page (http://www.cqs.washington.edu/dart/).

Effects of Proposed Reservoir Drawdowns on the Productivity of White Sturgeon

The spatial distribution of habitats suitable for spawning and rearing white sturgeon is being estimated for the lower Snake River and for the John Day Reservoir on the Columbia River under natural river conditions. Suitable habitat is being determined by applying spawning and rearing criteria via a geographic information system to physical characteristics of the river under a free-flowing scenario.

The physical river characteristics used are water depths, mean water column velocities, and substrates. Depths and mean water column velocities that could be present under natural river conditions are being generated from two-dimensional numerical hydraulic modeling. The Pacific Northwest National Laboratory (PNNL), Richmond, WA has already conducted modeling on the lower Snake River downstream from Hells Canyon dam. The USGS has conducted the modeling on the John Day Reservoir of the Columbia River.

For the lower Snake River, the simulated depth and velocity values were based on a typical low flow in August, approximately 680 m^3/s (24,000 ft^3/s), and on riverbed elevations derived from maps drawn in 1934. Substrate information for the lower Snake River was based on the interpretation by PNNL of 1) written notations on historic War Department Maps made in 1934, 2) channel morphology, and 3) channel hydraulics. The dominant substrate was classified as silt-, sand, gravel, cobble+, boulder, or bedrock. When a second substrate class was present in significant amounts, a subdominant substrate was also listed. Table 1 defines the grain size ranges for each of the substrate classes and Table 2 lists the historic substrates interpreted for the lower Snake River. The above data has a horizontal resolution of 9.1 meters (30 ft) and was provided to us by PNNL in raster format as ARC/INFO Grids.

Table 1. Substrate Class Definitions. (Tim Hanrahan, PNNL, personal communication, 1998.)

Substrate class	Grain size diameter
Silt-	< 0.0625 mm
Sand	0.0625 - 2.0 mm
Gravel	2.0 - 64 mm
Cobble+	anything > 64 mm, unless boulders were noted on historic map
Boulder	> 256 mm
Bedrock	Immeasurable

Table 2. Dominant/Subdominant Substrate Classes Interpreted from Maps for the Lower Snake River, 1934

Dominant/subdominant substrate
Silt-/cobble+
Sand/gravel
Sand/cobble+
Gravel/silt-
Gravel/sand
Gravel/cobble+
Cobble+
Cobble+/sand
Cobble+/gravel
Cobble+/bedrock
Boulder/cobble
Bedrock
Bedrock/cobble+

For the John Day Reservoir, we used a river discharge of 4,420 m^3/s (156,000 ft^3/s) which represents the 50% exceedence flow for March through October, and riverbed elevations derived from a bathymetric survey conducted by the Army Corps of Engineers during 1994. Substrate information for the John Day Reservoir was based on our interpretation of 1) written notations on historic War Department Maps, 2) channel morphology, and 3) channel hydraulics.

Parsley and Beckman (1994) provided suitability index curves describing habitats used by spawning white sturgeon. Curves describing rearing habitat are presented in this report. These selection criteria are being applied cell by cell using ARC/INFO software to the raster data layers of depth, velocity, and substrate. Those cells meeting all three criteria are being classified as "suitable", while those failing one or more of the criteria are being classified as "not suitable". For those areas where substrate information was not available because the wetted area extended beyond the substrate delineation, the habitat classification is being classified as "unknown" if the cells fell within the preferred ranges for both depth and velocity, or "not suitable" if they failed the depth or velocity criteria.

Habitat for fish has been related to meso-habitat features such as pools, runs, and riffles or rapids (Yu and Peters 1997). Thus, the spatial distributions of these features were predicted for natural river conditions for the lower Snake River and the John Day Reservoir. Calculating the Froude number and equating this value to one of the three meso-habitat types identified pools, runs, and riffles. The Froude number is the dimensionless function of velocity and depth $Fr = V/(gD)^{0.5}$, where V is the mean water column velocity, D is the water depth, and g is the acceleration due to gravity. This application of the Froude number has been used as an objective method for determining habitat types in other streams (Yu and Peters 1997; Jowett 1993).

Froude numbers were calculated from depths and mean water column velocities generated from the two-dimensional numerical hydraulic modeling described above. During this analysis, each 9.1 by 9.1-meter (30 by 30-ft) cell in the river was classified as a pool, run, or riffle based on its Froude number. Classification of habitat types was based on the following Froude number ranges in Yu and Peters (1997): Pool, $Fr < 0.2$; Run, $0.2 \geq Fr \geq 0.4$; Riffle, $Fr > 0.4$.

Movements and Behavior of Pre-Spawn and Spawning White Sturgeon

The USGS began a telemetry study in December, 1998 to investigate the movements and behavior of pre-spawn and spawning white sturgeon in The Dalles reservoir. The fish were captured with setlining gear. The methodologies used while setlining, including handling of the fish and sexual staging, were similar to those described by Devore et al. (In press). Surgeries to determine the sex and state of maturation were performed on fish $\geq$ 153 cm total length. Radio and sonic transmitters were attached externally. A multi-stranded stainless steel wire was passed through the two holes on either end of the radio transmitter and then through the musculature ventral to the dorsal fin of the fish. The tag ends of the wire were then passed through the holes on the sonic tag and through three American Fishing Wire #4 double barrel compression sleeves. The tag ends were pulled tight and the compression sleeves compressed securing the tag. The tag ends of the wire were trimmed and the attachment area was bathed with a solution of nitrofurazone to reduce infections. Transmitters were verified to be functioning and the fish was released near where it was captured.

RESULTS

Habitat Use and Seasonal Movements

We classified substrates at 632 of the 650 locations where fish had been found from 1996 to 1998. We were unable to classify substrates at 18 locations for a variety of reasons, including inclement weather and large error associated with the position fixes from the GPS receiver. We classified substrates at 137 additional locations for creating the map of substrates (Figure 1).

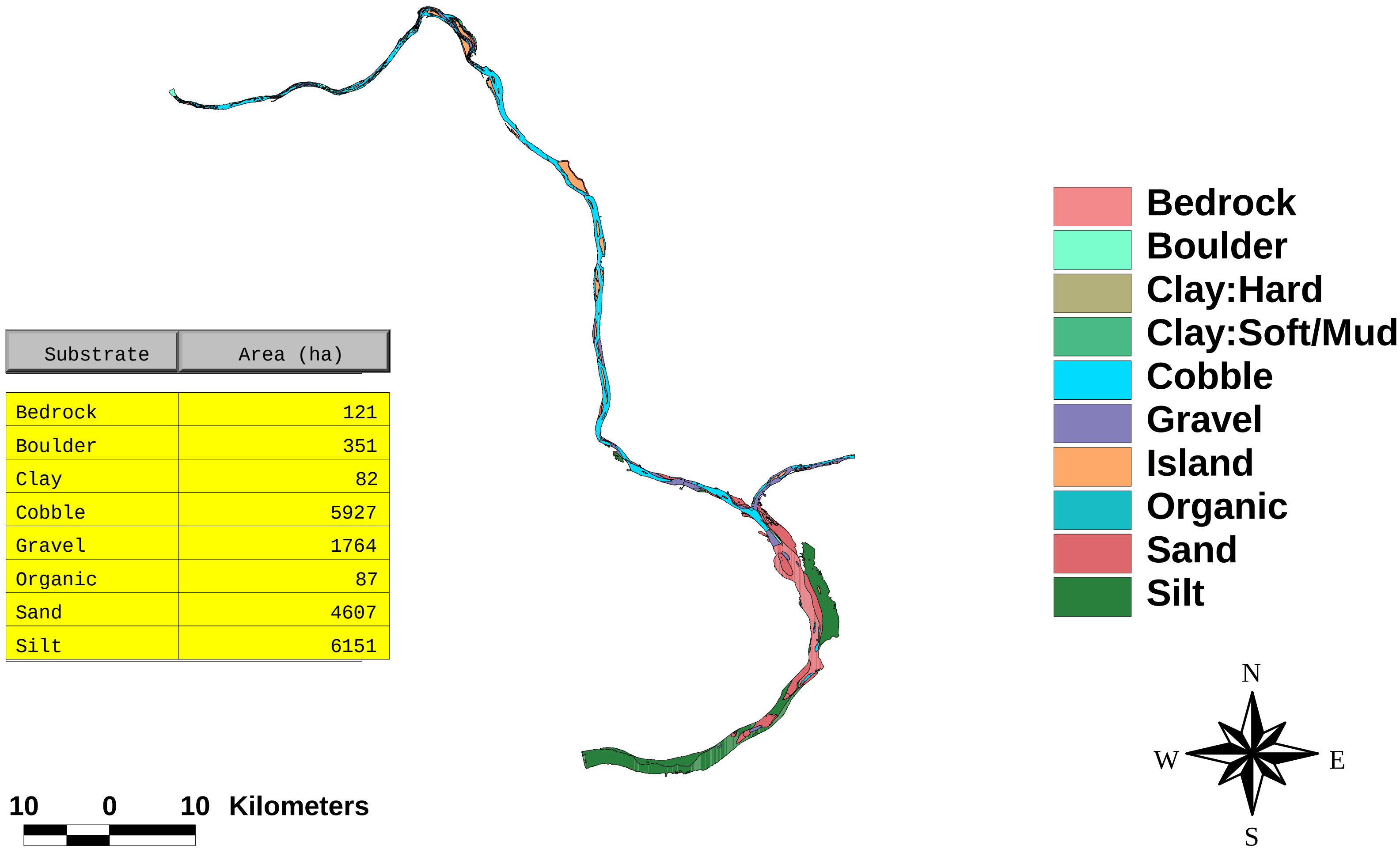
The study design allowed us to look at habitat use by fish size and season. Habitat use appeared to vary more by fish size than by season. Histograms of depth, velocity, and substrate use by fish size (FL <= 0.675 m, FL > 0.675 m but FL < 1.335 m, and FL >= 1.335 m) pooled by season show that the smaller fish generally used a narrower range of habitats than larger fish (Figures 2 to 4). White sturgeon less than 0.675 m FL did not use the deeper water that larger fish used, were not found over silt substrates, and were not found in areas where mean water column velocities exceeded 1.6 m/s. However, this may have been an artifact of small sample size. Bovee (1986) suggests a minimum sample size of N=150 to obtain a smooth frequency histogram where an organism does not select for a very narrow subset of conditions. We obtained less than 45 observations of habitat use by the smallest size class of white sturgeon. Depth, velocity, and substrate use by medium and large fish were very similar (Figures 2 to 4). Habitat use by season showed no apparent differences in depth, velocity, or substrate use between the spring, fall, and winter periods (Figures 5 to 7).

Habitat suitability index curves were constructed by pooling the data from all fish lengths and seasons. Figure 8 shows the suitability index values that result from three curve-fitting techniques for depth and velocity use, and a single suitability index value for each of the six-substrate types used in this study. The resultant curves show that broad ranges of habitats are suitable for rearing white sturgeon. Water depths between 4.5 m and 10.5 m, water velocities near 0.3 m/s, and sand or cobble substrates are most suitable with suitability index values > 0.75.

Young-of-the-Year Indexing

Bonneville Reservoir

Recruitment to YOY occurred in the Bonneville Reservoir in 1998. Young of the year were easily distinguished from older fish by length frequency analysis (Figure 9). We captured 345 juvenile white sturgeon with the high-rise trawl during our sampling of Bonneville Reservoir, 117 (34%) of these were YOY. Young-of-the-year white sturgeon were captured at all 11 sites (Table 3). The YOY ranged in



Substrate	Area (ha)
Bedrock	121
Boulder	351
Clay	82
Cobble	5927
Gravel	1764
Organic	87
Sand	4607
Silt	6151

Figure 1. Substrates found within the Columbia and Snake rivers between McNary, Ice Harbor, and Priest Rapids dams.

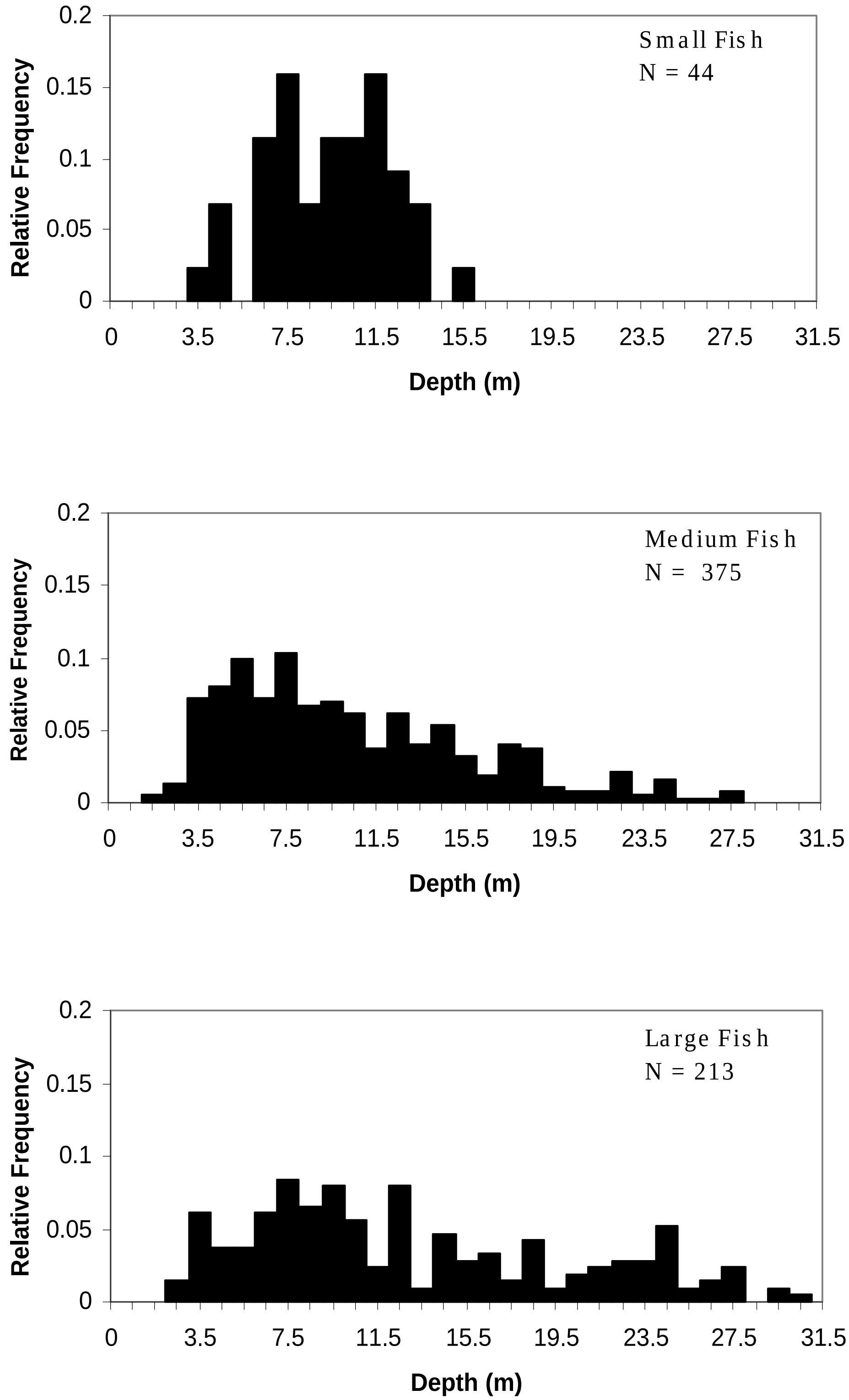


Figure 2. Depth use by white sturgeon during all seasons separated into small fish (fork length = 506-674 mm), medium fish (fork length = 814-1,334 mm) and large fish (fork length = 1,540-2,310 mm).

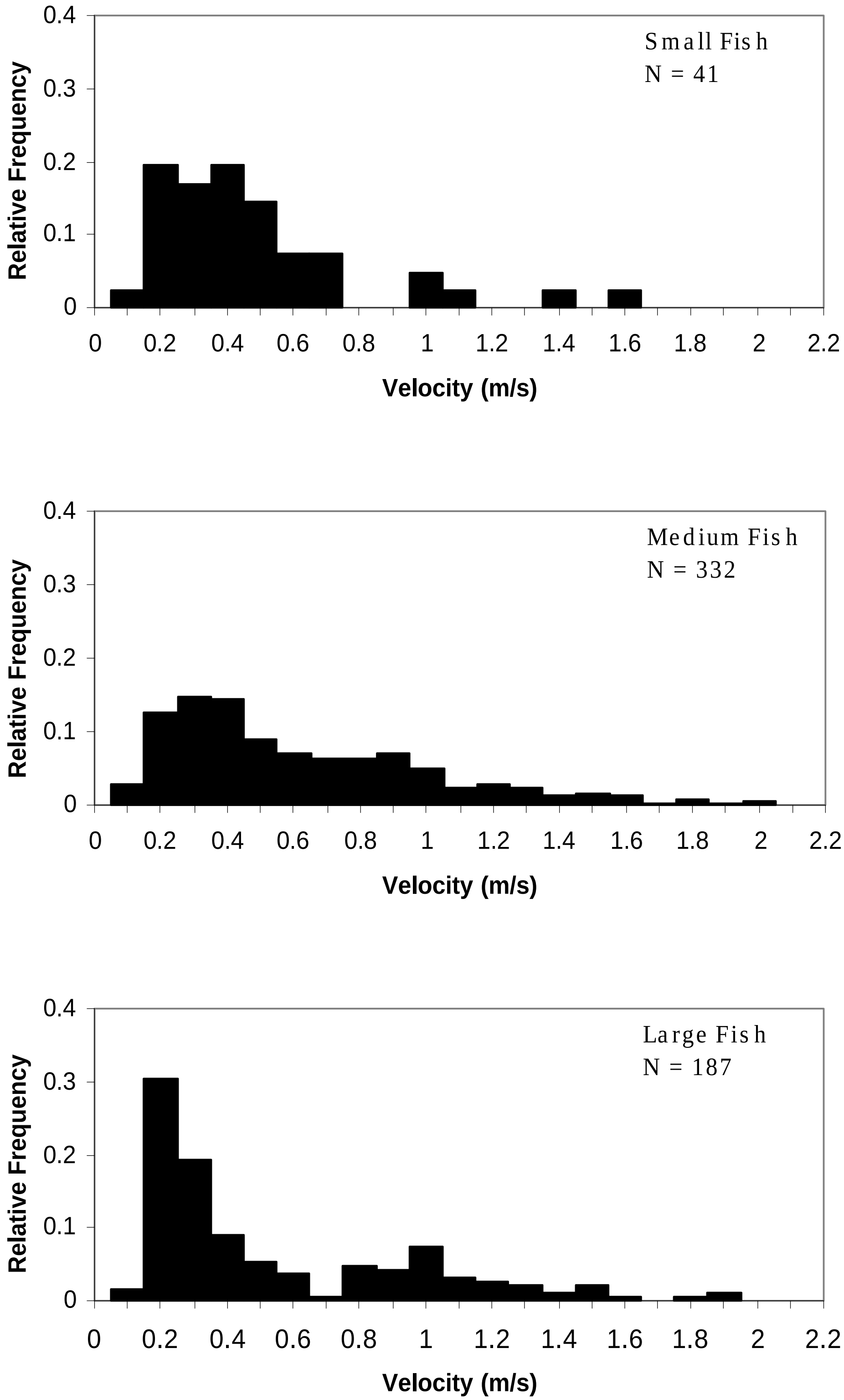


Figure 3. Velocity use by white sturgeon during all seasons, separated into small fish (fork length = 506-674 mm), medium fish (fork length = 814-1,334 mm) and large fish (fork length = 1,540-2,310 mm).

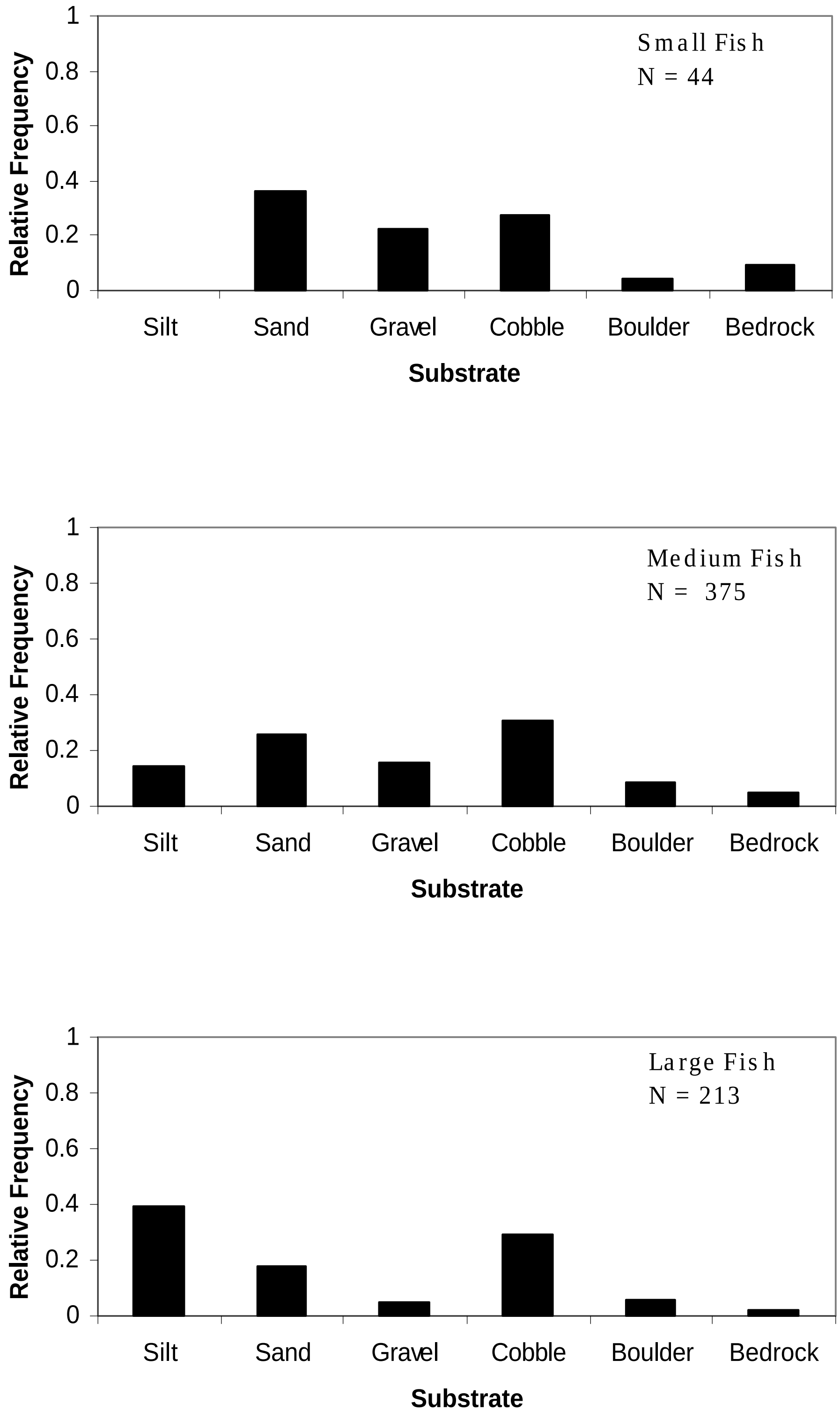


Figure 4. Substrate use by white sturgeon during all seasons separated into small fish (fork length = 506-674 mm), medium fish (fork length = 814-1,334 mm) and large fish (fork length = 1,540-2,310 mm).

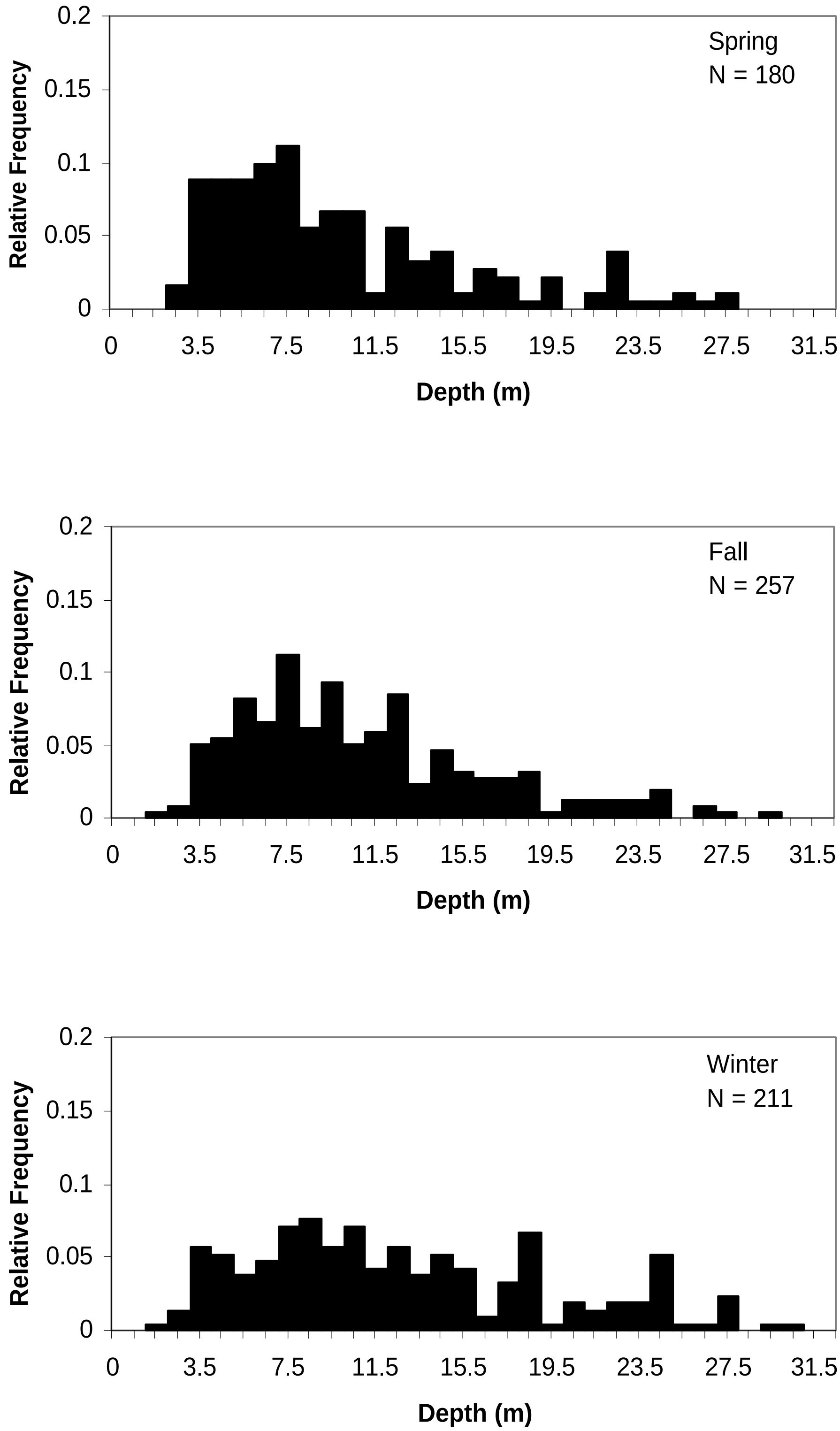


Figure 5. Depth use by all size classes of white sturgeon separated into spring, winter and fall seasons.

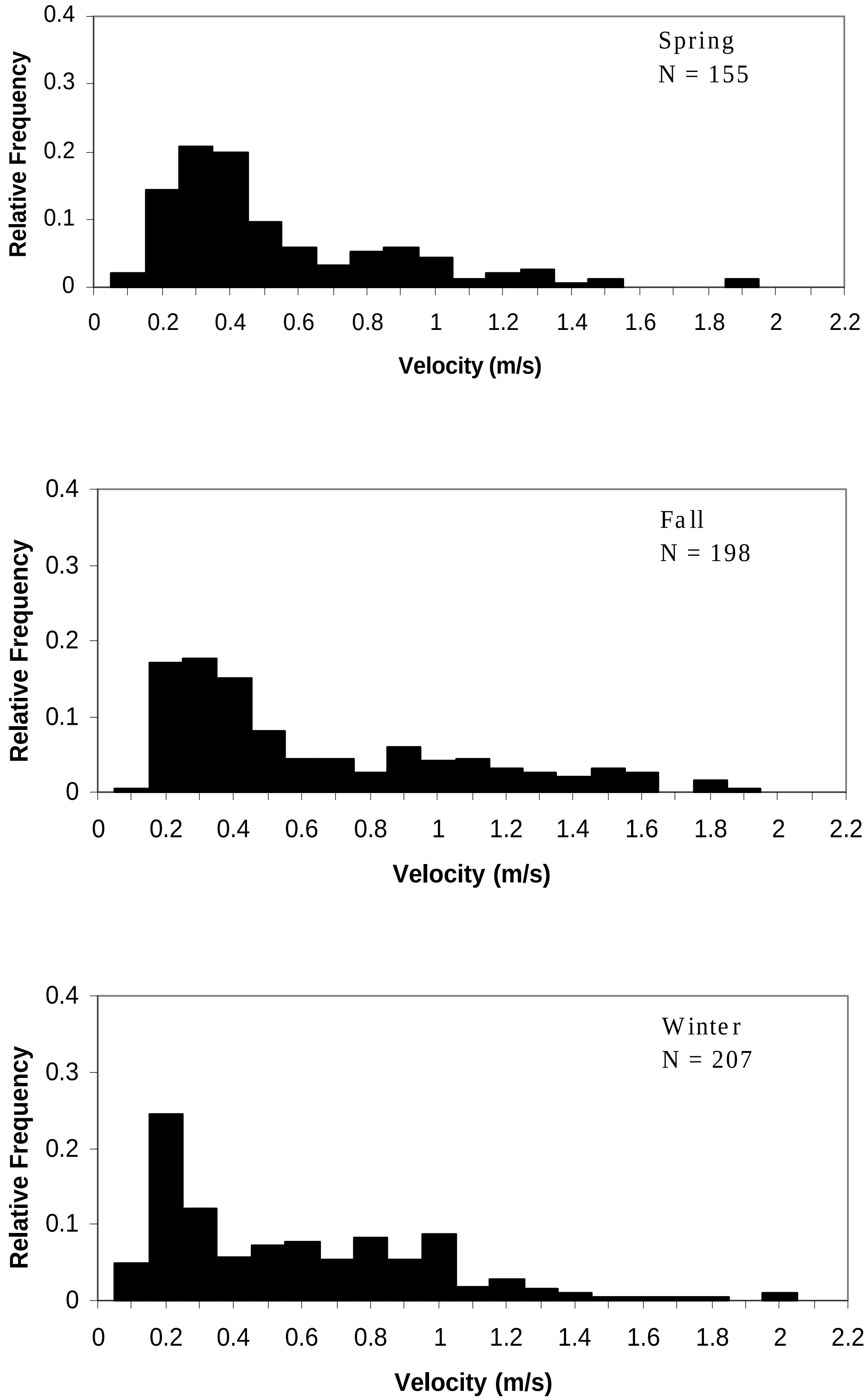


Figure 6. Velocity use by white sturgeon for all size classes, separated into spring, winter and fall seasons.

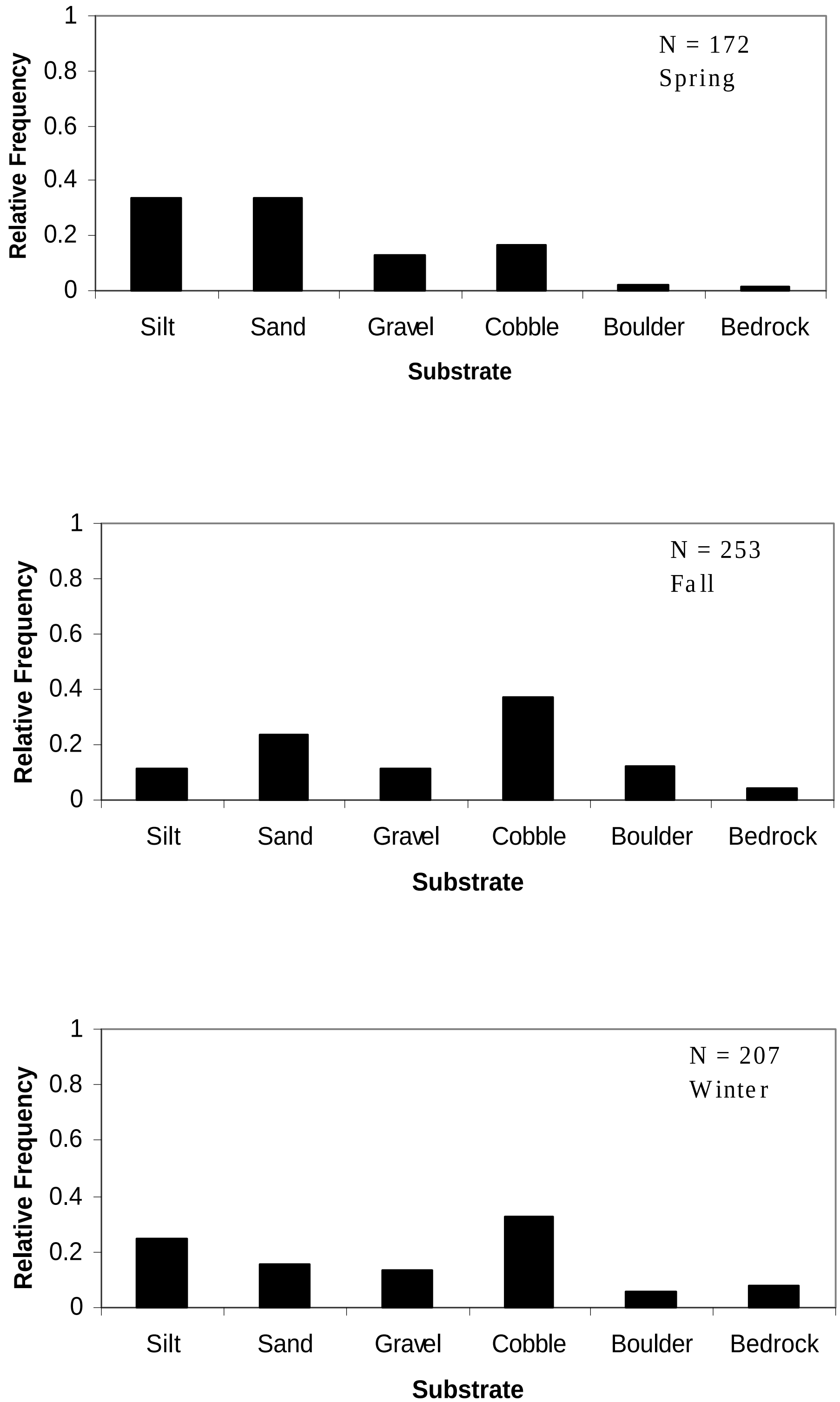


Figure 7. Substrate use by all size classes of white sturgeon, separated into spring, winter and fall seasons.

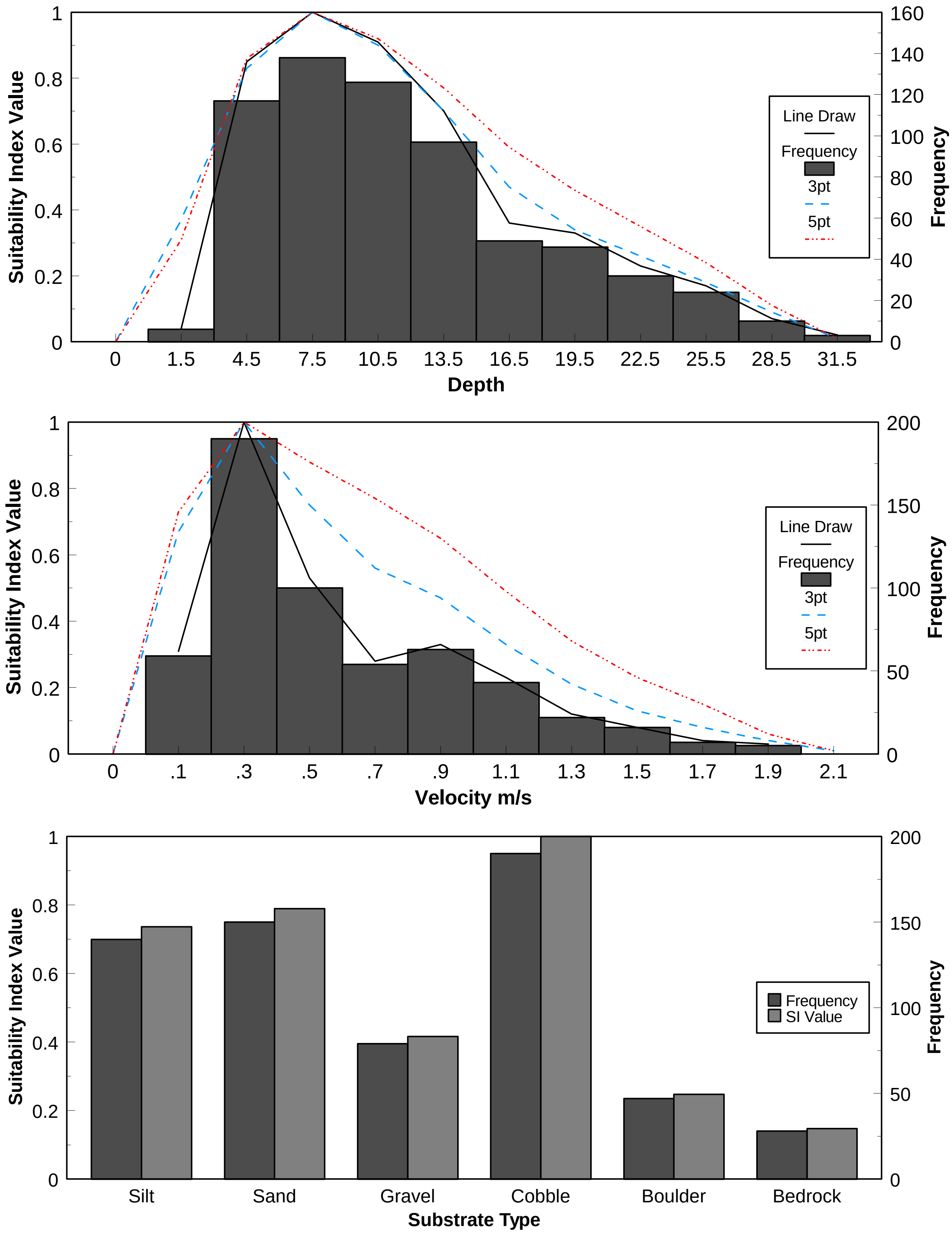
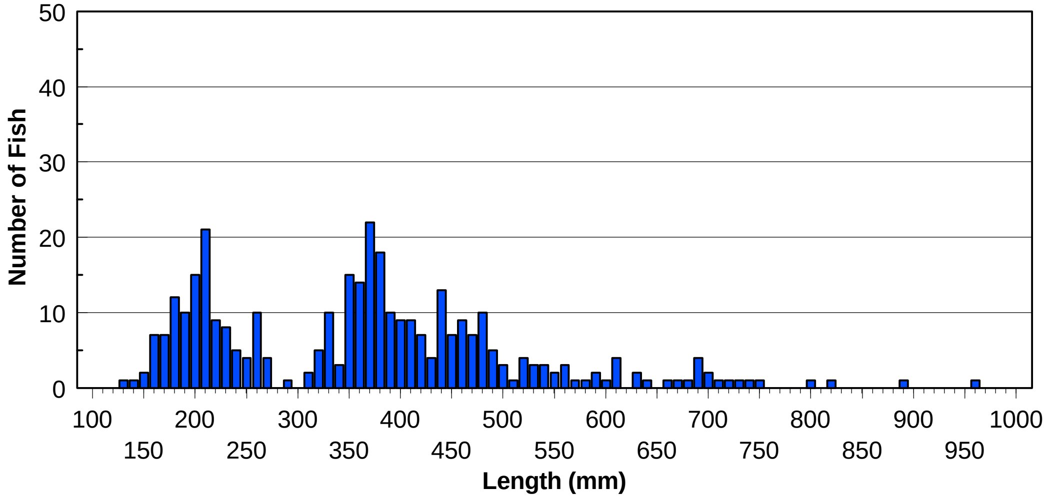
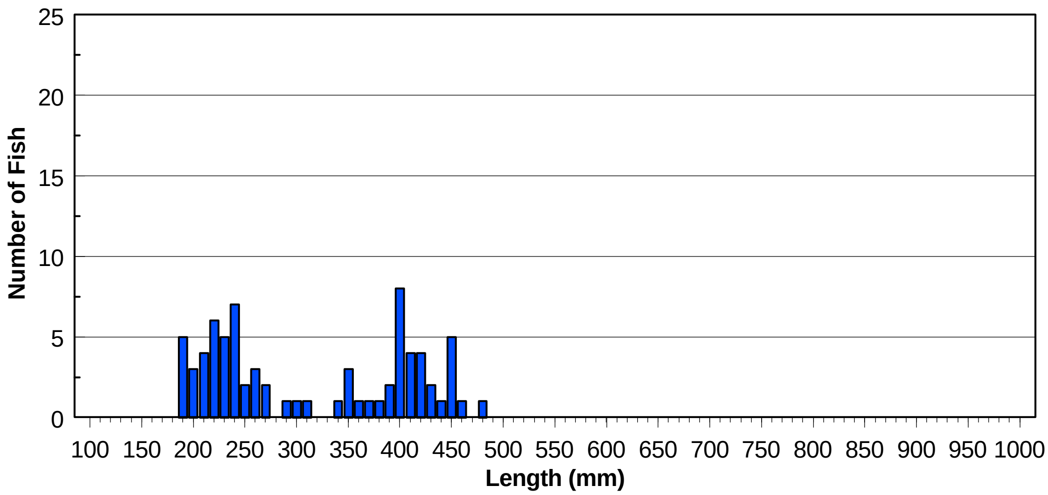


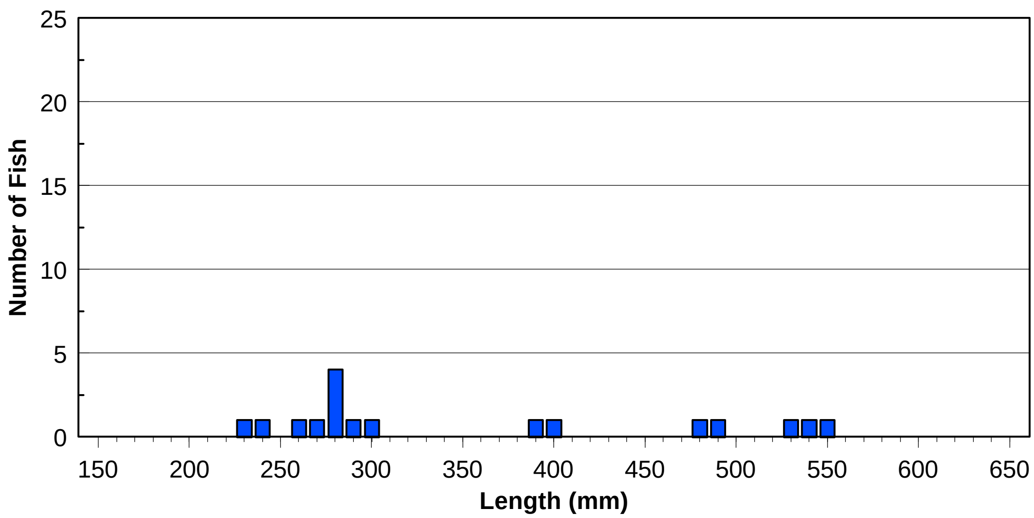
Figure 8. Habitat criteria curves depicting the suitability of depths, mean column velocity and substrates for rearing white sturgeons. Hatched bars are the data from which the curves were drawn.The line draw curve was constructed from raw frequency data. The three and five point curves were developed using three and five point running means.



N=345



N=79



N=17

Figure 9. Length frequency histograms depictingYOY and juvenile white sturgeon captured with a bottom trawl net during index recruitment to YOY surveys for Bonneville (top), The Dalles (middle), and John Day (bottom) reservoirs.

length from 122 to 286 mm TL and weighed from 8 to 92 g. The mean length of YOY captured was 203 mm TL and mean weight of 37.6 g. Older juvenile white sturgeon were also captured at all 11 sites trawled. The older juvenile white sturgeon measured from 260 to 813 mm FL and weighed 115 to 3,500 g.

The CPUE of combined effort for each of the 11 sites sampled with the bottom trawl in Bonneville Reservoir ranged from 0.19 to 6.23 YOY per 2,500 m^2 and from 0.36 to 19.43 fish per 2,500 m^2 for all white sturgeon caught (Table 3). The mean CPUE of the 66 completed tows was 1.97 YOY per 2,500 m^2 (SE = 0.31) and 5.84 fish per 2,500 m^2 (SE = 1.03) for all juvenile sturgeon. The proportion of positive tows for YOY white sturgeon (*Ep*) was 0.68, which was less than that observed in 1996 (*Ep* = 0.89) and 1997 (*Ep* = 0.82).

Table 3. Site designation, area sampled (ha), number of white sturgeon collected, and catch per 2500 m^2 of white sturgeon during sampling conducted in Bonneville Reservoir from 14 September to 1 October 1998.

		Number of white sturgeon collected		Catch/2500 m^2	
Site	Area sampled (ha)	All ages	YOY	All ages	YOY
15052	1.402	2	2	0.36	0.36
15734	1.338	7	1	1.31	0.19
15951	1.407	26	13	4.62	2.31
16522	1.368	10	6	1.83	1.10
16851	1.344	5	3	0.93	0.56
17063	1.362	38	16	6.98	2.94
17374	1.288	39	14	7.57	2.72
17652	1.336	24	14	4.49	2.62
17911	1.365	50	34	9.16	6.23
18351	1.390	108	10	19.43	1.80
18523	1.327	36	4	6.78	0.75
Total	14.926	345	117		

The Dalles Reservoir

Recruitment to YOY also occurred in The Dalles Reservoir in 1998. We captured 79 juvenile white sturgeon with the bottom trawl during sampling in The Dalles Reservoir; 41 (52%) of these were YOY. Young-of-the-year white sturgeon were captured at 4 of the 12 sites (Table 4).

The YOY ranged in length from 182 to 303 mm TL and weighed 25 to 100 g. The mean length of YOY captured was 227 mm TL and the mean weight was 47.9 g. Older white sturgeon were captured at 8 of the 12 sites trawled. The older juvenile white sturgeon measured 291 to 430mm FL and weighed122 to 480 g.

The CPUE of combined effort for each of the 12 sites sampled with the bottom trawl in The Dalles Reservoir ranged from 0 to 13.0 YOY per 2,500 m^2 and from 0 to 26.54 fish per 2,500 m^2 for all white sturgeon caught (Table 4). The mean CPUE of the 24 completed tows was 1.92 YOY per 2,500 m^2 (SE = 0.93) and 3.67 fish per 2,500 m^2 (SE = 1.61) for all juvenile sturgeon. The proportion of positive tows for YOY white sturgeon (*Ep*) in The Dalles Reservoir was 0.25.

John Day Reservoir

We captured 15 juvenile white sturgeon with the bottom trawl during our sampling in John Day Reservoir; 9 (60%) of these were YOY indicating that recruitment to YOY occurred in 1998. Young-of-the-year white sturgeon were captured at 6 of the 19 sites (Table 5). The YOY ranged in length from 227 to 285 mm TL and weighed 45 to 105 g. The mean length of YOY captured was 264 mm TL and the mean weight was 68.1 g. Older white sturgeon were captured at 6 of the 19 sites trawled. The older juvenile white sturgeon measured 289 to 448 mm FL and weighed 256 to 595 g.

The CPUE of combined effort for each of the 19 sites sampled with the bottom trawl in John Day Reservoir ranged from 0 to 2.36 YOY per 2,500 m^2 and from 0 to 4.12 fish per 2,500 m^2 for all white sturgeon caught (Table 5). The mean CPUE of the 38 completed tows combined was 0.28 YOY per 2,500 m^2 (SE = 0.11) and 0.46 fish per 2,500 m^2 (SE = 0.18) for all juvenile white sturgeon. The proportion of positive tows for YOY white sturgeon (*Ep*) was 0.18 in John Day Reservoir.

Lake Roosevelt

No white sturgeon were captured in the 19 tows we made with the 6.2-m high-rise trawl or the 13 tows made with the 3-m beam trawl in Lake Roosevelt. Sampling was done primarily in the area near Marcus Flats (Figure 10). With the exception of *Cottus* spp., few other fish were caught (Table 6). At the lower-most sampling sites, we were able to sample at depths of up to 48 m because of reduced water velocities in this reservoir. At these depths however, the nets often became clogged with fine sediments. High water velocities precluded sampling with either trawl in the upper reaches of this reservoir.

Table 4. Site designation, area sampled (ha), number of white sturgeon collected, and catch per 2500 m^2 of white sturgeon during sampling conducted in the Dalles Reservoir from 23 October to 28 October 1998.

		Number of white sturgeon collected		Catch/2500 m^2	
Site	Area sampled (ha)	All ages	YOY	All ages	YOY
19463	0.461	3	3	1.63	1.63
19683	0.425	7	3	4.11	1.76
19981	0.462	49	24	26.54	13.0
20012	0.422	11	11	6.51	6.51
20244	0.450	0	0	0.0	0.0
20432	0.450	1	0	0.56	0.0
20451	0.443	0	0	0.0	0.0
20651	0.475	2	0	1.05	0.0
20752	0.446	0	0	0.0	0.0
21014	0.433	1	0	0.58	0.0
21103	0.434	5	0	2.88	0.0
21412	0.409	0	0	0.0	0.0
Total	5.309	79	41		

Table 5. Site designation, area sampled (ha), number of white sturgeon collected, and catch per 2500 m^2 of white sturgeon during sampling conducted in John Day Reservoir from 19 October to 12 November 1998.

Site	Area sampled (ha)	Number of white sturgeon collected		Catch/2500 m^2	
		All ages	YOY	All ages	YOY
21924	0.472	0	0	0.0	0.0
22533	0.442	0	0	0.0	0.0
22931	0.423	0	0	0.0	0.0
23352	0.443	0	0	0.0	0.0
24173	0.423	0	0	0.0	0.0
24324	0.436	0	0	0.0	0.0
24822	0.445	0	0	0.0	0.0
25283	0.475	0	0	0.0	0.0
25623	0.448	0	0	0.0	0.0
26382	0.440	1	1	0.57	0.57
26422	0.425	7	4	4.12	2.36
26803	0.460	0	0	0.0	0.0
27054	0.453	0	0	0.0	0.0
27384	0.433	2	1	1.16	0.58
27851	0.463	0	0	0.0	0.0
27974	0.434	2	1	1.15	0.58
28074	0.429	2	1	1.17	0.58
28184	0.422	1	1	0.59	0.59
28972	0.409	0	0	0.0	0.0
Total	8.374	15	9		

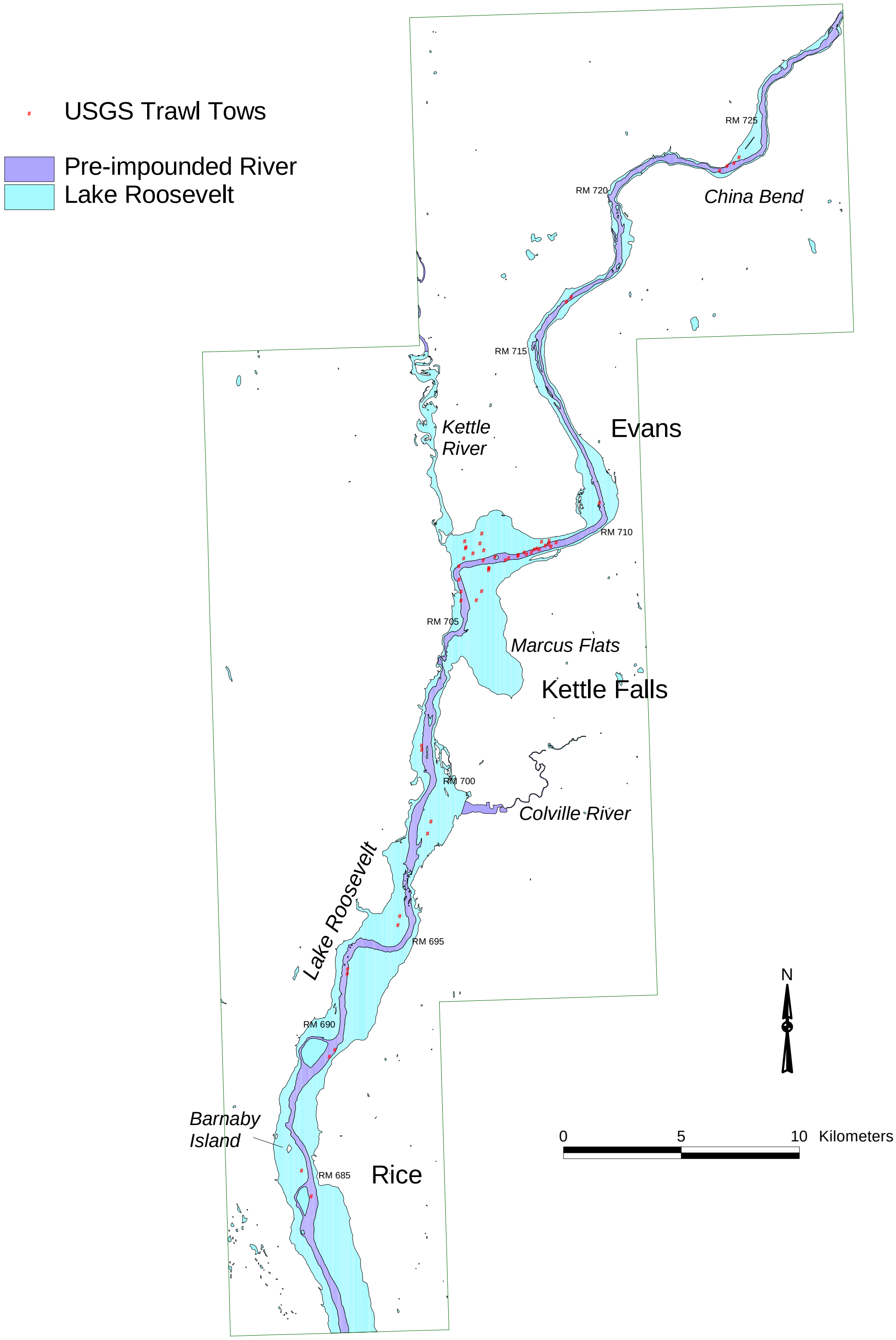


Figure 10. Sites where bottom trawls were fished in Lake Roosevelt during August, 1998. Dots indicate the beginning and ending points of individual tows.

Table 6. Species captured with bottom trawls in Lake Roosevelt.

Species	6.2-m high-rise trawl	3-m beam trawl
Burbot (*Lota lota*)	1	0
Kokanee (*Oncorhynchus nerka*)	1	0
Largescale sucker (*Castomus macrocheilus*)	1	0
Walleye (*Stizostedion vitreum*)	2	0
Sculpins (*Cottus sp*.)	321	902

Comparison of Gill Nets and Bottom Trawls to Index Recruitment to Young of the Year

The ODFW and WDFW began sampling with gillnets in 1997 to index recruitment to young of the year. During that year, they fished 8.9-cm and 10.2-cm stretched-mesh nets. In 1998 they began fishing 5.1-cm stretched-mesh nets to investigate whether these smaller mesh nets were more effective at capturing young-of-the-year, and whether the bycatch of other fish could be reduced. The ODFW has provided us with their data, however, before we can begin analyzing whether indices of recruitment derived from trawling data and gill-net data follow similar trends over time, the ODFW must determine which gear they will use as a standard gear.

The Relation of the Timing of White Sturgeon Egg Development to Water Temperature

The experiments involving the incubation of eggs at different temperatures at two facilities were successfully completed. The samples collected at the KTEH and CRRL have been examined and assigned developmental stages. The data have been entered into an electronic database and proofed for errors. Analysis of the data collected is ongoing.

Availability of Habitat

Bonneville, The Dalles, John Day, and McNary Dam Tailraces

River discharges and water temperatures that occurred during April through July 1998 provided conditions that were favorable for spawning by white sturgeon downstream from Bonneville, The Dalles, John Day, and McNary dams. The river hydrograph (Figure 11) shows that discharges rose during the latter part of April and in early May, were relatively stable between 8,000 and 10,000 m^3/s for several weeks, and then peaked during the last week in May and the first week in June. Water temperatures, which determine the time period when spawning will occur, rose to optimal levels for spawning by white sturgeon on or about 23 April (Figure 12) then decreased to temperatures below optimal levels. Thus the suitability

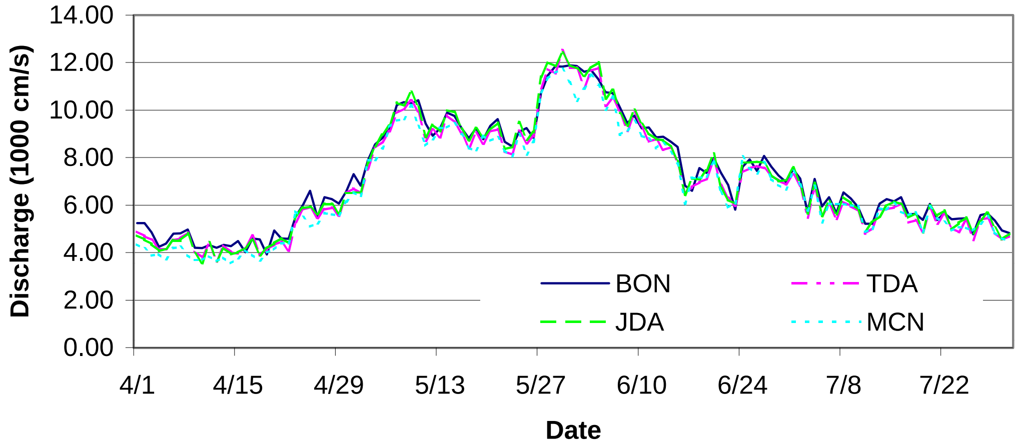


Figure 11. River discharges at Bonneville (BON), The Dalles (TDA), John Day (JDA), and McNary (MCN) dams during 1998. Data were obtained from the DART website (http:\\www.cqs.washington.edu\dart\).

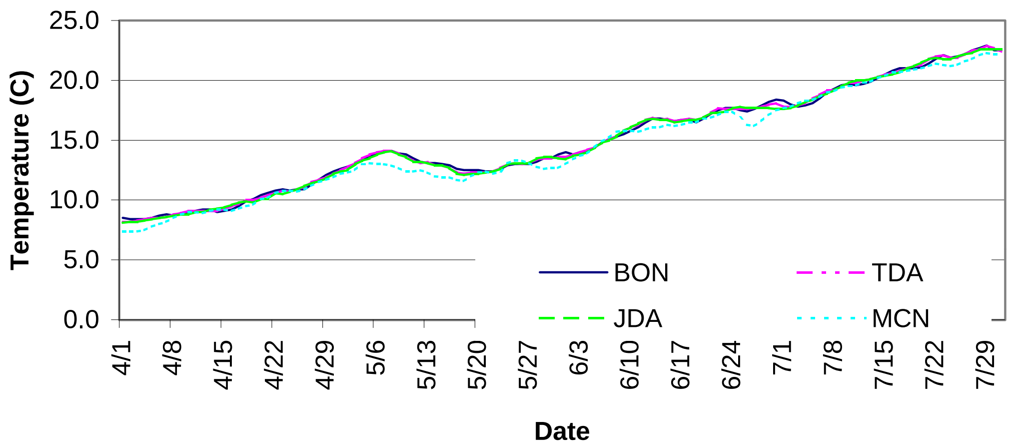


Figure 12. Water temperatures at Bonneville (BON), The Dalles (TDA), John Day (JDA), and McNary (MCN) dams during 1998. Data were obtained from the DART website (http:\\www.cqs.washington.edu\dart\).

of the habitat for spawning decreased substantially before rising to optimum levels again in mid-May (Figure 13). As a result of the hydrograph and temperature regime that occurred in 1998, our monthly estimates of the index of spawning habitat showed that the availability of habitat for spawning peaked in May and the estimates were much higher for this month than historical estimates dating back to 1985 (Figure 14). Annual indices for 1998 were higher than the long-term average for each spawning area (Figure 15).

McNary Reservoir

Criteria curves that depict rearing habitat were not completed in time for us to estimate the availability of rearing habitat within the McNary Reservoir during this reporting period. The USFWS (this report) is conducting analyses to estimate the availability of spawning and rearing habitats within the Hanford Reach and the Snake River downstream from Ice Harbor Dam. We will work with the USFWS to provide a comprehensive report on the availability of habitats for spawning and rearing white sturgeon in the Columbia and Snake rivers between McNary, Ice Harbor, and Priest Rapids dams.

Effects of Proposed Reservoir Drawdowns on the Productivity of White Sturgeon

Substantial progress was made in acquiring spatial data sets and completing the modeling necessary to estimate the water depths and velocities that may exist if water levels are manipulated in the John Day Reservoir or the lower Snake River through reservoir drawdown or dam breach. At the time of this writing, estimates of the availability of spawning and rearing habitat for white sturgeon have not been completed. These analyses will be completed and results presented during the reporting period for activities conducted during April 1999 - March 2000.

Movements and behavior of Pre-Spawn and Spawning White Sturgeon

A total of 215 white sturgeon were caught, with zero bycatch of salmonids, while deploying 87 sets of setline gear. Sonic and radio transmitters were attached to 7 mature male white sturgeon ranging in fork length from 1,350 mm to 1,580 mm (Table 7).

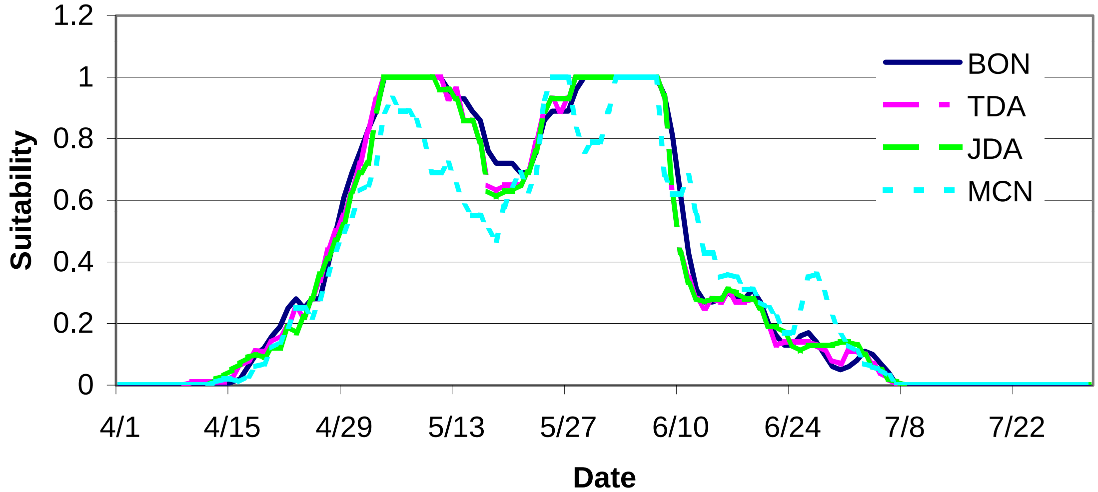


Figure 13. Time series of water temperature suitability for spawning by white sturgeons.

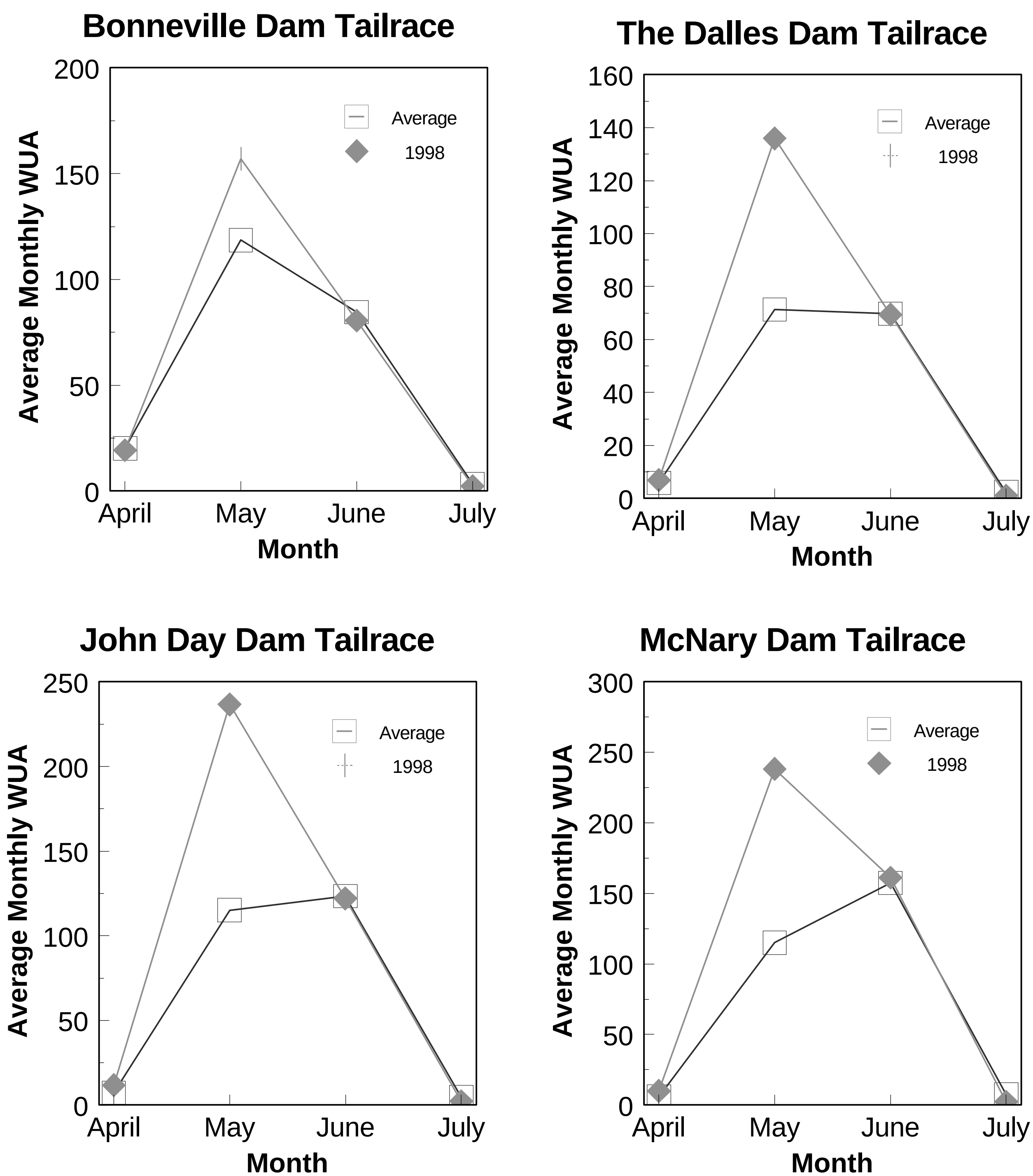


Figure 14. Mean monthly indices of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon during 1998 and the average for 1985 through 1997 for the four spawning areas that have been modeled.

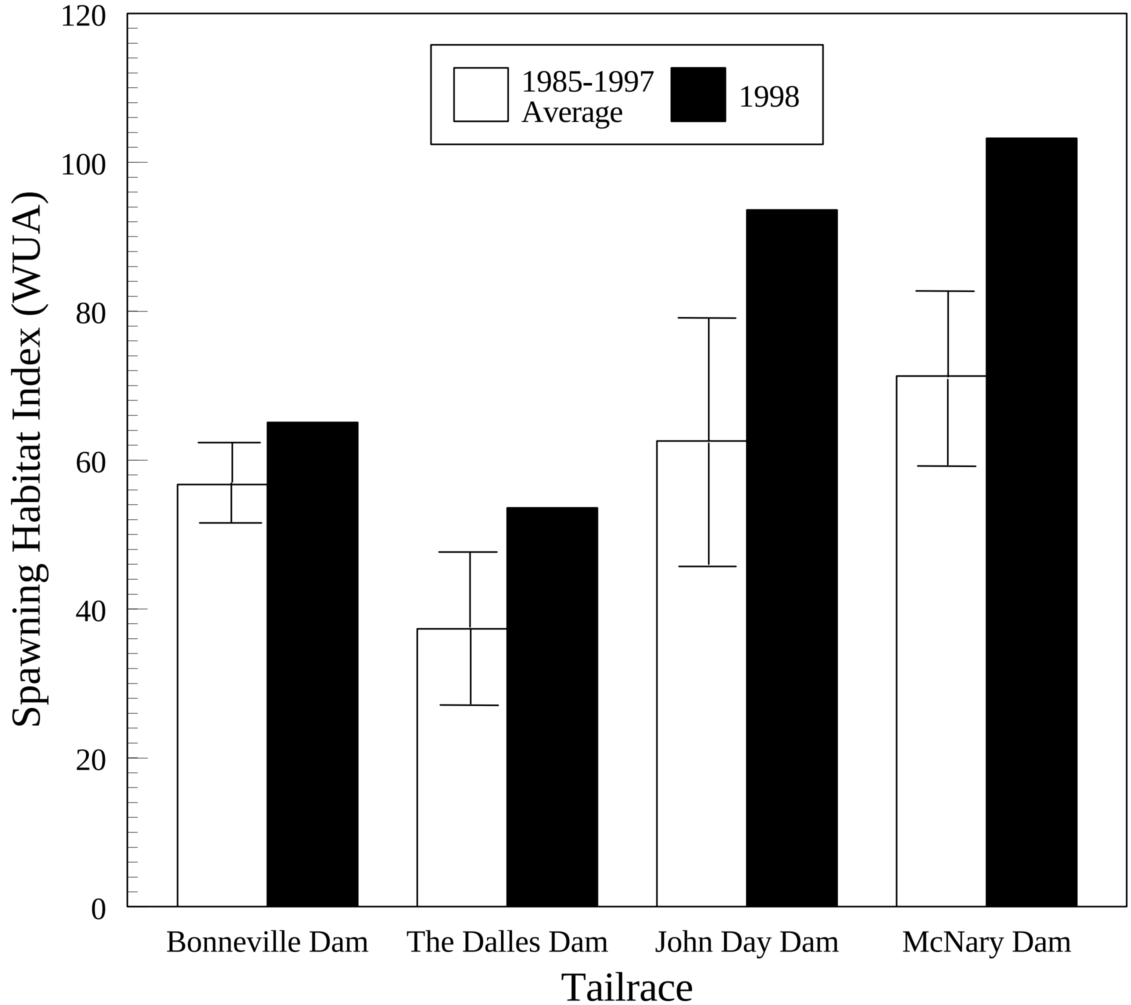


Figure 15. Annual mean composite index of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon for each of the four dam tailraces that have been modeled (Parsley and Beckman 1994). Shown are the indices for 1998 and the average for 1985 through 1997. The vertical lines within the bars for the averages depict one standard deviation.

Table 7. Characteristics of white sturgeon fitted with sonic transmitters (Sonotronics model CT-82-3) and radio transmitters (Lotek model CFRT-7DXT) during February 1999.

Tag Code		Date Captured			Weight	FL	TL	Location where captured[c]	
Sonic[a]	Radio[b]	YY	MM	DD	(kg)	(mm)	(mm)	Latitude	Longitude
72.247	149.210/27	99	02	18	30	1580	1740	45 41.406	120 47.091
72.238	149.200/22	99	02	23	28	1490	1650	45 39.506	120 53.963
73.338	149.200/21	99	02	25	25	1420	1580	45 39.108	120 57.794
73.347	149.210/26	99	02	23	23	1450	1570	45 39.506	120 53.963
73.356	149.220/31	99	02	26	33	1580	1770	45 39.504	120 54.000
74.448	149.220/33	99	02	23	24	1430	1560	45 39.494	120 54.040
74.466	149.200/23	99	02	17	17	1350	1530	45 39.673	120 53.113

[a]Digits preceeding the decimal point are the frequency in kHz. Digits after the decimal point indicate the code used to identify individual transmitters.

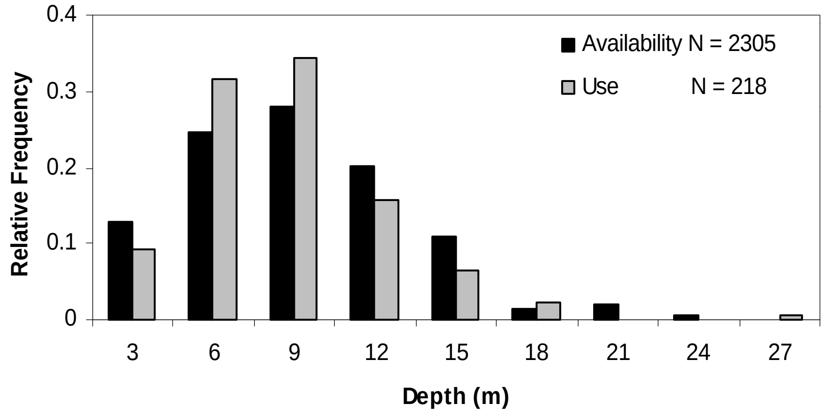
[b]Digits preceding the slash are the frequency in MHz. Digits after the slash indicate the code used to identify individual transmitters.

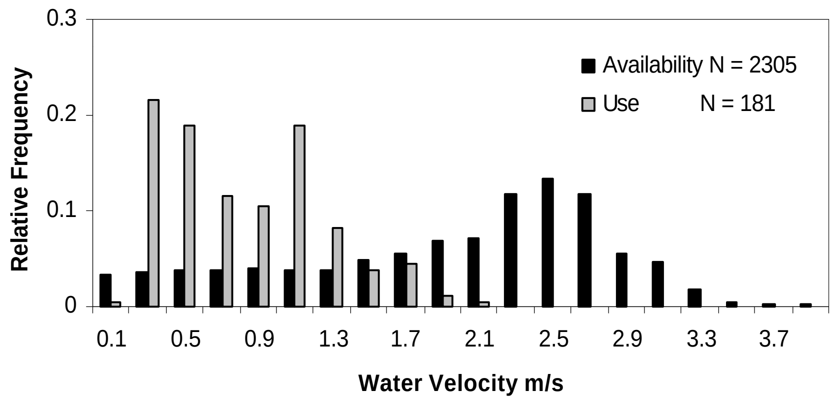
[c]Locations (latitude and longitude) were recorded in NAD27 datum.

DISCUSSION

During this reporting period, the USGS worked on seven tasks, each having distinct goals and products. Field sampling was necessary for two tasks (YOY indexing and monitoring the movements and behavior of pre-spawning and spawning white sturgeon in The Dalles Reservoir). Activities on the remaining tasks included the continued analysis of previously collected field or laboratory data (habitat use and movements of juvenile white sturgeon, effects of water temperature on the development of white sturgeon eggs) and incorporating annual data into new summaries (comparisons of catches of YOY from gill nets and bottom trawls, availability of spawning habitat). Substantial progress was also made to assess the potential effect of reservoir drawdowns on white sturgeon productivity.

Rearing habitat for white sturgeon is optimized where water depths are about 7.5 m, mean column water velocities are near 0.3 m/s, and substrates are composed of sand or cobbles. We recognized during the design of this study that it would be improbable to collect habitat availability information throughout the study area, thus, the suitability index curves we present are use curves only, not preference curves. We used a subset of our habitat use data and information collected by the USFWS (Anglin 1996) that described the availability of habitat within river km 592.2 to 638.9 as a check to compare habitat use and availability. This area is within the free-flowing Hanford Reach. We pooled the frequency of use data from all sizes and seasons and plotted it against availability (Figure 16). Comparisons between white sturgeon relative frequency of use and relative frequency of available depths, mean column water velocities, and substrates show that fish in this river reach are not selecting for particular depths or substrates, but are showing a strong selection for lower velocities. These results suggest that the suitability index curve for depth should not have a descending right limb but the velocity curve should, and that there is little or no





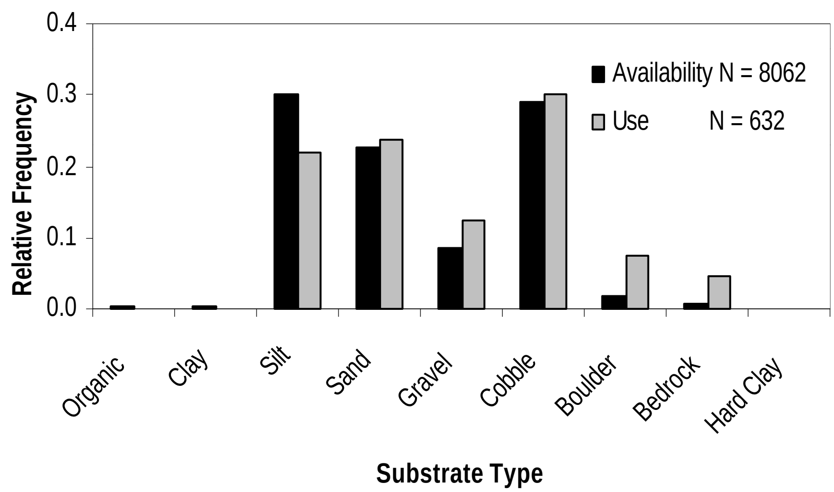


Figure 16. The relative frequencies of use versus availability for rearing Columbia River white sturgeon separated into depth, velocity and substrate.

selection for or against substrate (e.g. all substrates are equally suitable).

The habitat suitability curves resulting from this work will be used as input to models that identify the quality and extent of habitat available to rearing white sturgeon. These microhabitat criteria curves currently represent the best information of habitat use by rearing white sturgeon in the Columbia River and are an improvement over the rearing habitat curves presented by Parsley and Beckman (1994) in several respects. Parsley and Beckman used a population-based approach wherein the curves they presented were developed from catches made with bottom trawls. Because of the size selectivity of the trawl used in their study, Parsley and Beckman's (1994), analysis was restricted to fish generally less than 1 m in length. For this study, we used telemetry to follow individual fish throughout the year, and placed transmitters on fish ranging in size from 0.5 m to 2.3 m FL. The use of telemetry allowed us to accurately locate individual fish and measure microhabitat characteristics within meters of a fish's actual location. Our study also resulted in a greater number of velocity observations. Nearly 50% of the study area is not influenced by backwater effects from a downstream dam, thus, the range of velocities available for use by white sturgeon was greater during in this study than in the study reported by Parsley and Beckman (1994). Parsley and Beckman (1994) were unable to describe a descending right limb for the velocity use curves they constructed because their study was conducted only within low velocity reservoirs. Results from this telemetry study have shown that white sturgeon don't use habitats for rearing in which the mean column water velocity exceeds 2.1 m/sec, and that the suitability of habitats declines as mean column velocities exceed 0.3 m/sec.

Telemetry techniques are often used during studies undertaken to collect data necessary to construct habitat suitability index curves. However, there is always concern that the presence of a transmitter will affect the behavior of the fish. The effects of placing external transmitters on large white sturgeon are unknown. However, Counihan and Frost (1999) found reduced swimming performance on white sturgeon ranging in fork lengths from 319 mm to 370 mm when they attached small acoustic transmitters even though the ratio of the weight of the transmitter to the weight of the fish was below recommended criteria (Winter, 1996). A negative impact on swimming performance caused by transmitter attachment could bias information we collected on white sturgeon habitat use. However, the smallest fish in our study (505 mm) was much larger than those studied by Counihan and Frost (1999) and the effects of external transmitters on these larger fish are unknown.

The bottom trawling for juvenile white sturgeon revealed that recruitment to young of year occurred in occurred in Bonneville, McNary, and The Dalles reservoirs. Catches of juvenile white sturgeon were lower for each reservoir than catches for 1997 (Counihan et al, 1997). In Bonneville Reservoir, the majority (66%) of the white sturgeon captured were juveniles older than YOY, a similar percentage to that seen during the sampling in 1997 (69%; Counihan et al, 1997). Catches of YOY with the bottom trawl in The Dalles and John Day reservoirs, although lower than 1997 catches, remain high relative to past annual surveys conducted in these reservoirs.

The USGS recently published a manuscript describing the use of data from bottom trawls to index the recruitment of white sturgeon (Counihan et al. 1999). However, sampling with bottom trawls requires specialized equipment and trawls cannot be fished in many areas. Gill nets can be fished in a broader range of riverine conditions than bottom trawls, and do not require highly specialized boats and crews. Thus, gill nets may be a more desirable gear to use for indexing recruitment. However, several years of catch data from gill netting will be necessary to discern if trends in recruitment can be detected using this gear. The ODFW must decide on which mesh size will become their standard indexing gear. Eventually, our analyses will determine if trends can be derived from gill net data, and whether those trends follow those derived from trawling data. If so, sampling strategies could be implemented that use gill nets rather than bottom trawls, which may result in a significant savings in equipment and personnel costs.

With the completion of the egg incubation experiments this year we now have a data set comprised of incubation times of embryos obtained from the Kootenai, Columbia, and Snake rivers and incubated at different temperatures (Table 8). Ongoing analyses are investigating whether differences in incubation times exist among river systems.

Table 8. Temperatures, indicated by the year that the experiments were conducted, that white sturgeon embryos from three river systems were incubated to hatch.

	12 C	15 C	18 C
Kootenai River	1998	1997, 1998	1997
Snake River		1997	
Columbia River	1998	1998	1998

Plans for 1999

During 1999, the USGS will continue several tasks begun in previous years, including indexing the recruitment of white sturgeon to YOY in the Bonneville, The Dalles, and John Day reservoirs, and assessing the potential effects of reservoir water level manipulations on the productivity of white sturgeon. We will proceed with the analyses and preparation of manuscripts for studies completed during 1998. In particular, we will complete our analyses of data collected to describe the habitat use and movements of white sturgeon in the McNary Reservoir, and complete our analysis of the timing of the development of white sturgeon embryos. We'll continue a study using biotelemetry to monitor the movements of adult white sturgeon prior to and during the spawning period.

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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 1998 - MARCH 1999

Report D

Quantify physical habitat available for spawning and rearing white sturgeons in the free-flowing portion of the Columbia River between McNary Reservoir and Priest Rapids Dam and in the free-flowing portions of the Snake River Between McNary Reservoir and Lower Granite Dam

This report includes: A review of the status of investigations into the availability of spawning and rearing habitat for white sturgeons in the Hanford Reach of the Columbia River and in the lower Snake River.

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We would like to acknowledge the effort of our field personnel including Paul Ocker, Eric Hansen, and Julia Taylor for the hard work and long days pursuing constantly changing river flows, and the long hours viewing and classifying cross section substrates with the underwater video equipment. We would also like to acknowledge the Walla Walla District of the Army Corps of Engineers for providing rating curves for our cross section locations in the lower Snake River to enhance hydraulic simulations conducted for that area.

ABSTRACT

The U.S. Fish and Wildlife Service completed field data collection for the white sturgeon (*Acipenser transmontanus*) habitat assessment in Columbia and Snake river study areas during 1998, with the exception of several minor tasks. Cross section profile and velocity distribution data were collected at 30 cross sections, and stage-discharge data pairs were collected at 37 cross sections in the lower Snake River. Data were collected at total river discharges ranging from 2,892 to 6,041 m^3/s. A new underwater video equipment configuration was used to collect approximately 500 substrate data points and geographic locations in the Columbia River. Cross section profiles, velocity distributions, stage-discharge data pairs, and substrate characteristics were added to data files for existing cross sections, or used to build new data files for lower Snake River study areas. Calibration of hydraulic models for main channel cross sections in the Hanford Reach neared completion. A Snake River tailwater rating curve analysis was received from the Corps of Engineers, Hydrology Branch. The water surface elevations from the Corps HEC-2 model will be used calibrate hydraulic models for the lower Snake River study areas. Habitat modeling is currently underway for the Columbia River study area. Evaluations of total weighted usable area (WUA) as well as high quality WUA were initiated for main channel areas. An initial comparison of cross sections in the Hanford Reach showed that the majority of high quality spawning WUA was available on riffle-type cross sections at much lower flows than on pool-type cross sections.

INTRODUCTION

This annual report describes the progress made by the U.S. Fish and Wildlife Service (USFWS) from 1 April 1998 to 31 March 1999 towards completion of the habitat assessment tasks for white sturgeon (*Acipenser transmontanus)* studies on the mainstem Columbia and Snake rivers under the Bonneville Power Administration's Project 86-50. The habitat assessment was designed to address Objective 2, Task 2.2 from the FY1999 Performance Work Statement for the project. The purpose of Task 2.2 is to quantify physical habitat for spawning and rearing white sturgeon, determine the effect of hydrosystem configuration and operation on available habitat, and identify potential measures for protecting and enhancing white sturgeon habitat in the Columbia and Snake rivers upstream from McNary Dam. Habitat assessments are being conducted for the following areas:

1) Spawning and rearing habitat in the free-flowing Hanford Reach of the Columbia River between river mile (RM) 368 near the White Bluffs boat ramp and RM 397 near Priest Rapids Dam;

2) Spawning and rearing habitat in the free-flowing portion of the Snake River between the confluence with the Columbia River and Ice Harbor Dam (RM 9.7);

3) Spawning and rearing habitat in the tailrace areas downstream from Lower Monumental (RM 41.6), Little Goose (RM 70.3), and Lower Granite (RM 107.5) dams.

Specific tasks conducted by USFWS during the current reporting period were:

1) Measurement of cross section profiles in the lower Snake River;

2) Measurement of velocity distributions and water surface elevation (stage)-discharge data pairs for cross sections in the lower Snake River;

3) Characterization of substrate using underwater video in the White Bluffs Island Complex (WBIC) in the Hanford Reach;

4) Determination of geographic locations for cross section headpins, reference marks, hydraulic data, and substrate data using Global Positioning System (GPS) receivers in the WBIC in the Hanford Reach, and in the lower Snake River study areas;

5) Data reduction and import of Acoustic Doppler Current Profiler (ADCP) raw data files into hydraulic modeling programs and integration of survey data and/or substrate characteristics with hydraulic data;

6) Hydraulic model calibration and hydraulic modeling for the Hanford Reach and lower Snake River;

7) Habitat modeling for the Hanford Reach.

METHODS

Field Data Collection

The sampling program was designed to acquire field data for analysis using the Physical Habitat Simulation System (PHABSIM) which was developed as part of the Instream Flow Incremental Methodology (IFIM; Bovee 1982). The hydraulic and habitat modeling algorithms and other data processing functions which comprise PHABSIM, 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 (Payne 1994). As a result, no adjustments in the sampling program were required to use the RHABSIM software package. Sampling design, field methods, and data collection protocols are discussed in detail in previous Annual Reports for this project and objective (1993-97).

Study Design

Study design, river segmentation, and cross section placement for the main channel sections of the Hanford Reach study area in the Columbia River (Figure 1) were based on a sensitivity analysis conducted in 1994 (Anglin 1995). Study design and cross section placement for the WBIC (RM 371-377) in the Hanford Reach study area were based on a sample of river channel profiles and field observations, and were intended to capture the physical variation characteristic of the area. Study design and cross section placement for the Snake River dam tailrace study areas between McNary Pool (RM 4.5) and Lower Granite Dam (RM 107.5) (Figure 2) were also based on a sample of river channel profiles and field observations, and were intended to capture the physical variation characteristic of each area. Details regarding field setup activities and cross section locations were presented in the 1994, 1995, and 1996 Annual Reports for this project (Anglin 1996, Anglin et al. 1997, Anglin et al. 1998), and a summary of work conducted and specific locations was presented in the 1997 Annual Report (Anglin et al. 1999).

Hydraulic Data Collection

Hydraulic data collection continued during spring of 1998 for the lower Snake River study areas. Cross section profiles, velocity distributions, and stage-discharge data were collected for most Snake River cross sections. Hydraulic data collection protocols were discussed in detail in the 1996 Annual Report (Anglin et al. 1998).

Substrate Data Collection

The field equipment configuration for river bed substrate characterization was modified during 1998 for work in the WBIC and lower Snake River. The Fish Eye[1] black and white underwater video camera with wide angle lens, built in light source, and 0.15 Lux minimum light level was available with the desired combination of features. A welded aluminum carriage was

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

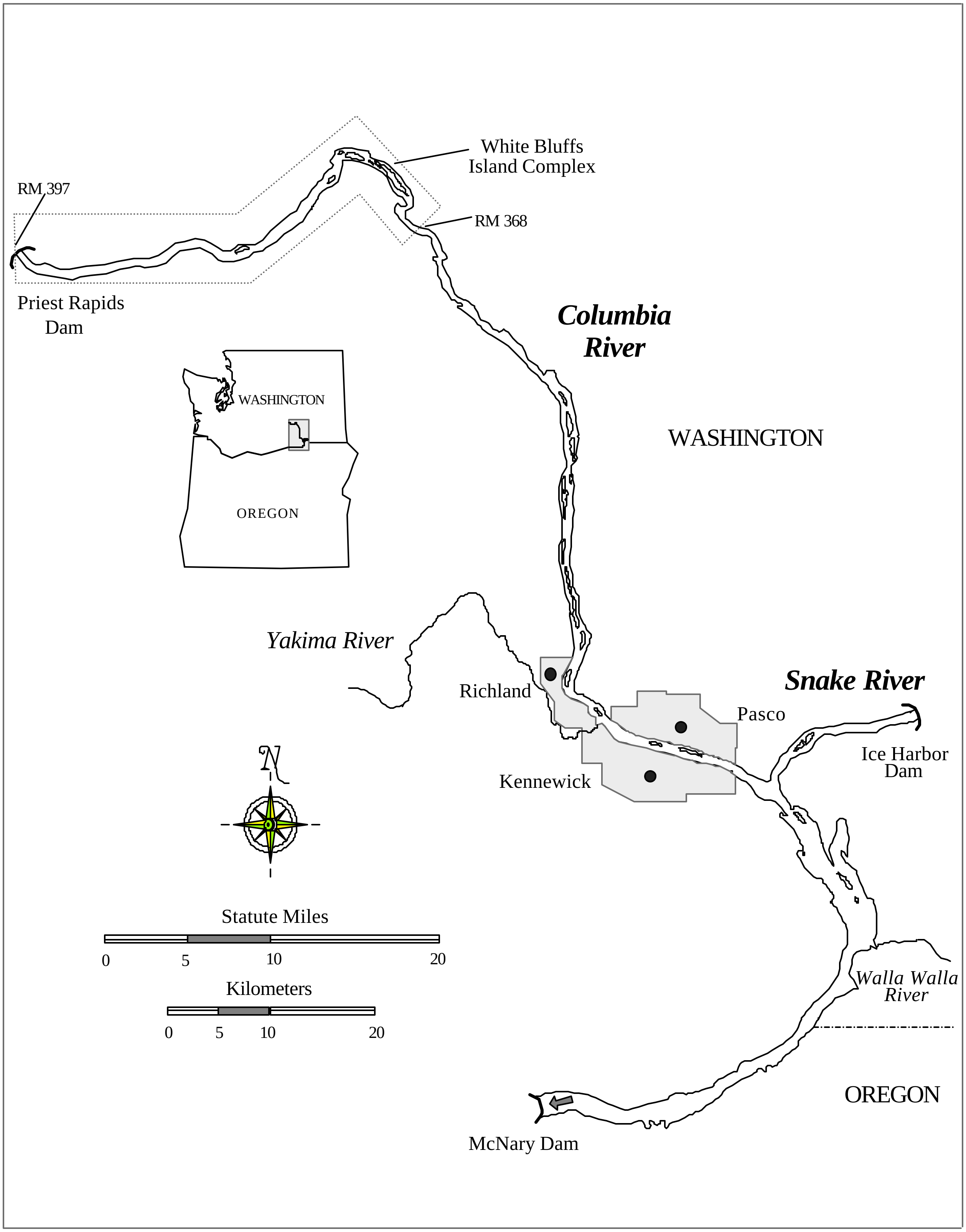

Figure 1. Location of the Hanford Reach study area between White Bluffs and Priest Rapids Dam on the Columbia River.

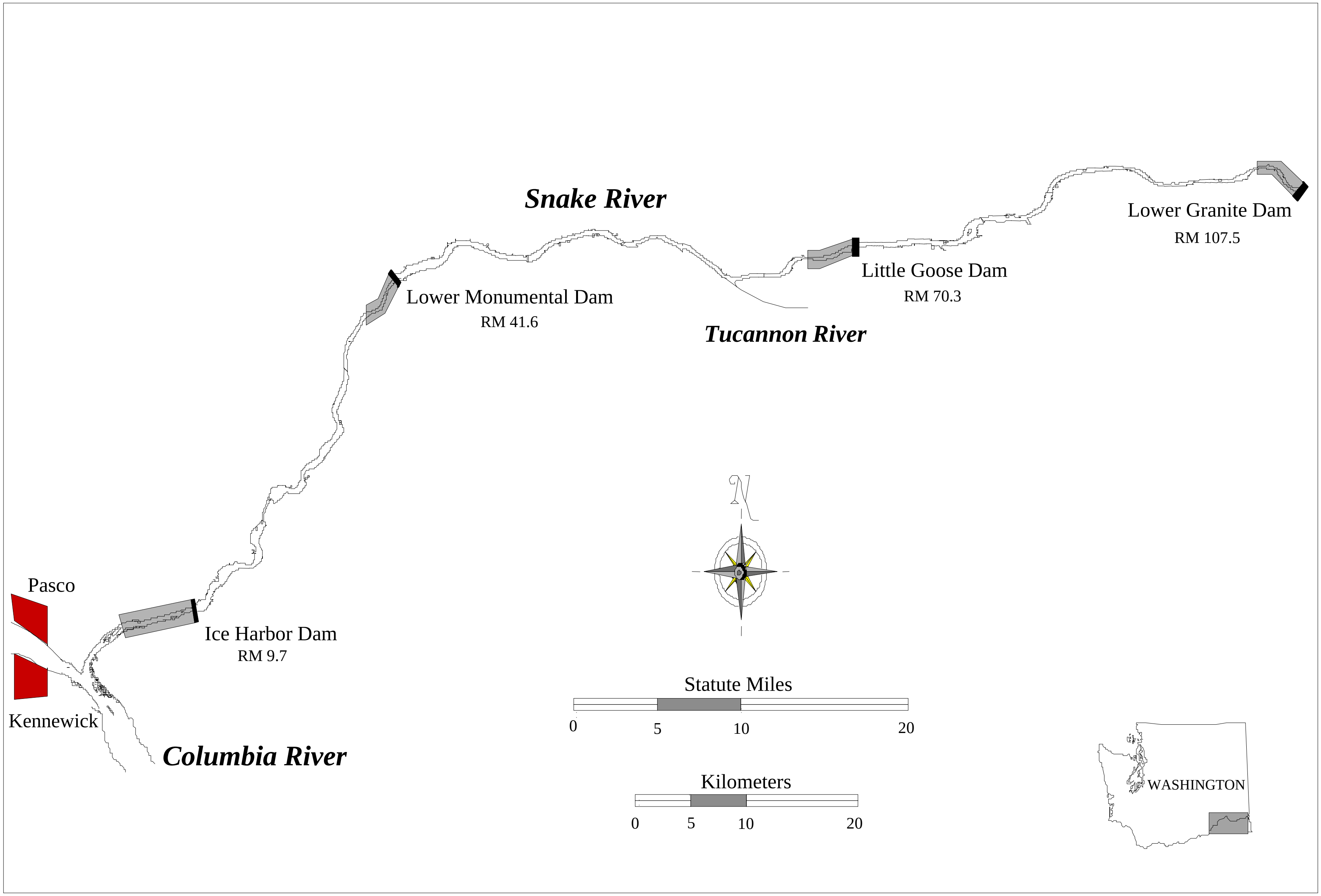

Figure 2. Lower Snake River dam tailrace study areas.

designed to accommodate the physical shape and size of the new camera, along with several additional features (Figure 3). The round "barrel" that houses the camera was designed for either upstream or downstream orientation, and with the capability to adjust the camera angle vertically, relative to the river bottom. The carriage design also included mounting locations for two underwater lasers on opposite sides of the camera housing for more efficient and accurate sizing of substrate elements regardless of camera angle or distance off of the river bottom. Field methods and data collection protocols for substrate characterization have not changed, and were discussed in detail in the 1996 Annual Report (Anglin et al. 1998).

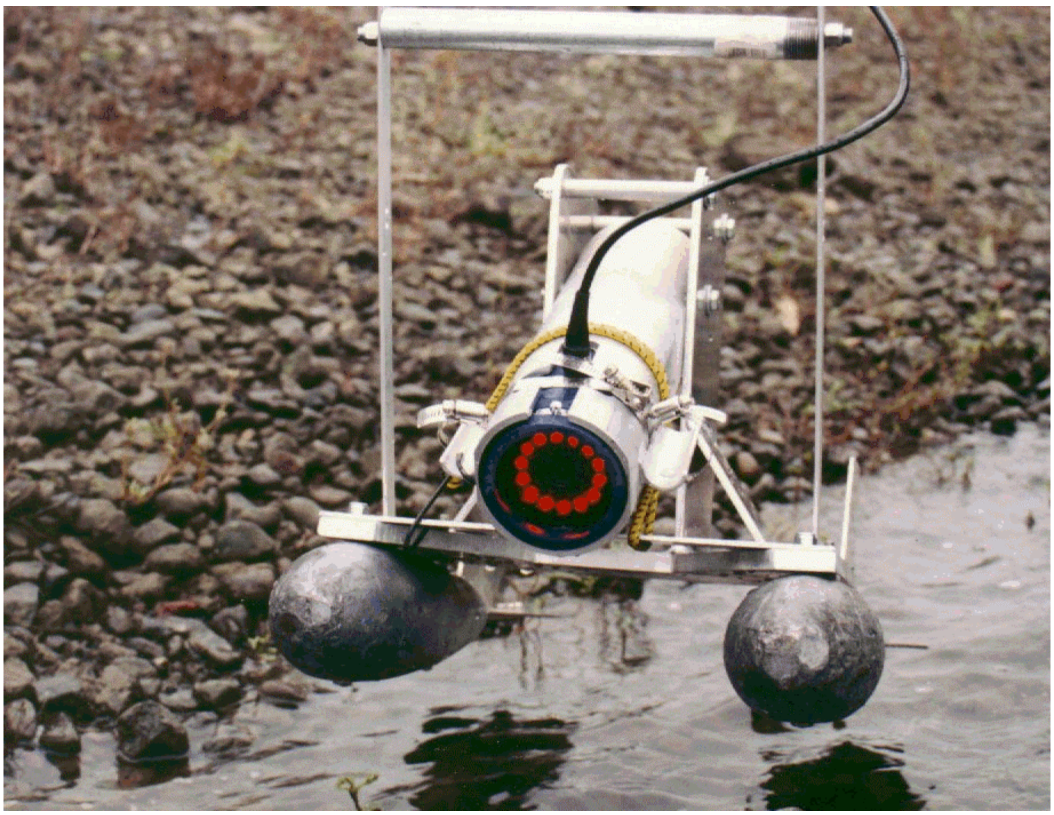

Figure 3. Underwater video camera and welded aluminum carriage.

Data Analysis

Data Reduction - Hydraulic Modeling

Hydraulic field data collected by the ADCP were converted from binary format to ASCII format, reduced, and imported into the RHABSIM field data spreadsheet. Horizontal distance and elevation for surveyed bank points, water edges, and water surface elevations were combined with the ADCP data, and near shore depths and velocities were entered at the correct distances from the water edges. Water surface elevations and the corresponding discharges were entered into the spreadsheet as the data pairs were collected. Analytical details associated with data reduction, input, hydraulic model calibration, and hydraulic simulations were discussed in detail in the 1996 Annual Report (Anglin et al. 1998). Hydraulic simulations were conducted to determine water column depth and mean column velocity at each vertical or data point along each cross section for a range of streamflows characteristic of the Columbia and Snake river hydrographs. Water column depth and mean column velocity together with substrate characteristics for each vertical were subsequently used as input to habitat models for habitat quantification.

Habitat Modeling

White sturgeon spawning and rearing habitat was calculated by multiplying the relative suitability of the depth, velocity, and substrate conditions for each streamflow by the river surface area resulting in a habitat index. RHABSIM hydraulic models were used to predict depth and velocity for each habitat cell across a range of streamflows. Substrate for each cell is fixed and does not vary with streamflow. Depth, velocity, and substrate conditions for each cell were then evaluated against microhabitat suitability criteria to determine the combined suitability or habitat quality for each cell. This value was combined with the surface area of each cell to derive a microhabitat index in terms of weighted usable area (WUA) (Figure 4).

Microhabitat criteria curves describe the relative suitability of a range of depths, velocities, and substrate sizes for the spawning (Figure 5) and rearing lifestages. Suitability is indicated on a scale from 0.0 to 1.0 for each lifestage, with 0.0 indicating unsuitable and 1.0 indicating optimal. Sturgeon spawning criteria curves used in this habitat assessment were developed recently in the lower Columbia River, downstream from McNary Dam (Parsley and Beckman 1994). The curves are shown graphically in Figure 5. Criteria curves to be used for assessment of sturgeon rearing habitat were developed by the Biological Resources Division of the U.S. Geological Survey (Report C in this volume). The suitability of each of the individual parameters (depth, velocity, substrate) was compared to determine the composite suitability factor (CSF) for each cell (Figure 4). Several mathematical functions can be used within the RHABSIM habitat models to determine the CSF. The "lowest limit" method was used for this analysis based on the limiting factor concept. We assumed the least suitable of the three parameters would control habitat use. Thus, the lowest suitability for either depth, mean column velocity, or substrate was used as the CSF. Finally, the surface area of each cell was multiplied by the CSF value to determine cell WUA. Habitat modeling results were then evaluated on a cell by cell basis to determine the distribution of habitat across the river channel, evaluated with all cells on a cross section combined to examine the distribution of habitat along a river segment, and evaluated with a number of cross sections combined to compare habitat between river segments or study sites.

The relative quality of the usable microhabitat was also examined. Microhabitat calculated as WUA combines all habitat cells with CSF values greater than 0.0. This combination includes both higher quality habitat (cells with CSF approaching 1.0) and lower quality habitat (cells with CSF approaching 0.0). Habitat quality was evaluated by partitioning WUA into CSF intervals. Higher quality microhabitat consisting of WUA with CSF values ranging from 0.81-1.00 was compared to total WUA (CSF=0.01-1.00) to determine the relative amount of higher quality habitat among cells, cross sections, and river segments. This range of

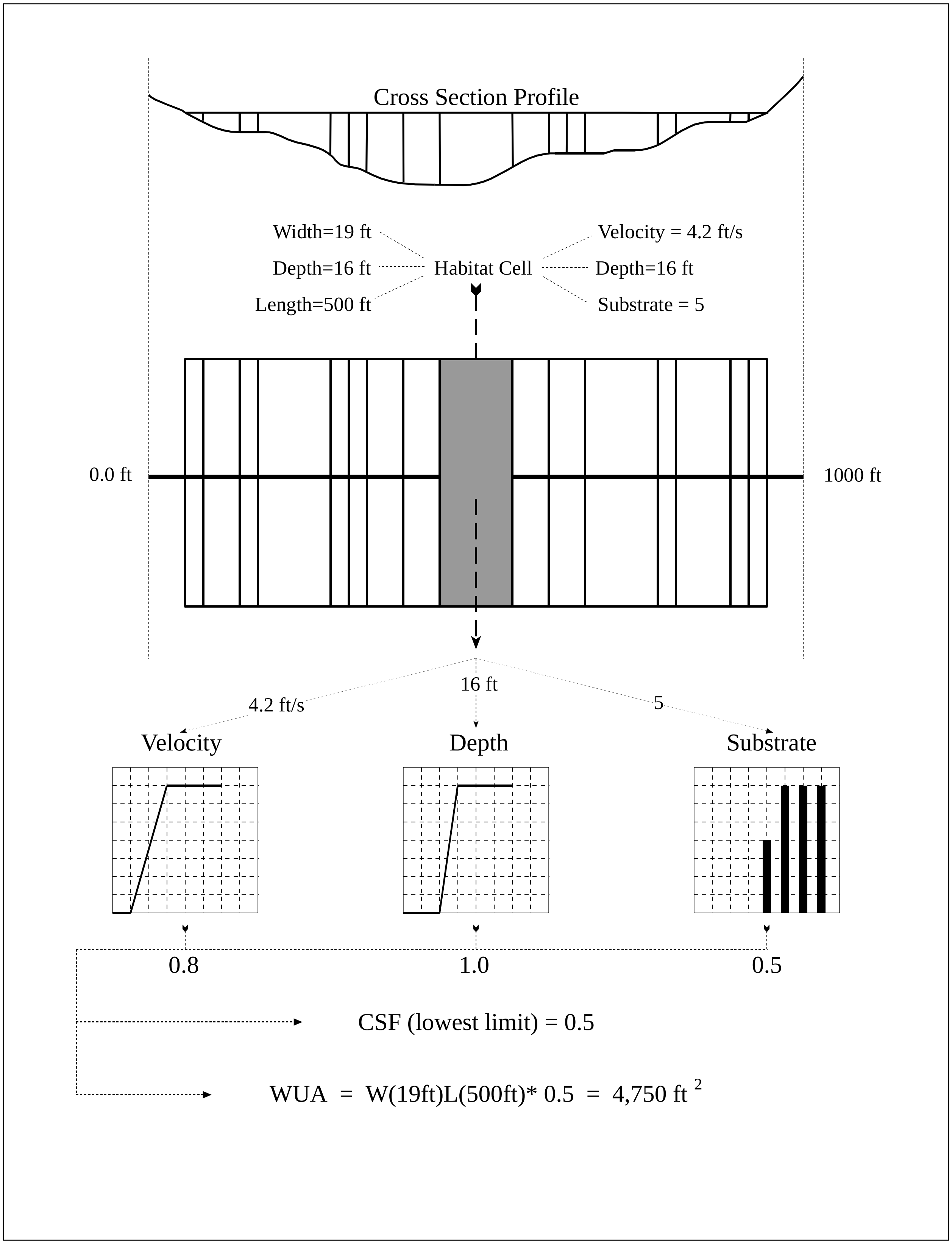

Figure 4. Derivation of weighted usable area (WUA) for a habitat cell using physical characteristics, habitat suitability curves, and the composite suitability factor (CSF).

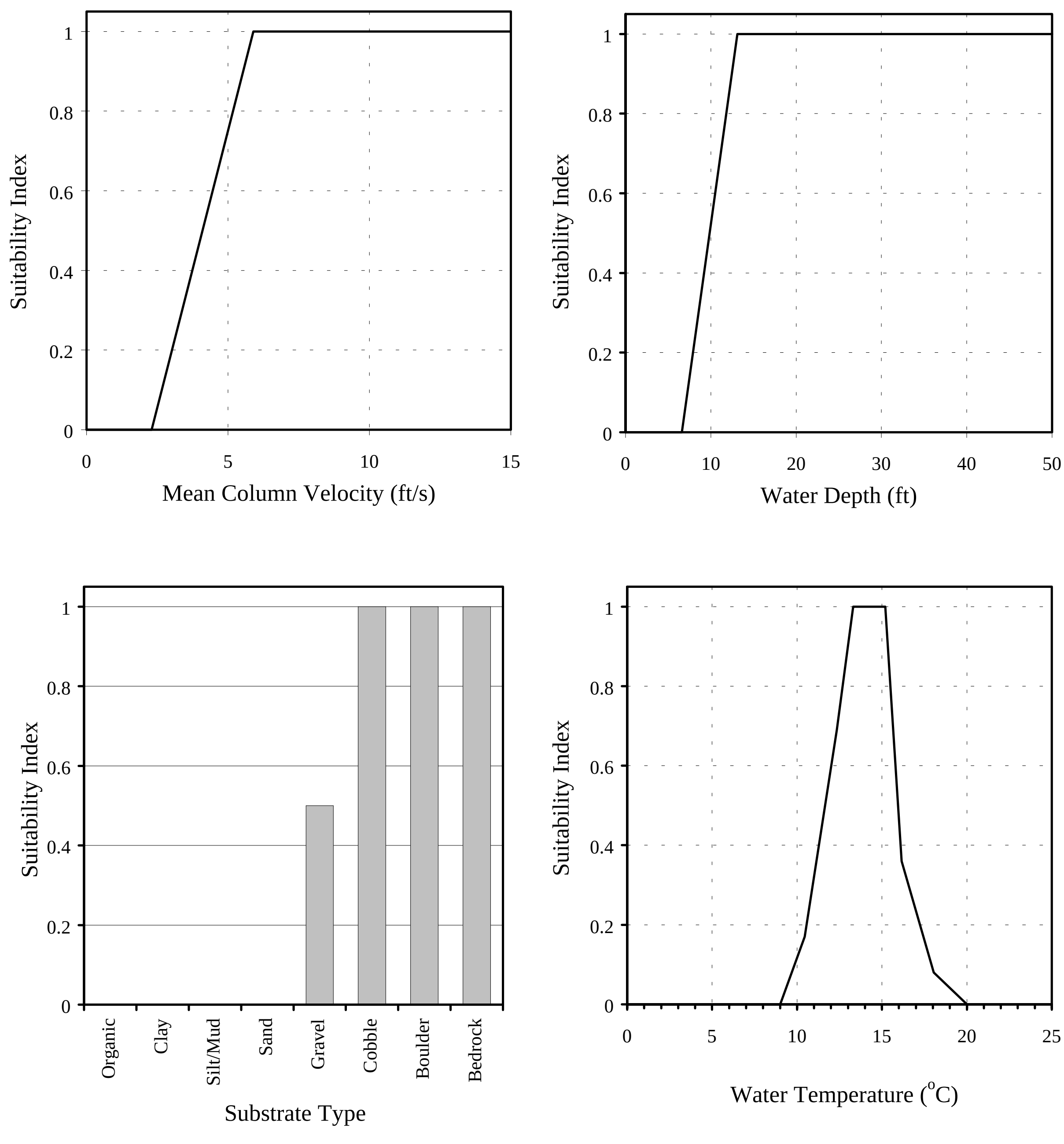

Figure 5. Microhabitat criteria curves indicating the relative suitability of mean column water velocity, water depth, substrate type, and water temperature for spawning white sturgeon (Parsley and Beckman 1994).

CSF values has been used by other white sturgeon researchers as an indication of higher quality habitat (Parsley et al. 1994).

RESULTS

Field Data Collection

Hydraulic Data Collection

Cross section distance and elevation profiling was completed for the lower Snake River study areas. Velocity distributions were measured at 30 cross sections for Snake River discharges ranging from 4,542 to 6,041 m^3/s in the Lower Monumental, Little Goose, and Lower Granite tailrace areas. Cross section profiling is now complete for all Columbia and Snake river study areas.

Stage-discharge data pairs were measured at 37 cross sections for the lower Snake River study areas. Data were collected at Snake River discharges ranging from 2,892 to 3,379 m^3/s in the Lower Monumental, Little Goose, and Lower Granite tailrace areas. Hydraulic data collection is now complete for Columbia and Snake river study areas with the exception of one stage-discharge data pair for the WBIC.

Substrate Data Collection

River bank and underwater substrate characterization were completed for the WBIC during 1998 with the collection of approximately 500 data points with geographic locations on 45 cross sections. Substrate characterization is now complete for all Columbia River study areas. Several cross sections remain to be completed in the lower Snake River study areas.

Data Analysis

Data Reduction - Hydraulic Modeling

Cross section profiles, velocity distributions, and stage-discharge pairs collected in the lower Snake River were reduced and added to the existing data files, or input to create new data files for cross sections that had not previously been sampled. Substrate data were added to cross section data files for the WBIC. Calibration of hydraulic models for the Hanford Reach main channel cross sections neared completion, and hydraulic simulations were conducted for total river flows ranging from 708 to 14,150 m^3/s. Model calibration for the WBIC will begin following the addition of the last high flow stage-discharge data point.

The Corps of Engineers report, "Snake River Tailwater Rating Curves in the Vicinity of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite" was received in December 1998. The report provides water surface elevations at our cross section locations over the operating range of the downstream pool for Snake River flows from 255 to 9,905 m^3/s. The Walla Walla District, Hydrology Branch used the Hydrologic Engineering Center's HEC-2 step-backwater model to generate the elevations. Pool elevation and river discharge data for field survey dates were acquired and a comparison of field measured water surface elevations to modeled elevations was initiated. Hydraulic model calibration will begin for Snake River study areas following completion of this evaluation.

Habitat Modeling

Habitat modeling is currently underway for main channel cross sections in the Hanford Reach study area. Examination of the location and suitability of all habitat (CSF=0.01-1.00) as well as high quality habitat (CSF=0.81-1.00) within each cross section was a preliminary step in the modeling process. Habitat suitability and location within the cross section for a typical pool cross section in the Hanford Reach and a Priest Rapids dam tailrace cross section are compared for discharges of 2,832 m^3/s, 4,248 m^3/s, and 5,664 m^3/s, respectively, in Figures 5, 6, and 7. Plots on the left illustrate all usable habitat with CSF values from 0.01 to 1.00, and plots on the right illustrate high quality habitat with CSF values ranging from 0.81 to 1.0.

DISCUSSION

Field Data Collection

Extensive discussions of field data, field data collection activities, techniques, and protocols have been presented in previous Annual Reports and a detailed summary was presented in the 1997 Annual Report (Anglin et al. 1999). Field work for the Columbia and Snake river study areas is essentially complete, with several minor tasks remaining. The new underwater video camera and assembly worked well and provided high quality images under low light conditions. We planned to use underwater lasers for more efficient and accurate sizing of the substrate elements. The lasers worked well when conditions were ideal. The laser "spots" were not visible on the river bottom under less than ideal conditions, such as bright sunlight in shallow water on light-colored substrates. We hope to adjust the focus and intensity to correct the problem.

Data Analysis

Hydraulic model calibration has been efficient and water surface models and velocity simulations for the Hanford Reach are working well in most cases. Cross section profiles, substrate characteristics, and hydraulic simulation results were presented in the 1997 Annual Report (Anglin et al. 1999). Hydraulic model calibration will begin for Snake River study areas following calculation and verification of water surface elevations from the Corps of Engineers tailwater rating curves. Cell depth and velocity data from hydraulic simulations along with substrate characteristics will comprise the primary input to the habitat models.

Habitat modeling is in progress for the Hanford Reach main channel cross sections, and is not yet complete. Habitat modeling will begin for the WBIC and Snake River study areas following completion of hydraulic simulations for those areas.

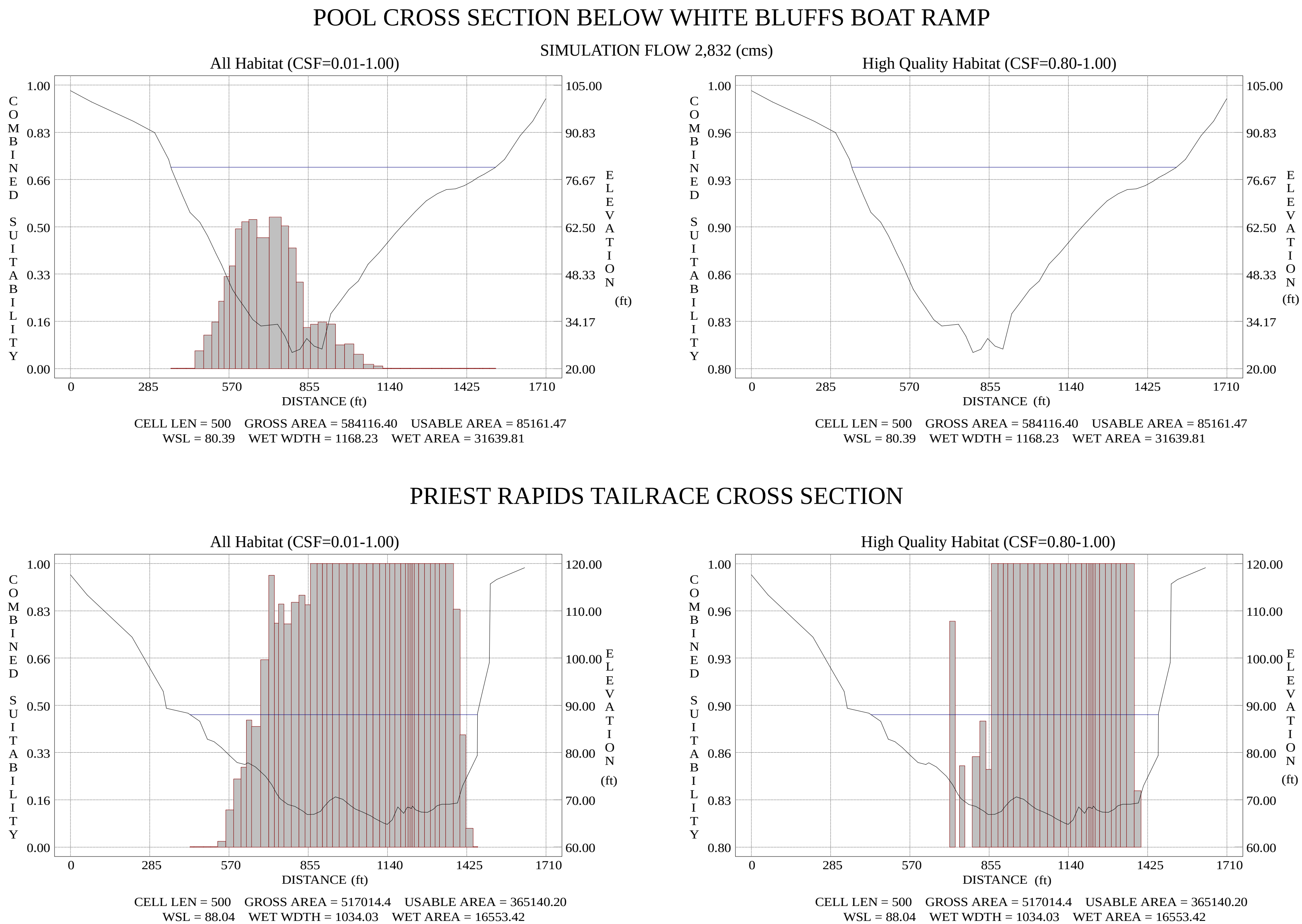

Figure 6. Cross section plots for the Hanford Reach showing distribution and quality (CSF) of spawning habitat cells for all habitat (left plots, CSF=0.01-1.00) and high quality habitat (right plots, CSF=0.80-1.00) at a river flow of 2,832 cms (100,00 cfs).

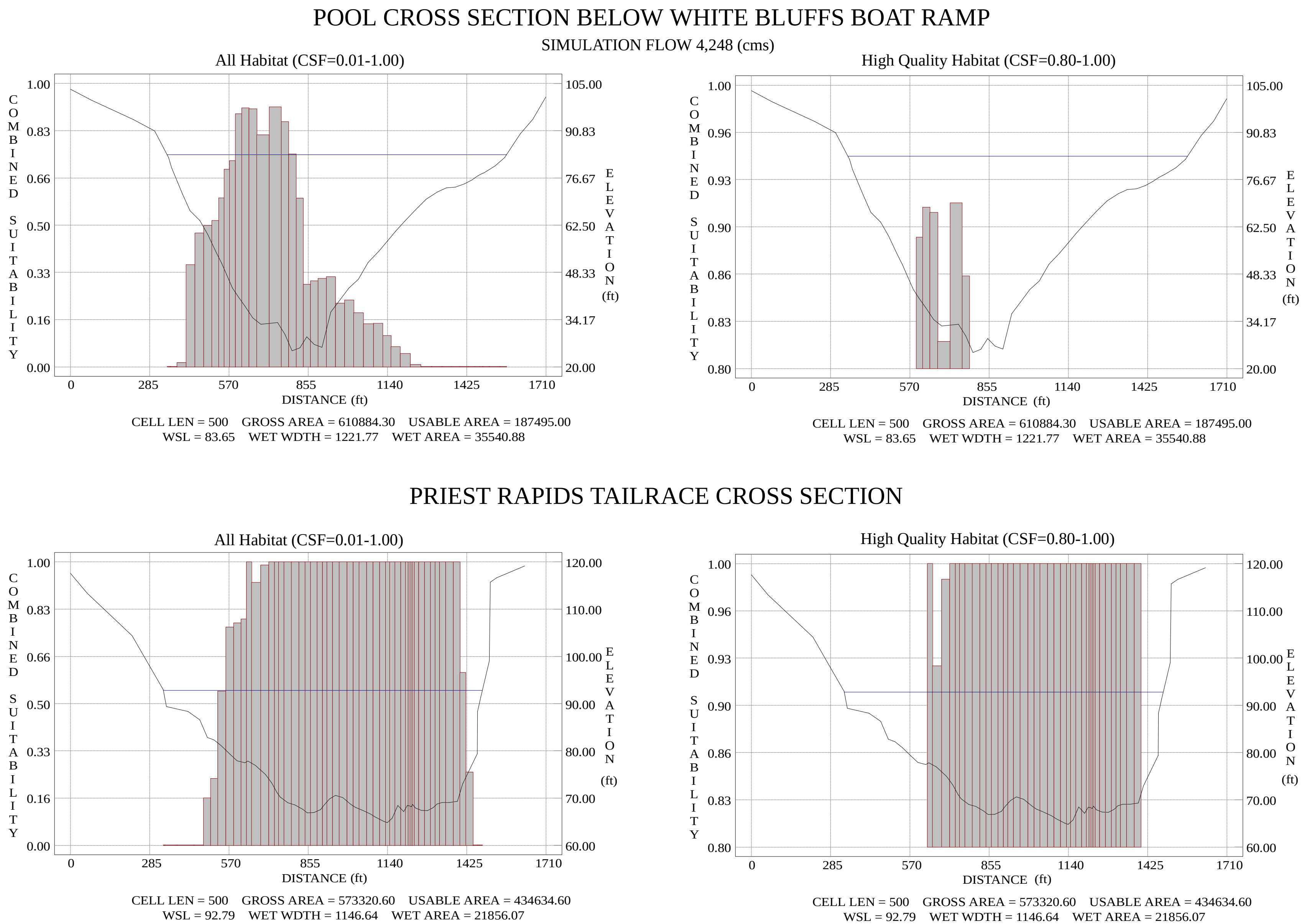

Figure 7. Cross section plots for the Hanford Reach showing distribution and quality (CSF) of spawning habitat cells for all habitat (left plots, CSF=0.01-1.00) and high quality habitat (right plots, CSF=0.80-1.00) at a river flow of 4,248 cms (150,000 cfs).

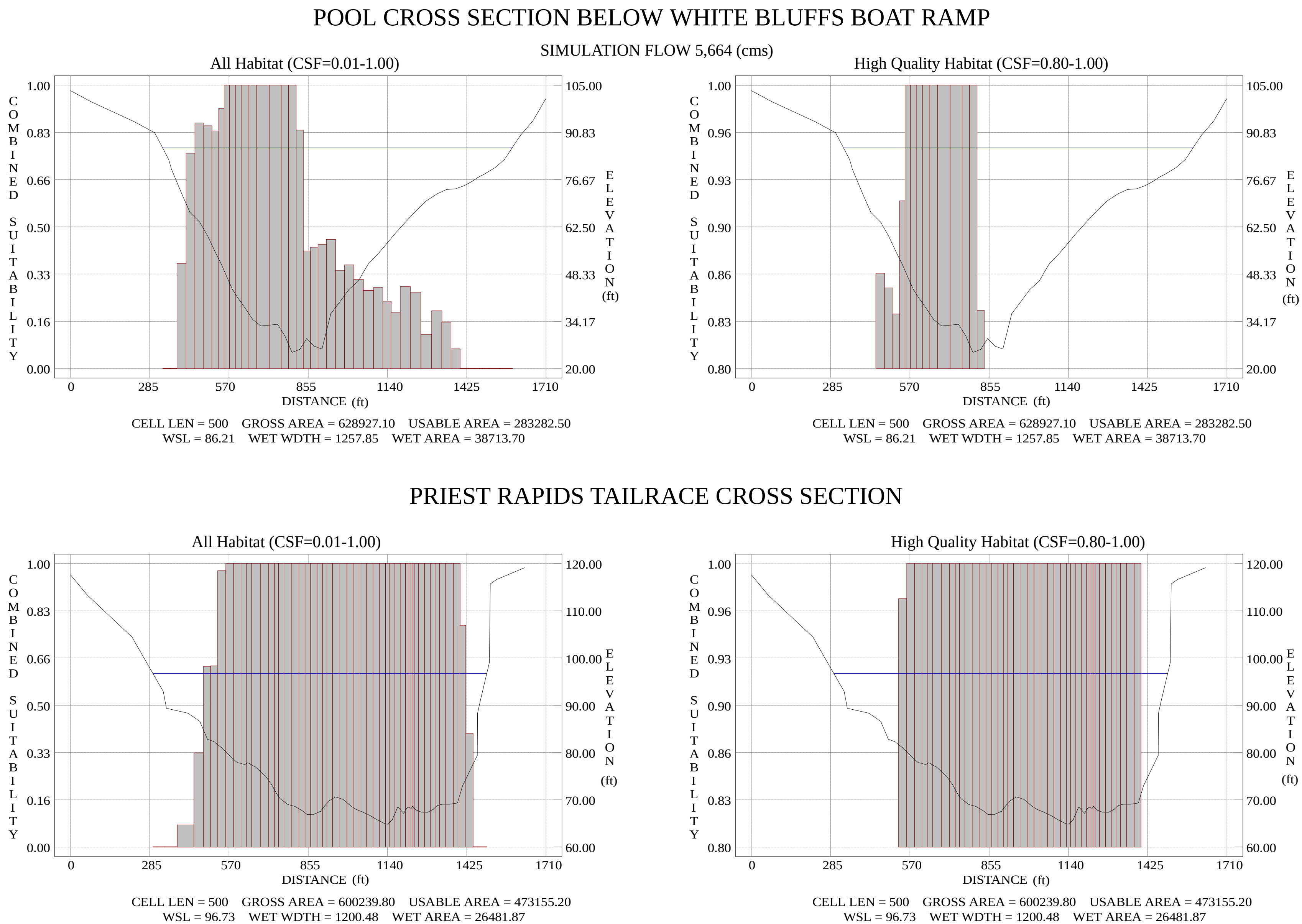

Figure 8. Cross section plots for the Hanford Reach showing distribution and quality (CSF) of spawning habitat cells for all habitat (left plots, CSF=0.01-1.00) and high quality habitat (right plots, CSF=0.80-1.00) at a river flow of 5,664 cms (200,00 cfs).

Several patterns can be observed in the spawning habitat plots shown in Figures 6-8. Both total WUA and high quality WUA are available on the tailrace cross section at lower flows than observed for the pool cross section. In addition, a much higher proportion of the tailrace cross section is usable. High quality habitat comprises most of the WUA on the tailrace cross section at all flows whereas high quality habitat is not present at all on the pool cross section until flows reach approximately 4,248 m^3/s. High quality habitat continues to comprise a relatively small portion of the pool cross section area, even at a flow of 5,664 m^3/s. Considering the preference of spawning white sturgeon for fast, turbulent water and larger substrate (see Figure 5), this is not surprising. The configuration of the tailrace cross section is more typical of a riffle-type configuration, with higher velocities, a higher slope, and shallower depths compared to the pool cross section. Although it appears that the pool cross section has characteristics that indicate a small amount of high quality habitat at higher flows, the majority of spawning habitat in the Hanford Reach will likely be available at riffle-type cross sections similar to the tailrace cross section, particularly at lower flows.

Plans for 1999

The USFWS plans to complete field data collection for all Columbia and Snake river study areas during 1999. Data reduction and entry should be complete, and significant progress is planned towards completion of hydraulic modeling for most areas. Habitat modeling will continue as time permits. Work will also continue on hydrographs to be used for the habitat time series analysis.

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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM

ANNUAL PROGRESS REPORT

APRIL 1998 – MARCH 1999

REPORT E

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

This report includes: Results of a survey performed on the tribal subsistence fishery for white sturgeon in The Dalles and Bonneville reservoirs.

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ACKNOWLEDGEMENTS

We offer our appreciation to Yakama Indian Nation fishery technicians Chuck Gardee and James Kiona for their dedicated efforts in conducting angler counts and interviews during the spring and summer of 1998. Our thanks to Brad James of Washington Department of Fish and Wildlife for his assistance designing the survey, specifically we wish to thank and credit his assistance with sampling route design, selection of index sites and insightful input on interviewing tribal fishers.

ABSTRACT

Tribal and state fishery managers identified the need for a survey that would provide a more accurate characterization and catch estimation of the hook and line tribal subsistence white sturgeon *Acipenser transmontanus* fishery. The Columbia River Inter-Tribal Fish Commission in cooperation with Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife conducted a survey to meet this objective. Though there have been previous attempts to quantify this fishery, this is the first survey to use scientific methods to provide information regarding fishers' catch and effort. From 2 June 1998 through 11 November 1998, we randomly selected one to four days to sample per week based on a six day fishing week, Sundays were closed to fishing. Two tribal fishery technicians from the Yakama Nation surveyed Bonneville and The Dalles reservoirs traveling a pre-defined route to survey nine index sites twice each sampling day. Technicians conducted over 102 survey counts putting in about 282 surveying man-hours that resulted in counting only six fishers. None of the fishers were at their sites for an interview after the count. Based on the low number of fishers we conclude that the impact of the tribal hook-and-line subsistence sturgeon fishery was insignificant on white sturgeon populations in Bonneville and The Dalles reservoirs. Additionally, the results of this survey question the accuracy of previous harvest estimates for the Zone 6 tribal subsistence sturgeon fishery. The small fisher effort may be attributed to recently enacted management regulations that narrowed size limits for commercial and subsistence white sturgeon.

INTRODUCTION

This annual report describes work completed by Columbia River Inter-Tribal Fish Commission (CRITFC) staff, under subcontract with Oregon Department of Fish and Wildlife (ODFW), from 1 April 1998 through 31 March 1999, performed to meet the objectives of Bonneville Power Administration (BPA) tasks outlined under project 86-50. The primary task of CRITFC was to assist the states of Oregon and Washington with their task of monitoring tribal commercial and subsistence white sturgeon fisheries in Zone 6 during the 1998 fishing season. Specific to this task, CRITFC in cooperation with ODFW and Washington Department of Fish and Wildlife (WDFW) performed a survey of the tribal subsistence hook-and-line white sturgeon fishery in The Dalles and Bonneville reservoirs. John Day Reservoir was excluded from the survey based on the results of previous state creel surveys that reported low numbers of tribal hook-and-line fishers. The survey was designed to:

- Estimate fishing effort
- Estimate the annual harvest catch
- Determine catch per unit effort estimate for legal and sublegal fish in the two reservoirs
- Determine the size range of harvested fish

The survey was designed to achieve these goals through interviews of tribal fishers, a fisher count survey, and collection of biological information from white sturgeon caught in the fishery. The primary goal of monitoring the subsistence fishery was to increase the accuracy of catch estimation from this fishery and provide previously unknown information regarding the characteristics of this fishery and its importance to tribal fishers.

METHODS

The tribal subsistence white sturgeon fishery was investigated using a survey designed cooperatively by CRITFC and WDFW. The survey was based on methodologies described by Malvestuto (1978 and 1983) for sampling hook and line consumptive fisheries. Malvestuto describes two components to the survey: 1) a random, stratified, two-stage probability sampling process to estimate angling pressure, and 2) a roving angler interview process to estimate catch per unit effort. The stages refer to two components used in sub-sampling angling pressure. The first "stage" refers to counts being made on randomly selected days during the week. The second "stage" refers to counts representing only partial estimates of the day's total angling pressure (i.e. the count represents one hour of the total hours available for angling). The start time of the day's count is randomly selected. The roving interview process refers to the method of contacting anglers. A creel clerk intercepts anglers as he travels along a predetermined route (as opposed to access point surveys where all anglers exit the water via a single access point).

Our survey was designed to sample nine known fishing sites between Bonneville and The Dalles Dam (Table 1). These nine sites, eight in Bonneville Reservoir and one in The Dalles Reservoir, were selected as index sites representative of tribal subsistence fishing pressure because of their historical use as subsistence fishing sites and because of their accessibility to technicians and fishers alike (Figures 1-9). Two trained fishery technicians from the Yakama Nation performed the survey on a rotating basis. Technicians traveled by automobile over the exact same route from the start of the survey at Ft. Rains (Figure 1), approximately river kilometer 237, to the end at Giles French park (Figure 9), about river kilometer 348, a total survey distance covering about 111 river kilometers. Technicians performed counts at the exact same count site location for each index site to avoid any viewing bias. At the first index site they recorded the randomly pre-selected survey start time and began counting the number of fishers present within and outside the index site. After performing the fisher count the technician continued to the next site along the route until all index sites had been counted. A survey end time was recorded after the last count had been performed.

Interviews with fishers were conducted either before or after the count so that they would not interfere with the fisher count. Fisher interviews were designed to obtain information on the number of fishers present, amount of time spent fishing, number and size of sturgeon caught, and to determine if the fisher was involved in a hook and line commercial fishery for white sturgeon. Biological data consisting of white sturgeon catch length and tag/marks/missing scutes was recorded during these interviews.

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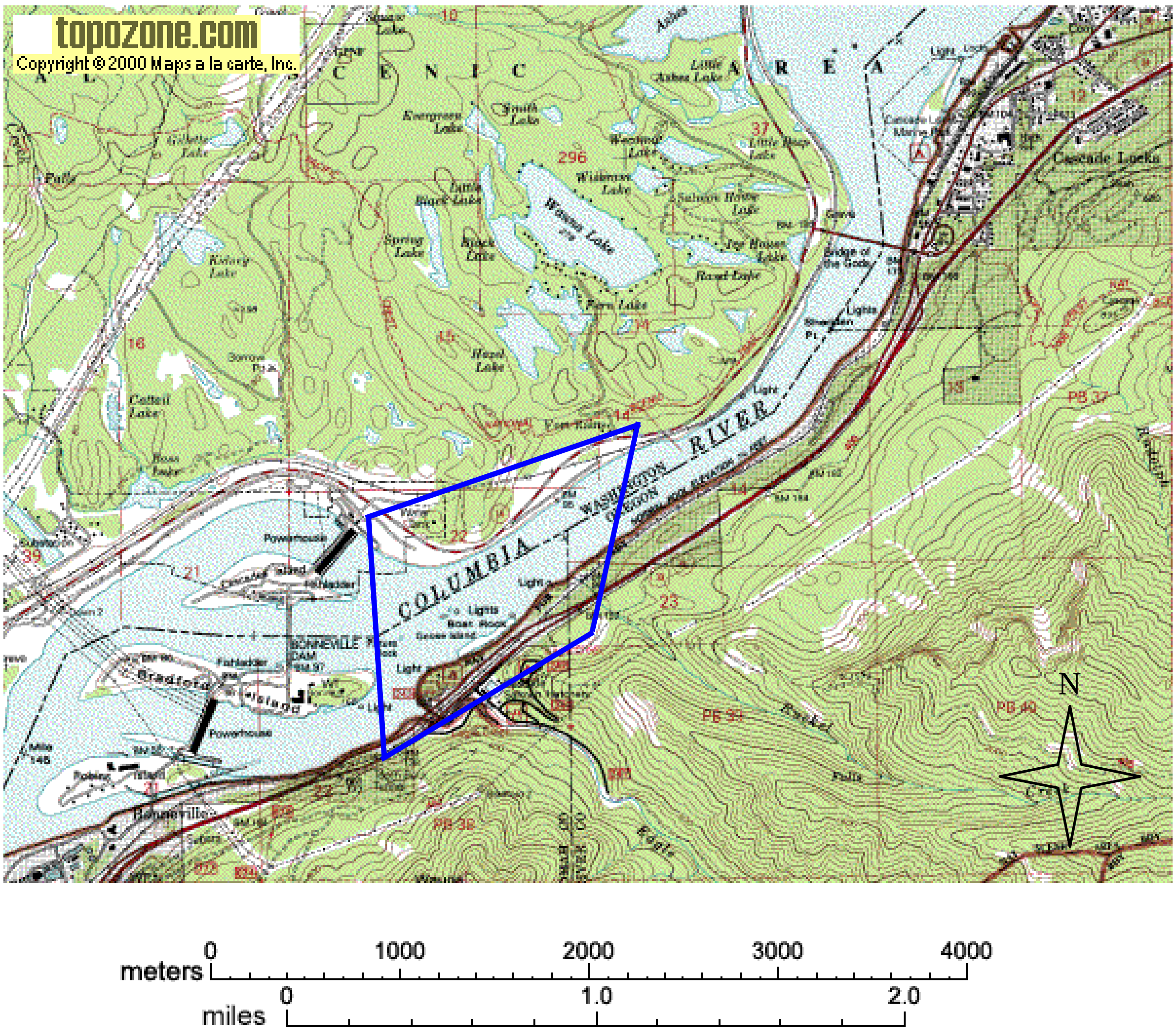

Figure 1- Site 1, Fort Rains In-Lieu Site, area inside blue box represents approximate index site area.

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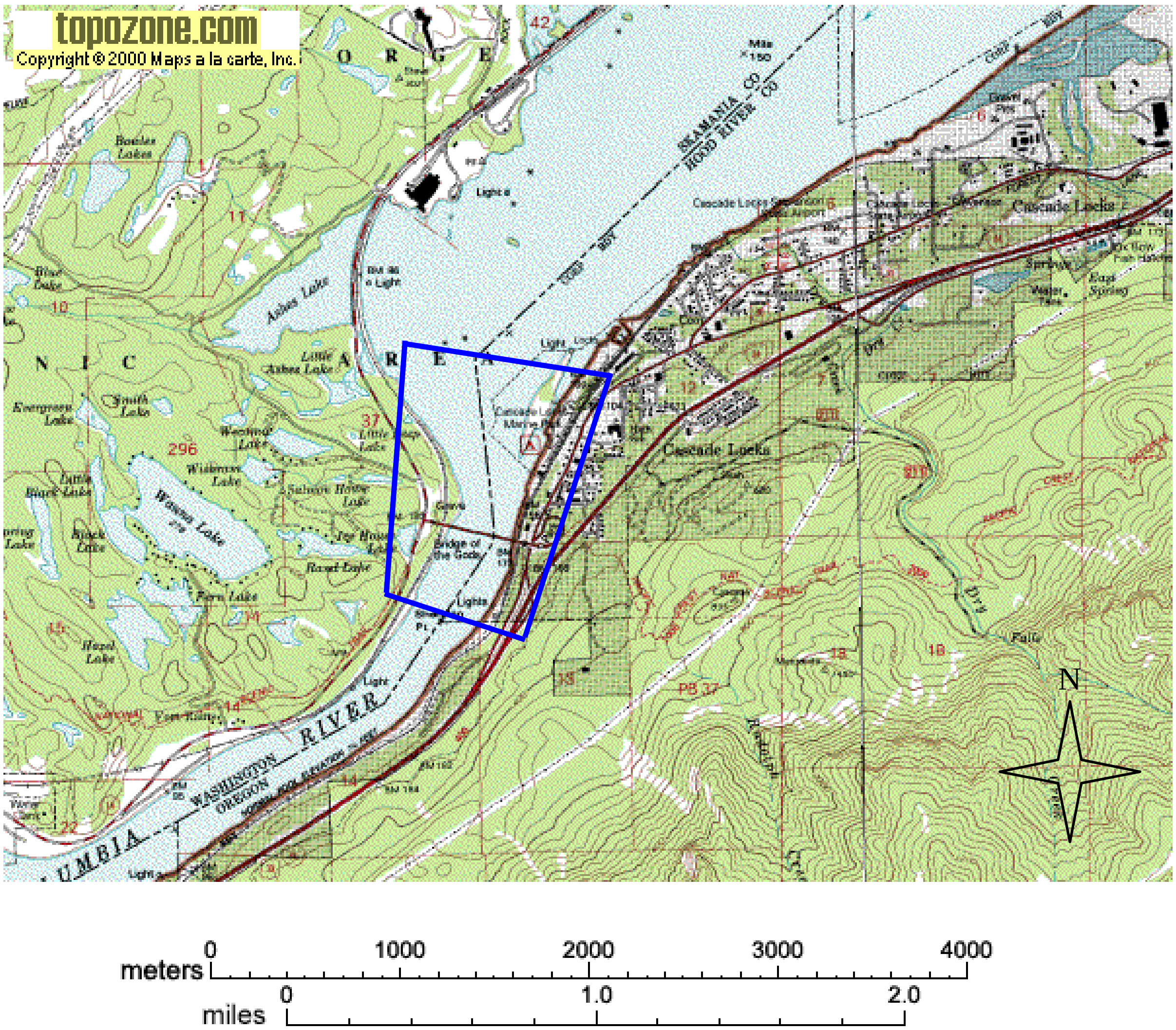

Figure 2- Site 2,Cascade Locks In-Lieu Site,area inside blue square represents the approximate index site area.

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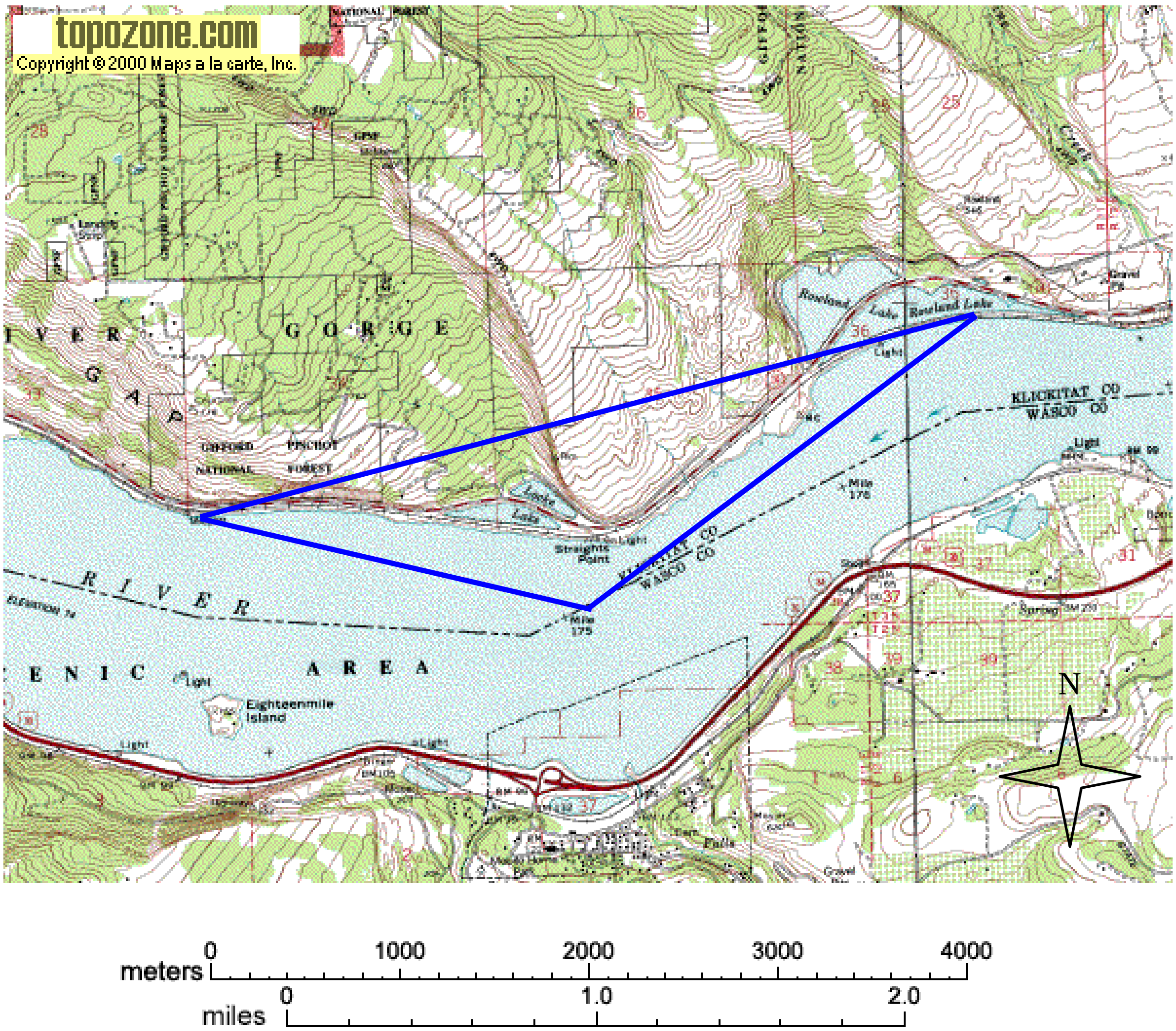

Figure 3- Site 3, Old tunnel upstream of Bingen to Courtney Road pond, area inside blue triangle represents approximate index site area.

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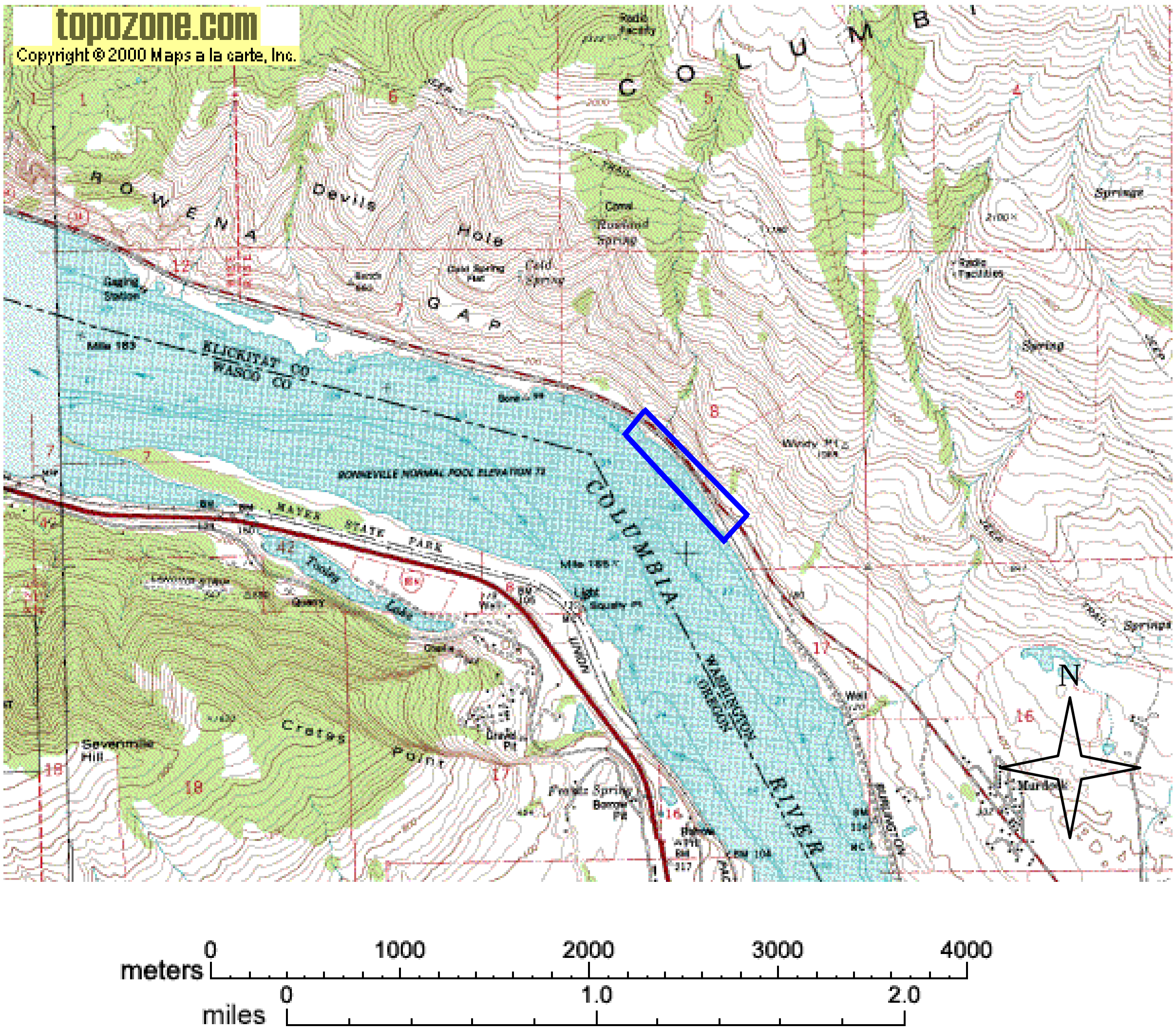

Figure 4-Site 4, Doug's Beach, area inside blue box represents approximate index site area.

Map target is 45.6251°N, 121.1819°W - UTM Zone 10, N 5053784, E 641731

Exact center of display is UTM Zone 10, N 5054346, E 641096

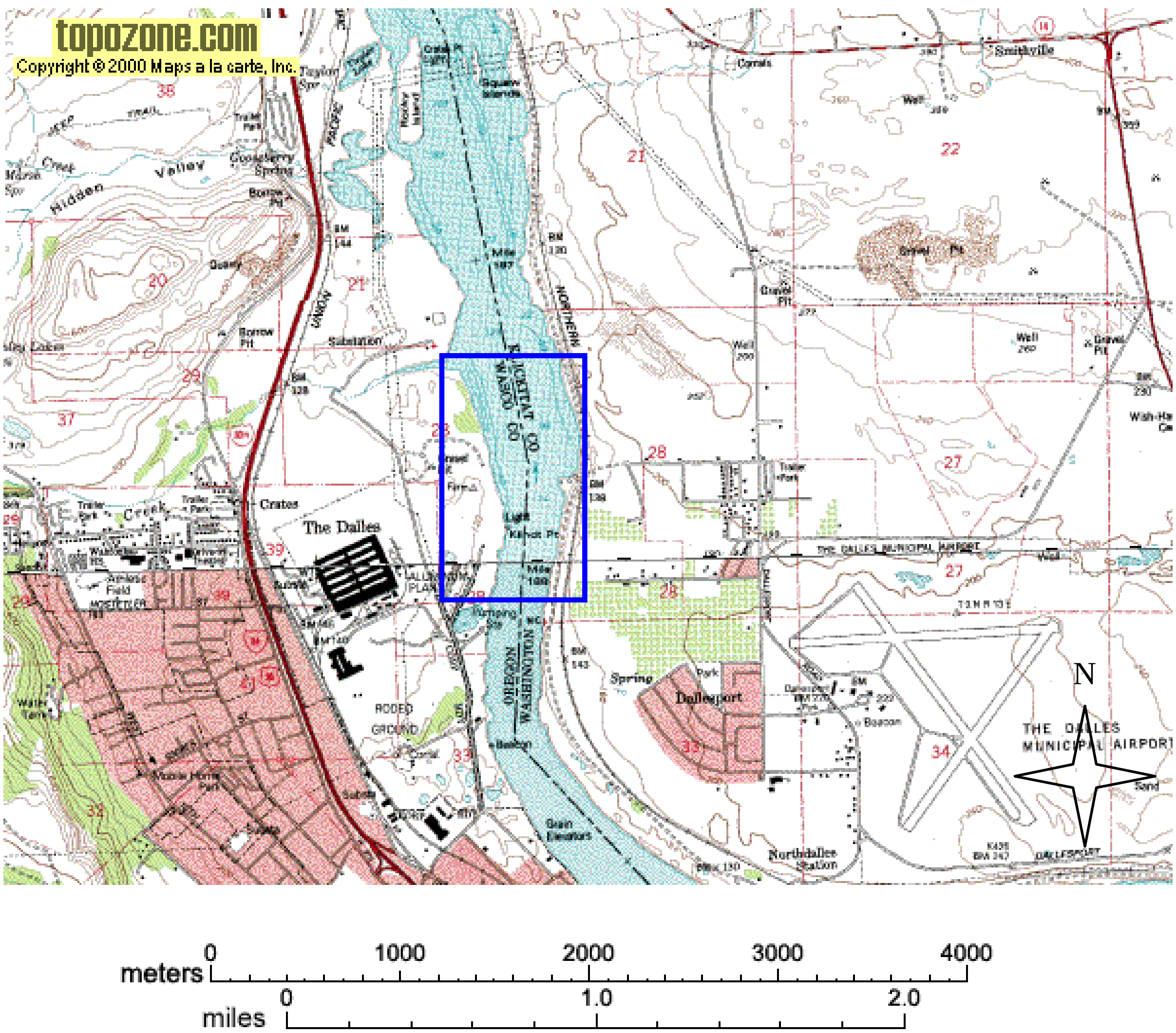

Figure 5- Site 5, Pump House, area inside blue rectangle represents approximate index site area.

Map target is 45.5971°N, 121.1566°W - UTM Zone 10, N 5050718, E 643774
Exact center of display is UTM Zone 10, N 5051298, E 643128

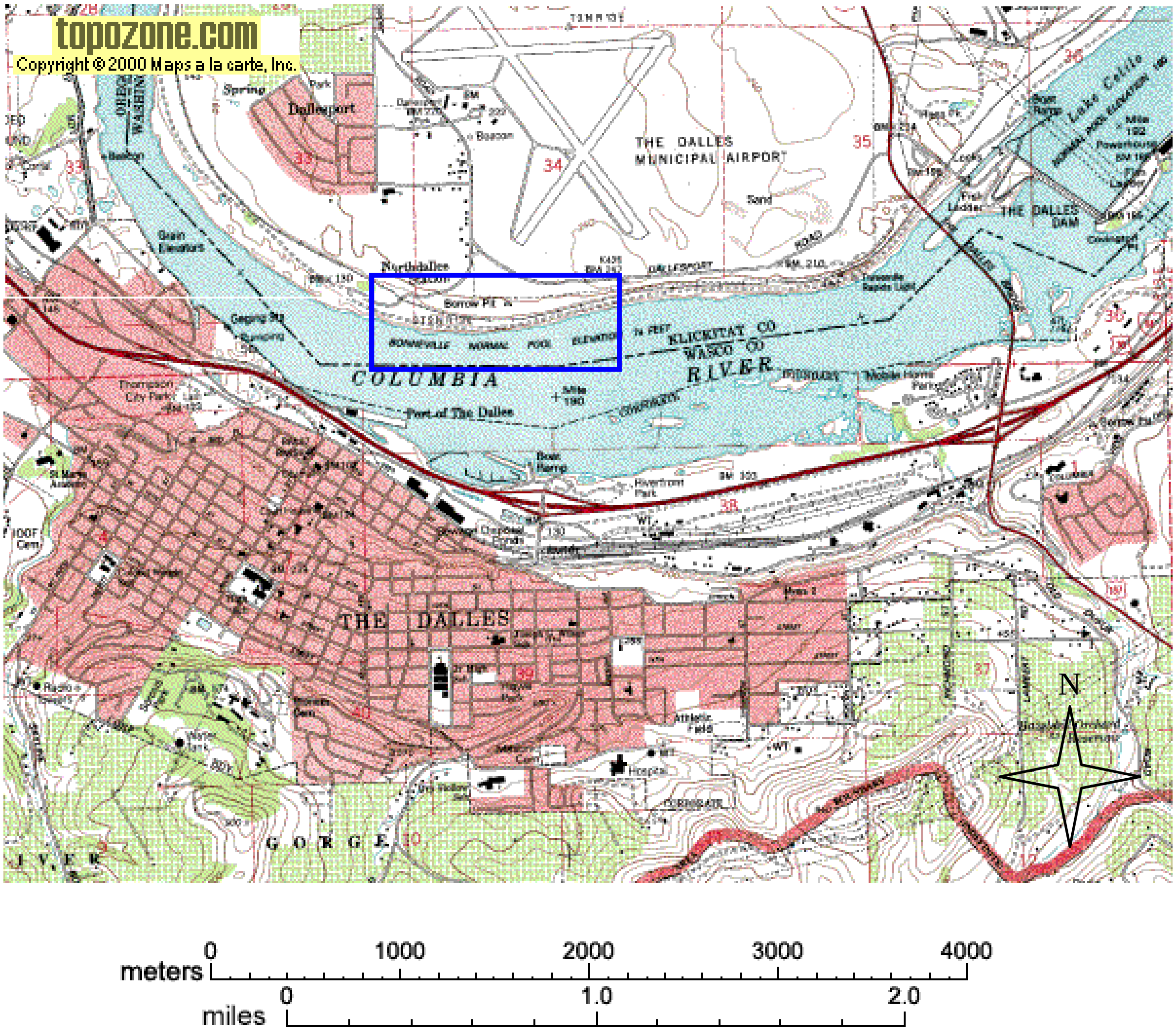

Figure 6- Site 6, Ferry Landing, area inside blue rectangle represents approximateindex index site area.

Map target is 45.6078°N, 121.1509°W - UTM Zone 10, N 5051917, E 644192
Exact center of display is UTM Zone 10, N 5051298, E 645160

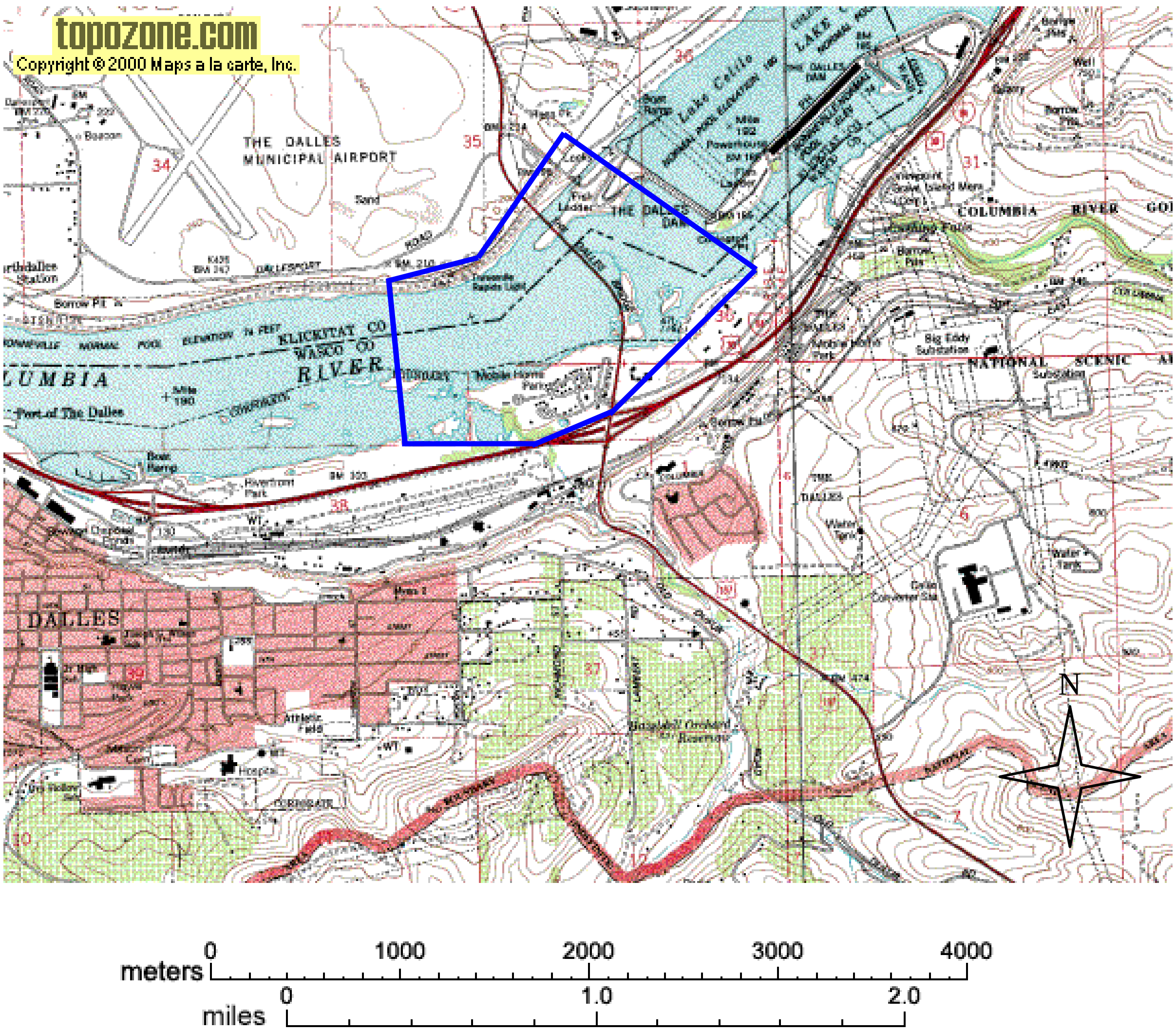

Figure 7- Site 7, The Dalles Bridge Site, area within blue boundary represents approximate index site area.

Map target is 45.6209°N, 121.1241°W - UTM Zone 10, N 5053421, E 646247

Exact center of display is UTM Zone 10, N 5052822, E 647192

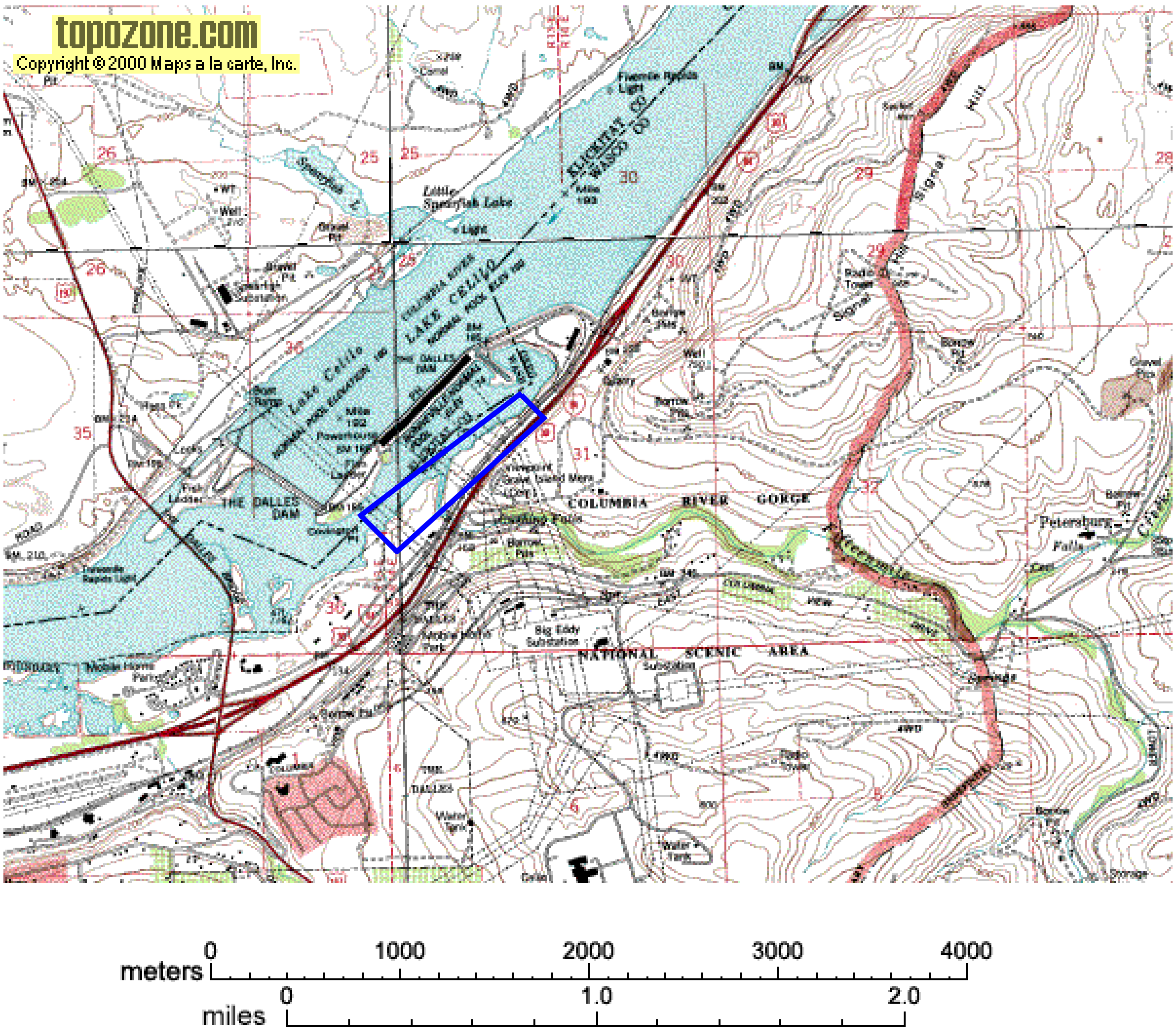

Figure 8- Site 8, The Lone Pine In-Lieu Site, area inside blue rectangle represents the approximate index site area.

Map target is 45.7079°N, 120.7076°W - UTM Zone 10, N 5063931, E 678441
Exact center of display is UTM Zone 10, N 5063490, E 677672

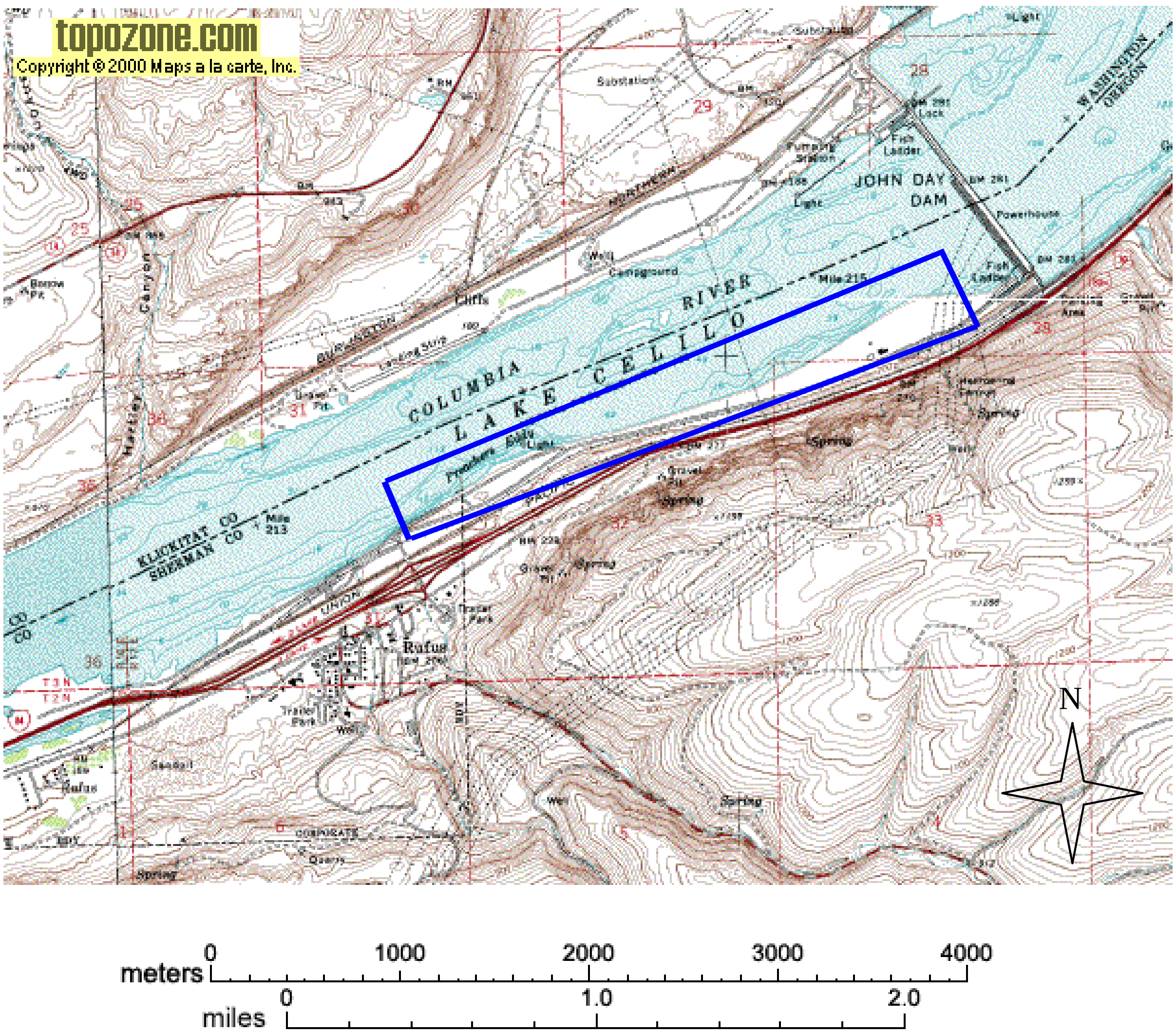

Figure 9- Site 9, Giles French State Park, area inside blue rectangle represents approximate index site area.

Table 1. Location and descriptions of index sites surveyed in 1998 for documentation of tribal subsistence fisheries on white sturgeon in Bonneville and The Dalles reservoirs.

Index Site	**Location and Description**
Ft. Rains In-Lieu Site	The count area is from the entrance road downstream to the boundary fence just past the last scaffold
Cascade Locks In- Lieu Site	The site is counted from the turnout just upstream of the Bridge of the Gods on the Washington side of the river. The upstream end of the site begins at the gray building and extends downstream to Robert Brigham's scaffold
Old Tunnel upstream of Bingin to Courtney Road Pond	Look for cars parked in this area and walk over the railroad tracks to count fishers in this site.
Doug's Beach	Site across from the Squally/Creb's Point on the Oregon shore, just downstream from River Mile 185. Count all sturgeon fishers along the 3 rocky points.
Pump House	Along the river near the town of Dallesport. Count from the pumphouse upstream to the first group of ponderosa pine trees.
Ferry Landing	Just outside the town of Dallesport. Count the fishers at the ramp site only.
The Dalles Bridge	The Dalles Bridge Site – This site includes both sides of the river and is to be counted in the following manner. Count first from the WA side of the bridge using the pullout on the upstream side of the bridge. The Lone Pine In-Lieu Site will be the most visible and easiest to count, although some fishers may be visible on the WA shore of the river, downstream of the dam. Immediately after crossing the bridge, pull off on the right-hand side of the road. The visible count areas are the WA shore and the OR shore downstream of the Lone Pine In-Lieu Site. The WA shore count should only go downstream as far as the trails on the hillside.
Lone PineIn-Leiu Site	From The Dalles Bridge drive around to the Lone Pine In-Lieu Site access road and park at the first picnic table and view the remaining locations on the WA and OR shorelines that were not seen clearly from The Dalles Bridge Site.
Giles FrenchPark	This park immediately downstream of the John Day Dam is the last site on the count circuit. Fishers should be counted in the first 3 gravel pullouts (not campsite areas) downstream from the fenced off restricted area, the first gravel pullout is adjacent to the fenced area of the dam.

The survey was performed from 2 June 1998 through 11 November 1998, with no sampling in September (Table 2). Sampling times and dates were chosen randomly where applicable. The survey period was divided into weeks, each week contained 6 fishing days (Monday through Saturday) and one non-fishing day (Sunday is traditionally observed as a non-fishing day). Sampling was performed one to four days out of each week, no distinction was made between weekdays and Saturdays. A Hewlett-Packard[1] hand held calculator (HP-15) with random number generation function was used to select sampling days. On each sampling day two surveys of the index sites were performed.

[1] Mention of trade names does not imply endorsement by the Columbia River Inter-Tribal Fish Commission

From 2 June through 17 October, each sampling day was divided into three time periods, each period consisted of 4 hours in which a survey start time could occur: 6 am to 10 am, 11 am to 3 p.m., and 4 p.m. to 8 p.m. The two survey periods and the start times within each period were randomly selected using a similar method as described for selecting survey days. From 19 October through 7 November, due to shorter days, the survey day was divided into two time periods. Each time period was sampled each survey day with survey start times randomly chosen from 7 am to 11 am and 12 pm to 4 pm respective to the time period. The average time it took to perform one survey transect was two hours and forty-five minutes.

Table 2. Survey months and sampling dates used by technicians during the tribal hook-and-line sturgeon subsistence fishery in Bonneville and The Dalles reservoirs in 1998.

Month	Dates Sampling Performed
June	2,5,10,13, 15,17,19,20,22,25,26,30
July	3, 7,10,11 13,14,18,21,23,24,25,27,29,30
August	3,5,6,7,12,14,15,20,21,22,24
September	none
October	13,14,16,17,19,21,22,23,27,28,30
November	4,6

The nature of the transect route that technicians followed allowed them to casually survey a broader portion of the two reservoirs than what is quantified by the indexed sites. State highway 14 and Interstate 84 run parallel to and alongside the Columbia River and it is possible to view much of the river and it’s banks while driving. To characterize the fishery to the best of our ability, technicians were encouraged to note the location of fishers in non-index areas and interview these fishers when appropriate. Though this data is difficult to quantify it was felt that the results would lend support to validate index sites as indicators of fishing pressure and supply information necessary to better understand the white sturgeon subsistence fishery.

RESULTS

Fishing activity was surveyed on fifty-one days over a six-month period in the summer and fall of 1988. A total of 102 transect counts were performed with actual field survey hours totaling about 282. The results from the indexed survey revealed a total of only six fishers counted on four different days at four different index sites, with two fishers each at two sites and a single fisherman at each other site. All six fishers were counted in Bonneville Reservoir and no fishers were counted in The Dalles Reservoir. None of the fishers counted were available for interviews after the survey was completed as they had left the site before the return of the technician. No activity of fishers outside the index sites was reported, substantiating that index sites were representative of fishing pressure on the two reservoirs and reaffirming that there was very little hook-and-line fishing pressure for white sturgeon in either reservoir by tribal subsistence fishers.

Due to the low amount of fishing effort the survey provided inadequate information for the analysis we intended when designing the study. Estimates of fishing effort, annual harvest, catch per unit effort and the size range of harvested fish could not be reported due to lack of fishers and subsequent lack of fisher interviews and catch data.

DISCUSSION

The survey we conducted was necessary because of adaptations to white sturgeon management regulations in the mid 1990's that changed minimum length restrictions of commercial and subsistence white sturgeon taken by tribal fishers. These regulation changes and more recent regulation changes have had a significant impact on the white sturgeon hook-and-line subsistence fishery. We feel it is important to present some history of regulations governing the Zone 6 tribal commercial and subsistence fishery in order to understand the reasons for this study, the impacts of and objectives for regulation changes, and the results regulation changes had on our study.

Prior to 1993, the tribal subsistence fishery for white sturgeon was a minor component of the total Zone 6 white sturgeon harvest (WDFW, 1998). From 1994 through 1995 the annual subsistence white sturgeon harvest increased substantially. State and tribal fish management staff were concerned that the previous harvest guideline of 300 white sturgeon for the annual tribal subsistence white sturgeon harvest was being surpassed. Although there were some concerns on the disposition of white sturgeon taken in the subsistence fishery, the most important concern was the impact on near-term recruitment of legal sized white sturgeon to the commercial setline and gillnet fisheries. A survey conducted on the 1994 winter commercial fishery (Parker 1996) supported this concern, noting that many fish taken for subsistence were less than 2 inches from the 48 inch total length required for commercial catch. In 1996, the Sturgeon Management Task Force (SMTF) recommended that the minimum total length for subsistence white sturgeon be increased from 36 inches to 48 inches to reduce the number of subsistence white sturgeon taken during the winter commercial fishery. The Columbia River Compact adopted this recommendation for the winter commercial season in 1996, with the remainder of the year returning to the previous 36 to 72 inch size limit. As a result of this management act the number of subsistence white sturgeon taken by tribal fishers declined substantially in 1996 and 1997 (WDFW, 1998).

Beginning in 1997, management instituted a strategic shift in harvest plans from a proportional based harvest plan to an Optimal Sustained Yield (OSY) harvest plan. The OSY model provided a greater rate of harvest but targeted a smaller segment of the population. Modeling indicated that to provide for OSY for Zone 6 populations, commercial minimum and maximum size ranges would need to be narrowed from a total length size range of 48 to 72 inches to a total length size range of 48 to 60 inches. The OSY model provides greater commercial catch but increases the susceptibility of white sturgeon populations to over harvest. If guidelines are exceeded on a consistent basis, the OSY model will not accurately predict the out year production and the population will decrease. Because of the model's sensitivity to over harvest, it is necessary for all fisheries, including tribal subsistence fishery to be managed within the 48 to 60 inch size range. This change greatly reduces the catch rates of hook-and-line tribal fishers.

Given the substantial reduction of available harvestable size white sturgeon, the results of our survey are not surprising. Surveying technicians reported, based on conversations with known tribal sturgeon anglers, that most anglers felt it was no longer worth their time to fish for sturgeon. These conversations also revealed that most tribal fishers do not target white sturgeon. Fishers stated that white sturgeon were casually fished for while pole fishing for salmonids or tending platform nets targeted for salmonids. Additionally, tribal fishers tend to fish for consumptive purposes and are not interested in the sport possibilities available by catching and releasing more abundant non-legal white sturgeon.

The involvement of CRITFC and the employment of tribal technicians to perform surveys of tribal fishery programs can have advantages over surveys run by non-tribal agencies. Many tribal fishers are inherently distrustful of management and research activities and often view these activities as a means to further restrict an already limited harvest. This was the initial case with size reduction regulations instituted on the Zone 6 sturgeon fisheries under the OSY management plan, but meetings directed to the fishers concerning this issue, combined with data collected by tribal fishers and technicians was key to a general acceptance of these regulations. Unfortunately some tribal hook-and-line fishers incurred a loss of opportunity imposed by regulation changes associated with the OSY management plan. Off setting this loss is a substantial increase in fishing opportunities for commercial tribal sturgeon fishers as evidenced by the increased guidelines since 1997 (WDFW, 1998). We feel that the benefits of this project and others initiated by CRITFC are important scientifically in producing a well-managed fishery, but also have value beyond their scientific implications. Involving tribal fishers in these projects produces benefits such as a conveyance of understanding of management activities and the development of a sense of self-governance among tribal fishers. This is extremely valuable in a fishery containing diverse interest groups including sport, commercial and subsistence fisherman with different values and cultural backgrounds.

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WHITE STURGEON MITIGATION AND RESTORATION IN THE COLUMBIA AND SNAKE RIVERS UPSTREAM FROM BONNEVILLE DAM.

ANNUAL PROGRESS REPORT

APRIL 1998 - MARCH 1999

Report F

Preliminary report of mitochondrial DNA diversity and variation of white sturgeon (*Acipenser transmontanus*) from the Columbia River Basin

This report includes: An initial summary of Columbia Basin white sturgeon mitochondrial DNA diversity and variation based on analysis of samples collected from five Basin locations.

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ABSTRACT

We report on work performed from August 1998 through December 1998, involving mitochondrial DNA (mtDNA) analysis of white sturgeon samples collected from five Columbia River Basin locations. Genetic analysis of white sturgeon during this time period consisted of a total length variation screen of the D-loop region, a hyper-variable region of the mitochondrial genome. Of 300 tissue samples collected for genetic analysis from five Basin locations, 211 have been analyzed during this reporting period. Analysis of these 211 fish identified five mtDNA haplotypes (D-loop length variants) present upstream from Bonneville Dam, and a sixth haplotype represented by two individuals from the lower Columbia River, downstream from Bonneville Dam. Of five mtDNA haplotypes observed upstream from Bonneville Dam, the most common haplotype, LV-01, accounted for 44% of overall D-loop length variation in fish from all sample locations; the second most common haplotype, LV-02, accounted for an additional 30%. The prevalence and relatively wide distribution of haplotypes in this study thus far suggest historical migration and gene flow among larger areas of the Columbia River Basin than currently probable following hydroelectric development. The distribution of haplotype frequencies based on research presented in this report suggests some population structuring. However, no distinct clinal variation in any consistent geographic pattern was evident. The mechanism of replication and/or containment of repetitive DNA copy number in mtDNA length variants has been speculative to this point. Future analyses will have to address mutation rate in mtDNA length variants using available family lines of commercially raised white sturgeon. Future analyses, incorporating larger, equal sample sizes from more Basin locations should likewise shed more light on white sturgeon mtDNA diversity and variation in the Columbia River Basin.

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) (NPPC 1987). This report presents the results of initial white sturgeon genetic research performed from August 1998 through December 1998, subcontracted by the Oregon Department of Fish and Wildlife (BPA Project 86-50).

Genetic relationships of Columbia Basin white sturgeon remain unclear. Previous examinations of genetic variation among white sturgeon from several Basin locations using protein electrophoresis (Bartley et al. 1985; Setter and Brannon 1992) reported a reduced level of genetic variation in the Kootenai River population relative to downstream Columbia River Basin locations. However, the level of genetic variation and the degree to which conspecifics in the Columbia and Snake Rivers form genetically distinct populations or evolutionary significant units (ESUs) remains unknown (see Setter and Brannon 1992 to review results of allozyme analysis of white sturgeon from four Basin locations and one out of Basin location).

Although the viability of many white sturgeon "populations" in the Basin is currently unknown, some are declining due to recruitment limitation or failure, and one, the Kootenai River population, is listed as endangered and considered at risk of extinction (USFWS 1999). A general trend of progressive reduction in population status appears positively related to upstream distance from the free-flowing Columbia River, downstream from Bonneville Dam. White sturgeon recruitment appears limiting or nearly absent in several reaches of the Snake River downstream from Shoshone Falls (natural upstream migration barrier), and in most impounded Upper Columbia River reaches (LePla and Chandler 1999; Hammond 1999). This finding is consistent with productivity estimates, empirical white sturgeon growth rates (DeVore 1999; DeVore et al. 1999), and theory of reduced gene flow in upper watershed habitats, fragmented during the past century by hydroelectric dams.

To date, no comprehensive genetic assessment or population definition studies of Columbia Basin white sturgeon have been performed. Consequently, population definition and genetic population structure of this species in the Columbia Basin remain undefined. Genetic population structure is the pattern in which alleles are distributed within and among populations or the geographic range of a species (Porter 1999). Although demographic and environmental conditions can affect short-term survival of white sturgeon populations, their long-term survival may be adversely affected by a loss of genetic variability (see reviews by Lacy 1997; Frankham 1995; Avise 1994; O'Brien and Evermann 1988; and Allendorf and Leary 1986). Definition of empirically-based population genetic parameters is a very important prerequisite for defining white sturgeon population and conservation units and their subsequent successful management and perpetuation throughout the Basin.

Accordingly, the goal of this project is to assess white sturgeon genetic diversity and variation, delineate populations, and determine gene flow, population structure, phylogenetic relationships and phylogeography in the Columbia River Basin. In addition to valuable scientific contributions regarding genetic population structure and evolutionary history of this species, this research will also provide the scientific foundation for comprehensive management and conservation of white sturgeon at the species level on a Basin scale.

Research Objectives: This study contains three distinct yet complementary objectives: 1) Definition of D-loop length variation; 2) Assessment of mitochondrial sequence divergence among Columbia Basin white sturgeon; and 3) Assessment of nuclear genetic variation among Columbia Basin white sturgeon. This report presents preliminary data addressing only Objective 1. Objective 1 involves preliminary assessment of genetic variation within and among groups of Columbia Basin white sturgeon based on variable number tandem repeats (VNTRs) of mitochondrial DNA-specifically, length variant analysis of the D-loop (control region) of white sturgeon mtDNA. Length variation arises in the D-loop of white sturgeon as a consequence of a gain or loss of 1-5 perfectly repeated tandem 78-82 base-pair nucleotide sequences (see Brown 1992; Brown et al .1996; Buroker et al. 1990). Length variation (or polymorphisms) in the D-loop has been previously examined in a phylogenetic context in white sturgeon of the Columbia Basin (Brown et al., 1992) but has not been explored as a means of delineating genetic identity and population structure of white sturgeon throughout the Basin. This delineation can provide valuable contributions to white sturgeon biology, management, and conservation in the Columbia Basin and elsewhere. Results of research and analysis addressing Objectives 2 and 3 will be presented in subsequent BPA Project 99-22 quarterly and annual reports.

METHODS

White sturgeon tissue samples (pectoral fin clips) were collected non-lethally from 300 white sturgeon at five locations within the Columbia River Basin by the Oregon Department of Fish and Wildlife and the Washington Department of Fish and Wildlife (Table 1). Each collected tissue sample was immediately stored in 5 ml of lysis buffer at ambient temperature (Appendix F-1). Sample storage in lysis buffer allows partial tissue breakdown, but prohibits DNA degradation during sample shipment and longer-term storage. Mitochondrial DNA from each of the 300 samples was isolated using a chloroform-isoamyl alcohol extraction procedure (Appendix F-2). The D-loop region of white sturgeon mtDNA was amplified using the polymerase chain reaction (PCR) in a separate 40 µl reaction for each sample containing:

0.5-2.0 µl isolated DNA
4.0 µl of D-loop A and B primers (10X)
4.0 µl of 10mM dNTP mix
4.0 µl $MgCl_2$
3.2 µl BSA
1.0 µl DMSO
0.2 U *Thermus aquaticus* (Taq) DNA polymerase

All PCR reactions were performed using a 60 well MJ Research PTC-100 Thermal Cycler (MJR, Waltham, MA.). Each cycle of the PCR program consisted of denaturation for 90 seconds at 95^{o} C, annealing for 88 seconds at 54^{o} C, and elongation for 2.5 minutes at 72^{o} C. This cycle was repeated 38 times, followed by a terminal 10 minutes at 72^{o}C for complete product elongation. The final PCR products were then cooled and stored at 4^{o}C. D-loop A and B primer sequences, originally designed as generalized D-Loop primers (Kocher et al. 1989) were altered and published by Beckenbach (1991; Appendix F-3) and ordered from Genosys (The Woodlands, TX). Amplified PCR products were run out on 2.9% agarose gels, applying up to 110 Volts to separate and visualize D-loop length variants for each individual fish. Gels were run in 750 ml of TAE buffer, stained with 37.5 µl of ethidium bromide to visualize PCR-amplified DNA fragments (Figure 1).

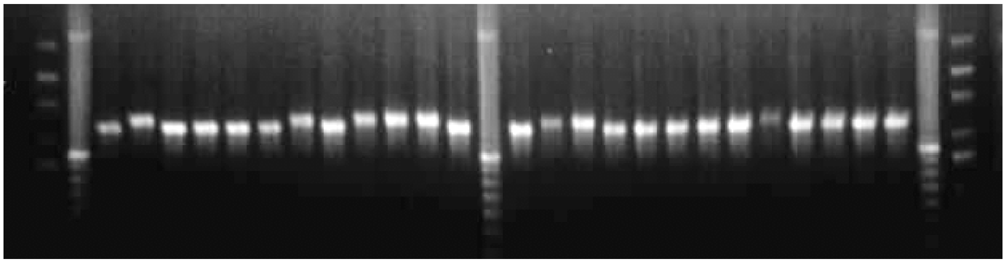


Figure 1. Agarose gel showing PCR amplified white sturgeon D-loop length variation. A band in each lane represents an individual fish, bracketed by a molecular ladder used to estimate fragment size.

Length variation in amplified sequences of the D-loop region of mtDNA was documented and quantified, either visually or with a computer scanner and image analysis software (SigmaScan/Image, Jandel Scientific, San Rafael CA.). Length variation in amplified D-loop sequences was examined from up to 57 individuals per location. (sample sizes of 60 allow a 95% probability of detecting haplotypes present in the target population at frequencies of 5% or greater). Detailed methodologies for this type of analysis are summarized and reviewed by Carvalho and Pitcher (1995) and Avise (1994) and references therein.

Length variants characterized by variable numbers of tandem repeats were designated LV-01 through LV-06 to denote "length variant" and the corresponding number of repeats in the haplotype.

Table 1. Numbers and locations of white sturgeon samples collected by cooperating agencies in the Columbia Basin for use in genetic analysis. Samples for genetic analysis were provided by Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW).

River System	Yr. sampled	Collection location	No. samples collected	Collecting agency
Columbia	1997	Lower Columbia*	60	ODFW
	1997	The Dalles Pool	60	ODFW
	1997	John Day Pool	60	ODFW
Snake	1997	Lower Monumental	60	ODFW/WDFW
	1997	Little Goose Pool	60	ODFW/WDFW

* Lower Columbia River refers to all waters downstream from Bonneville Dam.

RESULTS

Columbia River Basin

D-loop length variation analysis of 211 white sturgeon to date identified five mtDNA haplotypes (D-loop length variants) from samples collected upstream from Bonneville Dam, and a sixth haplotype, only observed downstream from Bonneville Dam. Of the five mtDNA haplotypes observed upstream from Bonneville Dam, the most common haplotype, LV-01 (with one repeat), accounted for 43% of all D-loop length variation of fish from all sampled locations; the second most common haplotype, LV-02 (two repeats), accounted for an additional 30% (Figure 2). Table 2 shows that white sturgeon sampled in all impounded Columbia Basin locations exhibited 5 mtDNA haplotypes, with the exceptions of Lower Monumental Pool (4 haplotypes, n=38) and John Day Pool (3 haplotypes, n=18)(Table 2). Comparison of white sturgeon haplotype diversity from these two pools with other Basin locations in this study with larger sample sizes suggests that the smaller number of mtDNA haplotypes in Lower Monumental and John Day Pool may be due to reduced sample sizes and thus is a sampling artifact.

Columbia vs. Snake River samples

With the exception of John Day Pool (n=18), white sturgeon at all sampling locations were represented by four or five haplotypes (Figures 2 and 3). However, haplotype frequency was more evenly distributed among fish within sampling locations on the Columbia River than in the two Snake River locations, again with the John Day Pool as the exception and likely due to small sample size. Haplotype frequencies from white sturgeon in the two lower Snake River pools (n=95) were dominated by one prevalent mtDNA haplotype, LV-01 which accounted for 55% and 74% of all fish from Lower Monumental and Little Goose pools respectively (Figure 4).

One haplotype was only observed in samples from a single location during this study to date. Haplotype LV-06 was observed in 2 samples from the lower Columbia River, downstream from Bonneville Dam. Given the currently limited scope of this research, and the demonstrated highly migratory ability and reproductive and life history strategies of white sturgeon, greater sample representation from more Columbia Basin locations is warranted to draw reliable inferences about genetic population structuring within the Columbia Basin and beyond.

Table 2. Numbers of identified white sturgeon haplotypes and analyzed samples by sampling location in the Columbia Basin.

Sampling location	Number of haplotypes	No. samples analyzed	Reference figures
Lower Columbia River	6	46	Figure 4
The Dalles Pool	5	49	Figure 5
John Day Pool	3	18	Figure 6
Lower Monumental	4	38	Figure 7
Little Goose Pool	5	57	Figure 8

Figure 2. White sturgeon mtDNA haplotype frequencies from five Columbia Basin locations (n=211)

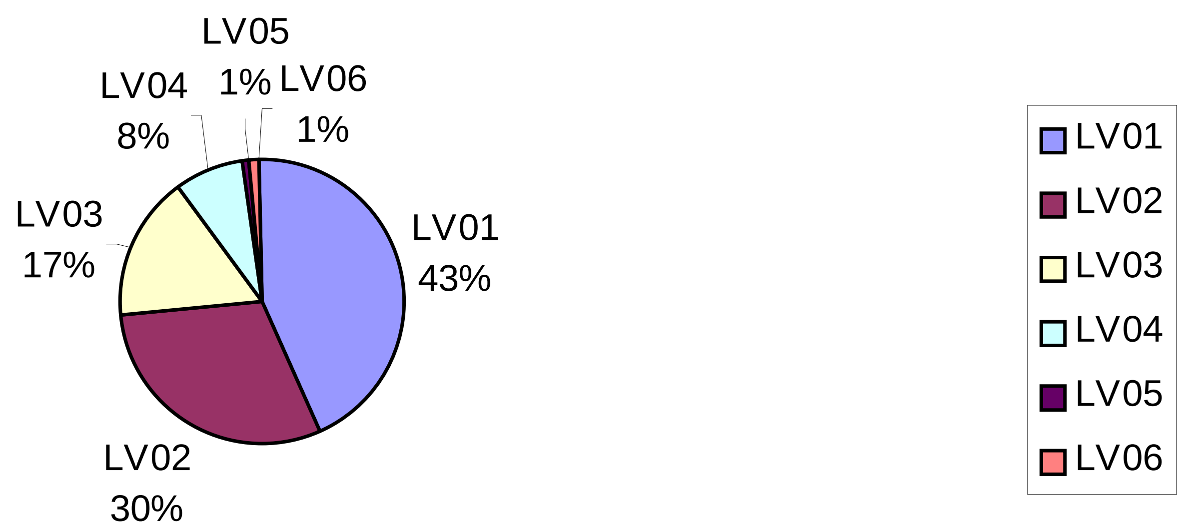


Figure 3 . Agarose gel of 24 white sturgeon from the lower Columbia River illustrating D-loop length polymorphisms.

Figure 4. White sturgeon D-Loop length variant frequencies, Lower Columbia River (n=46)

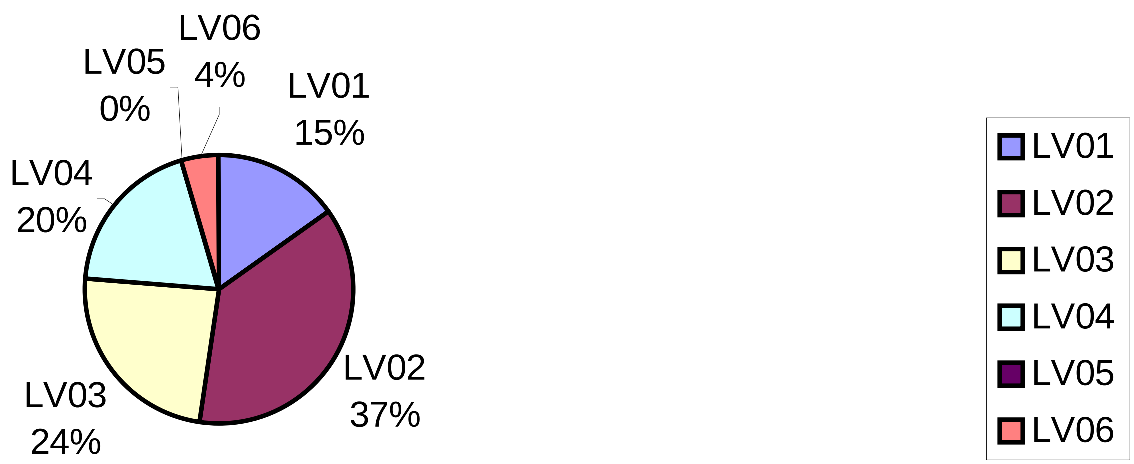


Figure 5. White sturgeon D-Loop length variant frequencies,
The Dalles Pool (n=49)

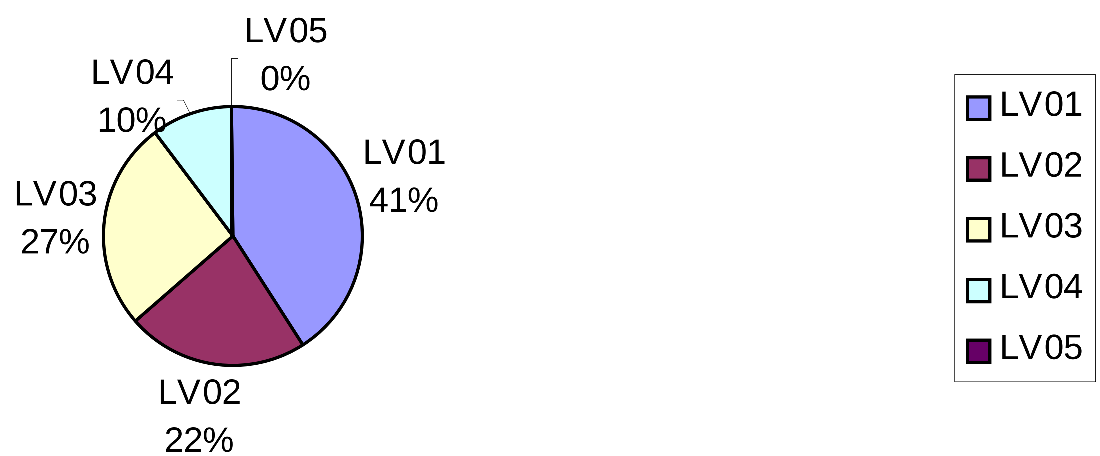
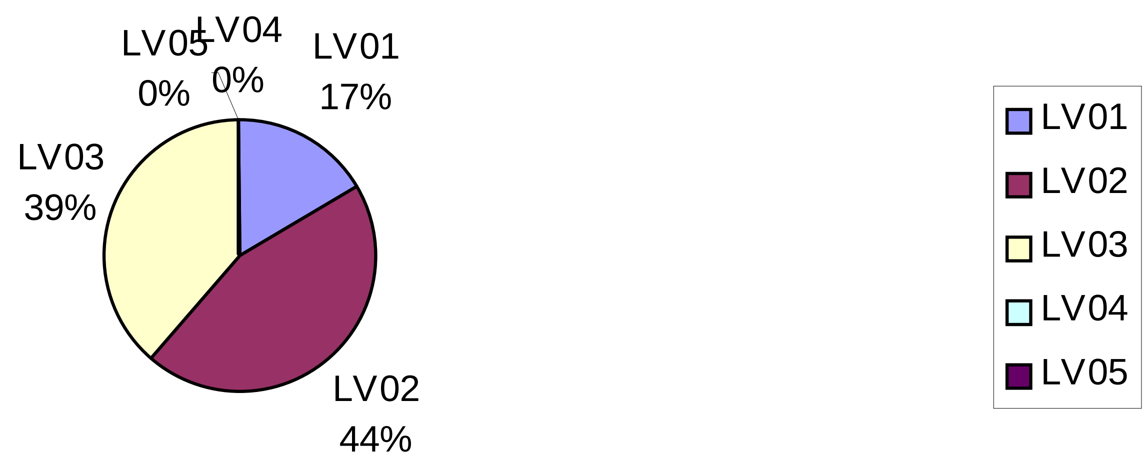


Figure 6. White sturgeon D-loop length variant frequencies, John Day Pool (n=18)



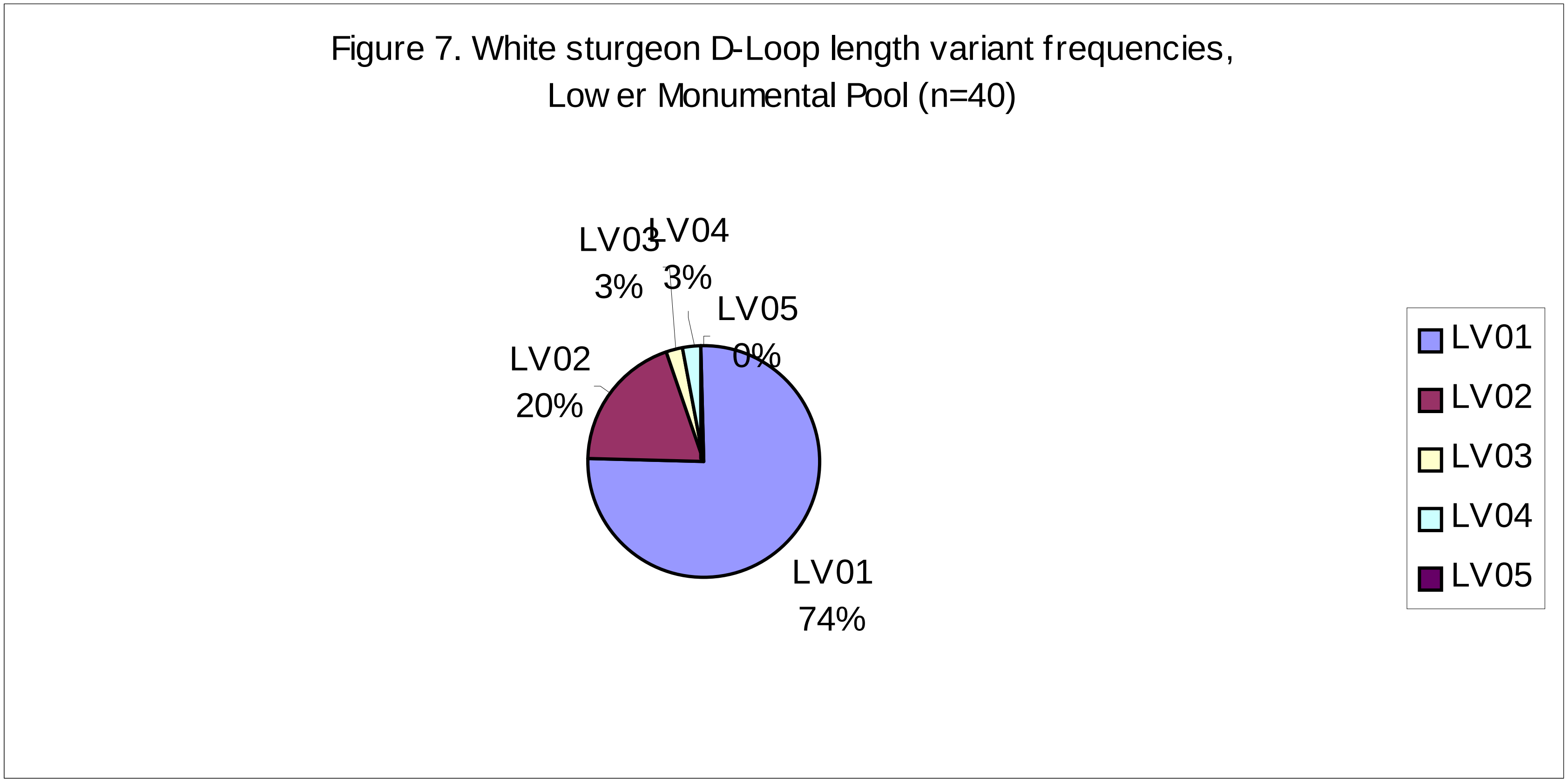


Figure 7. White sturgeon D-Loop length variant frequencies,
Lower Monumental Pool (n=40)
LV03
3%
LV04
3%
LV05
0%
LV02
20%
LV01
74%
LV01
LV02
LV03
LV04
LV05

Figure 8. White sturgeon D-Loop length variant frequencies, Little Goose Pool (n=57)

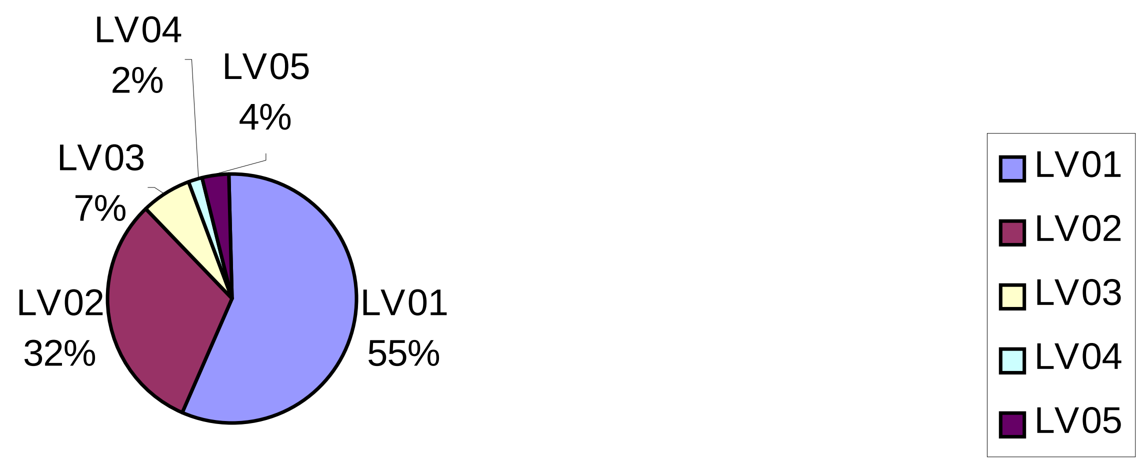


Figure 9. White sturgeon D-Loop length variant frequencies, Kootenai River (n=66)

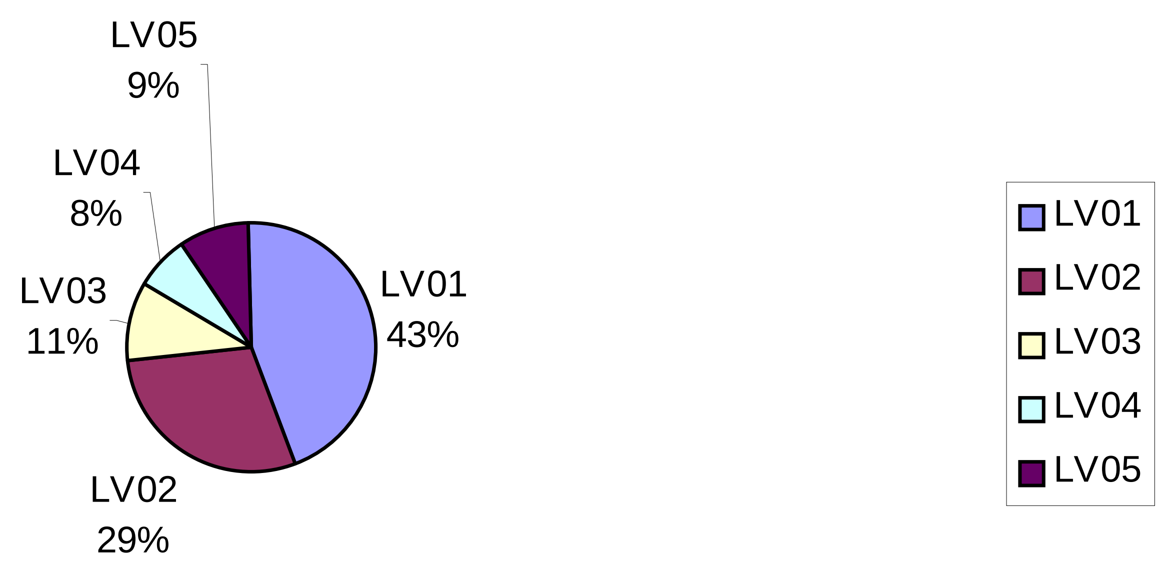
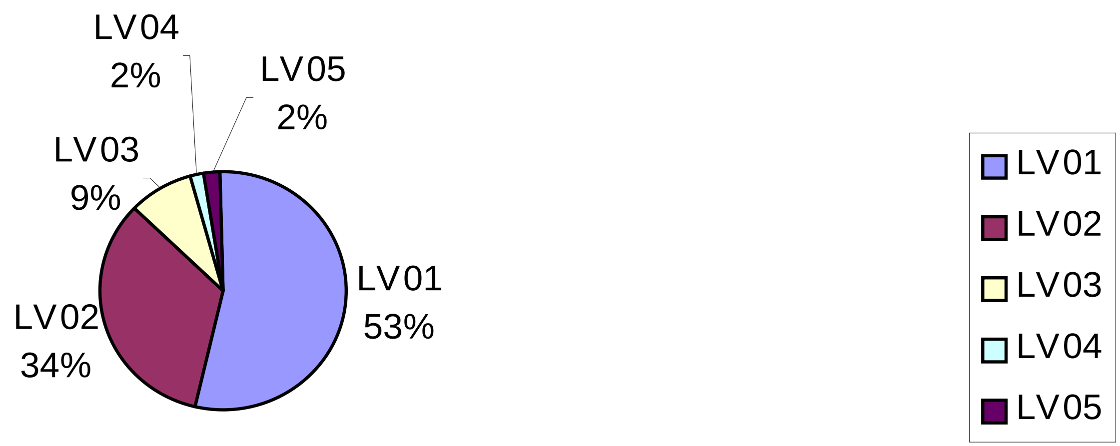


Figure 10. White sturgeon D-Loop length variant frequencies, Kootenay Lake (n=47)



DISCUSSION

The presence of several common mtDNA haplotypes (D-loop length variants) in several geographically distant Columbia Basin locations reported in this study provides evidence to suggest past migration and gene flow among white sturgeon on a Basin scale. With the addition of comparable white sturgeon mtDNA data from the Kootenai River (ID) and Kootenay Lake, British Columbia. in the upper Columbia Basin (University of Idaho, Aquaculture Research Institute, P. Anders, unpublished data), we see more evidence for a historical panmictic population condition for white sturgeon in the Columbia Basin (Figure 2). Excluding data from John Day Pool due to small sample bias (n=18), we observe a general pattern of local predominance by one or two haplotypes in the upper Basin compared to greater or more even representation of the same haplotypes in the Dalles Pool and the lower Columbia River. If future analysis including increased sample sizes from more Basin locations enhances or confirms this observation, several explanations are possible for such a condition.

First, sturgeons throughout the world exhibit a wide array of migratory patterns. However, in most species, including white sturgeon, spawning occurs in freshwater often following an upstream migration, likely covering great distances (Bemis and Kynard 1997). In Figure 2, the predominance of the most common haplotype in the upper Basin (LV-01) could be the result of founding effects, which by chance, or due to pre-founding frequency distributions, over-represented individuals carrying this particular molecular marker. Such long distance natural migrations have largely disappeared due to hydroelectric development on many of the world's large river systems (Birstein 1997). In a reach of the Kootenai River several hundred kilometers in length, upstream spawning migrations of white sturgeon have been consistently observed during the past 10 years (Paragamian 1999; Anders 1991). In many cases, sturgeon spawning occurs in a temporary upstream extension of the species' home range, used exclusively for spawning (Bemis and Kynard 1997). Conversely, long migrations of white sturgeon from the Nechako River system, an upper Fraser River tributary in central British Columbia, have not been documented as part of an ongoing telemetry study of Fraser River white sturgeon (Larry Hildebrand, Scott McKenzie, pers. comm., RL&R Environmental Services Ltd., Castlegar, BC. 1999). Additionally, telemetry of white sturgeon in the lower Fraser River has also failed to document long distance migration.

Secondly, theoretical historical and pre-dam gene flow differences between the upper and lower areas of the Basin, and differential upstream and downstream migration rates could affect observed haplotype frequencies and their geographic distribution. If gene flow is thought of as genetically effective migration, theory might predict a greater number of individuals representing the observed mtDNA haplotypes present in the lower Basin than in the upper Basin. This could be true because in the lower Basin migration and potential pre-dam gene flow may have been multidirectional (upstream and downstream), while in upper reaches of the Basin both become exceedingly unidirectional (downstream), especially in the post-impoundment Basin. Likewise, white sturgeon ascending the Columbia River from the Pacific Ocean and the estuaries may have had a higher probability of being represented in the lower or central Basin than in the upper due simply to differences in required migratory distances, or due to differences in biological or reproductive requirements causing migration to or from either location.

Thirdly, development of the Columbia Basin hydroelectric system, with its series of dams, has artificially obstructed passage for white sturgeon, and many other native fish species (NRC 1996). Although changes in genetic population structure and haplotype frequencies due to natural selection are likely to occur over thousands or more generations (see Mitton 1997 for a review), "artificial selection" due to dams and other non-biological fragmenting and population size reducing mechanisms need not require evolutionary time to affect population genetic parameters. Hydropower development in the Basin during the past century may have affected haplotype frequencies and distributions reported in this study. Construction and completion of dams may have physically trapped seasonally migrating fish with non-representative haplotype frequencies, analogous to observable results of founder effects in natural populations. In cases of relatively "damlocked" populations (Paragamian 1999), natural multidirectional gene flow may have been replaced by unidirectional, downstream gene flow and migration, thus potentially changing haplotype frequencies and geographic distributions over relatively short time.

Finally, the interpretation of these preliminary genetic data are premature to establish genetic structure given the currently limited scope and geographic scale of analyzed data. (This report only summarizes the first six months of Columbia River white sturgeon genetic research). Based on documented longevity and migratory potential of white sturgeons, population structuring and potential substructuring may exist on a scale larger than the Columbia Basin, perhaps on a continental scale rather than a subbasin or drainage scale such as demonstrated by homing anadromous Pacific salmon (Groot and Margolis 1991). Over a recent 22 year period (1977-1998) 471 white sturgeon tagged in the Columbia River were recaptured at 23 separate locations outside the Columbia Basin, as distant as the Sacramento River in central California, the Fraser River in southwest British Columbia, and the Puget Sound (DeVore et al. 1999).

If in fact, white sturgeon existed as a historically panmictic population throughout the Columbia River Basin, and historically incorporated fish from outside the Basin, management and conservation programs might be considerably different than if Basin white sturgeon were assumed to be locally adapted resident Basin populations. If the above historical panmixis scenario is confirmed in the future, management and conservation strategies designed to reestablish historical gene flow and migration could be prudent. Future analytical results with an expanded series of sample location and sample numbers, along with initiation of the second and third objectives of this research will shed more light on white sturgeon population genetics. This research will also contribute to a scientific foundation on which to develop comprehensive management and conservation strategies for white sturgeon in the Columbia River Basin and elsewhere.

Although differences in frequencies and geographic distribution of haplotypes were observed in our initial analyses presented in this report, caution is urged regarding formulation of any inferences based on these preliminary data. Likewise, these data currently do not provide adequate scope or power for use in formulating any management strategies or activities.

PLANS FOR NEXT YEAR

During calendar year 1999, genetic research presented in this report will be expanded to include mtDNA analysis of up to 60 white sturgeon samples (limited to sample availability) from the following locations:

Columbia River:

Bonneville Pool
McNary Pool
Rock Island Pool
Chief Joseph Pool
Lake Roosevelt
Lower Granite Reservoir

Outside Columbia Basin:

Sacramento River (CA.)
Lower Fraser River (British Columbia)
Upper Fraser River (Nechako River, upper Fraser tributary, British Columbia)

In addition to initiating genetic analysis on over 500 samples from the above locations, considerable effort will be expended to complete analysis of samples from Basin locations presented in this report that had not successfully PCR amplified during the time period covered by this report.

During calendar year 1999, genetic research presented in this report will be expanded to include mtDNA analysis of up to 80 white sturgeon samples (limited to sample availability) from each the following Snake River locations (Figure 6):

Snake River:

Hells Canyon (upstream from Salmon River confluence)
Brownlee Dam to Swan Falls Dam
Swan Falls Dam to CJ Strike Dam
CJ Strike to Bliss Dam

Genetic analysis of white sturgeon from the above four Snake River locations will be funded by separate contract with the Idaho Power Company (Boise, ID.)

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Appendix F-1 .Lysis buffer recipe for tissue storage used in genetic analysis.

For 1 Liter of Lysis Buffer:

Into a 1000 ml graduated cylinder:

200 ml	0.5 M EDTA, pH 8.0
50 ml	2 M Tris, pH 7.5
2 ml	5 M NaCl

dH20 to 975 ml mark on cylinder
add 25 ml 20% SDS
Mix gently.
Note: SDS will foam

Appendix F-2. Chloroform Iso-Amyl Alcohol extraction protocol.

GENOMIC EXTRACTION

NOTE: For use on fish tissues.

PART I. Sample handling and digestion.

Materials:
autoclaved wide bore pipette tips (1000 ul tips with about 1 cm of tip cut off)
100 ul and 1000 ul pipettes
10 ml glass pipette
weigh boats
digestion solution (protocol digsoln.xls)
2.0 ml screwcap Eppendorf tubes with O-ring caps (autoclaved)
250 ml beaker of bleach solution (20 ml bleach + 180 ml water)
gloves
forceps and scalpel with blade
1.7 ml microcentrifuge tubes with attached screw cap (Fisher Cat. No. 05-402-37)
This tube will stand up to centrifuging with chloroform which occurs in Part II of extraction.

Setup:
- Prepare appropriate amount of digestion solution (see digsoln.xls) for number of samples.
  i.e. Each sample requires 650 ul digestion solution.
  24 samples require 15.6 ml digestion solution; therefore make 17 ml of solution.
- Wear gloves at all times.
- Between each sample, clean forceps and scalpel with bleach solution, then dry off with Kimwipe.
- Use a new weigh boat and/or pipette tip for each sample.

Procedure:
1. Fill all extraction vials (1.7 ml attached screw cap tubes) with 650 ul digestion solution, and label cap with sample number.

2. Place sample tissue into extraction vial and cap tightly.

   - If tissue is fairly solid:
   Pour tissue and storage medium into new weight boat.
   Remove small piece of tissue about 3-5 mm square, and place into digestion solution.

   - If tissue is mostly digested (as in lysis buffer samples):
   Use 1000 ul cut pipette tip to remove about 100 ul of lysis buffer/sample from bottom of tube, and add to digestion solution.

3. Place filled tubes in 55°C gently shaking incubator overnight.

GENOMIC EXTRACTION

PART II. DNA extraction and precipitation.

Materials:
70% ethanol (store in freezer)
100% ethanol (store in freezer)
alcohol waste container (store in waste cabinet)
24:1 chloroform:isoamyl alcohol (store in fridge)
24:1 chloroform:isoamyl alcohol waste container (store in waste cabinet)
5 M ammonium acetate (store in fridge): ***Do NOT use stock solutions over 1 month old.***
1X TE
autoclaved wide bore pipette tips (1000 ul tips with about 1 cm of tip cut off)
pipettes and autoclaved pipette tips to handle a range of 50-1000 ul
1.7 ml microcentrifuge tubes with snap cap (autoclaved)
2.0 ml microcentrifuge tubes with attached screw cap (autoclaved). (Fisher Cat. No. 05-669-14)
Do **not** use this 2.0 ml tube with chloroform!

Setup:
- Wear gloves at all times.
- Do not contaminate pipette tips between samples.

Extraction Procedure:
1. Remove samples from shaking incubator.

2. *****Add 650 ul of 24:1 chloroform:isoamyl alcohol to each 2.0 ml sample tube. Invert rack of tubes several times until entire mixture in each tube is cloudy white.

3. Immediately spin down tubes in centrifuge until interface is thin and firm, 15 minutes @ 13,000 rpm. If necessary, spin extra 5-15 min to get firm interface.

4. Remove aqueous top layer and place in a new 1.7 ml snap cap tube, using a new wide bore pipette tip for each sample. Be careful to not remove any material from the interface.

   Dump waste from old tube into waste chloroform:isoamyl alcohol container, and throw away old tube.

5. *Add 650 ul of 24:1 chloroform:isoamyl alcohol to each 1.7 ml tube from step 4. Invert rack of tubes several times until entire mixture in each tube is cloudy white.

6. Immediately spin down tubes in centrifuge until interface is thin and firm, 5 min @ 13,000 rpm.

***NOTE:** *Chloroform eats away at plastic. It is very important to not let the Chloroform mixture stand in the tubes for any length of time. Add the chloroform:isoamyl alcohol to tubes only after all sample solutions are in their tubes, then centrifuge immediately.*

GENOMIC EXTRACTION

Precipitation Procedure:

7. Add 1/10 volume (65 ul) of ammonium acetate to new labeled 2 ml screw cap tubes with attached caps. These tubes will be the final permanent tubes for the extracted DNA.

8. Remove aqueous top layer from 1.7 ml tube (from step 6), and add to 2 ml tube from step 7.

9. Add 2 volumes (1300 ul) of cold 100% ethanol to each 2 ml tube. Invert rack of tubes several times to gently mix, then place in -20° freezer for 30 minutes minimum, or into -80°C freezer for 15 minutes maximum. (We want the solution cold, not frozen).

10. Spin down tubes in centrifuge (hinge side out) for 10 min @ 13,000 rpm.

11. Decant supernatant away from pellet side (hinge side) to waste alcohol container.

12. Add 500 ul of 70% ethanol to each tube to wash pellet free of salts.

13. **Immediately spin tubes down for 30 - 60 sec in centrifuge.

14. **Immediately decant supernatant away from pellet side (hinge side) to waste alcohol container.

*******Note*: Do not allow pellet to sit in the 70% alcohol solution; process immediately. Otherwise the DNA pellet may start to go back into solution.

15. Repeat steps 12 - 14.

16. Invert tubes onto a test tube rack layered with kimwipes. Place rack in 37°C incubator for 30 - 60 min to dry pellet and remove alcohol from tubes.

17. Turn tubes right side up and add 100 ul of warm (65-70°C) 1X TE. Incubate for 60 min in 37°C incubator (optional if extracts will not be used immediately).

18. Store at 4°C in refrigerator.

19. Record estimated amounts of waste on hazardous waste sheets.
ie. For 24 samples: 31 ml of 24:1 chloroform:isoamyl alcohol
31 ml 100% ethanol, 2 ml ammonium acetate (5 M), 24 ml 70% ethanol

Appendix F-3.

Primer sequences (5' to 3') used in PCR amplification of white sturgeon D-loop region:

D-Loop A: T T G G G T T T C T C G T A T G A C C G

D-Loop B: A G A G C G T C G G T C T T G T A A A C C