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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

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In Cooperation With:

Washington Department of Fish and Wildlife
U.S. Geological Survey Biological Resources Division
National Marine Fisheries Service
U.S. Fish and Wildlife Service
Columbia River Inter-Tribal Fish Commission

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EXECUTIVE SUMMARY

We report on our progress from April 1997 through March 1998 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), National Marine Fisheries Service (NMFS; Report D), U.S. Fish and Wildlife Service (USFWS; Report E), and Columbia River Inter-Tribal Fish Commission (CRITFC; 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 1997 through March 1998 are:

Report A

(1) 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) Recreationa lfisheries for white sturgeon in Zone 6 (between Bonneville and McNary dams) were sampled throughout the 1997 season and fishery managers were provided with weekly updates of estimated harvest. When harvest approached recommended limits (2,280 fish) fisheries were closed to retention: April 5 for Bonneville Reservoir, May 5 for The Dalles Reservoir, and September 2 for John Day Reservoirs. Recreational white sturgeon harvest was kept within guidelines for the third consecutive year.

(2) Harvest in the 19 97 treaty Indian Zone 6 commercial fishery was 1,850 white sturgeon from Bonneville Reservoir, 500 from The Dalles Reservoir, and 1,260 from John Day Reservoir. Guidelines (Bonneville = 1,300, The Dalles = 400, and John Day = 1,160) were exceeded in all reservoirs. An additional 230 fish were harvested during 1997 subsistence fisheries.

(3) We estimated the abundance of 110-209 cm fork length white sturgeon to be 2,230 in Lower Monumental reservoir and 4,180 in Little Goose Reservoir. The lack of young fish in Ice Harbor and Lower Monumental reservoirs indicate that the populations are recruitment-limited.

Report C

(1) Field data collection to determine the habitat use and seasonal movements of white sturgeons in McNary Reservoir and the Hanford Reach was completed.

(2) Sampling with bottom trawls in Bonneville, The Dalles, and John Day reservoirs revealed white sturgeons successfully spawned and recruited to age 0. Indices of the availability of spawning habitat during 1997 were high.

(3) Spawning by white sturgeons was documented for the first time downstream from Lower Granite, Little Goose, and Lower Monumental dams by the collection of eggs.

(4) The manuscript "Influence of externally attached transmitters on the swimming performance of juvenile white sturgeon" was accepted for publication in *Transactions of the American Fisheries Society*.

Report D

(1) Young of the year comprised approximately 16% of the total trawl catch of juvenile white sturgeon downstream from Bonneville Dam in September. Densities of young of the year in 1997 (4.9 fish/ha) were less than densities found in previous years (6.7 - 11.7 fish/ha).

Report E

(1) Hydraulic data collection began in new areas in both the Columbia and Snake rivers during 1997. Reconnaissance and study design were completed, and data collection was initiated for 43 cross sections in the White Bluffs Island Complex in the Hanford Reach of the Columbia River, and for 12, 10, and 15 cross sections, respectively, in the Lower Monumental, Little Goose, and Lower Granite tailraces in the Snake River. Data collection was also initiated for 10 cross sections around the four islands in the Ice Harbor tailrace.

(2) Hydraulic data collection was conducted at Columbia River discharges ranging from 3,317 to 9,152 m^3/s, and at Snake River discharges ranging from 1,528 to 3,379 m^3/s. Cross section profile and velocity distribution data were collected at 51 cross sections, and 126 stage-discharge data pairs were collected at 90 cross sections. Approximately 700 total stage-discharge data points, including 177 for the current year, have been collected for calibration of hydraulic models.

(3) Calibration of hydraulic models for main channel cross sections in the Hanford Reach neared completion. Hydraulic data files were assembled for cross sections in the new study areas, and all velocity distribution and stage-discharge data were reduced and entered.

(4) An agreement was made with the Corps of Engineers to provide water surface elevations for Snake River study areas using their existing step-backwater models for McNary, Ice Harbor, Lower Monumental, and Little Goose pools. Water surface elevations will be obtained for the entire time-series analysis and will result in a significant savings of both time and effort. Measured field data will be used to evaluate the accuracy of the modeled data.

(5) An evaluation of the Columbia River hydrograph for time-series analysis revealed at least two distinct patterns within the period of record. Historically, the hydrograph was seasonal, with a significant spring freshet and low winter flows. During recent years, the hydrograph has become more constant and less seasonal as a result of hydropower and water storage development in the basin.

Report F

(1) Tribal fishers caught 3,747 white sturgeon in 771 overnight gillnet sets in The Dalles Reservoir. A total of 1,789 fish were marked with PIT tags, and 1,578 fish were marked with individually-numbered spaghetti tags. Mark and subsequent recapture information was used to estimate the abundance of white sturgeon in the reservoir (Report A).

(2) Recaptures of fish transplanted from below Bonneville Dam constituted 21% (N = 776) of the catch.

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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

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: An update of abundance, life history parameters, and population dynamics of white sturgeon in The Dalles Reservoir, including an estimate of survival of white sturgeon transplanted from below Bonneville Dam

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Tom Rien directed our sampling design and provided many constructive recommendations regarding data analyses and content of this report. Christie Campbell, Matthew Howell, Tess Longlade, Wendy Martin, Jamie Scroggie, and Ronald Reeves conducted field sampling. Elizabeth Cleveland, Dannette Ehlers, Craig Gunderson, Jennifer Harrington, Julian Hudson, Janelle McFarland, Adam Palmer, and Scott Ziegenhagen assisted with sampling when regular staff was unavailable. Dennis Gilliland and Brad James of Washington Department of Fish and Wildlife forwarded recreational and commercial tag returns to us. Kevleen Melcher of Oregon Department of Fish and Wildlife also forwarded commercial tag returns to us. Curtis Melcher of Oregon Department of Fish and Wildlife classified deformities of, and collected blood samples from white sturgeon captured during tagging efforts conducted in Oregon coastal estuaries for the Northwest Emergency Assistance Program. Blaine Parker coordinated our cooperative sampling program with Columbia River Inter-Tribal Fish Commission. Grant Feist of the Department of Fisheries and Wildlife at Oregon State University conducted laboratory analyses of plasma samples.

ABSTRACT

We report on work performed from April 1997 through March 1998 in The Dalles Reservoir to update life history parameters and population dynamics of indigenous white sturgeon *Acipenser transmontanus* and estimate the survival of white sturgeon transplanted from below Bonneville Dam. Mark and recapture sampling was coordinated with staff of Columbia River Inter-Tribal Fish Commission (CRITFC) who contracted commercial fishers to capture and tag white sturgeon in The Dalles Reservoir from December 1996 through early February 1997. We set 731 setlines from May through August and caught 4,512 white sturgeon. An additional 22 white sturgeon were collected in 7 gill net sets. White sturgeon were distributed throughout The Dalles Reservoir but catch rates were significantly different between sampling sections. We applied 3,319 passive integrated transponder (PIT) tags and 2,797 wire-core spaghetti tags to fish 70-166 cm fork length (FL). Within-year retention rates were 96% for spaghetti tags (fish at large 8-251 days) and 99% for PIT tags (fish at large 7-256 days). We were unable to estimate instantaneous mortality due to an insufficient number of fin-spines from all age classes and uncertainty associated with aging impounded white sturgeon. We recaptured 219 indigenous white sturgeon (70-166 cm FL), including 155 fish tagged by CRITFC and estimated an abundance of 59,800 white sturgeon in this size range, and 8,100 legal-size fish (110-137 cm FL). This estimate represents a six-fold increase in abundance from our 1994 estimate of 9,700 fish (70-166 cm FL). The magnitude of difference between these population estimates is likely due to an underestimate of fish abundance in 1994 and inherent uncertainty with mark and recapture estimates. The density of white sturgeon (>54 cm FL) was estimated to be 2.8 fish/hectare in 1994 and 16.3 fish/hectare in 1997.

INTRODUCTION

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

In this report we describe activities and results of work conducted from April 1997 through March 1998 to update life history parameters and population dynamics of white sturgeon in The Dalles Reservoir. We conducted mark and recapture sampling in The Dalles Reservoir jointly with staff of Columbia River Inter-Tribal Fish Commission (CRITFC) similar to 1996 sampling (North et al. in press*a*). The CRITFC contracted commercial tribal fishers to capture, mark, and tag white sturgeon in The Dalles Reservoir from December 1996 through early February 1997 to increase the number of tagged fish available for recapture. A summary of this work is provided by Parker (this report); however, we report results of our recapture of fish tagged by CRITFC. Results of work conducted this year to estimate survival, growth, and condition of white sturgeon transplanted to The Dalles Reservoir from below Bonneville Dam during 1994 and 1995 are presented as part of a summary report on white sturgeon transplant supplementation (Appendix A-5).

METHODS

We sampled for white sturgeon in The Dalles Reservoir from early May through late August to estimate population statistics. The reservoir was divided into 6 sections, 5.1 to 7.2 km long (Figure 1). The boat-restricted zone (BRZ) immediately downstream from John Day Dam was considered an additional section but we were unable to sample there due to spill. Past sampling has shown white sturgeon densities are typically highest in the BRZ (North et al. 1993b). We distributed setline sampling effort equally among and within the remaining six sections to obtain a representative sample of the population. We divided the field season into five, 3-week sampling periods and sampled all sections during each period (Table 1).

We recaptured fish tagged by CRITFC and ODFW during 1996 and 1997 both upstream and downstream of original tagging locations with no migration patterns evident (Table 5). Approximately 30% of fish tagged by CRITFC and 45% of fish tagged by ODFW were recaptured by ODFW within 1 km of the original tagging location. The average distance between capture and recapture locations was 4.8 km for fish tagged by CRITFC and 3.4 km for fish tagged by ODFW. We recaptured white sturgeon originally tagged in McNary, John Day, and The Dalles reservoirs during previous sampling efforts. Since 1987, at least 4 white sturgeon have been recovered in a reservoir upstream from where they were originally captured and approximately 95 fish have been recaptured in reservoirs downstream of original marking locations (Appendix A-2).

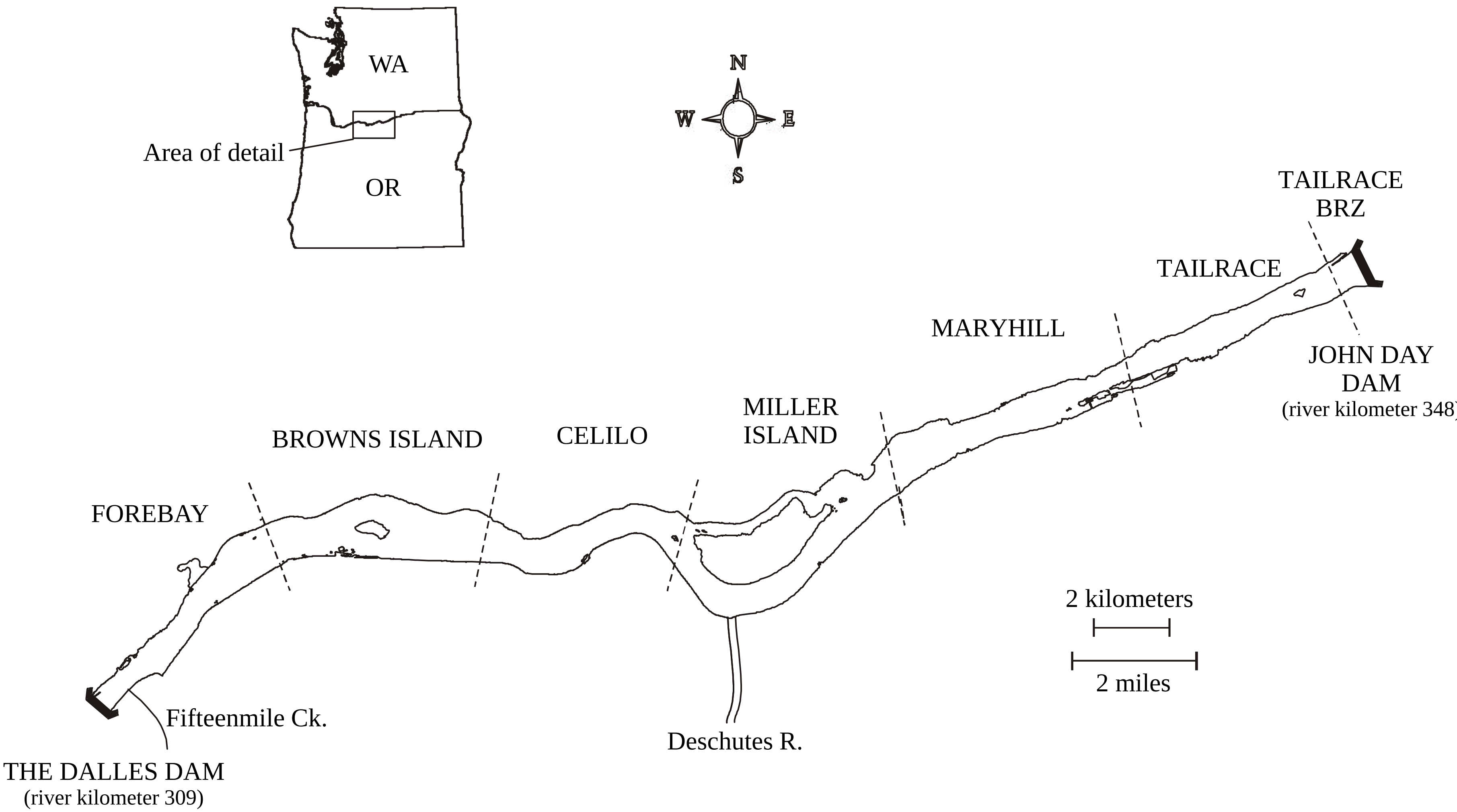

Figure 1. The Columbia River between The Dalles and John Day dams. Sampling section boundaries are indicated by dashed lines. The scale is approximate. Boat-restricted zone (BRZ).

Table 1. Sampling effort (number of setline or gill net sets) for white sturgeon (all lengths) in The Dalles Reservoir by week and sampling section, May through August 1997. A "-" indicates sampling was not conducted.

Gear	Sampling section[a]						
Week of year	1	2	3	4	5	6	Total
Standard setlines[b]							
19	-	1	-	-	-	-	1
20	-	-	21	5	-	-	26
21	11	13	-	-	-	-	24
22	-	-	-	-	12	9	21
23	-	-	15	14	-	-	29
24	14	13	-	-	-	-	27
25	-	-	-	-	12	13	25
26	-	-	13	15	-	-	28
27	12	15	-	-	-	-	27
28	-	-	-	-	18	10	28
29	-	-	9	16	-	-	25
30	11	15	-	-	-	-	26
31	-	-	-	-	23	6	29
32	-	-	9	18	-	-	27
33	15	15	-	-	-	-	30
34	-	-	-	-	18	7	25
Total	63	72	67	68	83	45	398
Experimental setlines[c]							
19	1	2	-	-	-	-	3
20	-	-	-	13	1	-	14
21	12	12	-	-	-	-	24
22	-	-	-	-	11	9	20
23	-	-	8	10	-	-	18
24	10	12	-	-	-	-	22
25	-	-	-	-	15	5	20
26	-	-	7	14	-	-	21
27	7	14	-	-	-	-	21
28	-	-	-	-	12	12	24
29	-	-	6	18	-	-	24
30	11	11	-	-	-	-	22
31	-	-	-	-	12	12	24
32	-	-	9	18	-	-	27
33	11	15	-	-	-	-	26
34	-	-	-	-	15	8	23
Total	52	66	30	73	66	46	333

Table 1. Extended.

Gear Week of year	Sampling section[a] 1	2	3	4	5	6	Total
Gill nets							
29	-	-	-	1	-	-	1
31	-	-	-	-	-	1	1
32	-	-	-	1	-	-	1
33	1	1	-	-	-	-	2
34	-	-	-	-	-	2	2
Total	1	1	-	2	-	3	7

[a] Sampling sections: 1=The Dalles Dam forebay, 2=Browns Island, 3=Celilo, 4=Miller Island, 5=Maryhill, 6=John Day Dam tailrace.

[b] 12/0, 14/0, and 16/0 hooks.

[c] 10/0 and 12/0 hooks.

We measured fork length (cm), and looked for tags, tag scars, fin marks, and scute marks on each white sturgeon captured. All measurements herein are fork length unless otherwise noted. We weighed and removed a pectoral fin-spine section from a subsample of the catch (up to 30 fish per 20-cm length interval). Most white sturgeon were tagged with a 125-Mhz passive integrated transponder (PIT) tag. The second left lateral scute was removed to identify PIT-tagged fish (Rien et al. 1994). White sturgeon ≥80 cm were also tagged with a wire-core spaghetti tag placed about 1 cm beneath the dorsal fin insertion. We did not externally-tag smaller fish because they tend to shed external tags due to rapid growth. The seventh right lateral scute was removed as a secondary mark to indicate the fish was tagged or marked in 1997. All recaptures tagged during previous sampling efforts were weighed to calculate growth rate.

We examined a subsample of the catch for morphological abnormalities and categorized each occurrence by type. These data were compared with similar data collected in the Columbia River estuary (Appendix A-3).

We injected 1,243 white sturgeon (<80 cm or >164 cm) with oxytetracycline (OTC) to validate age interpretations from fin-spine sections that may be obtained from fish recaptured in future years (Rien and Beamesderfer 1994). White sturgeon between 80 and 164 cm fork were not injected with OTC to prevent consumption of this product because as fish in this size range can legally be harvested. We injected 100 mg/mL OTC into the red muscle under the dorsal scutes immediately posterior to the head at a rate of 25 mg/kg of body weight (McFarlane and Beamish 1987). The second right lateral scute was removed from OTC-injected fish for identification if recaptured.

We examined the gonads of most white sturgeon >137 cm to determine sex and stage of maturity following surgical procedures similar to those reported by Beamesderfer et al. (1989). A small sample (<1 g) of the gonad was removed from most fish using biopsy forceps. We verified field sex identification in the laboratory by microscopic examination and classified maturation stage of females according to criteria in North et al. (1993a) that is modified slightly from Chapman (1989). Gonad tissue samples were also examined for sex-specific germ cells by Department of Fisheries and Wildlife staff at Oregon State University (OSU) to assess the accuracy of our classifications.

Distribution of white sturgeon was examined by comparing setline catch rate among sampling sections. We investigated efficiency and selection of setline types by comparing catch rate and mean size of the catch. Statistical differences ($P<0.05$) in catch rates were evaluated on transformed catch-per-set data [$\log_e$(catch+1)] with Statistical Analysis System (SAS 1988a; 1988b). Comparisons between sample means were made using analysis of variance (ANOVA) and Tukey's studentized range test. We determined movement of individual tagged fish by comparing river kilometer of capture and recapture locations.

Catch rates of white sturgeon ≥167 cm with “standard” setlines were calculated and compared with 1994 catch-rate-data for setlines fished outside the John Day Dam tailrace BRZ. We also adjusted the 1997 catch rate for this size-group of fish to reflect expected catch rates if we had used Pacific Lamprey *Lampetra tridentata*, the only bait used in 1994. Adjustments were based on results of 1996 sampling in John Day Reservoir where we fished "standard" setlines with several baits (North et al. in press*a*).

The within-year retention rate of PIT tags was estimated as the percent of recaptured fish with readable PIT tags which were originally fitted with both PIT and spaghetti tags or appropriately scute-marked when first captured. Passive integrated transponder tags were considered lost whenever they could not be detected at recapture regardless of whether the tag was expelled, missing, defective, or mistakenly not applied. We determined the within-year retention rate of wire-core spaghetti tags as the percent of recaptured fish retaining this external tag which were also PIT-tagged or appropriately scute-marked at first capture. Wire-core spaghetti tags were considered lost when physically absent at recapture, unreadable, or mistakenly not applied.

Age of white sturgeon <110 cm was estimated from thin cross-sections of pectoral fin-spines following procedures outlined in Beamesderfer et al. (1989). Each fin-spine section was aged twice each by two experienced staff, and up to 20 fish for each 20-cm length interval were aged. An age-length frequency distribution was developed from these age assignments.

We used two standard methodologies described by Ricker (1975) to estimate the instantaneous rate of mortality (Z) for fish <110 cm. One estimate was obtained by calculating the slope of the descending limb of a catch curve derived from the age-frequency distribution of white sturgeon caught in gill nets during 1996-1997 by CRITFC. A second estimate was calculated from the estimated abundance of individual cohorts captured with setlines in 1994 and 1997. We did not collect fin-spines from fish ≥110 cm because age-assignments based on fin-spines of these larger white sturgeon have been shown to be inaccurate and imprecise for impounded white sturgeon (Rien and Beamesderfer 1994).

Paired samples of fork length and weight were used to calculate regression. Relative weights (W_r) were calculated to estimate the condition of white sturgeon captured and were compared using ANOVA to values for fish sampled in 1994 (Beamesderfer 1993).

We collected two 3-mL blood samples from each of the first two white sturgeon caught each day for future analyses of DNA. We used an evacuated tube and needle to draw blood from the caudal vein. Plasma samples were collected from most surgically-examined fish for analyses of testosterone, 11-ketotestosterone, estradiol, and dihydroxyprogesterone concentrations by personnel at OSU. We collected additional blood plasma samples for cortisol analyses from white sturgeon exposed to various capture and handling methods and prepared a summary report (Appendix A-4).

Abundance of fish 70-166 cm was estimated with a Schnabel multiple mark and recapture estimator (Ricker 1975) according to methods outlined in Beamesderfer et al. (1995). Mark and recapture samples were grouped by sampling period; CRITFC sampling was considered period one, and Oregon Department of Fish and Wildlife (ODFW) sampling comprised periods two through six. We accounted for harvest of tagged fish by expanding the number observed in recreational and commercial fisheries based on the sampling rate (DeVore et al. this report). Fish that lost all tags were identified from secondary marks. We adjusted the observed length frequency based on size-specific recapture rates reported by Beamesderfer et al. (1995) and expanded our abundance estimate based on the adjusted length frequency (Beamesderfer and Rieman 1988).

To corroborate the abundance estimate we used 1997 recaptures by ODFW of fish that were 70-166 cm when marked by ODFW in 1994 to perform a Petersen estimate of abundance. We did not attempt to adjust the number of 1994 marked white sturgeon at large to account for fishing and natural mortality.

RESULTS

Catch

We caught 4,512 white sturgeon (31-229 cm) with setlines in The Dalles Reservoir (6.2 fish per setline; Table 2; Figure 2; Appendix A-1). We caught 2,459 white sturgeon (42-229 cm) on "standard" setlines (6.2 fish per setline) and 2,053 (31-164 cm) on "experimental" setlines (6.2 fish per setline; Table 3). We caught 22 white sturgeon (30-105 cm) with gill nets (3.1 fish per gill net; Table 2; Table 3; Appendix A-1). The setline catch consisted of 87.9% sublegal (≤109 cm), 11.6% legal (110-137 cm), and 0.5% "over-size" (≥138 cm) white sturgeon (Table 4). The observed catch rate of white sturgeon ≥167 cm with "standard" setlines was 0.020 fish per setline which increases to a theoretical catch rate of 0.023 fish per setline when adjusted to reflect predicted catches with Pacific lamprey. Mean lengths (±SE) of white sturgeon captured by gear were 65.8 cm (±4.8) for gill nets, 85.7 cm (±0.4) for "experimental" setlines, and 90.6 cm (±0.4) for "standard" setlines. The two setline types caught fish of significantly different sizes (df=1, 4,510; $P \leq 0.001$) but catch rates were nearly identical (df=1, 729; $P=0.904$).

Distribution and Movement

We captured white sturgeon throughout The Dalles Reservoir but most fish (72%) were caught in the upper half of the reservoir (Table 4). Catch rates averaged 3.6 white sturgeon per setline-day in sections 1-3, and 8.6 white sturgeon per setline-day in sections 4-6. We found significant differences in log-transformed catch rates among sampling sections (df=5, 725;$P<0.001$).

We recaptured fish tagged by CRITFC and ODFW during 1996 and 1997 both upstream and downstream of original tagging locations with no migration patterns evident (Table 5). Approximately 30% of fish tagged by CRITFC and 45% of fish tagged by ODFW were recaptured by ODFW within 1 km of the original tagging location. The average distance between capture and recapture locations was 4.8 km for fish tagged by CRITFC and 3.4 km for fish tagged by ODFW. We recaptured white sturgeon originally tagged in McNary, John Day, and The Dalles reservoirs during previous sampling efforts. Since 1987, at least 4 white sturgeon have been recovered in a reservoir upstream from where they were originally captured

Table 2. Catches of white sturgeon (all lengths) with setlines and gill nets in The Dalles Reservoir by week and sampling section, May through August 1997. A "-" indicates sampling was not conducted.

Gear	Sampling section[a]						
Week of year	1	2	3	4	5	6	Total
Standard setlines[b]							
19	-	4	-	-	-	-	4
20	-	-	8	8	-	-	16
21	13	30	-	-	-	-	43
22	-	-	-	-	38	45	83
23	-	-	15	149	-	-	164
24	13	46	-	-	-	-	59
25	-	-	-	-	67	92	159
26	-	-	76	239	-	-	315
27	41	87	-	-	-	-	128
28	-	-	-	-	149	79	228
29	-	-	42	214	-	-	256
30	44	99	-	-	-	-	143
31	-	-	-	-	177	67	244
32	-	-	83	213	-	-	296
33	90	65	-	-	-	-	155
34	-	-	-	-	127	39	166
Total	201	331	224	823	558	322	2,459
Experimental setlines[c]							
19	0	8	-	-	-	-	8
20	-	-	-	82	11	-	93
21	4	24	-	-	-	-	28
22	-	-	-	-	4	70	74
23	-	-	7	81	-	-	88
24	21	28	-	-	-	-	49
25	-	-	-	-	90	41	131
26	-	-	9	200	-	-	209
27	43	119	-	-	-	-	162
28	-	-	-	-	108	123	231
29	-	-	13	275	-	-	288
30	15	84	-	-	-	-	99
31	-	-	-	-	76	119	195
32	-	-	26	137	-	-	163
33	35	60	-	-	-	-	95
34	-	-	-	-	81	59	140
Total	118	323	55	775	370	412	2,053

Table 2. Extended.

Gear Week of year	Sampling section[a]						Total
	1	2	3	4	5	6	
Gill nets							
29	-	-	-	16	-	-	16
31	-	-	-	-	-	1	1
32	-	-	-	5	-	-	5
33	0	0	-	-	-	-	0
34	-	-	-	-	-	0	0
Total	0	0	-	21	-	1	22

[a] Sampling sections: 1=The Dalles Dam forebay, 2=Browns Island, 3=Celilo, 4=Miller Island, 5=Maryhill, 6=John Day Dam tailrace.

[b] 12/0, 14/0, and 16/0 hooks.

[c] 10/0 and 12/0 hooks.

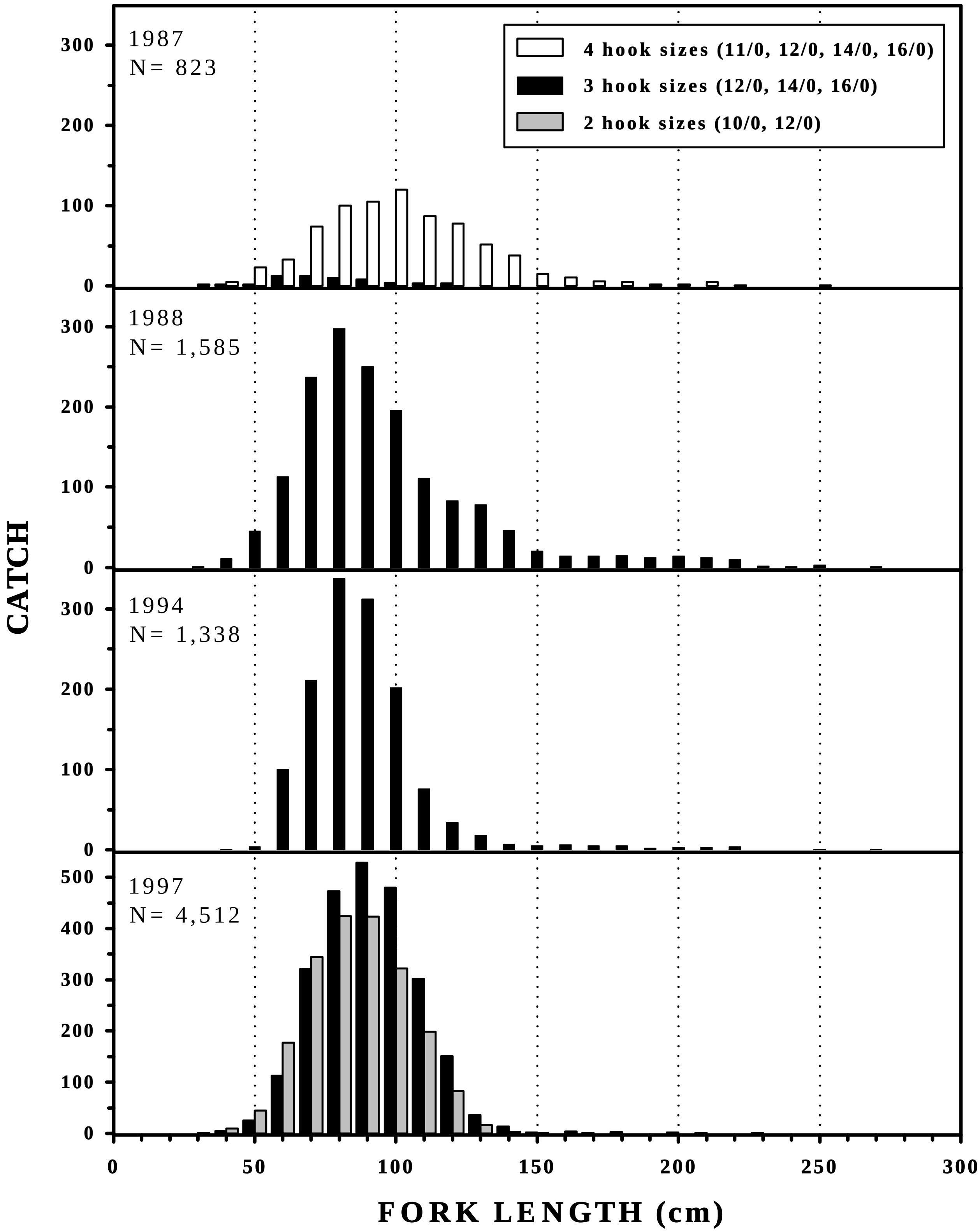

Figure 2. Frequency of catch of white sturgeon collected with setlines by Oregon Department of Fish and Wildlife in The Dalles Reservoir, May through August 1997 (1987, 1988, and 1994 data included for comparison).

Table 3. Mean catches of white sturgeon (all lengths) per set-day by month and sampling section in The Dalles Reservoir, May through August 1997. A "-" indicates sampling was not conducted.

Gear Month	Sampling section[a] 1	2	3	4	5	6	All sections
Standard setlines[b]							
May	1.2	2.4	0.4	1.6	3.2	5.0	2.0
June	0.9	3.5	3.3	13.4	5.6	7.1	6.4
July	3.7	6.2	4.7	13.4	8.0	9.1	7.4
August	6.0	4.3	9.2	11.8	7.1	5.6	7.5
All months	3.2	4.6	3.3	12.1	6.7	7.2	6.2
Experimental setlines[c]							
May	0.3	2.3	-	6.3	1.2	7.8	3.3
June	2.1	2.3	1.1	11.7	6.0	8.2	5.9
July	3.2	8.1	2.2	15.3	7.7	10.1	8.5
August	3.2	4.0	2.9	7.6	5.4	7.4	5.2
All months	2.3	4.9	1.8	10.6	5.6	9.0	6.2
Gill nets							
May	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-
July	-	-	-	16.0	-	1.0	8.5
August	0.0	0.0	-	5.0	-	0.0	1.0
All months	0.0	0.0	-	10.5	-	0.3	3.1

[a] Sampling sections: 1=The Dalles Dam forebay, 2=Browns Island, 3=Celilo, 4=Miller Island, 5=Maryhill, 6=John Day Dam tailrace.

[b] 12/0, 14/0, and 16/0 hooks.

[c] 10/0 and 12/0 hooks.

Table 4. Catches of white sturgeon by fork length (cm) interval with setlines in The Dalles Reservoir, May through August 1997 (1994 data are included for comparison). A "-" indicates sampling was not conducted.

Year / Fork interval	Sampling section[a] 1	2	3	4	5	6	7	Total
1994								
21-40	0	0	0	0	0	0	0	0
41-60	0	1	0	6	10	26	5	48
61-80	5	26	59	115	93	117	49	464
81-100	43	119	91	85	82	111	60	591
101-120	19	30	23	25	19	27	23	166
121-140	5	2	6	4	3	9	4	33
141-160	0	0	3	3	2	2	0	10
161-180	1	0	4	3	0	2	2	12
181-200	0	0	0	2	1	2	0	5
201-220	1	0	1	2	0	1	0	5
221-240	0	0	2	0	0	0	0	2
>241	1	0	1	0	0	0	0	2
Total	75	178	190	245	210	297	143	1,338
Percent	5.6	13.3	14.2	18.3	15.7	22.2	10.7	100
Setline sets	69	74	68	72	72	64	9	428
1997								
21-40	0	0	0	0	1	5	-	6
41-60	1	6	4	32	59	120	-	222
61-80	36	98	68	498	341	311	-	1,352
81-100	124	293	120	695	359	211	-	1,802
101-120	133	234	77	329	142	73	-	988
121-140	19	18	8	43	26	11	-	125
141-160	3	1	1	1	0	0	-	6
161-180	1	2	1	0	0	1	-	5
181-200	2	0	0	0	0	2	-	4
201-220	0	1	0	0	0	0	-	1
221-240	0	1	0	0	0	0	-	1
>241	0	0	0	0	0	0	-	0
Total	319	654	279	1,598	928	734	-	4,512
Percent	7.0	14.5	6.2	35.4	20.6	16.3	-	100
Setline sets	115	138	97	141	149	91	-	731

[a] Sampling sections: 1=The Dalles Dam forebay, 2=Browns Island, 3=Celilo, 4=Miller Island, 5=Maryhill, 6=John Day Dam tailrace, 7=John Day Dam tailrace boat restricted zone.

and approximately 95 fish have been recaptured in reservoirs downstream of original marking locations (Appendix A-2).

Marking and Mark Recovery

The ODFW tagged or marked 3,637 white sturgeon (70-166 cm) including 389 recaptured-fish marked prior to 1996. We recaptured 64 of these fish and 155 additional fish (70-166 cm) previously tagged or marked by CRITFC from December 1996 through early February 1997 (Table 6). We also recaptured 19 white sturgeon that were marked by CRITFC and 149 fish marked prior to 1996 that were not used in the abundance estimate due to their size (<70 cm or >166 cm). The abundance of white sturgeon (70-166 cm) was estimated to be 59,800 (95% confidence limits 52,400-68,200) using a Schnabel mark and recapture estimator based on combined CRITFC 1996-1997 and ODFW 1997 mark and recapture data (Table 7). An additional Petersen estimator based on recaptures of white sturgeon (70-166 cm) tagged by ODFW in 1994 and recaptured by ODFW this year indicates an adundance of 61,400 (95% confidence limits 53,400-67,700). Density of white sturgeon (≥54 cm) was estimated at 16.3 fish (66.2 kg) per hectare in The Dalles Reservoir (Table 7).

The within-year retention rate for PIT tags was 98% for fish tagged by CRITFC and recaptured by ODFW and 100% for fish tagged by ODFW and recaptured by ODFW. We released 3,822 fish with PIT tags and recaptured 69 (after 7-144 days at large), of which none had lost PIT tags. The CRITFC released 2,160 fish with PIT tags and we recaptured 143 (after 103-256 days at large) of these fish and 3 did not have detectable tags. The within-year retention for wire-core spaghetti tags was 100% for fish tagged and recaptured by ODFW and 95% for fish tagged by CRITFC and recaptured by ODFW. We released 2,805 fish with spaghetti tags and recaptured 47 (after 8-82 days at large), all with tags present. The CRITFC released 1,586 fish with wire-core spaghetti tags and we recaptured 93 (after 119-251 days at large), of which 5 had lost spaghetti tags.

Age and Growth

We assigned ages to 103 white sturgeon <110 cm (Table 8). Assigned ages ranged from 1-15 years. We collected fin-spine samples from 394 fish previously injected with OTC that will be used for age validation.

Paired samples of fork length and weight were sufficient to calculate a regression equation with high degrees of confidence ($W=1.404\ E\text{-}06 x FL^{3.3878}$; df=1, 601; F=22,561; r^2=0.974; P<0.001). The mean W_r of 105.8 for 500 fish (>69 cm) weighed this year was not significantly different from the mean W_r of 105.4 for 346 fish (>69 cm) weighed in 1994 (df=1, 844; P=0.744).

Mortality

The slope of the regression of fish aged 6-15 produced an estimate of instantaneous mortality less than zero (Z=-0.05). Similarly, efforts to track abundance of individual cohorts

Table 5. Numbers of white sturgeon (all lengths) tagged by agency and location in The Dalles Reservoir, December 1996 through August 1997, and location of recapture by Oregon Department of Fish and Wildlife (ODFW), May through August 1997. A "-" indicates sampling was not conducted.

Agency Tagging location	Number tagged	Recapture location[a]						
		1	2	3	4	5	6	7
ODFW								
1. The Dalles Dam forebay	289							-
2. Browns Island	584	2	1	1		2		-
3. Celilo	253				2			-
4. Miller Island	1,429		3	1	14	5	3	-
5. Maryhill	830	1			6	9	1	-
6. John Day Dam tailrace	615		1				28	-
7. John Day Dam tailrace BRZ[b]	-	-	-	-	-	-	-	-
Total	4,000	3	5	2	22	16	32	
CRITFC[c]								
1. The Dalles Dam forebay	44	1	1					-
2. Browns Island	1,542	17	41	4	22	5	2	-
3. Celilo	246	1	8	4	10	1		-
4. Miller Island	127		1		14	3	1	-
5. Maryhill	20				1	2	1	-
6. John Day Dam tailrace	303				2	2	19	-
7. John Day Dam tailrace BRZ	8						1	0
Total	2,290	19	51	8	49	13	24	0

[a] To clarify trends, this table is not zero-filled.
[b] Boat-restricted zone (BRZ).
[c] Columbia River Inter-Tribal Fish Commission.

Table 6. Mark and recapture data for white sturgeon 70-166 cm fork length captured with setlines and gill nets and estimated removals by recreational, commercial, and subsistance fisheries in The Dalles Reservoir, May through August 1997.

Period	Number caught	Number marked[a]	Number recaptured	Number removed[b] Unmarked	Number removed[b] Marked	Number of marks at large
12/2/96-5/4/97[c]	2,278	2,036	0	715	19	0
5/5/97-6/1/97[d]	243	232	11	2	1	2,017
6/2/97-6/22/97[d]	520	493	27			2,248
6/23/97-7/13/97[d]	1,115	1,063	51			2,741
7/14/97-8/3/97[d]	1,072	999	72			3,804
8/4/97-8/22/97[d]	909	850	58			4,803
Total	6,137	5,673	219	717	20	

[a] Includes recaptures of fish marked during previous years which are counted as new marks for population estimation. Within period recaptures not counted as new marks.

[b] Includes estimated harvest in recreational and commercial fisheries sampled by Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife and estimated tribal subsistance harvest (DeVore et al. this report).

[c] Capture and marking of white sturgeon was conducted by Columbia River Inter-Tribal Fish Commission (Parker this report). Fish marking occurred from 2 December 1996 through 1 February 1997.

[d] Capture and marking of white sturgeon was conducted by Oregon Department of Fish and Wildlife.

Table 7. Estimated abundance (Ñ) of white sturgeon 70-166 cm fork length based on mark and recapture data and length-frequency distribution in The Dalles Reservoir, December 1996 through August 1997. Data for other areas of the Columbia River upstream from Bonneville Dam are included for comparison. Confidence intervals (95%) surrounding the abundance estimates are in parentheses. A "-" indicates data are not available.

			Number of fish by fork length interval [a]						
Year	Ñ		54-81	82-109	110-166	≥167	Sum	No./ha	kg/ha
				Bonneville Reservoir					
1989[b]	35,400	(27,500-45,400)	32,900	16,700	1,200	600	51,400	6.1	30.0
1994[c]	35,200	(24,800-66,000)	31,300	18,300	1,500	900	52,000	6.2	-
				The Dalles Reservoir					
1987[b]	23,600	(15,700-33,600)	7,800	11,000	7,900	1,000	27,700	6.2	81.4
1988[b]	9,000	(7,300-11,000)	4,200	4,300	2,000	800	11,300	2.5	35.5
1994[c]	9,700	(7,500-14,000)	5,800	5,700	800	300	12,600	2.8	-
1997	59,800	(52,400-68,200)	26,500	38,500	8,300[d]	200	73,500	16.3	66.2
				John Day Reservoir					
1990[b]	3,900	(2,300-6,100)	3,600	1,700	500	500	6,300	0.3	3.6
1996[e]	27,100	(23,800-30,800)	5,800	19,700	4,400	700	30,600	1.5	12.3
				McNary Reservoir and the Hanford Reach					
1995[f]	5,200	(3,800-9,100)	1,100	2,100	2,500	800	6,500	0.4	6.6

[a] Abundance estimates for these fork length intervals are expanded from the mark and recapture abundance estimate (Ñ) based on the observed length frequency of white sturgeon ≥54 cm captured during each years sampling. Numbers are rounded to the nearest 100 for consistency. Fork length intervals approximate total lengths of 24-35, 36-47, 48-72, and >72 inches.

[b] Beamesderfer et al. 1995.

[c] North et al. 1996.

[d] Fork length interval 110-137 cm (48-60 inches total length)=8,100 fish.

[e] North et al. in press*a*.

[f] Rien et al. in press.

Table 8. Age-length frequency distribution of white sturgeon 30-109 cm fork length collected in The Dalles Reservoir, May through August 1997.

Age	Fork length interval (cm)[a]					Mean length	Standard deviation	N
	20-39	40-59	60-79	80-99	100-109			
1	9					35.7	3.3	9
2	1	4				42.2	3.3	5
3		1				51.0	--	1
4		5	2			55.4	5.0	7
5		3	1			59.5	7.3	4
6		3	8	1		63.6	7.7	12
7		2	6	1		66.4	10.7	9
8		1				59.0	--	1
9		3	3			67.2	10.9	6
10		2	2	2	3	82.7	18.2	9
11			1	7	6	96.4	9.9	14
12			1	3	3	96.4	10.7	7
13				5	5	96.9	9.1	10
14				3	4	99.4	9.3	7
15				1	1	93.5	14.8	2
N	10	24	24	23	22	74.3	23.2	103

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

in 1994 and 1997 resulted in a series of catch curves with positive slopes. Both results are unrealistic.

Genetic Analyses

We collected 108 whole blood samples for DNA analyses. Personnel of the ODFW Inter-Jurisdictional Fisheries Unit collected an additional 37 blood samples for DNA analyses from fish sampled in Yaquina Bay, Oregon during April 1997. None of these samples have been examined yet but add to our inventory of blood samples for future DNA analyses. The ODFW inventory includes over 100 raw blood samples from each of The Dalles, John Day, and McNary reservoirs and 37 samples from Yaquina Bay, Oregon.

Reproduction

We surgically examined 20 white sturgeon (>137 cm) and collected 18 gonad tissue samples including 16 paired tissue and blood plasma samples for laboratory analyses. Results of field, microscopic, and histologic examinations were inconsistent (Table 9). Field sex determinations infrequently (28%) matched results based on histologic examination of gametes. Results of sex determinations by microscopic and histologic examination matched for 72% of all gonad samples. Similar to 1996, some of the samples we collected from fish which were classified in the field as male or unknown sex consisted of fat and non-germinal tissue which commonly surrounds male gonads and cannot be used to determine sex. Some biopsy samples contained very little tissue which further complicated sex determination and classification of maturation stages. Female maturity stages determined by microscopic examination of 10 ovary samples were: 6 pre-vitellogenic, 2 early vitellogenic, 1 late vitellogenic, 0 pre-vitellogenic with attritic oocytes, and 1 ripe fish. Since 1987 we have examined ovary samples of 1,767 maturing female white sturgeon (>79 cm fork length) recovered during ODFW research sampling and from sampling of fisheries occurring between Bonneville and Priest Rapids dams (Table 10). Only 2% of these samples were from ripe fish expected to spawn in the year of capture and 10% were in early or late stages of vitellogenesis and were expected to spawn the year following capture. We have not identified any annual patterns among maturing and ripe female white sturgeon but we lack samples from fish collected from October through January (Figure 3). Diameters of ripe eggs collected since 1987 exhibit a positive correlation with fork length (df=1, 32; F=14.64; r^2=0.314; P<0.001) (Figure 4). Blood plasma samples collected for sex steroid analyses have not yet been analyzed.

DISCUSSION

Our 1997 estimate of white sturgeon abundance in The Dalles Reservoir represents a six-fold increase from our 1994 estimate. This is very similar to our findings for John Day Reservoir where we observed a seven-fold increase in estimated abundance from 1990 to 1996. In John Day Reservoir, we suspect restrictive harvest guidelines imposed on sport and commercial fisheries were responsible for some of the observed increase in abundance. In The Dalles Reservoir however, the tremendous difference between abundance estimates is more

Table 9. Gender classification of 18 white sturgeon >137 cm fork length by three examination methods. Fish were collected in The Dalles Reservoir, May through August 1997.

	Gender		
Examination method	Female	Male	Unknown
Field biopsy[a]	3	5	10
Microscopic[b]	11	-	7
Histologic[c]	10	4	4

[a] Visual examination of gonads via biopsy conducted by Oregon Department of Fish and Wildlife (ODFW) personnel.

[b] Microscopic examination of gonad samples collected during field biopsies. Examinations were conducted by experienced ODFW personnel. All non-females are classified as unknown.

[c] Histologic examinations of gonad samples collected during field biopsies. Examinations were conducted by personnel at Oregon State University, Department of Fisheries and Wildlife.

Table 10. Gonad developmental stage of female white sturgeon collected from the Columbia River between Bonneville and Priest Rapids dams by fork length interval, 1987-1997. Fish were obtained from Oregon Department of Fish and Wildlife research sampling and from sampling of commercial and recreational fisheries.

Reservoir: Fork length interval	Developmental stage[a]							Expected spawning year[b]		
	1	2	3	4	5	6	Total	Year of capture	Year after capture	>one year post-capture
Bonneville:										
80-99	3	1	2	0	2	170	178	2	4	172
100-119	37	8	7	0	13	444	509	7	45	457
120-139	2	1	3	0	1	77	84	3	3	78
140-159	1	0	1	0	0	11	13	1	1	11
160-179	1	1	0	0	0	3	5	0	2	3
180-199	2	1	1	0	0	3	7	1	3	3
200-219	3	6	2	0	1	3	15	2	9	4
>219	7	10	5	2	2	2	28	5	17	6
Total (%)	56	28	21	2	19	713	839	21 (3%)	84 (10%)	734 (87%)
The Dalles:										
80-99	0	0	0	0	0	14	14	0	0	14
100-119	4	1	0	0	0	240	245	0	5	240
120-139	5	3	0	0	3	199	210	0	8	202
140-159	12	5	4	0	2	95	118	4	17	97
160-179	7	5	1	0	1	17	31	1	12	18
180-199	4	2	1	0	1	3	11	1	6	4
200-219	5	0	2	0	0	1	8	2	5	1
>219	5	2	2	0	0	2	11	2	7	2
Total (%)	42	18	10	0	7	571	648	10 (2%)	60 (9%)	578 (89%)
John Day:										
80-99	0	0	0	0	0	9	9	0	0	9
100-119	0	0	0	0	0	82	82	0	0	82
120-139	2	1	0	0	0	43	46	0	3	43
140-159	1	0	2	0	1	22	26	2	1	23
160-179	2	1	1	0	0	3	7	1	3	3
180-199	2	1	0	0	0	1	4	0	3	1
200-219	4	2	0	0	1	2	9	0	6	3
>219	4	1	1	0	2	1	9	1	5	3
Total (%)	15	6	4	0	4	163	192	4 (2%)	21 (11%)	167 (87%)

Table 10. Extended.

Reservoir: Fork length interval	Developmental stage[a] 1	2	3	4	5	6	Total	Expected spawning year[b] Year of capture	Year after capture	>one year post-capture
McNary Reservoir and the Hanford Reach[c]:										
100-119	0	0	0	0	0	0	0	0	0	0
120-139	0	0	0	0	0	0	0	0	0	0
140-159	0	1	0	0	0	1	2	0	1	1
160-179	1	1	2	0	0	6	10	2	2	6
180-199	0	2	0	0	1	2	5	0	2	3
200-219	0	1	0	0	0	1	2	0	1	1
>219	6	0	0	0	0	5	11	0	6	5
Total (%)	7	5	2	0	1	15	30	2 (7%)	12 (40%)	16 (53%)
Unknown:										
80-99	0	2	0	0	0	0	2	0	2	0
100-119	1	0	1	0	0	31	33	1	1	31
120-139	1	0	2	0	0	11	14	2	1	11
140-159	0	1	1	0	0	4	6	1	1	4
160-179	1	0	0	0	0	1	2	0	1	1
180-199	0	0	0	0	0	0	0	0	0	0
200-219	0	0	0	0	0	0	0	0	0	0
>219	0	0	1	0	0	0	1	1	0	0
Total (%)	3	3	5	0	0	47	58	5 (9%)	6 (10%)	47 (81%)

[a] 1=Early vitellogenic, 2=Late vitellogenic, 3=Ripe, 4=Spent (post-spawn), 5=Pre-vitellogenic with attritic oocytes, and 6=Pre-vitellogenic.

[b] Fish in stage 3 were expected to spawn in the year they were captured; fish in stages 1 and 2 were expected to spawn the year after they were captured; and fish in stages 4, 5, and 6 were not expected to spawn until two or more years after capture.

[c] White sturgeon <110 cm fork length were not available for examination due to the legal-size slot limit for the recreational fishery in this area and period. Fish 110-137 cm fork length were unlikely to be sampled since commercial fisheries did not occur in this area and the recreational fishery was only sampled in 1994.

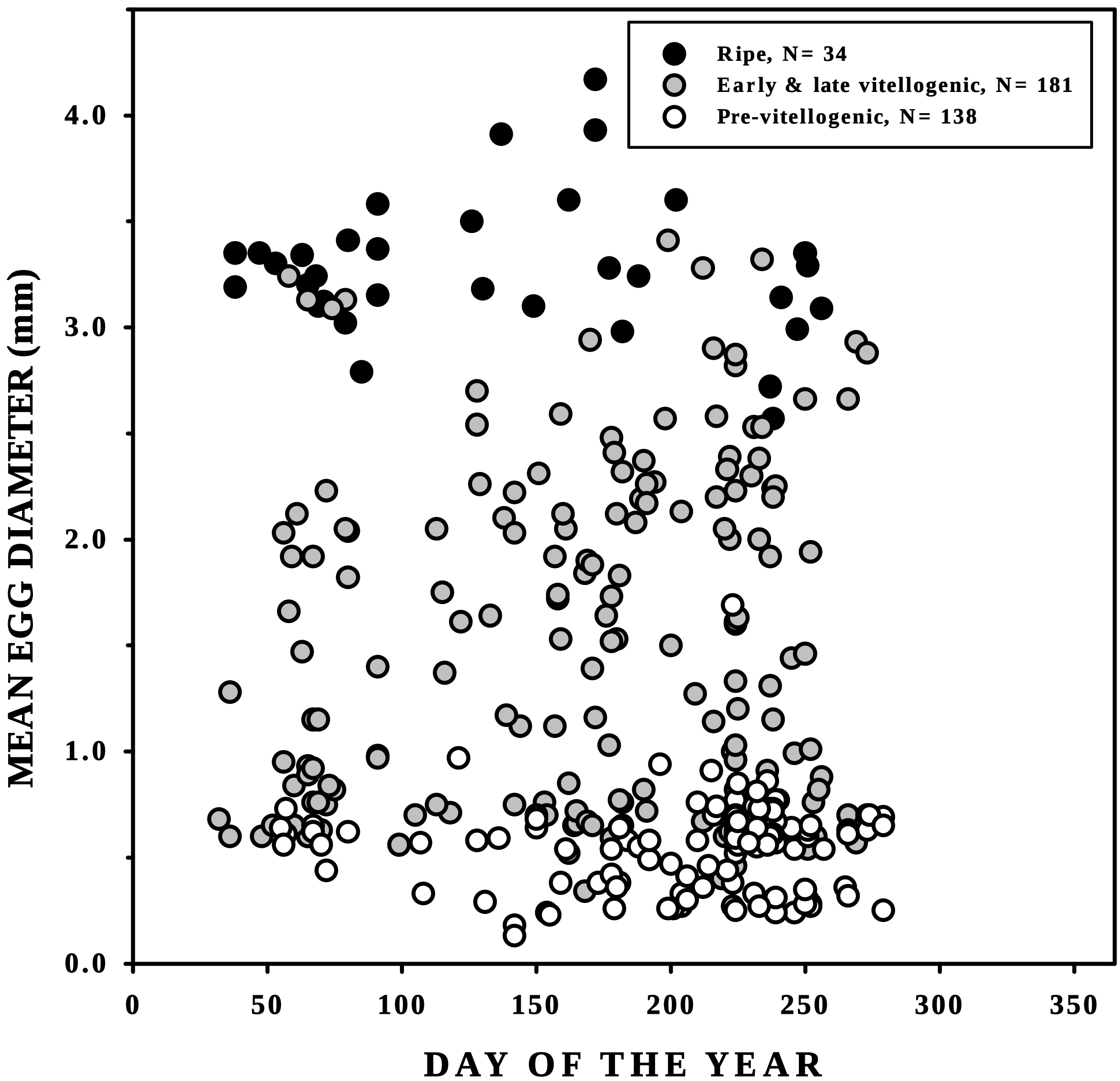

Figure 3. Mean egg diameters of pre-vitellogenic, early and late vitellogenic, and ripe female white sturgeon collected downstream of Priest Rapids Dam by day of the year, 1987-1997.

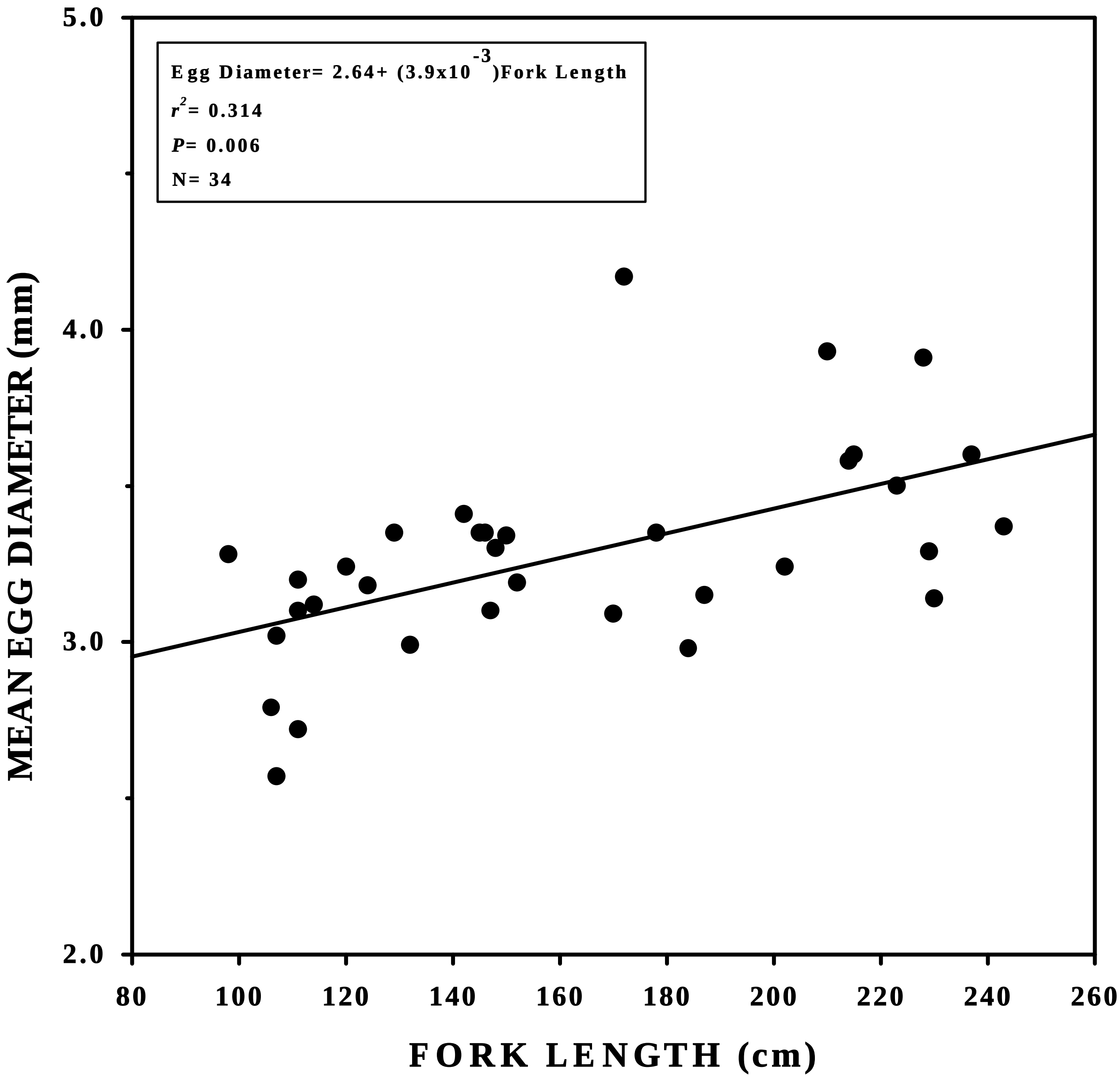

Figure 4. Mean egg diameters of ripe female white sturgeon collected downstream of Priest Rapids Dam by fork length, 1987-1997. Eggs were preserved in 10% buffered formalin. Preservation times of individual samples are unknown.

likely the result of potential under- and over-estimates of abundance in 1994 and 1997, and less the result of management actions because of the relatively short interval.

While corroboration among our 1997 population estimates support this seemingly high increase in the estimated abundance of white sturgeon in The Dalles Reservoir, ancillary indicators of abundance do not. Computer simulations, recreational fishery catch rates, and research setline catch-per-unit-effort indicate an increasing abundance of white sturgeon in The Dalles Reservoir but not of the magnitude shown by this years mark and recapture sampling (WDFW and ODFW 1997; DeVore et al. this report). These indicators may reduce confidence in the current population estimate but this product is based on extensive sampling that far exceeds any of our previous work. Utilization of experimental gillnets described by Parker (in press) and pickled squid for setline bait have improved catch rates, which, combined with increased effort, has resulted in a five-fold increase in the number of fish being tagged since 1996. This should have increased the precision of current estimates and the use of two gear types should have further reduced any unforeseen bias. It is possible that we have historically under-estimated white sturgeon abundance in the reservoirs above Bonneville Dam negating the above mentioned indices.

We plan to use PIT tag recoveries in 1998 recreational and commercial fisheries to estimate exploitation rates and further corroborate our 1997 population estimate. In the interim, we recommend conservative increases in harvest rates until the extent of population growth in The Dalles Reservoir can be verified. Interestingly, the high abundance estimates completed recently in John Day and The Dalles reservoirs have both incorporated a multi-agency sampling approach and pickled squid for bait as opposed to previous estimates conducted by ODFW alone with Pacific lamprey for bait. We have not identified any sources of bias in recent or earlier sampling to explain the magnitude of difference between estimates but it will be interesting to see if future sampling will also result in an increased abundance estimate in Bonneville Reservoir.

We are concerned with the apparent continual decline in estimated abundance of large white sturgeon (≥167 cm) in The Dalles Reservoir. The current estimate of 200 fish is the lowest of any of the four estimates conducted in The Dalles Reservoir since 1987. Admittedly, the variance associated with abundance of this size group is large and was likely compounded this year because: 1) we could not sample in The Dalles Dam BRZ where these fish are typically more common than in the remainder of the reservoir, and 2) we used pickled squid exclusively which caught fish of significantly smaller size than lamprey when we compared these baits in 1996. Lacking any 1997 recapture data for these large fish, it is difficult to determine relative abundance based on setline catch rates in The Dalles Reservoir since we have modified our setlines over time. The observed catch rate (0.020) for this size group was lower than in 1994 (0.052) indicating abundance of this size group is decreasing. We hypothesized this difference may be the result of different baits but the predicted catch rate (0.023) for this size group adjusted for bait type also shows a declining trend.

The observed positive correlation between ripe egg diameter and fork length indicates larger female white sturgeon tend to produce larger eggs which has been associated with larger larvae and subsequent increased survival in paddlefish *Polyodon spathula* (Reed et al. 1992), rainbow trout *Oncorhynchus mykiss* (Pitman 1979), and S*almo* sp. (Bardach et al. 1972). Although we have observed ripe eggs in female white sturgeon of approximately 100 cm fork length, the larger female fish (>167) have greater importance because of superior fecundity and this potential for increased larvae survival. Preservation times and the subsequent shrinkage of individual egg samples has been inconsistent between and among years but this should not effect the observed trend of larger females producing larger eggs.

We elected to use pickled squid exclusively this year based on results of our comparison of bait types last year (North et al. in press*a*). Our overall catch rate with setline gear this year (6.2 fish/setline) was twice the 1994 catch rate (3.1 fish/setline) for setlines baited with lamprey but did not exceed the catch rate for setlines baited with squid (8.7 fish/setline) fished in John Day Reservoir during 1996. Considering the estimated densities of white sturgeon in these reservoirs, we expected the catch rate in The Dalles Reservoir to exceed the rate observed in John Day Reservoir (Table 7). High water velocities throughout much of the 1997 sampling season may have reduced setline efficiency. Pickled squid appears to be the best bait available although it may be less effective than lamprey for catching large fish (personnel communication with Jim Chandler, Idaho Power Company, Boise, Idaho; North et al in press*a*). We intend to use this bait during future sampling provided it remains commercially available.

The observed difference in the size range of white sturgeon captured with the two setline types used this year was less than we expected. Catch rates for the two setline types were identical and length frequencies were very similar. “Experimental” setlines did catch a slightly higher percentage of white sturgeon ≤80 cm than “standard” lines but this gear also didn’t catch any fish >164 cm. We did not document catch by hook size but field staff believe 12/0 hooks were responsible for the majority of the catch on the “experimental” setlines. A sampling regime that incorporates 10/0, 12/0, 14/0, and 16/0 hooks may be advantageous because it should increase the size range of the catch.

This is the fourth year we have observed PIT tag retention rates exceeding 95%. The ease of application and a proven high retention rate makes this the ideal tag for identifying individual fish. Management agencies are currently using PIT tag detectors while sampling commercial and recreational sturgeon fisheries to identify tagged fish with a high degree of certainty. Retention of wire-core spaghetti tags also exceeded 95% for the second year, which surpasses the retention rate observed for other external tags we have used. We will continue to use this tag whenever future studies require visual identification of tagged fish by fishers.

The multi-agency mark and recapture sampling conducted this year was effective. The amount of inter-agency coordination required was minimal, but substantially more time was required to verify the increased volume of data and solve the corresponding increase in errors resulting from such intensive sampling. Future sampling programs may benefit from a multi-agency approach because it establishes a broad knowledge base for development of sampling design and promotes “ownership” of results.

We were unable to validate the current estimate of instantaneous mortality (0.213) presented in Beamesderfer et al. (1995) for unexploited white sturgeon (<110 cm) based on either gill net catch data or cohort analyses. The difficulty of developing accurate mortality rates for impounded white sturgeon can be attributed to uncertainty associated with aging these fish and extreme variations in annual recruitment. Instantaneous mortality rates for young age classes of this long-lived species may be so low that these methodologies lack the precision required to detect differences between ages and cohorts. We may assign ages to the OTC fin-spine sections we collected this year to supplement age-frequency data from non-OTC fin-spine sections. Unfortunately, even with these additional samples, we may still lack a sufficient number of fin-spines from all age classes to develop a more reasonable estimate of mortality.

PLANS FOR NEXT YEAR

From April 1998 through March 1999 we will conduct reconnaissance sampling with staff of Washington Department of Fish and Wildlife in Chief Joseph and Grand Coulee reservoirs to describe the status of white sturgeon populations. Since the combined area of these two reservoirs is so large, we will only conduct one sampling pass through each reservoir, which will negate any attempt to estimate abundance from recaptures of marked fish. We will collect length, age, and catch-rate data that will allow us to describe the relative condition and distribution of white sturgeon in these reservoirs. We plan to begin transplant supplementation of juvenile and subadult white sturgeon from below Bonneville Dam to either or both of The Dalles and John Day reservoirs beginning in October. We will also assist with young-of-the-year sampling in The Dalles and John Day reservoirs, and a Snake River reservoir during November and December.

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Appendix A-1. Number and disposition of all fishes caught with setlines and gill nets in The Dalles Reservoir, May through August 1997.

Species	Standard setline[a]		Experimental setline[b]		Gill net	
	Live	Dead	Live	Dead	Live	Dead
White sturgeon (*Acipenser transmontanus*)	2,459		2,053		22	
Common carp (*Cyprinus carpio*)	1					
Northern pikeminnow (*Ptychocheilus oregonensis*)	18		20			
Largescale sucker (*Catostomus macrocheilus*)			3		2	
Channel catfish (*Ictalurus punctatus*)	1		2			
Steelhead (*Oncorhynchus mykiss*)						1[c]
Yellow perch (*Perca flavescens*)					3	

[a] 12/0, 14/0, and 16/0 hooks.

[b] 10/0 and 12/0 hooks.

[c] Caught 7 July at river kilometer 330.

Appendix A-2. Numbers of white sturgeon tagged and recaptured by Columbia River reach and year, 1987-1997. Recoveries are from Oregon Department of Fish and Wildlife research sampling, commercial fisheries, angler creel, and volunteer angler returns.

Tag reservoir:		McNary		John Day				The Dalles								Bonneville				
Year tagged:		93	95	89	90	91	96	87	88	89	91	93	94	95	97	88	89	91	93	94
Number tagged:		156	787	21	516	85	4,111	830	1,281	147	379	7	3,649[a]	5,611[b]	7,732	417	2,514	1,141	8	1,010
Recap location	Year																			
McNary Reservoir	93	6																		
	94	4																		
	95	7	13																	
	96	2	10																	
	97	3	7																	
John Day Reservoir	87							1												
	90			3	35															
	91				29															
	92				7	1					1									
	93	2		1	2															
	94	1			4	1														
	95				2	1														
	96		2	2	38	12	238			1										
	97		1			1	126													
The Dalles Reservoir	87							69												
	88							86	115											
	89							16	58	3										
	90							6	15	1										
	91			1	1			13	24	4	7									
	92							3	7	1	5									
	93				1			1	7	1	9									
	94				3			3	6	6	15		30							
	95												3							
	96										1		1					1		
	97	2			7		9	1	17	20	31		385	448	268					

Bonneville	88					2			
Reservoir	89			4		44	91		
	90		2	1		5	46		
	91	1	1	14		11	89	33	
	92			1			19	23	
	93		1	2		2	12	13	4
	94			1		4	37	36	17
	95				1	1	7	4	11
	96						9	5	12
	97					1	7	4	4
Below	87		1			3			
Bonneville Dam	89					1	4		
	90						1		
	91						7	2	
	92						3	1	
	93				1		1	5	
	94			1				1	
	95							2	
	96						1	1	
	97								

[a] Includes 2,838 white sturgeon transplanted from below Bonneville Dam (North et al. in press*b*).
[b] Includes 5,611 white sturgeon transplanted from below Bonneville Dam (North et al. in press*b*).

APPENDIX A-3

Incidence of white sturgeon deformities in two reaches of the Columbia River

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ABSTRACT

We sampled two functionally isolated populations of white sturgeon, *Acipenser transmontanus*, to measure the occurrence of physical deformities. In the Columbia River estuary we found the frequency of all deformities among white sturgeon to be 8.1% while in The Dalles Reservoir the frequency was 11.7%. The most common deformity observed in white sturgeon from the estuary was an additional row of lateral scutes on both sides of the fish. In The Dalles Reservoir the most prevalent malformation was misshapened fins, which typically presented itself as bilateral curled pectoral fins, followed by abnormal barbels manifested as shortened or forked barbels. The frequency of misshapened fins was significantly greater among white sturgeon in The Dalles Reservoir than in the estuary. Although no causal relationship has been determined, there is evidence that Columbia River sediment is contaminated with organic pollutants that are known to be harmful to aquatic organisms. Further study is needed to evaluate whether the observed deformities have an environmental or genetic basis.

INTRODUCTION

Morphological anomalies are uncommon in natural fish populations (Dahlberg 1970) yet deformed wild sturgeon have been reported. Schwartz (1992) described a Russian beluga sturgeon, *Huso huso*, possessing spinal and body deformities. Dadswell et al. (1984) summarized abnormalities observed in shortnose sturgeon, *Acipenser brevirostrum*, during 6 years of sampling in the St. John estuary, Canada. Deformities included nasal septum absence, spinal curvature, blindness, and extra or missing fins. We surveyed sturgeon biologists and found that deformities, especially those affecting the fins, have been observed in Atlantic sturgeon, *A. oxyrhynchus*, captured from the Hudson River, New York (Jerre Mohler, U.S. Fish and Wildlife Service, personal communication), lake sturgeon, *A. fulvescens*, from the Moose River, Ontario (David Noakes, University of Guelph, personal communication), and white sturgeon, *A. transmontanus*, from several British Columbia waters including the upper Columbia River (Larry Hildebrand, RL&L Environmental Services Ltd., personal communication) and the Nechako and Fraser river drainages (Scott McKenzie, RL&L Environmental Services Ltd., personal communication).

Previous studies implicate water-borne contaminants as one agent contributing to abnormalities in wild fish populations (Mehrle et al. 1982, Malins et al. 1984, Lindesjöö and Thulin 1992). Several water-borne contaminants in natural systems are found to occur in river sediments (CBFWA 1996). In the lower Columbia River Basin, there is strong evidence that fish and wildlife are being exposed, via water, sediments, and prey, to a range of pollutants, including heavy metals, organochlorine pesticides, dioxins and furans, and other organic compounds known to cause adverse physiological effects (Tetra Tech 1996). Because white sturgeon are primarily bottom-dwelling organisms that commonly feed on benthos, they are regularly exposed to sediment-borne contaminants. Therefore, a causal link between contaminant concentrations and white sturgeon deformity in the Columbia River may exist. Other factors contributing to the frequency of deformity among fishes include nutritional deficiencies (Halver et al. 1969, Lovell and Lim 1978), environmental variables such as water temperature, salinity, and dissolved oxygen concentration (Seymour 1959, Alderdice and Velsen 1971, Rosenthal and Alderdice 1976), disease (Sindermann 1979), injury (Dahlberg 1970) and genetic disposition (Gordon 1954).

White sturgeon roamed freely throughout the Columbia River Basin prior to the introduction of hydropower development in 1933 with the construction of Rock Island Dam. During the next 35 years, ten additional dams were constructed on the mainstem Columbia River within Oregon and Washington. Although there is evidence that impounded white sturgeon migrate past Columbia River dams via fish ladders and locks (Warren and Beckman 1993), most exhibit restricted movement and likely remain within a single reservoir their entire life (ODFW and WDFW 1998). The result is a series of functionally isolated white sturgeon populations throughout the Columbia River basin (North et al. 1993). Each discrete population is subjected to dam operations that regulate seasonal discharge patterns and reservoir retention times thus affecting water quality including water temperature, depth, and nutrient and contaminant loading. Additionally, point source contaminants vary among reaches and potentially impact reservoir white sturgeon populations disproportionately.

We compared the frequency of deformity between an impounded population of white sturgeon and an unimpounded, diadromous population. Previous field observations led us to suspect a high incidence of deformity among Columbia River white sturgeon. In 1997, we began monitoring white sturgeon by examining individuals for growth deformities. Relative health of Columbia River white sturgeon from an impounded reach and from the estuary was documented by recording the presence or absence of deformities.

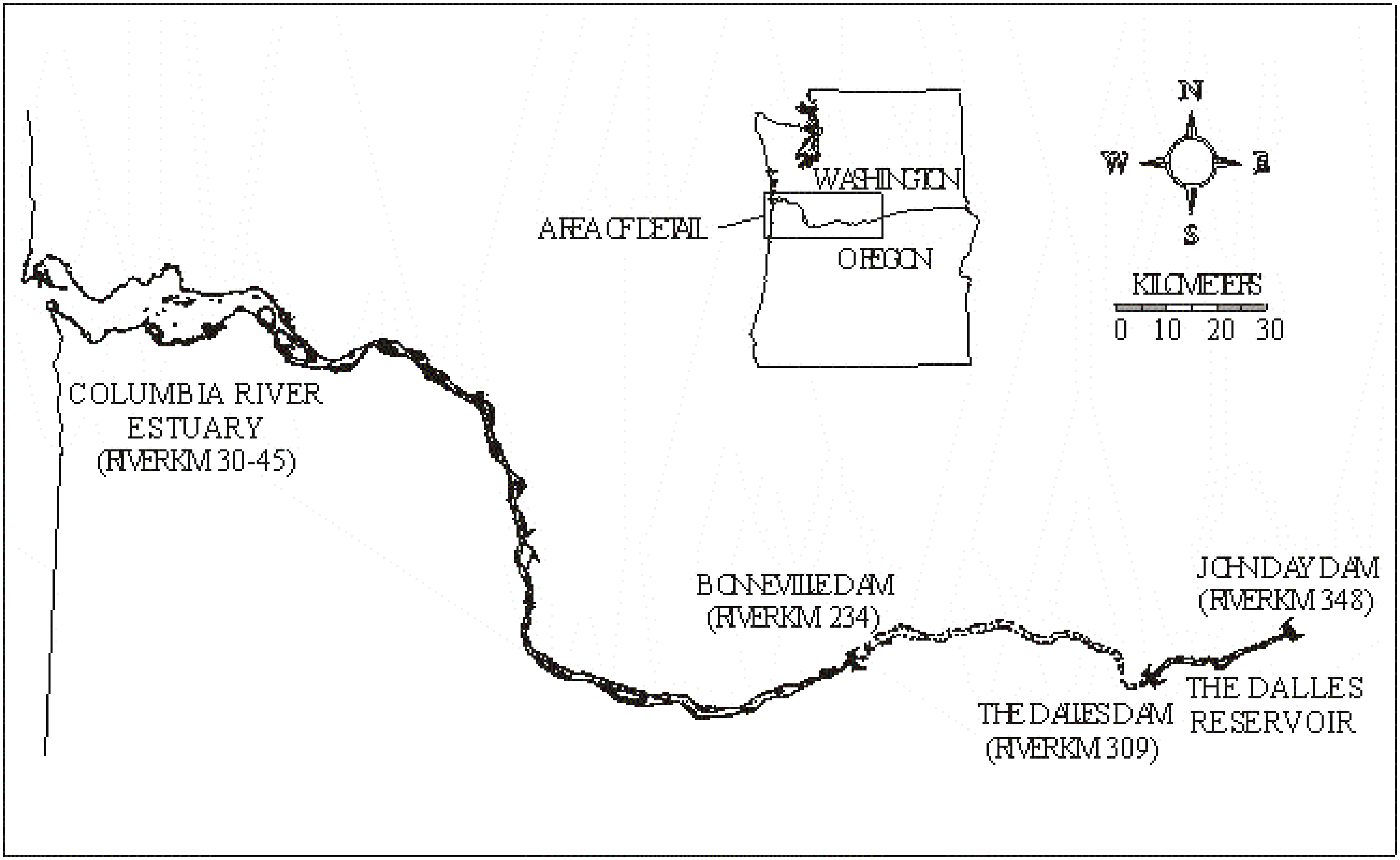
METHODS

The study area included two regions of the mainstem Columbia River: The Dalles Reservoir (river km 309-347) and the upper estuary (river km 30-45; Fig. 1). The Dalles Reservoir (Lake Celilo) is a 4,500 ha impoundment formed in 1957 by the construction of The Dalles Dam. The second area included a 15-km section of the estuary in the lower Columbia River, a free-flowing stretch providing direct access to the ocean. These study areas are separated by two dams and approximately 264 river km.

White sturgeon were examined for morphological deformities in conjunction with ongoing white sturgeon tagging studies occurring in the study areas (North et al. in press, Watts and Whisler 1998). These large-scale efforts provided sample sizes that enabled us to measure the prevalence of deformity among white sturgeon. In The Dalles Reservoir white sturgeon were captured using setline gear. Setlines were 183-m long with 40 circle halibut hooks attached every 4.6 m. Hook sizes were 10/0, 12/0, 14/0, and 16/0 and were baited with pickled squid, *Loligo* spp. Lines were fished for an average 23 hours per set. Multifilament nylon nets (19.7-cm stretched mesh) were used to capture white sturgeon in the Columbia River estuary. Nets measured 274-366 m in length by 10 m in depth. Nets were fished for approximately 1 hour.

A numerical coding system was developed to aid samplers in recording deformities previously observed in white sturgeon. Each white sturgeon was assigned a code after visual examination of all sides of the fish. No attempt was made to quantify the degree of individual deformities, we merely documented presence or absence.

Each region within the study area was sampled by two separate field crews using two different gear types. Deformity criteria applied among crew members and between crews may exhibit inherent differences. Therefore, care should be exercised when using this information since the current rating system is subjective. In addition, our analyses assumed both gear types had equal likelihood of capturing deformed fish.



Appendix Figure A-4.1. White sturgeon deformity sites (all capital letters) on the Columbia River, 1997. The scale is approximate.

The frequency of fish with misshapened fins was compared between the estuary and The Dalles Reservoir using a chi-square test of independence (SAS 1990), as was the frequency of all other deformities combined. Differences in deformity frequencies were considered statistically significant when $P \leq 0.05$.

Fisher's exact test (FET) of independence was used to compare the rate of deformity among 10-cm fork length (FL) intervals in white sturgeon by region. Correlation analyses were performed on fish length and rate of deformity. Coefficients of determination (r^2) were obtained using least-squares linear regression analysis.

RESULTS

We examined 1,459 white sturgeon during July and August 1997 in The Dalles Reservoir of which 171 (11.7%) had at least one growth deformity (Table 1). The most prevalent malformation was misshapened fins, which typically presented itself as bilateral curled pectoral fins, followed by abnormal barbels manifested as shortened or forked barbels. Multiple deformities were apparent in a few individuals (N=16). The most common combination, observed in six individuals, was misshapened fins coupled with abnormal barbels.

Of 383 fish examined in the Columbia River estuary during three days of sampling in August 1997, 31 (8.1%) exhibited a physical deformity. The most common deformity observed was an additional row of lateral scutes on both sides of the fish. Thirteen fish (3.4%) had these extra rows of scutes in addition to the one dorsal, two lateral and two ventral rows seen normally. Misshapened fins and atypical coloration were the next most frequently observed abnormalities.

The frequency of misshapened fins was significantly greater among white sturgeon in The Dalles Reservoir than in the estuary (X^2=16.442; df=1; $P \leq 0.001$). Analysis of all deformities other than misshapened fins revealed no significant difference in frequency between the two reaches (X^2=2.205; df=1; P=0.138).

Rate of deformity varied significantly among FL intervals in white sturgeon from The Dalles Reservoir (FET: df=12; P<0.001), however, correlation analyses found no relationship between FL and incidence of deformity (Fig. 2). In the estuary, the rate of deformity was significantly different among FL intervals (FET: df=8; P=0.006) but, again, correlation analyses found no evidence of an association between FL and incidence of deformity.

DISCUSSION

The occurrence of abnormalities observed in white sturgeon from the Columbia River far exceeds rates reported for other fish populations. In the Columbia River estuary we found the frequency of all deformities among white sturgeon to be 8.1% whereas in The Dalles Reservoir the frequency was 11.7%. A literature review by Berra and Au (1981) cited six studies where the frequency of deformities among natural populations of fishes ranged from 0.03% to 0.24% with a weighted average of 0.18%. Their own study revealed 47 deformed individuals (0.26%) out of 18,361 fishes collected from Cedar Fork Creek, Ohio.

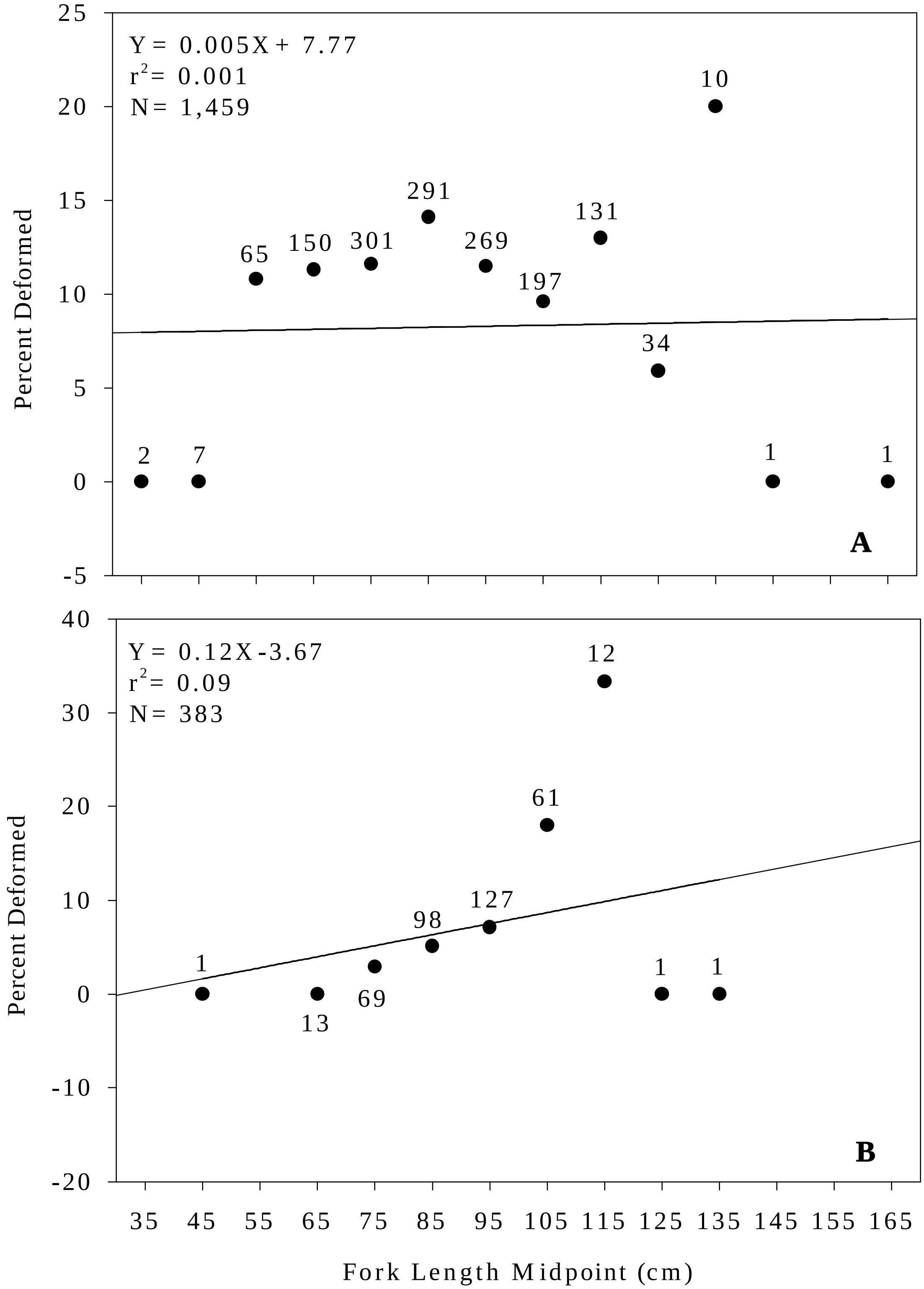
Previous Columbia River white sturgeon studies have reported physical deformities. Bajkov (1955) noted white sturgeon with seven rows of scutes while tagging in the Columbia River near Prescott, Oregon (river km 114). Approximately 0.3% of nearly 7,000 fish possessed this anomaly. A study conducted by the U.S. Fish and Wildlife Service (Macy et al. 1997) recorded the incidence of abnormalities in white sturgeon from John Day Reservoir (Lake

Appendix Table A-4.1. Incidence of white sturgeon deformities in The Dalles Reservoir and the Columbia River estuary, 1997.

Deformity	The Dalles Reservoir Number Observed	The Dalles Reservoir Percent of Total	Columbia River Estuary Number Observed	Columbia River Estuary Percent of Total
No anomaly	1,288	88.3	352	91.9
Atypical skin coloration	4	0.3	5	1.3
Misshapened fin(s)	103	7.0	6	1.6
Total or partial fin absence	4	0.3	3	0.8
Eroded nare(s)	9	0.6	1	0.3
Abnormal barbel(s)	19	1.3	0	0.0
Asymmetrical snout	3	0.2	0	0.0
Eye(s) malformed or missing	3	0.2	2	0.5
Skeletal deformity	4	0.3	0	0.0
Other	6 [a]	0.4	14 [b]	3.6
Fish with multiple anomalies	16	1.1	0	0.0
Total	1,459	100.0	383	100.0

[a] Two fish with incomplete opercles; one fish with a fused pelvic fin; and three fish with tumorous growths.

[b] Thirteen fish with extra rows of scutes and one fish with an incomplete opercle.



Appendix Figure A-4.2. Percent deformed white sturgeon by fork length midpoint in A) The Dalles Reservoir and B) Columbia River estuary, 1997. Sample size for each fork length interval is indicated.

Umatilla), located immediately upriver from The Dalles Reservoir. Of 2,965 white sturgeon handled in John Day Reservoir, abnormalities were noted in 5.8% of the fish. Similar to the results from The Dalles Reservoir, misshapened fins comprised the majority of the deformities in this impoundment. Anders and Beckman (1993) compared the rate of deformity among juvenile white sturgeon populations in the two aforementioned reservoirs and Bonneville Reservoir (Lake Bonneville). They found a greater percentage of juvenile white sturgeon in The Dalles Reservoir (4-18%) were physically deformed compared to fish captured in Bonneville (0-0.5%) and John Day (0%) reservoirs. Again, fin deformities were the most prevalent physical anomaly.

We compared our results to similar data summarized by Macy et al. (1977) from the John Day Reservoir. A chi-square contingency table was used to test for independence of deformity frequency among reaches. Comparisons of deformity frequency among the estuary, The Dalles Reservoir, and John Day Reservoir showed significant differences among reaches (X^2=48.481; df=2; $P \leq 0.001$). The relatively high rate of misshapened fins in The Dalles and John Day reservoirs probably drives these differences. This is consistent with findings of previous white sturgeon deformity studies as discussed above.

Results of Fisher's exact test imply that white sturgeon from different FL intervals had different frequencies of deformity in The Dalles Reservoir, however, no trend is evident in the regression of percent deformed by fork length midpoint (Fig. 2). Outliers with moderate sample sizes at 125 cm and 135 cm appear to drive the results for the test of independence. Similarly, frequency of deformity varied significantly among FL intervals in white sturgeon from the estuary. Although poor agreement was attained describing the association between these variables, our observations found that larger fish exhibited greater rates of deformity. This may be attributed to older individuals having experienced more injurious events or long-term exposure to environmental insults having cumulative effects.

Although no cause-and-effect relationship has been determined, there is evidence that gross morphological defects in aquatic organisms can result from contaminant exposure (Warwick et al. 1987, Hamilton and Reash 1988, Fournie et al. 1996). Analyses of river sediment from the lower Columbia River suggest that aquatic organisms and wildlife are being negatively affected by exposure to pesticide and polychlorinated biphenyl (PCB) contamination throughout the Columbia River basin (Tetra Tech 1996). Of special concern are PCBs because they are known mutagenics and teratogenics (Bosley and Gately 1981, Sanderson et al. 1994). Because PCBs are lipophilic, sturgeon are particularly susceptible to contamination due to their high body fat content (Mecozzi 1988). Additionally, the longevity of this species allows for greater accumulation of toxic substances due to repeated or chronic exposure. This information lends credence to the suspicion that PCBs are one agent contributing to the frequency of deformities in white sturgeon. However, no concurrent sediment or fish tissue sampling was performed thus, we can only speculate on what may be contributing to the high rate of deformity among Columbia River white sturgeon. Further study is needed to evaluate whether the observed deformities have an environmental or genetic basis. Nevertheless, these data provide baseline information to document the incidence of deformity in Columbia River white sturgeon and help investigators monitor long-term trends which may require closer study.

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APPENDIX A-4

Response of white sturgeon plasma cortisol to capture and handling

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This manuscript is intended for submission to *Transactions of the American Fisheries Society*

APPENDIX A-5

Evaluation of transplantation as a method to supplement white sturgeon populations

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This manuscript is intended for submission to *North American Journal of Fisheries Management*

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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

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 1997 recreational and commercial fisheries for white sturgeon between Bonneville and McNary dams, and a stock assessment of white sturgeon in the three lowermost reservoirs of the Snake River

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ABSTRACT

The Washington Department of Fish and Wildlife (WDFW) conducted a census of the 1997 recreational fisheries on the Columbia River from Bonneville Dam upstream to McNary Dam to estimate white sturgeon *Acipenser transmontanus* harvest. Harvest and biological data were collected as part of a white sturgeon stock assessment conducted by the Oregon Department of Fish and Wildlife (ODFW). Harvest monitoring was also used to evaluate the success of managing fisheries to protect and enhance white sturgeon populations between Bonneville and McNary dams (Zone 6 management unit of the Columbia River).

Zone 6 recreational fisheries are managed by WDFW and ODFW within the purview of the Sturgeon Management Task Force (SMTF). The SMTF recommended a modification of the recreational fishery harvest guidelines in effect since 1991. The SMTF also recommended a reduction in the allowable maximum size limit from 66 inches total length to 60 inches for all Zone 6 sturgeon fisheries. Decreasing the maximum size limit benefits consumptive fisheries by allowing a greater number of fish to be harvested for the same level of future broodstock recruitment. New stock assessment data and other population indices also indicated an increased abundance in each of the Zone 6 reservoirs (North et al. Report A, this report). Therefore, in 1997 the recreational harvest guidelines were increased to 1,520 from 1,350 in Bonneville Reservoir, 200 from 100 fish in The Dalles Reservoir, and 560 from 100 fish in John Day Reservoir. The management intent for 1997 recreational fisheries was to allow sturgeon retention in each reservoir until the harvest guideline was reached and then only allowing catch and release fisheries. The SMTF also increased the treaty Indian commercial fishery harvest guidelines in each reservoir. The treaty Indian commercial harvest guidelines by reservoir were changed as follows: 1,300 from 1,250 in Bonneville Reservoir, 400 from 300 in The Dalles Reservoir, and 1,160 from 100 in John Day Reservoir.

The WDFW and ODFW closed the recreational fishery to the retention of white sturgeon in Bonneville Reservoir on April 5, The Dalles Reservoir on May 5, and John Day Reservoir on September 2 when harvest was projected to reach respective guidelines. We estimated 1,460, 180, and 460 white sturgeon were harvested in 1997 recreational fisheries in Bonneville, The Dalles, and John Day reservoirs, respectively.

The Treaty Indian commercial fishers landed 1,850 white sturgeon from Bonneville Reservoir during gillnet and setline fisheries, 500 from The Dalles Reservoir, and 1,260 from John Day Reservoir. The Columbia River Inter-Tribal Fish Commission (CRITFC) and the Yakama Indian Nation estimated an additional 230 fish were harvested during 1997 subsistence fisheries (130, 40, and 60 white sturgeon in Bonneville, The Dalles and John Day reservoirs, respectively) .

White sturgeon stock assessment was done in the lowermost three reservoirs of the Snake River using setlines. The focus of 1997 work was in Lower Monumental and Little Goose reservoirs. We estimated the abundance of 110-209 cm fork length (FL) white sturgeon in Lower Monumental Reservoir to be 2,230 and that of the Little Goose white sturgeon population to be 4,180. The lack of younger fish in Ice Harbor (DeVore et al. In press) and in Lower Monumental

reservoirs led investigators to characterize the population as recruitment-limited. Future research may shed light on what factors are limiting recruitment in these areas.

INTRODUCTION

This annual report describes work completed by the Washington Department of Fish and Wildlife (WDFW) as part of the Bonneville Power Administration (BPA) white sturgeon *Acipenser transmontanus* research project 86-50. The WDFW is responsible for portions of tasks related to Objective 1: to experimentally implement and evaluate the success of selected measures to protect and enhance white sturgeon populations and mitigate for effects of the hydropower system on the productivity of white sturgeon in the Columbia River downstream from McNary Dam. These tasks include surveying the recreational fishery between Bonneville and McNary dams to estimate annual white sturgeon harvest and to evaluate management plans intended to regulate sturgeon fisheries at optimum sustainable exploitation rates.

The WDFW also shares responsibility for tasks relating to Objective 3: to evaluate the need and identify potential measures for protecting and enhancing populations and mitigating for effects of the hydropower system on productivity of white sturgeon in the Columbia and Snake rivers upstream from McNary Dam. We intend to describe population characteristics and to estimate productivity of white sturgeon populations in the lower three reservoirs on the Snake River. Our sampling closely follows the methods developed and used since 1987 by the Oregon Department of Fish and Wildlife (ODFW) on the Columbia River reservoirs (Rien et al. 1993). In this report we will describe our 1997 stock assessment effort in Lower Monumental and Little Goose reservoirs of the lower Snake River and present our results and conclusions regarding the productivity of these populations.

Specific activities reported include: 1) surveying the recreational 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 Lower Monumental and Little Goose reservoirs in the lower Snake River.

METHODS

Recreational Fishery Census

The 1997 recreational 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 three full-time creel samplers hired by ODFW, five full-time samplers hired by WDFW, one staff person from the ODFW Columbia River Management office, and two staff people from the WDFW Columbia River Anadromous Fish Division office.

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 squawfish *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 recreational fishing boats within each index area. Average numbers of anglers per boat were determined from angler interviews. Angling pressure within index areas was counted once a day between 1000 and 1300 hours. 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 squawfish sport reward program 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.

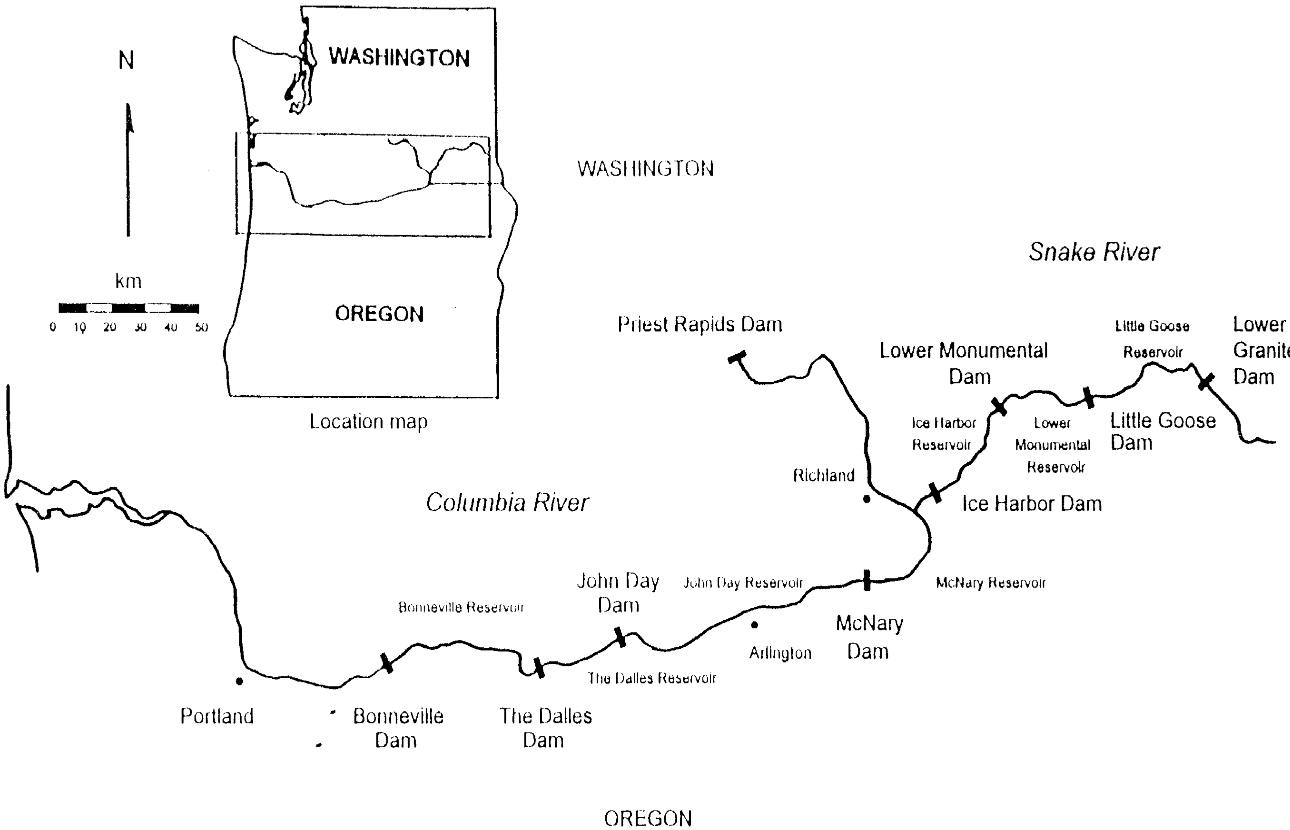

Figure 1. The Columbia River upstream to Priest Rapids Dam and the Snake River upstream to Lower Granite Dam.

Harvest estimates for all boat anglers were calculated by multiplying the observed catch per hour for each angling method within a reservoir subsection by the total estimated effort for each angling method for that subsection. White sturgeon harvest by bank anglers was calculated in a different manner since successful bank anglers may have been missed due to the one fish daily bag limit. The ratio of bank vs. boat harvest per angler hour was determined for years when the daily limit was two fish. This ratio was applied to the 1997 boat harvest per angler hour rate to estimate 1997 bank harvest per angler hour. The 1997 bank harvest rate was then applied to the 1997 estimate of bank angling effort for white sturgeon.

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. Annual harvest estimates were calculated from survey period estimates by applying monthly harvest proportions based on 1987-1995 Washington and Oregon sturgeon catch record card reports.

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.

Lower Snake 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 the lowermost three impoundments of the Snake 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 spp*. Setlines were deployed parallel to the current and set two per mile. An additional 13 sets were made with baited setlines constructed with 40 size 10/0 circle halibut hooks. Six sets were made in the Lower Granite Dam tailrace and seven sets were made in Little Goose Dam tailrace to test the efficacy of smaller hooks in targeting smaller sturgeon. These sets augmented sampling in these tailraces using the standard gear described above.

Lower Monumental and Little Goose reservoirs were stratified into 3 and 4 sampling sections, respectively, and were systematically fished weekly. We made four passes in each sampling section.

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. Sturgeon ≤109 cm FL or ≥155 cm FL (sturgeon outside the harvestable size slot) 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 1997 lower Snake River stock assessment efforts were also marked by removal of the seventh right lateral scute.

Abundance of white sturgeon was estimated using a modified Schnabel multiple mark-recapture population estimator. Capture numbers were adjusted for setline gear size selectivity by estimating the ratio of recaptures to marked fish at large for the 50-109, 110-209, and > 209 cm FL intervals (Hamley 1975, Lagler 1978, Beamesderfer and Rieman 1988). Recapture rates for the 50-109 and > 209 cm FL size classes were divided by the rate calculated for the 110-209 cm FL size class, which was considered the size class most vulnerable to our gear. Abundance was calculated for the 110-209 cm FL size class and extrapolated for the entire population using length frequencies adjusted for gear size selectivity. A 95% confidence interval was calculated for the estimated abundance of the 110-209 cm FL size class by assuming random mixing and treating recaptures in this size class as a Poisson variable (Ricker 1975).

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 ½ 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 information was collected for fish $\geq$152 cm FL. Determination of sex and maturity was made by first trying to express eggs or milt from the vent by manual stripping. When the manual stripping method failed to produce gametes, this information was collected by surgical biopsy according to the procedures outlined by Beamesderfer et al. (1989). Paired gonad (approximately 10 g) and blood plasma samples were collected from females and fish of undetermined sex. These samples were used for final sex and maturity determination and to assist Oregon State University researchers in the development of a plasma steroid assay for non-invasive sturgeon sex and maturity determination. 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 also collected for genetic analysis. Blood and plasma samples were preserved by freezing. Gonad samples were preserved in 10% buffered formalin. Ova diameters were measured in gonad samples and maturity was determined according to the procedures outlined in Chapman (1989).

RESULTS

Recreational Fishery Census

Bonneville Reservoir

The 1997 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 May 2. State fishery managers closed the fishery to retention of white sturgeon on April 5 based on our projection that harvest would reach the guideline by that date.

Anglers fished an estimated 44,830 hours (8,087 trips) in Bonneville Reservoir from January 1 through April 4 (Table 1). Angling effort for sturgeon comprised 94% (7,628 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 0 (0%) for anadromous salmonids, 0 (0%) for American shad *Alosa sapidissima*, 248 (3%) for walleye, 102 (1%) for bass, 0 (0%) for northern squawfish, 31 (< 1%) for other resident fish, and 78 (1%) for anglers participating in tournaments.

Anglers harvested an estimated 1,463 white sturgeon during 7,628 trips for sturgeon between January 1 and April 4, an 8% increase in harvest and 33% increase in angler trips from the 1996 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 February at 0.21 fish per trip and averaged 0.16 fish per trip for bank anglers and 0.26 fish per trip for boat anglers during the retention fishery (Table 3). Approximately 31% of the estimated bank effort (angler hours) and 13% of the estimated boat effort for white sturgeon during the survey period were accounted for by the 3,170 sturgeon anglers interviewed (Table 4).

Anglers fished January 1 through April 4 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 4 reported catch was 88%, 12%, and < 1%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5. Harvest per trip

Table 1. Combined Washington and Oregon recreational fishery angling effort estimates for Bonneville Reservoir, January 1 through April 4, 1997; The Dalles Reservoir, January 1 through May 4, 1997; and John Day Reservoir, January 1 through August 31, 1997.

Species Method	Bonneville		The Dalles		John Day	
	Hours	Trips	Hours	Trips	Hours	Trips
Sturgeon [a]						
Bank	27,855	5,093	16,823	2,278	35,162	4,780
Boat	14,947	2,535	1,148	538	37,126	5,968
Total	42,802	7,628	17,971	2,816	72,288	10,748
Salmonid						
Bank	0	0	258	74	2,602	421
Boat	0	0	139	29	196	23
Total	0	0	397	103	2,798	444
Shad						
Bank	0	0	0	0	194	43
Boat	0	0	0	0	0	0
Total	0	0	0	0	194	43
Walleye						
Bank	0	0	383	73	657	79
Boat	883	248	9,087	1,440	43,152	7,160
Total	883	248	9,470	1,513	43,809	7,239
Bass						
Bank	39	13	210	40	3,832	801
Boat	361	89	534	128	16,509	3,093
Total	400	102	744	168	20,341	3,894
Squawfish						
Bank	0	0	0	0	110	19
Boat	0	0	0	0	41	5
Total	0	0	0	0	151	24
Other						
Bank	82	31	332	83	5,364	999
Boat	0	0	60	12	1,714	366
Total	82	31	392	95	7,078	1,365
Tournament						
Bank	0	0	0	0	0	0
Boat	663	78	630	70	12,814	1,489
Total	663	78	630	70	12,814	1,489
Combined total						
Bank	27,976	5,137	18,006	2,548	47,921	7,142
Boat	16,854	2,950	11,598	2,217	111,552	18,104
Total	44,830	8,087	29,604	4,765	159,473	25,246

[a] *White sturgeon retention allowed January 1 through April 4 in Bonneville Reservoir, January 1 through May 4 in The Dalles reservoir, and January 1 through September 1 in John Day reservoir.*

Table 2. Combined Washington and Oregon recreational fishery harvest, and catch and release estimates for Bonneville Reservoir, January 1 through April 4, 1997; The Dalles Reservoir, January 1 through May 4, 1997; and John Day Reservoir, January 1 through August 31, 1997

Species	Bonneville	The Dalles	John Day
White sturgeon [a]			
Legals kept	1,463	178	464
Sublegals released	11,649	2,275	8,611
Legals released	264	0	87
Oversize released	22	15	553
Total	13,398	2,468	9,715
Chinook salmon [b]			
Adults kept	0	0	0
Jacks kept	0	0	16
Total kept	0	0	16
Released	0	0	1
Coho salmon [b]			
Adults kept	0	0	4
Jacks kept	0	0	0
Total	0	0	4
Steelhead [c]			
Kept	0	85	114
Released	0	2	52
American shad			
Kept	0	0	120
Released	0	0	135
Walleye			
Kept	60	559	1,597
Released	15	523	832
Bass			
Kept	0	38	1,755
Released	0	14	3,894
Northern squawfish kept	11	97	472
Other resident fish kept	21	3	2,417

[a] *White sturgeon retention allowed January 1 through April 4 in Bonneville Reservoir, January 1 through May 4 in The Dalles reservoir, and January 1 through September 1 in John Day reservoir.*

[b] *Chinook and coho seasons were closed to retention January 1 - July 31.*

[c] *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 4, 1997; The Dalles Reservoir, January 1 through May 4, 1997; and John Day Reservoir, January 1 through August 31, 1997.

	Bonneville			The Dalles			John Day		
Method	Trips	HPUE	Harvest	Trips	HPUE	Harvest	Trips	HPUE	Harvest
January									
Bank	971	0.11	109	317	0.10	33			
Boat	138	0.25	34	12	0.17	2			
Total	1,109	0.13	143	329	0.11	35			
February									
Bank	1,664	0.19	320	593	0.08	46	558	0.05	29
Boat	957	0.24	229	183	0.03	6	401	0.09	38
Total	2,621	0.21	549	776	0.07	52	959	0.07	67
March									
Bank	2,295	0.16	371	658	0.06	39	698	0.05	38
Boat	1,235	0.27 [a]	334	167	0.04 [a]	6	942	0.08 [a]	80
Total	3,530	0.20	705	825	0.05	45	1,640	0.07	118
April									
Bank	163	0.13	22	597	0.07	39	521	0.01	5
Boat	205	0.22	45	176	0.04	7	524	0.02	12
Total	368	0.18	67	773	0.06	46	1,045	0.02	17
May									
Bank	0	0.00	0	113	0.00	0	650	0.02	10
Boat	0	0.00	0	0	0.00	0	450	0.02	11
Total	0	0.00	0	113	0.00	0	1,100	0.02	21
June									
Bank	0	0.00	0	0	0.00	0	888	0.03	26
Boat	0	0.00	0	0	0.00	0	353	0.04	15
Total	0	0.00	0	0	0.00	0	1,241	0.03	41
July									
Bank	0	0.00	0	0	0.00	0	1,072	0.05	56
Boat	0	0.00	0	0	0.00	0	1,496	0.07	108
Total	0	0.00	0	0	0.00	0	2,568	0.06	164
August									
Bank	0	0.00	0	0	0.00	0	393	0.01	5
Boat	0	0.00	0	0	0.00	0	1,802	0.02	30
Total	0	0.00	0	0	0.00	0	2,195	0.02	35
Combined									
Bank	5,093	0.16 [a]	821	2,278	0.07 [a]	157	4,780	0.04 [a]	170
Boat	2,535	0.26 [a]	642	538	0.04 [a]	21	5,968	0.05 [a]	294
Total	7,628	0.19 [a]	1,463	2,816	0.06 [a]	178	10,748	0.04 [a]	464

[a] *White sturgeon retention allowed January 1 through April 4 in Bonneville Reservoir, January 1 through May 4 in The Dalles reservoir, and January 1 through September 1 in John Day reservoir. 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 4, 1997; The Dalles Reservoir, January 1 through May 4, 1997; and John Day Reservoir, January 1 through August 31, 1997

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal released	Legal kept	Oversize released
Bonneville						
Bank						
January	317	878	155	4	17	0
February	860	2,369	483	7	77	0
March	1,585	5,133	1,644	19	139	1
April	76	196	41	0	3	0
Bank total	2,838	8,576	2,323	30	236	1
Boat						
January	24	133	28	5	6	0
February	123	773	245	18	40	1
March	180	1,037	406	3	54	2
April	5	18	11	0	2	0
Boat total	332	1,961	690	26	102	3
Combined total	3,170	10,537	3,013	56	338	4
The Dalles						
Bank						
January	118	384	61	0	6	0
February	262	892	121	0	9	2
March	306	1,109	109	0	10	1
April	305	1,367	99	0	11	0
May	35	161	12	0	0	0
Bank total	1,026	3,913	402	0	36	3
Boat						
January	1	4	0	0	0	0
February	9	44	3	0	0	0
March	22	132	18	0	0	0
April	20	129	67	0	2	0
May	0	0	0	0	0	0
Boat total	52	309	88	0	2	0
Combined total	1,078	4,222	490	0	38	3

continued

Table 4. Continued

Reservoir Method/Month	Anglers checked	Hours fished	Sublegal released	Legal released	Legal kept	Oversize released
John Day						
Bank						
January	—	—	—	—	—	—
February	203	707	71	1	1	0
March	405	1,091	130	1	7	12
April	268	610	58	0	0	0
May	328	1,011	121	0	5	13
June	498	1,559	183	3	11	15
July	284	1,203	94	0	10	12
August	199	828	57	0	1	4
Bank total	2,185	7,009	714	5	35	56
Boat						
January	—	—	—	—	—	—
February	54	310	59	0	6	1
March	247	1,207	211	3	14	6
April	149	835	87	3	4	11
May	127	726	89	0	3	6
June	96	513	174	2	4	6
July	245	1,700	403	5	22	20
August	258	1,762	150	2	7	13
Boat total	1,176	7,053	1,173	15	60	63
Combined total	3,361	14,062	1,887	20	95	119

Table 5. Length frequencies of harvested white sturgeon measured during sampling o recreational fisheries in Bonneville Reservoir, January 1 through April 4, 1997; The Dalles Reservoir, January 1 through May 4, 1997; and John Day Reservoir, January 1 throug August 31, 1997. Not all sampled fish were measured.

Fork length (cm)	Bonneville	The Dalles	John Day	Fork length (cm)	Bonneville	The Dalles	John Day
90				130			2
91				131		1	1
92				132			2
93	1			133		1	1
94	4			134	1		2
95	15			135			2
96	20			136			
97	24			137		1	1
98	26			138	1		4
99	33			139			1
100	12			140			3
101	19			141			
102	18			142			
103	19			143			
104	14	1		144			
105	10			145			
106	15	1		146			
107	12	2		147			
108	8	3	1	148			1
109	9	2	1	149			
110	10	2	4	150			
111	4	3	3	151			
112	5	1	3	152			
113	8	2	3	153			
114	6	2	4	154			
115	2		3	155			
116	4	2	2	156			
117	3	1	9	157			
118	6	2	4	158			
119	5	1	3	159			
120	3	1	3	160			
121	1		2	161			
122			2	162			
123			1	163			
124	1		2	164			
125		1	1	165			
126	2	1	1	166			
127	2	2	2	167			
128	1	3	6				
129	1	1	2	Total	325	37	82

of 107-152 cm (42-60 in) TL fish by bank anglers decreased from 1996 levels (Table 6). Harvest per trip by boat anglers has decreased each year since 1995.

The Dalles Reservoir

The 1997 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 it through May 4. State fishery managers closed the fishery to retention of white sturgeon on May 5 based on our projection that harvest would reach the guideline by that date.

Anglers fished an estimated 29,604 hours (4,765 trips) in The Dalles Reservoir from January 1 through May 4 1997 (Table 1). Angling effort for white sturgeon comprised 59% (2,816 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 103 (2%) for anadromous salmonids, 0 (0%) for American shad, 1,513 (32%) for walleye, 168 (4%) for bass, 0 (0%) for northern squawfish, 95 (2%) for other resident fish, and 70 (1%) for anglers participating in tournaments.

Anglers harvested an estimated 178 white sturgeon during 2,816 trips for sturgeon between January 1 and May 4, a 196% increase in harvest and 211% increase in angler trips from the 1996 retention period. The primary recreational 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 0.07 for bank anglers and 0.04 for boat anglers targeting white sturgeon during the retention fishery. Approximately 23% of the estimated bank effort (angler hours) and 26% of the estimated boat effort for white sturgeon were accounted for by the 1,078 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 May sampled catch was 92%, 7%, and 1%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 122-152 cm (48-60 in) TL fish by bank anglers has increased each year since 1993 (Table 6). Harvest per trip by boat anglers was substantially below 1996, but comparable to 1993-1995 levels.

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 1997.

		Bank anglers			Boat anglers		
Year	Period	Trips	Harvest	HPUE	Trips	Harvest	HPUE
Bonneville (107-152 cm total length interval)							
1987	-- a						
1988	Mar-Oct	5,653	532	0.094	4,776	688	0.144
1989	Mar-Oct	8,028	1,316	0.164	5,792	1,099	0.190
1990	Mar-Oct	7,213	719	0.100	7,349	1,055	0.144
1991	-- a						
1992	-- a						
1993	Mar-Oct	7,599	678	0.089	6,747	736	0.109
1994	Mar-Oct	7,821	1,024	0.131	5,329	1,089	0.204
1995	Feb-Apr	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
The Dalles (122-152 cm total 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	-- a						
1991	-- a						
1992	-- a						
1993	Mar-Oct	2,058	46	0.023	1,902	61	0.032
1994	Mar-Oct	3,124	75	0.024	1,863	68	0.037
1995	Mar-May	957	28	0.029	510	18	0.035
1996	Mar-Apr	655	21	0.031	251	29	0.115
1997	Jan-May 4	2,278	119	0.052	538	16	0.030
John Day (122-152 cm total length interval)							
1987	-- a						
1988	-- a						
1989	May-Jul	3,572	22	0.006	3,401	34	0.010
1990	Mar-Dec	3,806	33	0.009	3,063	82	0.027
1991	Apr-Sep	1,977	36	0.018	2,463	73	0.030
1992	-- a						
1993	Mar-Oct	3,208	56	0.018	4,466	111	0.025
1994	Mar-Oct	3,221	42	0.013	6,860	164	0.024
1995	Mar-May	1,891	12	0.006	2,407	30	0.013
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

[a] *Minimal or no sampling.*

John Day Reservoir

The 1997 retention season for white sturgeon in John Day Reservoir opened January 1 and was scheduled to run through June 30, but was extended through September 1. We began our survey of the fishery on January 2 and continued sampling it through August 31. State fishery managers closed the fishery to retention of white sturgeon on September 2 based on our projection that harvest would reach the guideline by that date.

Anglers fished an estimated 159,473 hours (25,246 trips) in John Day Reservoir from January through August (Table 1). Angling effort for white sturgeon comprised 43% (10,748 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 444 (2%) for anadromous salmonids, 43 (< 1%) for American shad, 7,239 (29%) for walleye, 3,894 (15%) for bass, 24 (< 1%) for northern squawfish, 1,365 (5%) for other resident fish, and 1,489 (6%) for tournament anglers.

Anglers harvested an estimated 464 white sturgeon during 10,748 trips for sturgeon between February 1 and August 31, an 828% increase in harvest and 243% increase in angler trips from the 1996 retention period (Tables 2 and 3). An additional 8 white sturgeon were harvested in January prior to our survey based on the monthly harvest distribution reported on previous sturgeon catch report cards.

The recreational fishery for white sturgeon was concentrated from McNary Dam downstream past Irrigon, Oregon (Rkm 449), with some additional boat effort out of Boardman, Oregon (Rkm 434), and at Crow Butte Island (Rkm 426). Effort for white sturgeon was greatest in July (Table 3). The average harvest per trip was 0.04 for bank anglers and 0.05 for boat anglers during the retention fishery. Approximately 20% of the estimated bank effort (angler hours) and 19% of the estimated boat effort for white sturgeon were accounted for by the 3,361 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 89%, 5%, and 6%, respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5. Harvest per trip of 122-152 cm (48-60 in) TL fish for both bank and boat anglers was significantly higher than any other year since monitoring began in 1989 (Table 6).

Treaty Indian Commercial and Subsistence Harvest

The 1997 treaty Indian commercial harvest estimates for Zone 6 were 1,852 white sturgeon from Bonneville Reservoir, 498 white sturgeon from The Dalles Reservoir, and 1,260 white sturgeon from John Day Reservoir (Table 7). Most of the harvest (2,622 fish) was landed in the winter gillnet fishery (April 1-May 31) with 906 fish harvested in the spring setline fishery (February 1- March 16), 82 fish harvested in the January setline fishery (January 1-31), and 10 fish illegally landed in the fall gillnet fishery. The treaty Indian Zone 6 subsistence white sturgeon harvest estimated by CRITFC and YIN was 130 fish from Bonneville Reservoir, 40 fish from The Dalles Reservoir, and 60 fish from John Day Reservoir (Table 7).

Lower Snake River Sturgeon Stock Assessment

Lower Monumental Reservoir

A total of 417 overnight setline sets were made to assess the white sturgeon population in Lower Monumental Reservoir (Table 8). Total catch (including all captures and recaptures) of white sturgeon was 733 (Table 9). Catch rates were greatest in the lowermost sections of Lower Monumental Reservoir (Table 10); a result contrary to the distribution of sturgeon found in other Columbia Basin impoundments (Beamesderfer et al. 1995), but similar to stock assessment results in Ice Harbor Reservoir in 1996 (DeVore et al. In press).

There were 658 white sturgeon captured with setlines, marked with PIT and spaghetti tags, and released back into Lower Monumental Reservoir in 1997. Of these, 563 were within the 110-209 cm FL size class used for abundance estimation (Table 11). There were 88 marked fish subsequently recaptured with 31 recaptures from the 110-209 cm FL size class. White sturgeon captured in Lower Monumental Reservoir ranged in length from 55-221 cm FL (mean = 116 cm FL).

Abundance of the 110-209 cm FL size class was estimated by the modified Schnabel estimator to be 2,230 with a 95% confidence interval of 1,411-5,322. Expanding catches of all size classes $\geq$54 cm FL by adjusting for gear size selectivity estimated a total population of 4,262 (Table 12). Given a surface area of 2,425 hectares (ha) for Lower Monumental Reservoir, density of white sturgeon $\geq$54 cm FL was 1.76 sturgeon/ha.

There were 189 length at age assignments made for Lower Monumental white sturgeon, ranging from 4 years (55 cm FL) to 34 years (191 cm FL). The von Bertalanffy growth equation, $L_t = 595.8\,(1-e^{-0.0095\,(t+5.6855)})$, best described these data (Figure 2A).

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 1997.

Fishery Guideline/Harvest Year	Bonneville Reservoir	The Dalles Reservoir	John Day Reservoir	Unspecified reservoir	Total
Recreational					
Guideline	1,520	200	560		2,280
Harvest					
1991	2,270	199	150	0	2,619
1992	1,717	139	147	0	2,003
1993	2,307	158	144	0	2,609
1994	2,223	154	234	0	2,611
1995	1,370	50	53	0	1,473
1996	1,353	80	62	0	1,495
1997	1,463	178	464	0	2,105
Indian commercial					
Guideline	1,300	400	1,160		2,860
Harvest					
1991	999	457	39	0	1,495
1992	1,146	431	23	0	1,600
1993	1,415	579	12	0	2,006
1994	1,176	309	117	0	1,602
1995	1,421	312	308	0	2,041
1996	1,005	230	360	0	1,595
1997	1,852	498	1,260	0	3,610
Combined fisheries					
Guideline	2,820	600	1,720		5,140
Harvest					
1991	3,269	656	189	0	4,114
1992	2,863	570	170	0	3,603
1993	3,722	737	156	0	4,615
1994	3,399	463	351	0	4,213
1995	2,791	362	361	0	3,514
1996	2,358	310	422	0	3,090
1997	3,315	676	1,724	0	5,715
Indian subsistence					
Expectation [a]	--	--	--	--	300
Harvest					
1991	-- [b]	-- [b]	-- [b]	-- [b]	-- [b]
1992	89	-- [b]	-- [b]	119	208
1993	146	31	30	56	263
1994	290	197	163	0	650
1995	570	260	320	0	1,150
1996	260	120	110	0	490
1997	130	40	63	0	233

[a] *The SMTF did not establish harvest guidelines for the subsistence fishery, however, the expected annual subsistence harvest was 300 white sturgeon for 1994 through 1997.*

[b] *Not available.*

Table 8. Sampling effort for white sturgeon in number of overnight setline sets, by sampling location and week, for Lower Monumental and Little Goose reservoirs, March 31 through September 18, 1997.

	Location (sampling sections)										
	Lower Monumental Reservoir					Little Goose Reservoir					
Week	1	2	3	4 [a]	Total	1	2	3	4	5 [a]	Total
Mar 31 - Apr 3	33	--	--	--	33	--	--	--	--	--	0
Apr 7 - Apr 10	--	--	--	--	0	30	--	--	--	--	30
Apr 14 - Apr 17	--	--	--	--	0	--	--	19	19	2	40
Apr 21 - Apr 24	--	--	34	3	37	--	--	--	--	--	0
Apr 28 - May 1	--	--	--	--	0	--	27	12	--	--	39
May 5 - May 8	--	30	--	--	30	--	--	--	--	--	0
May 12 - May 15	--	--	--	--	0	29	--	--	--	--	29
May 19 - May 22	30	--	--	--	30	--	--	--	--	--	0
May 26 - May 29	--	--	--	--	0	--	--	10	5	0	15
Jun 2 - Jun 5	--	--	28	0	28	--	--	--	--	--	0
Jun 9 - Jun 12	--	--	--	--	0	--	29	16	--	--	45
Jun 16 - Jun 19	--	47	--	--	47	--	--	--	--	--	0
Jun 23 - Jun 26	--	--	--	--	0	38	--	--	--	--	38
Jun 30 - Jul 3	36	--	--	--	36	--	--	--	--	--	0
Jul 7 - Ju110	--	--	--	--	0	--	--	--	27	3	30
Jul 14 - Ju117	--	--	30	4	34	--	--	--	--	--	0
Jul 21 - Ju124	--	--	--	--	0	--	27	13	--	--	40
Jul 28 - Ju131	--	30	--	--	30	--	--	--	--	--	0
Aug 4 - Aug 7	--	--	--	--	0	30	--	--	--	--	30
Aug 11 - Aug 14	33	--	--	--	33	--	--	--	--	--	0
Aug 18 - Aug 21	--	--	--	--	0	--	--	37	--	--	37
Aug 25 - Aug 28	--	--	39	6	45	--	--	--	--	--	0
Sep 1 - Sep 4	--	--	--	--	0	--	24	--	--	--	24
Sep 8 - Sep 11	--	34	--	--	34	--	--	--	--	--	0
Sep 15 - Sep 18	--	--	--	--	0	--	--	12	27	3	42
Total	132	141	131	13	417	127	107	119	78	8	439

[a] The tailrace boat-restricted zone at Little Goose and Lower Granite dams

Table 9. Catches of white sturgeon with setlines by sampling location and week in Lower Monumental and Little Goose reservoirs, March 31 through September 18, 1997.

	Location (sampling sections)										
	Lower Monumental Reservoir					Little Goose Reservoir					
Week	1	2	3	4 [a]	Total	1	2	3	4	5 [a]	Total
Mar 31 - Apr 3	53	--	--	--	53	--	--	--	--	--	0
Apr 7 - Apr 10	--	--	--	--	0	46	--	--	--	--	46
Apr 14 - Apr 17	--	--	--	--	0	--	--	3	7	5	15
Apr 21 - Apr 24	--	--	0	0	0	--	--	--	--	--	0
Apr 28 - May 1	--	--	--	--	0	--	10	0	--	--	10
May 5 - May 8	--	7	--	--	7	--	--	--	--	--	0
May 12 - May 15	--	--	--	--	0	64	--	--	--	--	64
May 19 - May 22	37	--	--	--	37	--	--	--	--	--	0
May 26 - May 29	--	--	--	--	0	--	--	10	3	0	13
Jun 2 - Jun 5	--	--	2	0	2	--	--	--	--	--	0
Jun 9 - Jun 12	--	--	--	--	0	--	29	1	--	--	30
Jun 16 - Jun 19	--	26	--	--	26	--	--	--	--	--	0
Jun 23 - Jun 26	--	--	--	--	0	161	--	--	--	--	161
Jun 30 - Jul 3	227	--	--	--	227	--	--	--	--	--	0
Jul 7 - Ju110	--	--	--	--	0	--	--	--	19	18	37
Jul 14 - Ju117	--	--	30	25	55	--	--	--	--	--	0
Jul 21 - Ju124	--	--	--	--	0	--	165	18	--	--	183
Jul 28 - Ju131	--	66	--	--	66	--	--	--	--	--	0
Aug 4 - Aug 7	--	--	--	--	0	106	--	--	--	--	106
Aug 11 - Aug 14	152	--	--	--	152	--	--	--	--	--	0
Aug 18 - Aug 21	--	--	--	--	0	--	--	66	--	--	66
Aug 25 - Aug 28	--	--	18	9	27	--	--	--	--	--	0
Sep 1 - Sep 4	--	--	--	--	0	--	49	--	--	--	49
Sep 8 - Sep 11	--	81	--	--	81	--	--	--	--	--	0
Sep 15 - Sep 18	--	--	--	--	0	--	--	6	7	9	22
Total	469	180	50	34	733	377	253	104	36	32	802

[a] The tailrace boat-restricted zone at Little Goose and Lower Granite dams

Table 10. Mean catch per setline set by sampling location and week in Lower Monumental and Little Goose reservoirs, March 31 through September 18, 1997.

	Location (sampling sections)										
	Lower Monumental Reservoir					Little Goose Reservoir					
Week	1	2	3	4 [a]	Total	1	2	3	4	5 [a]	Total
Mar 31 - Apr 3	1.61	--	--	--		--	--	--	--	--	
Apr 7 - Apr 10	--	--	--	--		1.53	--	--	--	--	
Apr 14 - Apr 17	--	--	--	--		--	--	0.16	0.37	2.50	
Apr 21 - Apr 24	--	--	0.00	0.00		--	--	--	--	--	
Apr 28 - May 1	--	--	--	--		--	0.37	0.00	--	--	
May 5 - May 8	--	0.23	--	--		--	--	--	--	--	
May 12 - May 15	--	--	--	--		2.21	--	--	--	--	
May 19 - May 22	1.23	--	--	--		--	--	--	--	--	
May 26 - May 29	--	--	--	--		--	--	1.00	0.60	--	
Jun 2 - Jun 5	--	--	0.07	--		--	--	--	--	--	
Jun 9 - Jun 12	--	--	--	--		--	1.00	0.06	--	--	
Jun 16 - Jun 19	--	0.55	--	--		--	--	--	--	--	
Jun 23 - Jun 26	--	--	--	--		4.24	--	--	--	--	
Jun 30 - Jul 3	6.31	--	--	--		--	--	--	--	--	
Jul 7 - Ju110	--	--	--	--		--	--	--	0.70	6.00	
Jul 14 - Ju117	--	--	1.00	6.25		--	--	--	--	--	
Jul 21 - Ju124	--	--	--	--		--	6.11	1.38	--	--	
Jul 28 - Ju131	--	2.20	--	--		--	--	--	--	--	
Aug 4 - Aug 7	--	--	--	--		3.53	--	--	--	--	
Aug 11 - Aug 14	4.61	--	--	--		--	--	--	--	--	
Aug 18 - Aug 21	--	--	--	--		--	--	1.78	--	--	
Aug 25 - Aug 28	--	--	0.46	1.50		--	--	--	--	--	
Sep 1 - Sep 4	--	--	--	--		--	2.04	--	--	--	
Sep 8 - Sep 11	--	2.38	--	--		--	--	--	--	--	
Sep 15 - Sep 18	--	--	--	--		--	--	0.50	0.26	3.00	
Average	3.55	1.28	0.38	2.62	1.76	2.97	2.36	0.87	0.46	4.00	1.83

[a] The tailrace boat-restricted zone at Little Goose and Lower Granite dams

Table 11. Mark-recapture data used to estimate the abundance of 110-209 cm FL white sturgeon in Lower Monumental and Little Goose reservoirs in 1997 using a modified Schnabel estimato

Reservoir	Period	Dates	Total number caught C	ecaptures R	Number caught (unmarked)	Mortalities/ removals	Number marked	Marked fish at large M
Lower Monumental	1	Apr 1-May 8	35	0	35	0	35	0
	2	May 20-June 19	46	1	45	0	45	35
	3	July 1-July 31	211	5	206	0	206	80
	4	Aug 12- Sept 11	177	25	152	0	152	286
		Totals	469	31	438	0	438	438
Modified Schnabel estimate		2,230						
95% confidence interval		1,411	to	5,322				
Little Goose	1	April 8-May 1	52	0	52	0	52	0
	2	May 20-June 12	79	1	78	0	78	52
	3	June 24-July 24	271	10	261	1	260	130
	4	Aug 5- Sept 18	188	16	172	0	172	390
		Totals	590	27	563	1	562	562
Modified Schnabel estimate		4,174						
95% confidence interval		2,570	to	11,093				

Table 12. Abundance estimates of white sturgeon in Lower Monumental and Little G
reservoirs based on 1997 mark-recapture estimates and length frequency distributions

Reservoir	Fork length (cm)	Abundance	Density (No./hectare)	Catch/ set	Surface area hectares
Lower Monumental	54-81	274	0.11	0.031	2,425
	82-91	212	0.09	0.060	
	92-166	3,679	1.52	1.309	
	>166	97	0.04	0.055	
Total		4,262	1.76		
Little Goose	54-81	993	0.26	0.118	3,887
	82-91	470	0.12	0.043	
	92-166	4,390	1.13	1.136	
	>166	640	0.16	0.127	
Total		6,492	1.67		

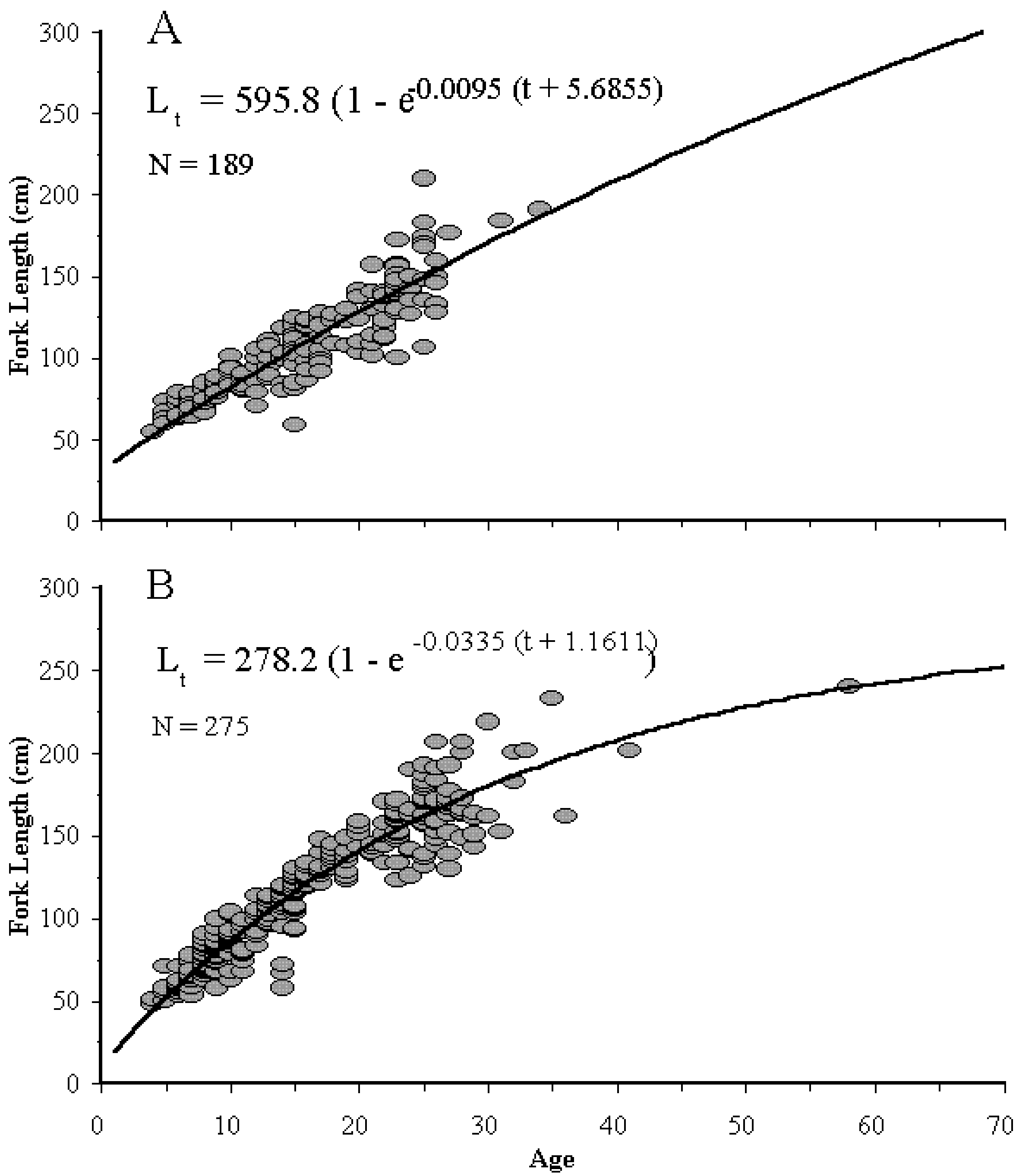

Figure 2. Length-at-age data and von Bertalanffy growth function for white sturgeon in Lower Monumental (A) and Little Goose (B) reservoirs. Samples collected in September, 1996 and from April through September, 1997.

A total of 696 paired length and weight samples that ranged from 50-240 cm FL with weights from 0.5-88.5 kg were taken for Lower Monumental white sturgeon. The exponential equation that best fit these data was $W = 7.613*10^{-6} (FL^{3.0131})$ (Figure 3A). Mean relative weight for the population was 99% of the standard weight for white sturgeon derived by Beamesderfer (1993) (Figure 3B).

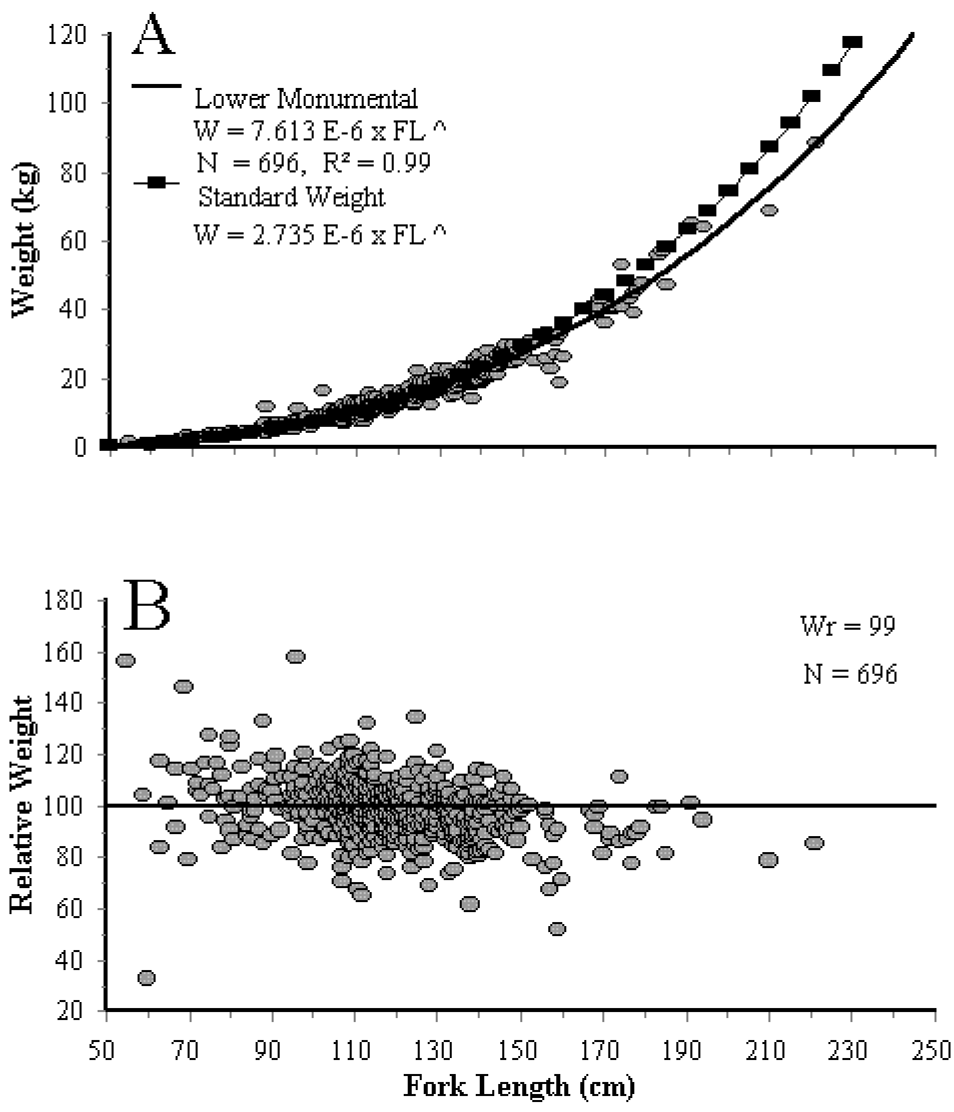

Figure 3. Length-weight relationship (A) and mean relative weight (B) of white sturgeon sampled in Lower Monumental Reservoir, April through September, 1997.

Thirty of the white sturgeon ≥139 cm FL caught in Lower Monumental Reservoir were surgically biopsied to determine sex and stage of maturity (Table 13). Thirteen (43%) of these fish were determined to be male, 15 (50%) were female, and 2 (7%) were of unknown sex. Of the gonad samples determined to be ovarian, 11 (73%) were previtellogenic, 1 (7%) was previtellogenic with attritic oocytes, 3 (20%) were early vitellogenic, none (0%) were late vitellogenic, none (0%) were ripe, and none (0%) were spent.

Little Goose Reservoir

A total of 439 overnight setline sets were made to assess the white sturgeon population in Little Goose 802 (Table 9). Catch rates were greatest in the lowermost sections of Little Goose Reservoir (Table 10); a result contrary to the distribution of sturgeon found in other Columbia Basin impoundments (Beamesderfer et al. 1995), but similar to stock assessment results in Lower Monumental Reservoir in 1997.

There were 731 white sturgeon captured with setlines, marked with PIT and spaghetti tags, and released back into Little Goose Reservoir in 1997. Of these, 563 were within the 110-209 cm FL size class used for abundance estimation (Table 11). There were 96 marked fish subsequently recaptured with 27 recaptures from the 110-209 cm FL size class. White sturgeon captured in Little Goose Reservoir ranged in length from 48-240 cm FL (mean = 126 cm FL).

Abundance of the 110-209 cm FL size class was estimated by the modified Schnabel estimator to be 4,174 with a 95% confidence interval of 2,570-11,093. Expanding catches of all size classes ≥54 cm FL by adjusting for gear size selectivity estimated a total population of 6,492 (Table 12). Given a surface area of 3,887 hectares (ha) for Little Goose Reservoir, density of white sturgeon ≥54 cm FL was 1.67 sturgeon/ha.

There were 275 length at age assignments made for Little Goose white sturgeon, ranging from 4 years (48 cm FL) to 58 years (240 cm FL). The von Bertalanffy growth equation, $L_t = 278.2\ (1-e^{-0.0335\ (t + 1.1611)})$, best described these data (Figure 2B).

A total of 787 paired length and weight samples that ranged from 50-240 cm FL with weights from 0.4-125.0 kg were taken for Little Goose white sturgeon. The exponential equation that best fit these data was $W = 1.314*10^{-5}\ (FL^{2.9089})$ (Figure 4A). Mean relative weight for the population was 97% of the standard weight for white sturgeon derived by Beamesderfer (1993) (Figure 4B).

Ninety-nine of the white sturgeon ≥137 cm FL caught in Little Goose Reservoir were surgically biopsied to determine sex and stage of maturity (Table 13). Thirty-three (33%) of these

Table 13. Sex and female maturity stage of white sturgeon from Lower Monumental and Litt Goose reservoirs, April through September 1997, as determined by biopsies.

Gender Maturity	Number	Size range (cm FL)	Percent of samples: Female samples	Percent of samples: All samples
Lower Monumental Reservoir				
Unknown	2	140-146		7%
Female				
Previtellogenic	11	140-221	73%	37%
Previtellogenic (attritic oocytes)	1	151	7%	3%
Early vitellogenic	3	141-184	20%	10%
Late vitellogenic	0	--	0%	0%
Ripe	0	--	0%	0%
Spent	0	--	0%	0%
Total female	15			50%
Male	13	139-183		43%
Total samples	30			
Little Goose Reservoir				
Unknown	10	141-202		10%
Female				
Previtellogenic	11	142-223	20%	11%
Previtellogenic (attritic oocytes)	0	--	0%	0%
Early vitellogenic	26	140-236	46%	26%
Late vitellogenic	17	157-161	30%	17%
Ripe	1	163	2%	1%
Spent	1	171	2%	1%
Total female	56			57%
Male	33	137-240		33%
Total samples	99			

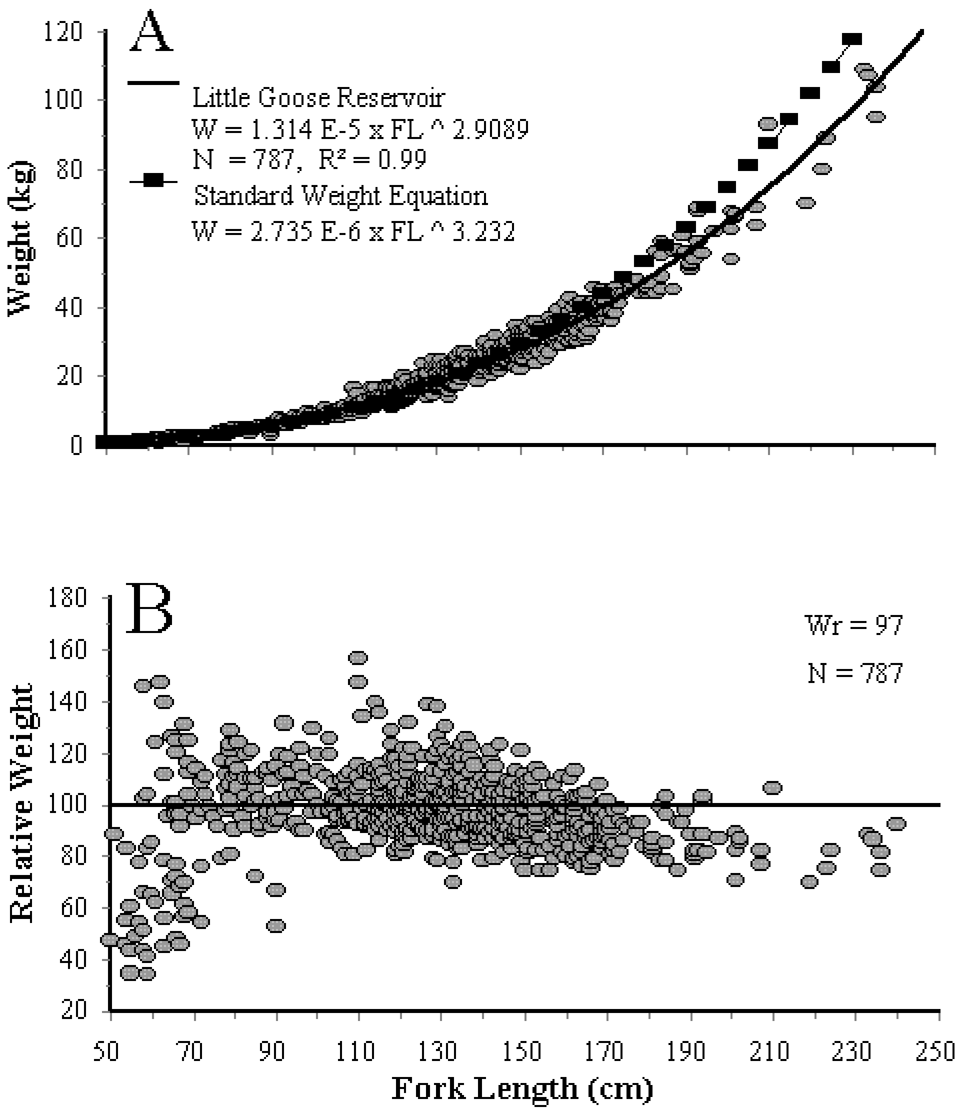

Figure 4. Length-weight relationship (A) and mean relative weight (B) of white sturgeon sampled in Little Goose Reservoir, April through September, 1997.

fish were determined to be male, 56 (57%) were female, and 10 (10%) were of unknown sex. Of the gonad samples determined to be ovarian, 11 (20%) were previtellogenic, none (0%) were previtellogenic with attritic oocytes, 26 (46%) were early vitellogenic, 17 (30%) were late vitellogenic, 1 (2%) was ripe, and 1 (2%) was spent.

DISCUSSION

Zone 6 Sturgeon Harvest Management

Harvest management of Zone 6 white sturgeon fisheries during 1997 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 1997 harvest guidelines of 1,520 recreational and 1,300 commercial white sturgeon from Bonneville Reservoir, 200 recreational and 400 commercial from The Dalles Reservoir, and 560 recreational and 1,160 commercial from John Day Reservoir. The SMTF also recommended a new maximum size limit of 60 inches total length for all Zone 6 sturgeon fisheries. This regulation change and new stock assessments indicating greater abundance of legal-sized white sturgeon justified the liberalization of harvest guidelines in 1997. Recreational white sturgeon harvest had exceeded the guidelines during 1991-94 despite a series of regulatory harvest reduction actions implemented from 1992 through 1994 (Table 14). 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 recreational fishery closures prior to June 30 were needed to stay within SMTF guidelines during 1995-97.

The 1997 treaty Indian commercial winter gillnet season was more productive than the flood-prone 1996 season. A significant increase in commercial catch rate and landings in the last two weeks of the winter gillnet fishery in Bonneville and The Dalles reservoirs caused guidelines to be exceeded in these fisheries. This increase in late winter season sturgeon landings is a normal pattern for these 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. The John Day Reservoir was opened to spring setlining (April 7- June 23) to achieve the commercial harvest guideline there. This guideline was exceeded slightly when unexpected landings were accounted for late in the season. Managers were able to quickly close this fishery in-season (the fishery was scheduled to close on July 5) to keep harvest close to the annual guideline. Treaty Indian commercial guidelines have been consistently exceeded in the last four years. The SMTF needs to take a more proactive approach in Zone 6 commercial sturgeon management to stay within annual pool-specific harvest guidelines. Since Zone 6 harvest guidelines are based on a three year average of estimated optimal sustainable rates of exploitation for each population, it is recommended that annual guidelines be adjusted downward in fisheries that exceed these prescribed limits in future years to maintain levels of harvest that are modeled to be optimally sustainable. Failure to heed harvest constraints will

Table 14. Recreational sturgeon fishery regulations for Bonneville, The Dalles, and John Day reservoirs, 1993-1997.

Year	Daily bag limit	Size limit	Other
1993	1/1	40" min 72" max	Oregon - No change from 1992 regulations for waters downstream of The Dalles Dam.
	1	48" min 66" max	Oregon - No change from 1991 regulations for waters upstream of The Dalles Dam.
	1/1	40" min 72" max	Washington - Size limit change effective April 16, 1993 for waters downstream of The Dalles Dam.
	1	48" min 66" max	Washington - Size limit change effective April 16, 1993 for waters upstream of The Dalles Dam.
1994	1/1	42" min 66" max	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" min 66" max	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" min 66" max	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" min 66" max	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" min 66" max	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" min 66" max	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" min 60" max	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" min 60" max	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.

hinder the recovery of Zone 6 sturgeon stocks resulting in less than optimal harvest benefits 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 relative high productivity of that population. A more significant result is the recovery of John Day Reservoir white sturgeon. Managers had been concerned about the annual decline in catch rates in John Day Reservoir sturgeon fisheries. However, for the first time since the population crashed in the mid-1980s, catch rates in the 1996 and 1997 sport fisheries increased relative to previous years. Stock assessment of the John Day Reservoir population by the Oregon Department of Fish and Wildlife in 1996 confirmed higher abundance of white sturgeon there (North et al. In press). A similar improvement in The Dalles sturgeon stock status was noted in the population assessment done in 1997 (see Report A).

Lower Snake River Sturgeon Stock Assessment

White sturgeon density, growth, and fitness in Lower Monumental and Little Goose reservoirs was less than described for other Columbia Basin sturgeon populations (Beamesderfer et al. 1995, DeVore et al. 1995) but similar to results obtained in 1996 for the population residing in Ice Harbor Reservoir (DeVore et al. In press). The relative lack of juvenile fish and a lopsided age structure with proportionally more older individuals indicates recruitment problems in Lower Monumental Reservoir (Figure 5). We do not believe that spawner abundance limits recruitment in Lower Monumental Reservoir since we observed a relatively high catch rate of mature and maturing females in our stock assessment. Extensive hydroelectric development in the Snake River Basin since the late 1950s is the most likely reason for the population age structure in these areas (Parsley and Beckman 1994, unpublished data from the Biological Resource Division of the USGS). Planned future habitat surveys and recruitment indexing in the lower Snake River reservoirs may confirm this suspicion.

Other factors may also contribute to declined productivity of lower Snake River white sturgeon. The slower growth rates and poorer condition factor observed in these fish may indicate problems with the forage base or available rearing habitat. The density of the population is low relative to other Columbia Basin populations studied (Beamesderfer et al. 1995, DeVore et al. 1995). It may be that ecosystem productivity has declined due to hydroelectric and/or agricultural development in the region. It is clear that anadromous prey has declined with time and food choices available to other impounded Columbia Basin sturgeon populations may not be found in lower Snake reservoirs.

Sturgeon productivity may be greater in Little Goose Reservoir relative to the other two lower Snake populations investigated. Proportionally more juvenile white sturgeon were found there indicating a healthier age structure. However, we are uncertain whether all of the juvenile recruitment originated from production within Little Goose Reservoir or whether these fish

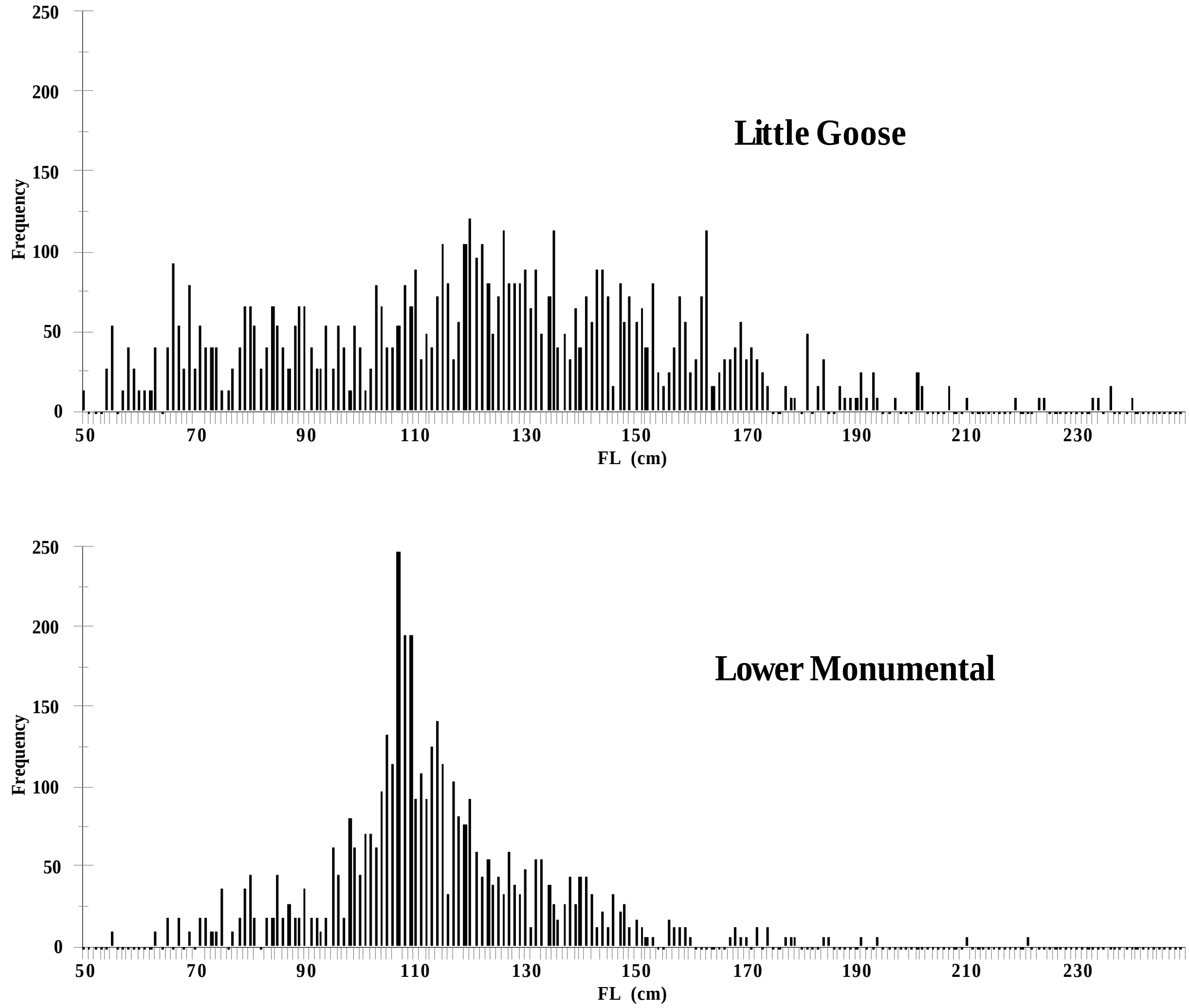

Figure 5. Length frequencies of white sturgeon in Lower Monumental and Little Goose reservoirs, 1997.

originated from Hells Canyon upstream from Lower Granite Dam where spawning habitats appear to be more intact. There appears to be a gradient of lesser juvenile abundance in the lower Snake white sturgeon populations as one moves downstream. We believe there is a high potential that many of the white sturgeon in the lower Snake reservoirs may have been entrained through the dams especially in the last two years of floods and higher than average spring and summer flows in the Snake River. Initial analysis of our collective stock assessment data indicates some downstream movement of tagged fish through the dams. We have not thoroughly investigated the level of entrainment as indicated by our data, but we plan on doing this analysis in the near future. Planned habitat assessments and young-of-year (YOY) recruitment indexing in the lower Snake reservoirs should help determine the potential of within-reservoir productive capacity. A sturgeon telemetry study should be conducted in the lower Snake River from Hells Canyon Dam downstream to Ice Harbor Dam to investigate white sturgeon entrainment.

Plans for 1998

We plan to conduct YOY white sturgeon recruitment indexing using small mesh gill nets in Ice Harbor, John Day, and The Dalles reservoirs in the 1998 fiscal year (November-December 1997). 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. Similar recruitment indexing will be done in FY99 (November-December 1998); however, sampling may be conducted in Little Goose Reservoir instead of Ice Harbor Reservoir due to the increased abundance of juvenile fish there. We would like to investigate the potential of YOY production within Little Goose Reservoir relative to possible entrainment of fish through Lower Granite Dam. We also plan to conduct stock assessment setline sampling in Lake Rufus Woods and Lake Roosevelt. The assessment of Lake Rufus Woods is designed to test the suitability of this reach as a site to conduct experimental supplementation using hatchery-propagated white sturgeon in the near future. Lake Roosevelt sampling is consistent with white sturgeon research priorities outlined in Fickeisen et al. (1984). We will continue monitoring Zone 6 recreational and treaty Indian commercial fisheries in 1998. We will continue working on a manuscript entitled, “The effect of flow on the recruitment of young-of-year Columbia River white sturgeon”.

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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

Report C

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

and

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

This report includes: Investigations on seasonal habitat use and movements of white sturgeons in McNary Reservoir and the Hanford Reach, and spawning, spawning habitat, and recruitment to young of year in Columbia and Snake River reservoirs

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ABSTRACT

Data collection investigating the seasonal habitat use and movements of white sturgeons *Acipenser transmontanus* in the Columbia and Snake rivers between Priest Rapids, Ice Harbor, and McNary dams was completed in February 1998. In addition to the 24 operational tags previously deployed, acoustic transmitters were attached to 27 white sturgeons. These 51 fish were subsequently relocated 372 times.

The Bonneville, The Dalles, and John Day reservoirs were sampled with a bottom trawl to determine if recruitment to young of the year occurred. In Bonneville Reservoir, we captured 567 juvenile white sturgeons, of which 171 were young of the year (YOY). In Bonneville Reservoir, the majority (69%) of the white sturgeons captured were juveniles older than YOY, a larger percentage than that seen during the sampling in 1996 (14%); suggesting that the strong year class observed during 1996 significantly contributed to the number of juveniles older than YOY caught with the bottom trawl in 1997. Catches of juvenile white sturgeons in The Dalles and John Day reservoirs were much higher than in past years. We captured 202 YOY white sturgeon and 25 older juveniles in The Dalles Reservoir and 47 YOY white sturgeon in John Day Reservoir.

River discharges and water temperatures that occurred during April through July 1997 provided conditions that should have been very favorable for spawning by white sturgeons. Our monthly and annual estimates of indices of spawning habitat showed that the availability of habitat for spawning were much higher for this month than the average of the estimates made since 1985.

We provide the first documentation of white sturgeon spawning in the Ice Harbor, Lower Monumental, and Little Goose reservoirs of the Snake River. White sturgeon spawning in these reservoirs of the Snake River occurred at water temperatures within the previously reported range of suitable spawning temperatures for white sturgeons. We estimated that white sturgeon spawned in Ice Harbor Reservoir on four days between 1 June and 8 June at water temperatures ranging from 12.3 C to 12.8 C, on 8 June through 10 June in Lower Monumental reservoir at water temperatures ranging from 12.1 C to 13.1 C, and occurred in Little Goose reservoir on at least 11 days between 7 June and 29 at water temperatures ranging from 11.7 C to 16.7 C.

INTRODUCTION

This annual report describes the progress of the U.S. Geological Survey's Columbia River Research Laboratory from 1 April 1997 through 31 March 1998 toward meeting the objectives of Bonneville Power Administration's Project 86-50. The primary goals of the U.S. Geological Survey under this project are to investigate the reproduction and early life history of white sturgeons *Acipenser transmontanus*. Our tasks for this period were to:

1) Describe the habitat use and movements of juvenile and adult white sturgeons 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 sturgeons in McNary Reservoir.

2) Determine if recruitment to young-of-the-year (YOY) white sturgeons occurred in the Bonneville, The Dalles, and John Day reservoirs.

3) Estimate the timing and duration of white sturgeon spawning in Ice Harbor, Lower Monumental, and Little Goose reservoirs of the Snake River.

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

5) Estimate the availability of spawning habitat for white sturgeons 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) Assess the effects external transmitter attachment on the swimming performance of juvenile white sturgeons.

In addressing task 7, we provide a manuscript as an appendix. This manuscript reports on an experiment we conducted to determine the effects of external transmitter attachment on the swimming performance of juvenile white sturgeons (Appendix C-1).

METHODS

Habitat Use and Seasonal Movements

Habitat use and movements of juvenile and adult white sturgeons were investigated by using acoustic underwater biotelemetry methods (Winter 1996). Ultrasonic transmitters (Table 1) and

Table 1. Sonotronics transmitter model, dimesions (diameter x length), weight in water (g), expected battery life, minimum fish weight (g) and fork length[a] (mm) that could be tagged so that transmitter weight (g) in water did not exceed 1.25% of fish weight in air, and fork lengths (mm) of tagged sturgeons.

				Minimum fish size		
Transmitter model	Dimensions	Transmitter weight	Expected life	Weight	Fork length	Fork lengths of tagged fish
IBT-96-2	8 mm x 28 mm	2.5	60 d	200	304	506 - 661
MT-95-2	9 mm x 35 mm	3	47 d	240	322	563 - 664
PRG-94-HP/M	18 mm x 70 mm	8	7 months	640	434	925 - 1330
PRG-94-HP-L/M	18 mm x 90 mm	12	18 months	960	491	1565 - 2255
DT-96-L	18 mm x 95 mm	14	12 months	1,120	515	1765

[a]- Fork lengths were calculated from the weight-length relation $W_{kg}=2.83x10^{-6}(FL_{cm})^{3.27}$

receivers were purchased from Sonotronics Inc.[1]. We used 2, 3, and 4-digit coded transmitters at frequencies of 74 and 76 kHz and depth-indicating transmitters at frequencies of 32, 34, 36, 37, 38, and 40 kHz to identify individual fish.

White sturgeons were captured by fishing longlines with 20-40 circle hooks per line baited with pickled and frozen squid. Hook sizes used were, 12/0, 14/0, and 16/0. The longlines were fished for up to 24 hours, and they were fished along the length of the study area in an attempt to capture and tag fish from throughout the study area. When transmitters were expected to expire, we captured and tagged additional fish.

All transmitters were attached externally. The transmitters, except the MT-95-2 and the IBT-96-2 transmitters, had a hole at each end for attachment. The transmitters were attached by passing a multi-stranded stainless steel wire (American Fishing Wire; 58.8 kg test) through the two holes on either end of the transmitter and then through the musculature ventral to the dorsal fin of the fish. The tag ends of the wires were then passed through a backing plate made of polyvinyl chloride plastic (PVC) and the tag ends were crimped with copper sleeves (American Fishing Wire # 4DB). The tag ends were then trimmed and the attachment area was bathed with a solution of nitrofurazone to reduce infections. The fish was then released. For the MT-95-2 and the IBT-96-2 transmitters, we attached two copper wires (22 gauge) to the transmitters with a clove hitch and cyanoacrylate glue and attached the transmitter as described above. It is common practice that the transmitter weight in water should not exceed 1.25% of the fish weight in air (Winter 1996). We used the weight/length relation developed by North et al. (1995) to calculate the minimum fish size appropriate for each transmitter model (Table 1).

White sturgeons with ultrasonic transmitters were located by using mobile tracking via boats. Tracking was confined to three periods of the year: spring (April-June), late summer (August-September), and winter (January-February). Tracking was generally done once each week during each season from upstream to downstream. The boat was stopped at approximately 0.8 km intervals to listen for transmitters, with more frequent stops made around islands and in areas with a complex channel structure. Fish were generally located not more than once each week to reduce autocorrelation in the habitat use data.

When fish were found, the latitude and longitude were measure with a Rockwell PLGR+ Global Positioning System (GPS) receiver using the Precise Positioning Service[2], along with a variety of habitat descriptors. The North American Datum of 1927 (NAD27) was used as the datum for all recorded positions. The positions were converted to state plane coordinates (Washington South Zone) for use in a geographic information system. Water temperatures, and current velocities where fish were located and across the river channel were measured with an acoustic Doppler current

[1] Mention of trade names does not imply endorsement by the U.S. Geological Survey.

[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.

profiler. This instrument was shared with the U.S. Fish and Wildlife Service (USFWS; Report E) and was not always available for our use. Water depths where fish were found were measured with an analog chart recorder. Turbidity near the surface was measured with a Hach model 2100 turbidity meter.

Young-of-the-Year Indexing

We fished for juvenile white sturgeons 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 the Bonneville, The Dalles, and John Day reservoirs. We fished the bottom trawl on 12 d from 15 September to 30 September 1997 in Bonneville Reservoir, on 5 d from 28 October to 4 November 1997 in the Dalles Reservoir, and on 7 d from 6 November to 18 November 1997 in John Day Reservoir. We trawled 11 sites in Bonneville Reservoir where YOY white sturgeons had been collected in previous years. Young-of-the-year white sturgeon catches have been sparse in the Dalles and John Day reservoirs in past years. Since past surveys may not reflect the current geographical distribution of YOY in these reservoirs, we trawled 12 sites in The Dalles Reservoir and 20 sites in John Day Reservoir, including sites where no YOY have been previously collected. Sample sites were designated with a code indicating statute river mile (rm) 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 (RM) to the nearest 0.1 mile from the mouth of the Columbia or Snake rivers. For example, a site coded as 34753 indicates that the location is near river mile 347.5 and in the third quadrant of the river from the left bank (looking upstream).

We estimated the distance fished during each tow with the GPS receiver described above and determined the area fished by multiplying the distance by 4.4 m, the estimated width of our bottom trawl. We also used the 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-year and measured the fork length (FL) and TL to the nearest mm on other juvenile white sturgeons. The fish were each weighed on a Pesola hanging scale. Usually, young-of-year white sturgeons were weighed to the nearest 1 g, and larger juveniles were weighed to the nearest 5 or 10 g.

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. *in press*) for YOY white sturgeons in Bonneville Reservoir was calculated as the ratio of tows where at least one YOY was captured to the total number of tows. We then used the Freeman-Tukey double arcsine test (Westphal and Young 1993, SAS Institute 1996) to evaluate differences in *Ep* between the YOY surveys done in 1996 and 1997.

Timing and Duration of Spawning in the Lower Snake River

We conducted exploratory sampling for white sturgeon eggs using artificial substrates

(McCabe and Beckman 1990) in the Snake River to estimate the timing and duration of white sturgeon spawning in Ice Harbor, Lower Monumental, and Little Goose reservoirs. Latitude and longitude of sampling sites was recorded with a Rockwell PLGR+ GPS receiver using the Precise Positioning Service. The North American Datum of 1927 was used as the datum for all recorded GPS positions. Sample sites were also designated with a code similar to our trawling location codes, that indicate statute river mile and relative position across the river channel.

Twenty artificial substrates were placed in Ice Harbor Reservoir on 8 May at 20 sites (Appendix C-2). An additional substrate was fished in this reservoir from 20 May to 3 June, 1997 at site 4021. Typically, substrates were checked once weekly in all reservoirs and, if located, retrieved and examined. Artificial substrates were removed on 9 July from Ice Harbor reservoir. Twenty artificial substrates were deployed in Lower Monumental Reservoir at 20 locations (Appendix C-3) between 30 April and 10 July, 1997. Substrates in Lower Monumental reservoir were removed from sampling on 10 July. We sampled Little Goose Reservoir with one artificial substrate at each of 20 sites (Appendix C-4). These substrates were deployed between 6 May and 7 May and removed on 8 July, 1997.

White sturgeon eggs collected in the field were preserved in a solution of 10% unbuffered formalin. White sturgeon eggs were assigned developmental stages in the laboratory based on criteria described by Beer (1981). Spawning dates were estimated by back-calculating the time of fertilization from the relations developed by Wang et al. (1985). Water temperatures at the time of collection were used in the relationship and assumed to have been constant during incubation. The timing and duration of white sturgeon spawning periods were determined from the first and last back-calculated spawning dates. Mean daily temperatures for Ice Harbor, Lower Monumental, and Little Goose reservoirs were obtained for April through July, 1997 from the U.S. Army Corps of Engineers. Water temperature was also measured with digital thermometers subsequent to most artificial substrate retrievals.

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

During June and July, 1997, we incubated white sturgeon eggs obtained from broodstock in the Kootenai and Snake rivers from fertilization to hatching at the Kootenai Tribal Experimental Hatchery (KTEH) in Bonners Ferry, Idaho, and at the University of Idaho Hagerman Fish Culture Experiment Station (HFCES) in Hagerman, Idaho. Gamete collection, insemination, de-adhesion, and incubation followed procedures described in Conte et al. (1988). Females were induced to spawn with injections of luteinizing hormone releasing hormone (LHRH).

After fertilization and de-adhesion, eggs were incubated in Macdonald jars. At the KTEH, 10,000 eggs were stocked into each of two Macdonald jars. 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 12 C water flushed through the tank at 0.5 l min^{-1}. At the KTEH, the eggs were warmed from the ambient hatchery water temperature (12 C) to the experimental incubation temperatures by incremental addition of progressively warmer (1 C

10 min^{-1}) suspensions of the fuller's earth. At the HFCES, eggs were incubated at ambient hatchery water temperature (15 C). Thus, the water did not require heating, was continuously replaced with fresh water, and did not pass through sterilization units. Approximately 3,000 eggs were stocked into each of two jars maintained at 15 C at the HFCES.

Samples of developing embryos were taken during the de-adhesion process and then from the Macdonald jars as they developed. Samples were taken 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. Samples of unfertilized eggs were collected just prior to fertilization, kept in 15 C water for one hour and preserved. Preserved eggs were then examined under a dissecting microscope and assigned a developmental stage using classifications developed by Beer (1981).

Availability of Habitat

The methods and hydraulic data described in Parsley and Beckman (1994) were used to model the availability of spawning habitat for white sturgeons downstream from McNary, John Day, The Dalles, and Bonneville dams. 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 1997 as inputs to create a daily index of spawning habitat for the four areas. Mean daily river discharges 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/). Water temperatures downstream from The Dalles, John Day, and McNary dams were automatically recorded every 2 h with Ryan Tempmentor thermographs placed on the river bottom at river kilometers 307.0, 346.5, and 467.6 in the Columbia River. Water temperatures for the Bonneville Dam tailrace were obtained from the DART Website.

Effects of Proposed Reservoir Drawdowns on the Productivity of White Sturgeons

The BRD is working closely with staff from the Army Corps of Engineers (Walla Walla and Portland districts), the U.S. Fish and Wildlife Service (Portland, OR), and the Pacific Northwest National Laboratory (Richland, WA) to evaluate the effects of the proposed water level manipulations (drawdown of the John Day Reservoir and breaching of the lower Snake River dams). Each of these groups have geospatial data or information pertinent to this analysis.

RESULTS

Habitat Use and Seasonal Movements

Transmitters were attached to 27 white sturgeons (Table 2) ranging in length from 506 mm FL to 2,255 mm FL. The sturgeons were captured and released throughout the study area (Figure

1). In addition to the 27 transmitters deployed from May 1997 through February 1998 there were 24 transmitters still operating. These 51 fish were found 372 times (Figure 2). One fish was never found after its release, while others were found many times (Table 2). Water depths were collected 649 times from May of 1996 through February of 1998 and ranged from 2 m to 30 m with a mean of 11 m (Figure 3). During the same time period, water velocity measurements obtained at 561 locations had a range of .1 m/s to 2 m/s with an average of .6 m/s (Figure 4).

Young-of-the-Year Indexing

Bonneville Reservoir

Recruitment to YOY occurred in the Bonneville Reservoir in 1997. We captured 567 juvenile white sturgeons with the high-rise trawl during our sampling in the Bonneville Reservoir; 171 (31%) of these fish were YOY. Young-of-the-year white sturgeons were captured at all 11 sites (Table 3). The YOY ranged in length from 82 to 252 mm TL and weighed 2.6 to 68 g. The mean length of YOY captured was 159 mm TL and the mean weight was 20.2 g. Older juvenile white sturgeons were also captured at all 11 sites trawled. The older juvenile white sturgeons measured 252 to 839 mm FL and weighed 100 to 4,500 g.

The CPUE at the 11 sites sampled with the bottom trawl in Bonneville Reservoir varied from 1.37 to 4.17 YOY per 2,500 m^2 and from 2.57 to 22.31 fish per 2,500 m^2 for all white sturgeons caught (Table 3). The mean CPUE for all sites combined was 2.69 YOY per 2,500 m^2 (SE = 0.26) and 8.95 fish per 2,500 m^2 (SE = 1.03) for all juvenile white sturgeons. The proportion of positive tows for YOY white sturgeon (*Ep*) was 0.82 was less than that observed for 1996 (*Ep* = 0.89), but the observed difference in this index was not statistically significant ($P = 0.11$).

The Dalles Reservoir

Recruitment to YOY also occurred in The Dalles Reservoir in 1997. We captured 227 juvenile white sturgeons with the bottom trawl during our sampling in The Dalles Reservoir; 202 (89%) of these fish were YOY. Young-of-the-year white sturgeons were captured at 6 of 12 sites (Table 4). The YOY ranged in length from 150 to 371 mm TL and weighed 16 to 205 g. The mean length of YOY captured was 264 mm TL and the mean weight was 69.1 g. Older juvenile white sturgeons were captured at 4 of the 12 sites trawled. The older juvenile white sturgeons measured 343 to 488 mm FL and weighed 240 to 830 g.

The CPUE at the 12 sites sampled with the bottom trawl in The Dalles Reservoir varied from 0 to 49.5 YOY per 2,500 m^2 and from 0 to 56.5 fish per 2,500 m^2 for all white sturgeons caught (Table 4). The mean CPUE for the 1997 YOY survey 8.50 YOY per 2,500 m^2 (SE = 3.27) and 9.58 fish per 2,500 m^2 (SE = 3.57) for all juvenile white sturgeons.

Table 2. Characteristics of white sturgeons and the ultrasonic transmitters that were attached from May 1997 through February 1998. FL = fork length, TL = total length.

Tag code[a]	Date captured	Transmitter model	FL (mm)	TL (mm)	Location where captured[b] Latitude	Longitude	Number of relocations
76.566	5 May 97	PRG-94HP/M	932	1079	46 11.809	-119 02.236	14
76.239	5 May 97	PRG-94HP/M	945	1075	46 12.416	-119 03.441	12
76.339	6 May 97	PRG-94HP/M	925	1049	46 12.939	-119 06.125	12
74.25	7 May 97	MT-95-2	664	760	46 40.565	-119 27.363	4
74.36	7 May 97	MT-95-2	563	635	46 42.428	-119 32.141	5
74.2344	8 May 97	PRG-94HP-L/M	1740	1925	45 55.765	-119 07.819	3
74.2326	8 May 97	PRG-94HP-L/M	1565	1690	45 55.660	-119 13.361	13
74.58	9 May 97	MT-95-2	600	694	46 01.566	-118 56.580	1
74.2236	9 May 97	PRG-94HP-L/M	2255	2400	45 56.785	-119 04.468	10
76.226	11 Aug 97	PRG-94HP/M	1050	1160	45 55.823	-119 13.977	8
74.3334	11 Aug 97	PRG-94HP-L/M	1735	1940	45 55.247	-119 11.729	8
76.258[c]	11 Aug 97	PRG-94HP/M	1330	1470	45 55.601	-119 13.008	7
76.2264	11 Aug 97	PRG-94HP-L/M	1600	1740	45 55.823	-119 13.977	6
76.246	11 Aug 97	PRG-94HP/M	1200	1320	45 55.247	-119 11.729	6
76.255	12 Aug 97	PRG-94HP/M	1050	1175	46 13.023	-119 06.173	7
76.235	12 Aug 97	PRG-94HP/M	1085	1230	46 13.994	-119 11.162	6
76.244	12 Aug 97	PRG-94HP/M	1070	1160	45 38.249	-119 39.109	6
76.224	13 Aug 97	PRG-94HP/M	1240	1360	46 37.540	-119 52.014	1
74.511	14 Aug 97	IBT-96-2	620	700	46 42.441	-119 32.155	0
74.412	14 Aug 97	IBT-96-2	645	715	46 40.489	-119 27.418	3
74.610	15 Aug 97	IBT-96-2	655	757	46 16.003	-119 14.532	2
76.233	15 Aug 97	PRG-94HP/M	1024	1183	46 18.441	-119 15.216	8
76.248	26 Aug 97	PRG-94HP/M	1000	1175	46 03.395	-118 56.307	7
37	27 Aug 97	DT-96-L	1765	1900	46 03.268	-118 56.390	6
74.410	6 Jan 6	IBT-96-2	661	750	46 40.505	-119 27.438	5
74.212	7 Jan 98	IBT-96-2	506	579	46 42.397	-119 32.223	5
74.311	7 Jan 98	IBT-96-2	622	714	46 40.265	-119 27.158	5

[a]Digits preceeding the decimal point are the frequency in kHz. Digits after the decimal point indicate the code used to identify individual transmitters. Transmitters listed without a decimal point following the frequency (e.g. 34) are depth-indicating transmitters, which vary the pulse interval with changes in depth.

[b]Locations were obtained with a global positioning system receiver using the Precise Positioning Service and the North American Datum of 1927.

[c]This transmitter was originally deployed on 9 May 1996. The fish was recaptured while setlining and the tag was removed, returned to the manufacturer to be rebatteried and then re-deployed.

Table 3. Site designation, area sampled (ha), number of white sturgeon collected, and catch per 2500 m^2 of white sturgeons for the young-of-the-year (YOY) white sturgeon recruitment survey conducted in Bonneville Reservoir from 15 September to 30 September 1997.

		Number of white sturgeon collected		Catch/2500 m^2	
Site	Area sampled (ha)	All ages	YOY	All ages	YOY
15052	1.489	17	12	2.85	2.01
15734	1.460	15	8	2.57	1.37
15951	1.493	22	14	3.68	2.34
16522	1.440	50	24	8.68	4.17
16851	1.414	25	20	4.42	3.54
17063	1.493	40	18	6.70	3.01
17374	1.390	100	15	18.0	2.70
17652	1.451	40	12	6.89	2.07
17911	1.489	72	20	12.1	3.36
18351	1.443	53	16	9.18	2.77
18523	1.490	133	12	22.3	2.01
Total	16.052	567	171		

Table 4. Site designation, area sampled (ha), number of white sturgeon collected, and catch per 2500 m^2 of white sturgeons for the young-of-the-year (YOY) white sturgeon recruitment survey conducted in the Dalles Reservoir from 28 October to 4 November 1997.

		Number of white sturgeon collected		Catch/2500 m^2	
Site	Area sampled (ha)	All ages	YOY	All ages	YOY
19463	0.479	7	7	3.65	3.65
19683	0.508	30	27	14.8	13.3
19981	0.505	114	100	56.5	49.5
20012	0.478	64	64	33.5	33.5
20244	0.505	0	0	0	0
20432	0.496	0	0	0	0
20451	0.496	0	0	0	0
20651	0.510	0	0	0	0
20752	0.488	0	0	0	0
21014	0.500	0	0	0	0
21103	0.466	10	3	5.37	1.61
21412	0.451	2	1	1.11	0.55
Total	5.882	227	202		

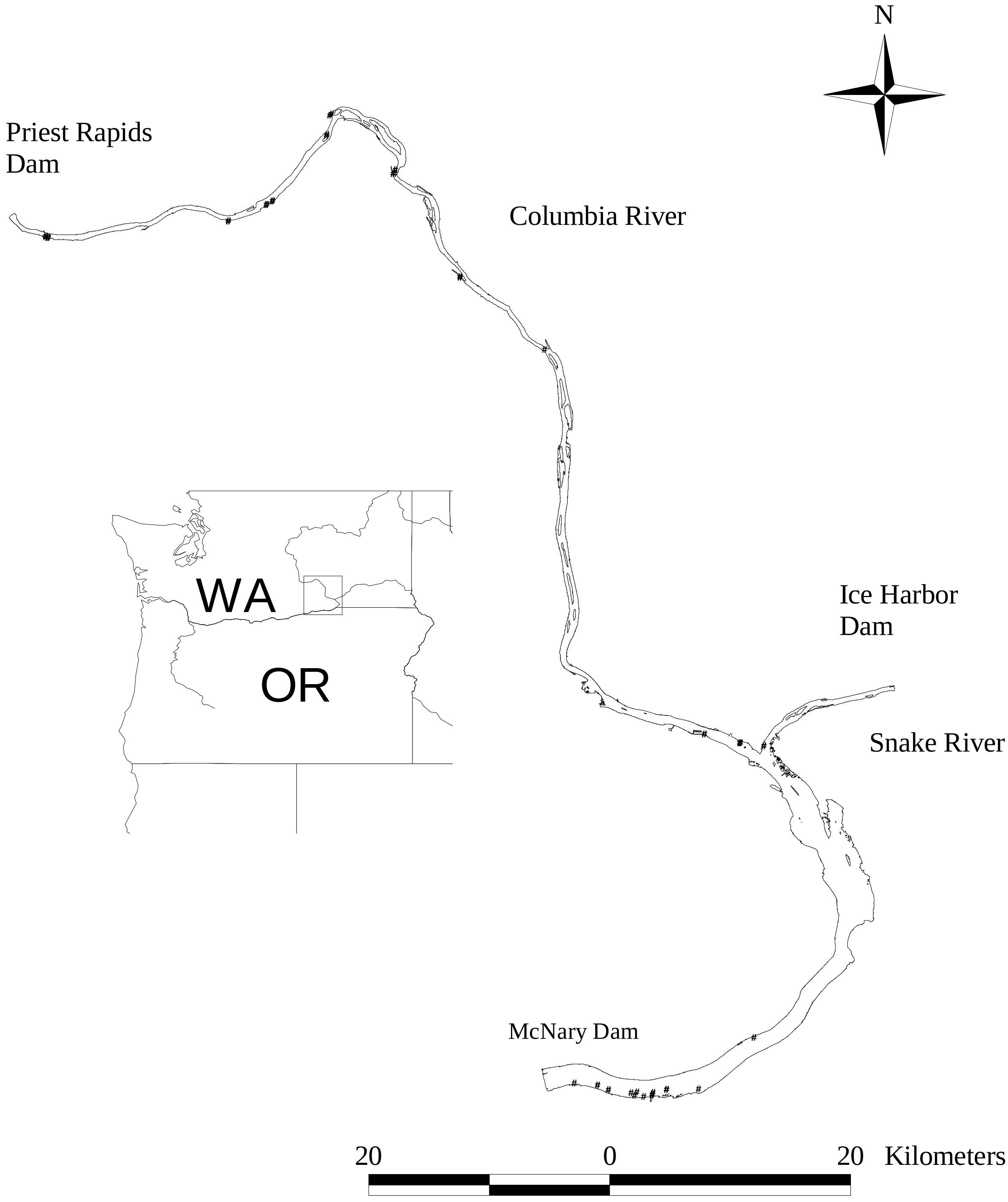

Figure 1. Locations (indicated by dots where 27 white sturgeons were captured and released in the Columbia and Snake rivers from May 1997 through February 1998. Several fish were captured and released at the same location.

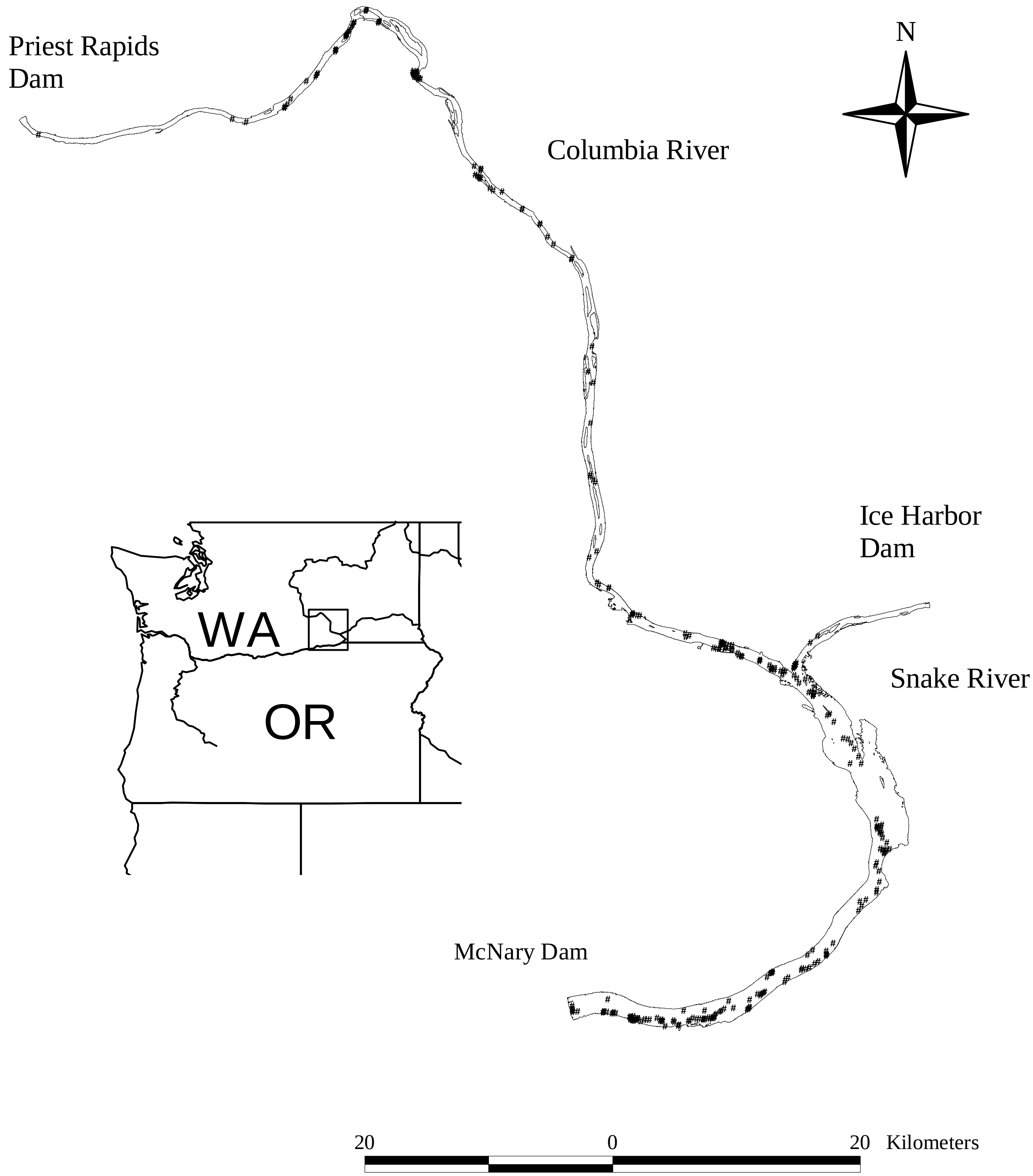

Figure 2. Locations (indicated by dots) where 51 white sturgeons (27 fish tagged during this reporting period and 24 from the previous period) were relocated 372 times in the Columbia and Snake rivers from May 1996 through February 1997.

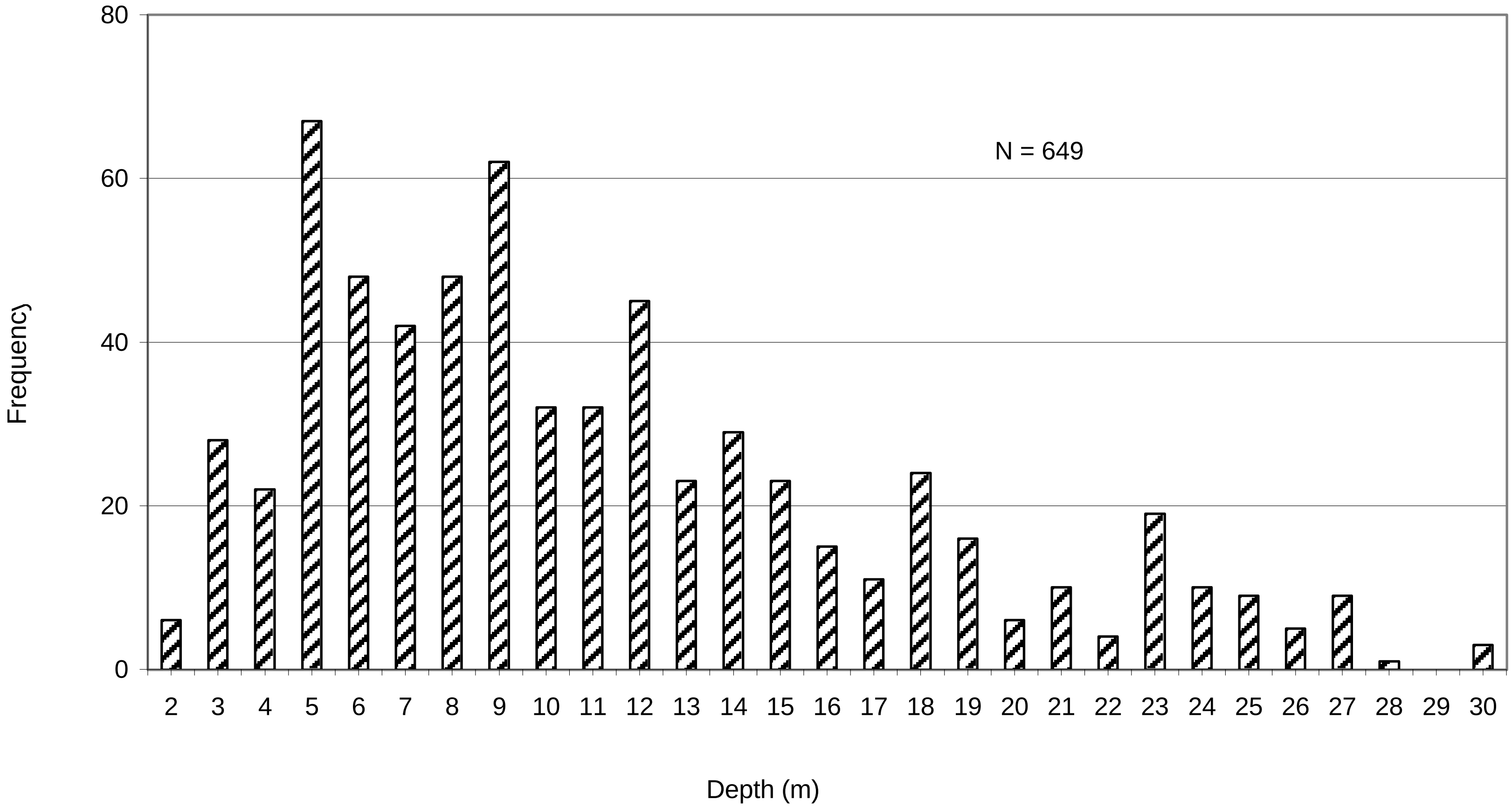

Figure 3. Distribution of depths used by 71 tagged white sturgeons in the Columbia river.

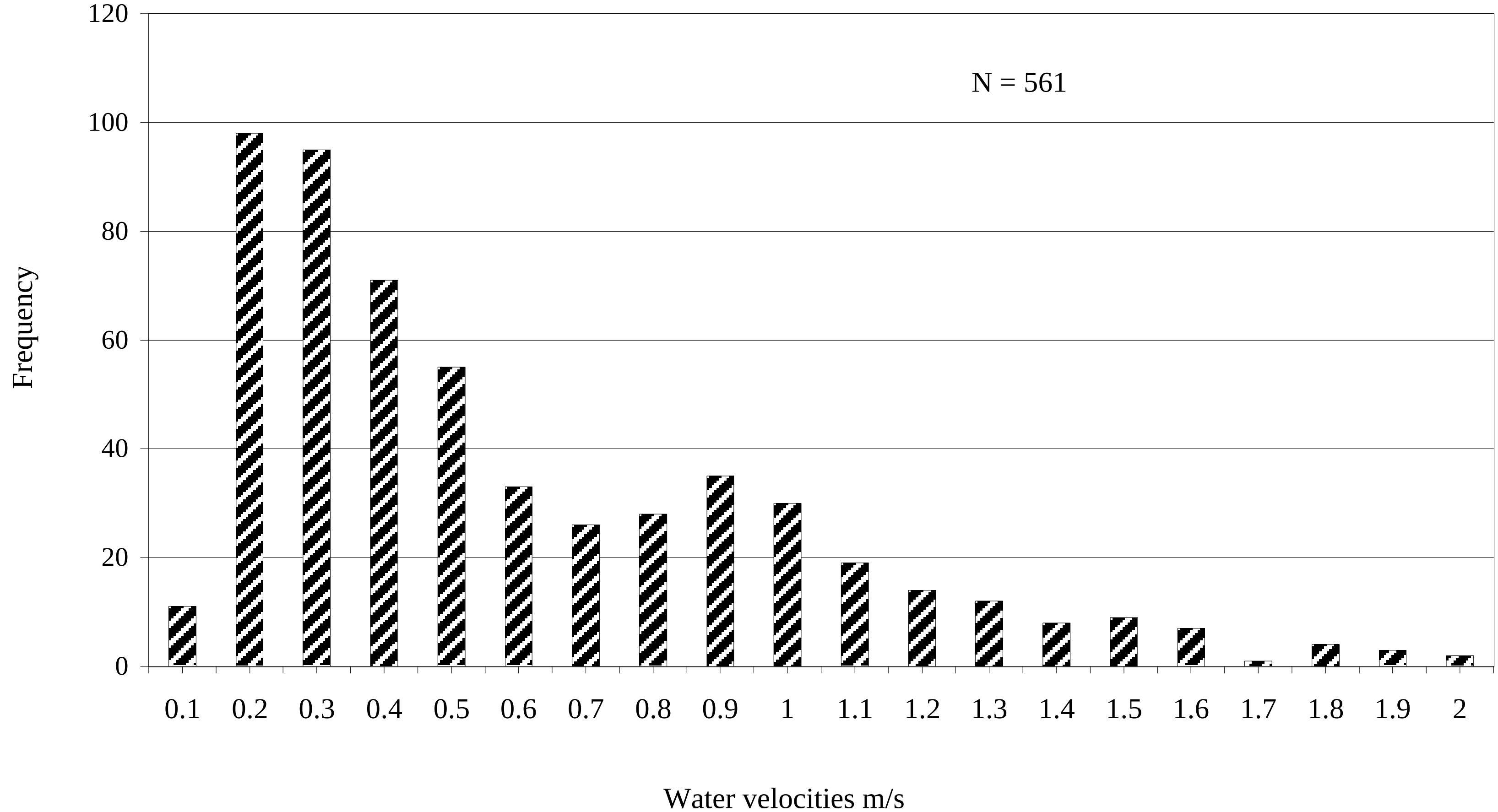

Figure 4. Distribution of mean column water velocities (m/s) used by 70 tagged white sturgeons in the Columbia river.

John Day Reservoir

We captured 47 YOY white sturgeons with the bottom trawl during our sampling in John Day Reservoir; indicating that recruitment to YOY occurred. No older juvenile white sturgeons were captured with the bottom trawl in John Day Reservoir during 1997. Young-of-the-year white sturgeons were captured at 13 of 20 sites sampled with the bottom trawl (Table 5). The YOY ranged in length from 157 to 334 mm TL and weighed 20 to 167 g. The mean length of YOY captured was 271 mm TL and the mean weight was 93.4 g.

The CPUE at the 20 sites sampled with the bottom trawl in John Day Reservoir varied from 0 to 9.66 YOY per 2,500 m^2 (Table 5) and the mean CPUE for the 1997 YOY survey was 1.21 YOY per 2,500 m^2 (SE = 0.38).

Timing and Duration of Spawning in the Lower Snake River

Ice Harbor Reservoir

A total of 18 white sturgeon eggs were collected at two sites (Figure 5) in Ice Harbor Reservoir on 4 days from 8 May through 9 July, 1997 (Table 6). The 16 viable eggs collected (89%) were represented by two developmental stages (Beer 1981); late epithelial and pre-hatch. Two eggs collected (11%) were not viable. We estimated that spawning in Ice Harbor reservoir occurred on five days between 1 June and 9 June by back-calculating spawning dates from the viable eggs collected. Water temperatures during this period varied from 12.3 C to 13.0 C.

Lower Monumental Reservoir

A total of 30 white sturgeon eggs were collected from Lower Monumental reservoir at two sites (Figure 6) on 2 days from 30 April through 10 July, 1997 (Table 6). Developmental stages of the 23 viable eggs collected ranged from third cleavage through large yolk plug. Seven eggs collected (23.3%) were not viable. We estimated that spawning in Lower Monumental reservoir occurred on 8 June through 10 June by back-calculating spawning dates from the viable eggs collected. Water temperatures during this period ranged from 12.9 C to 13.0 C.

Little Goose Reservoir

A total of 279 white sturgeon eggs were collected from Lower Monumental reservoir at 4 sites (Figure 7) on 3 days from 6 May through 8 July, 1997 (Table 6). Six eggs were damaged and we were unable to determine if they were viable or not. Of the 273 eggs we could stage, 21 (7.7%) were not viable. Development of the 252 viable eggs collected ranged from second cleavage through the prehatch stage. We estimated that spawning in Little Goose reservoir occurred on at least 11 days between 8 June and 29 June by back-calculating spawning dates from the viable eggs collected. Water temperatures during this period varied from 12.1 C to 16.7 C.

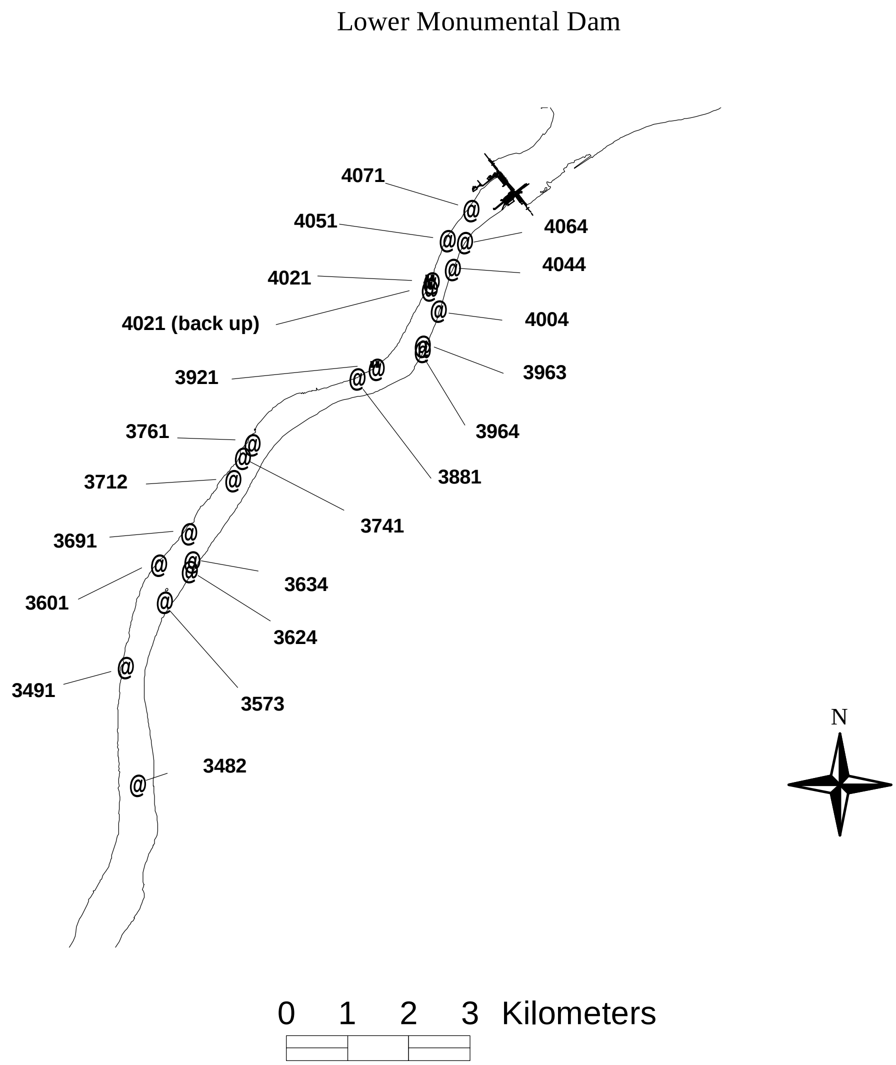

Figure 5. Locations that were sampled with artificial substrates in Ice Harbor Reservoir from 8 May to 9 July, 1997. Locations where white sturgeon eggs were collected are represented by circular symbols. The last digit of the site designation represents position in the channel, with 1 through 4 designating 1/4 channel 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 Snake River.

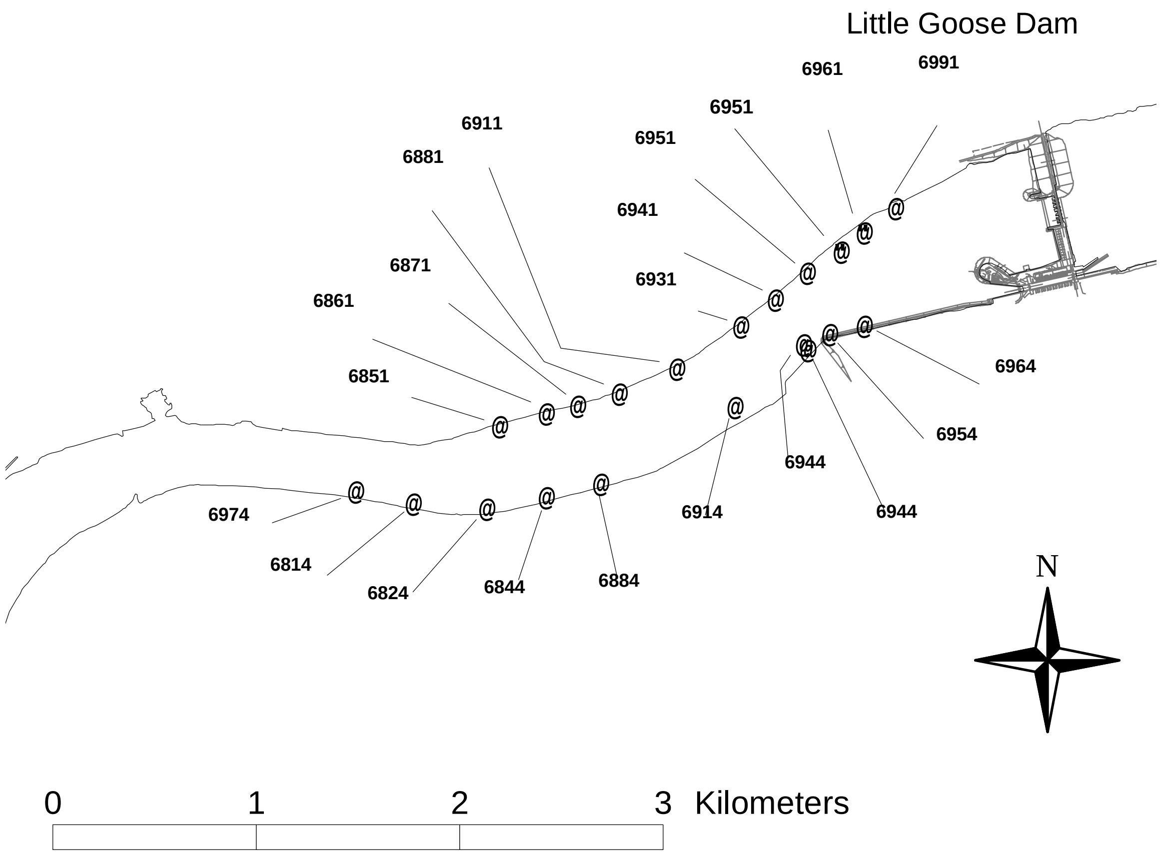

Figure 6. Locations that were sampled with artificial substrates in Lower Monumental Reservoir from 30 April to 10 July, 1997. Locations where white sturgeon eggs were collected are represented as circular symbols. The last digit of the site designation represents position in the channel, with 1 through 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 Snake River.

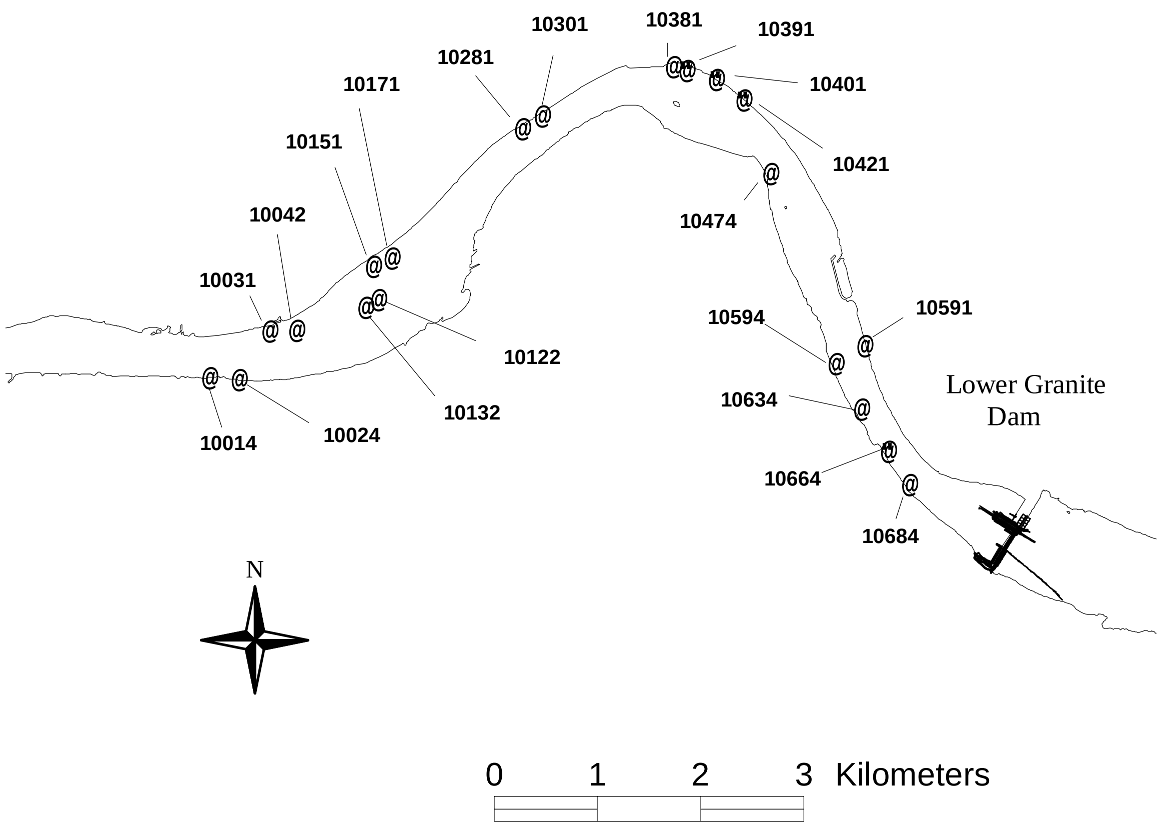

Figure 7. Locations that were sampled with artificial substrates in Little Goose Reservoir from 6 May to 8 July, 1997. Locations where white sturgeon eggs were collected are represented as circular symbols. The last digit of the site designation represents position in the channel, with 1 through 4 designating 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 Snake River.

Table 5. Site designation, area sampled (ha), number of white sturgeon collected, and catch per 2500 m^2 of white sturgeons for the young-of-the-year (YOY) white sturgeon recruitment survey conducted in John Day Reservoir from 6 November to 18 November 1997.

		Number of white sturgeon collected		Catch/2500 m^2	
Site	Area sampled (ha)	All ages	YOY	All ages	YOY
21924	0.553	0	0	0	0
22533	0.540	0	0	0	0
22931	0.505	0	0	0	0
23352	0.484	0	1	0	0.52
24173	0.508	0	2	0	0.98
24324	0.486	0	1	0	0.51
24502	0.264	0	0	0	0
24822	0.528	0	1	0	0.47
25283	0.494	0	1	0	0.51
25623	0.492	0	2	0	1.02
26382	0.492	0	19	0	9.66
26422	0.476	0	4	0	2.10
26803	0.533	0	2	0	0.93
27054	0.503	0	1	0	0.50
27384	0.501	0	5	0	2.50
27851	0.537	0	0	0	0
27974	0.450	0	3	0	1.67
28074	0.483	0	5	0	2.59
28813	0.428	0	0	0	0
28972	0.492	0	0	0	0
Total	9.749	0	47		

Table 6. The number of viable and non-viable white sturgeon eggs collected at sites sampled with artificial substrates in Ice Harbor, Lower Monumental, and Little Goose reservoirs.

		Number of Eggs Collected			
	Site	Viable	Dead or fungused	Unknown	% Dead or fungused
Ice Harbor	3921	5	0		0.0
	4021[a]	11	2		15.4
	Total	16	2	0	11.1
Lower Monumental	6951	15	1		6.3
	6961	8	6		42.9
	Total	23	7	0	23.3
Little Goose	10391	1	0		0.0
	10401	1	0	1	0.0
	10421	247	21	4	7.8
	10664	3	0	1	0.0
	Total	252	21	6	7.7

[a]An additional substrate was fished at this site from 20 May to 3 June.

We collected 247 of the 252 viable eggs on 18 June 1997 from one site (Table 6). The water temperature at the time of the collection was 14.3 C. This site (10421) is on the outside bend of the river approximately 5.2 km downstream from Lower Granite Dam and had very high current velocities during the sampling.

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

The samples collected at the KTEH and the HFCES have been examined and assigned developmental stages. All white sturgeon egg stages described by Beer (1981) were collected during the experiments. The data have been entered into a database and proofed for errors.

Availability of Habitat

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

River discharges and water temperatures that occurred during April through July 1997 provided conditions that should have been very favorable for spawning by white sturgeons. Mean daily river discharges during April through July 1997 were considerably higher than the discharges that have occurred in previous 11 years. Mean daily discharges peaked at 16,442 cubic meters per second on 13 June at John Day Dam; the peak was similar in magnitude and timing at the other dams. As a comparison, mean daily discharges at this dam in 1988 peaked at only 6,730 cubic meters per second. Water temperatures, which define the duration of the spawning period, remained favorable for spawning for an extensive period of time. The number of days that water temperatures were optimal for spawning (13.3 to 15.2 °C) ranged from 22 days downstream from McNary Dam to 27 days downstream from The Dalles Dam. As a result, our monthly estimates of the index of spawning habitat showed that the availability of habitat for spawning peaked in June, and the estimates were much higher for this month than the average of the estimates made since 1985 (Figure 8). Annual estimates of indices of white sturgeon spawning habitat for 1997 were the highest calculated to date (Figure 9). The estimates for 1997 were outside one standard deviation of the average for each spawning area.

McNary Reservoir

We are continuing to work with the USFWS (Report E) to quantify habitats for spawning and rearing within the McNary Reservoir and the free-flowing Columbia River downstream from Priest Rapids Dam and the Snake River downsteam from Ice Harbor Dam. The suitability index curves describing habitat use are being constructed.

Effects of Proposed Reservoir Drawdowns on the Productivity of White Sturgeons

We acquired digital data products of recent aerial photography and digital raster graphics for the John Day Reservoir and the Lower Snake River. These products, in concert with the work done by Parsley and Beckman (1994) which identified and quantified habitat for spawning and rearing

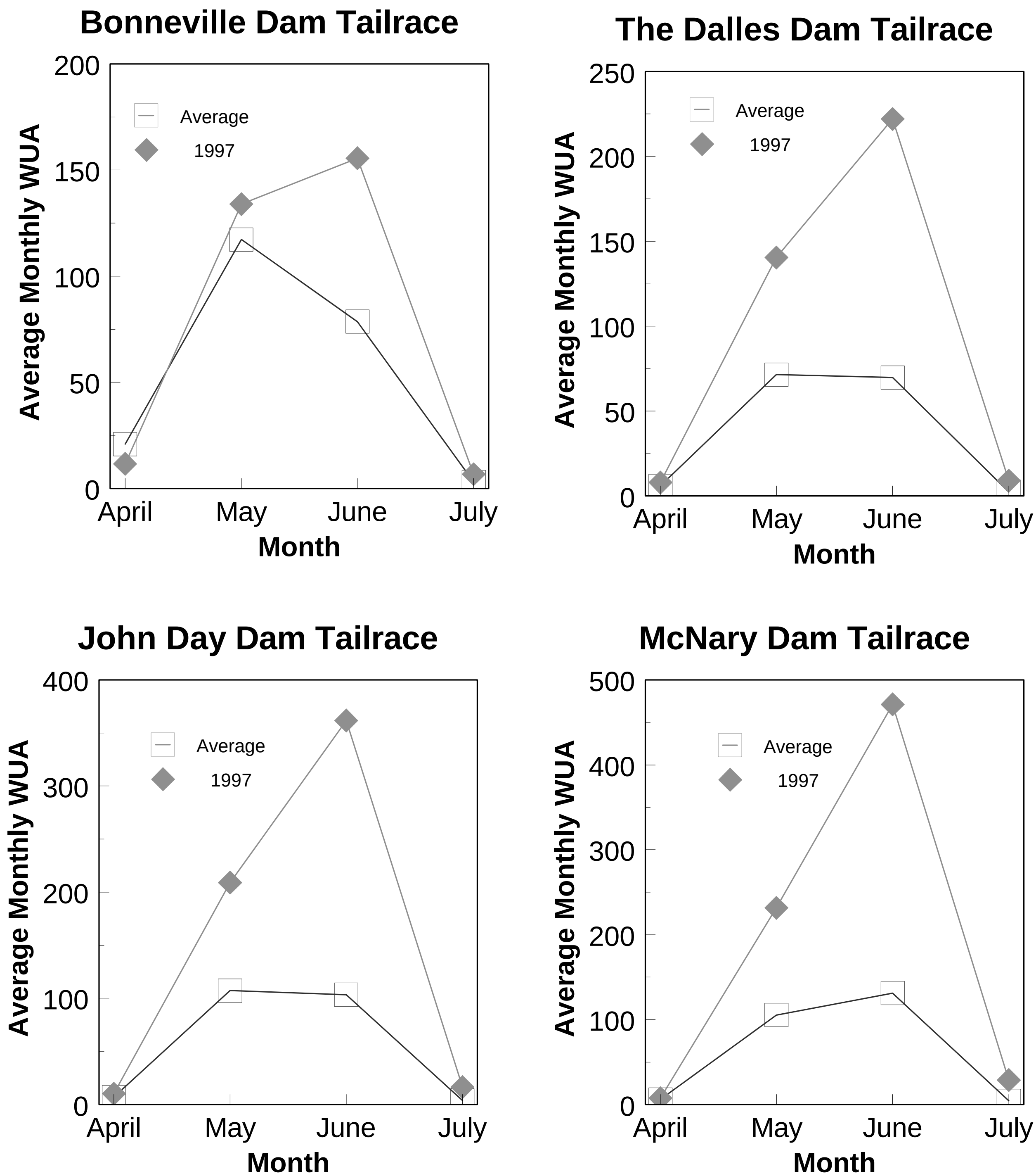

Figure 8. Mean monthly indices of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon during 1997 and the average for 1985 through 1996 for the four spawning areas that have been modeled.

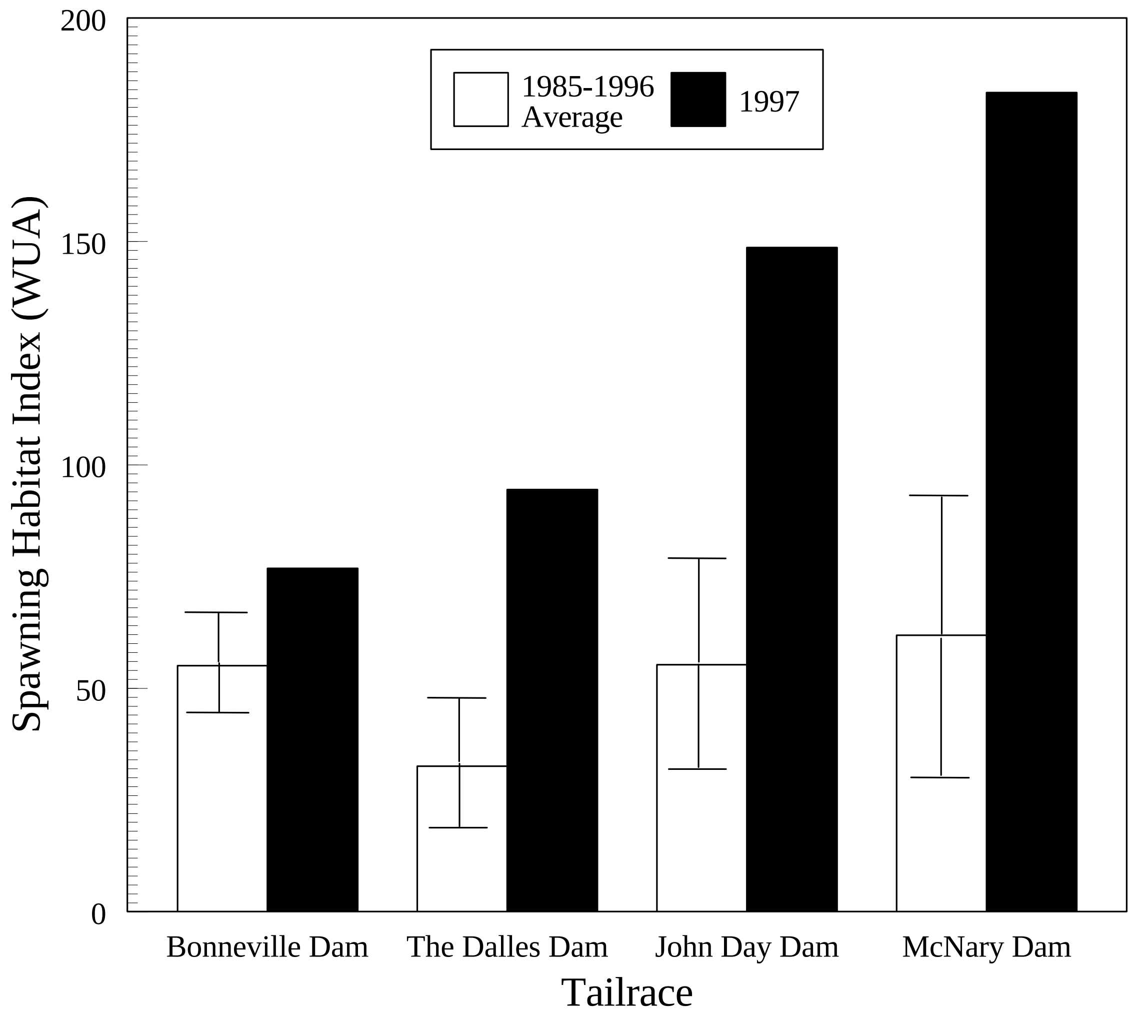

Figure 9. Annual mean composite index of spawning habitat (temperature conditioned weighted usable area (WUA)) for white sturgeon for each of the four dam tailraces that have been modeled (Parsley and Beckman 1994). Shown are the indices for 1997 and the average for 1985 through 1996. The vertical lines within the bars for the averages depict one standard deviation.

white sturgeon in the John Day Reservoir, and work currently underway by the BRD and the U.S. Fish and Wildlife Service (Report E) in the lower Snake River will be used to describe current physical habitat conditions in these areas.

We are also currently capturing historic bathymetry, river shorelines, elevations, and rudimentary substrate information from historic maps of and pre-impoundment aerial photography of the John Day Reservoir. The Army Corps of Engineers, Walla Walla District, is capturing similar information from historic maps of the lower Snake River. This information will be used to describe historic physical habitat conditions in these areas.

DISCUSSION

A variety of habitats are available for white sturgeons that reside in the Columbia and Snake rivers between McNary, Priest Rapids, and Ice Harbor dams (Figure 1). The Columbia River downstream from Priest Rapids Dam (river km 639) is considered free-flowing for approximately 84 km until backwater effects from McNary Dam (river km 470) reduce the water surface gradient and slow the water velocities. The reservoir created by McNary Dam is approximately 85 km in length, and the Snake River enters the reservoir at river km 523.

Habitat use by juvenile white sturgeons in reservoirs was previously investigated by Parsley et al. (1993) who used bottom trawls to capture fish. However, this gear does not capture adult fish, and proved to be ineffective in capturing juvenile fish from areas upstream from McNary Dam (Counihan et al. 1995). Thus, in 1996 we began a two-year study to determine the seasonal habitat use and movements of juvenile and adult white sturgeons residing in the Columbia and Snake rivers between Priest Rapids, Ice Harbor, and McNary dams. Data collection was completed in 1998 and further analysis will be presented in a draft manuscript at a later date.

The bottom trawling for juvenile white sturgeons revealed that recruitment occurred in the Bonneville, Dalles, and John Day reservoirs. In Bonneville Reservoir, the majority (69%) of the white sturgeons captured were juveniles older than YOY, a larger percentage than that seen during the sampling in 1996 (14%; Parsley et al. *in press*); suggesting that the strong year class observed during 1996 is significantly contributing to the number of juveniles older than YOY caught with the bottom trawl in 1997. Further, although we were unable to show statistical significant changes in the indices, both the *Ep* and μ_{cpue} during 1997 were less than that seen in 1996, despite the fact that annual estimates of white sturgeon spawning habitat indices for 1997 were the highest calculated to date. These results suggest a potential density-dependent interaction between the 1996 and 1997 white sturgeon year-class in Bonneville Reservoir. The disparity in the magnitude of change in YOY relative abundance shown by *Ep* and μ_{cpue} is consistent with our previous observations suggesting that *Ep* may underestimate changes in YOY white sturgeon relative abundance at higher levels (Counihan et al. 1996). This underestimation may have affected our ability to detect significant differences in the high relative abundance levels observed during 1996 and 1997.

Catches of YOY with the bottom trawl in The Dalles and John Day reservoirs were the highest since the YOY surveys began and appear to reflect the high estimates of white sturgeon spawning habitat indices in the John Day and McNary tailraces during 1997. Catches of YOY in past bottom trawl surveys conducted in these reservoirs have been sparse. Only three YOY were previously captured during four annual YOY surveys in John Day Reservoir and only 50 YOY were captured during six annual surveys in The Dalles Reservoir.

We provide the first documentation of white sturgeon spawning in Ice Harbor, Lower Monumental, and Little Goose reservoirs of the Snake River. White sturgeon spawning in these reservoirs of the Snake River occurred at water temperatures within the previously reported range of suitable spawning temperatures for white sturgeons (Wang et al. 1985; Parsley and Beckman 1994). Sampling will continue in 1998, and the results will be summarized and reported during 1999.

The experiment examining the relation of the timing of white sturgeon egg development to water temperature will continue during 1998. We will incubate white sturgeon eggs obtained from broodstock from the Kootenai River at water temperatures of 12 C and 15 C and incubate white sturgeon eggs obtained from broodstock from the Columbia River at water temperatures of 12, 15 and 18 C. Samples will be processed during 1998 and the results of this experiment will be analyzed and reported in a manuscript during 1999.

We obtained geospatial data pertinent to the assessment of the potential effects of reservoir drawdowns on the productivity of white sturgeons and coordinated with other agencies performing similar analyses. This work will continue and we will provide a report describing activities done in fiscal year 1999. A recent report by Hanrahan et al. (1998) exemplifies the use of a geographic information system to assess drawdown of the lower Snake River from a geomorphic perspective. Our final report will draw heavily from this and other work that is currently underway in the Columbia River Basin.

Plans for 1998

In 1998, the Biological Resources Division will continue to index the recruitment of white sturgeons to YOY in the Bonneville, The Dalles, and John Day reservoirs and conduct the assessment of the potential effects of reservoir drawdowns on the productivity of white sturgeons. We will also proceed with the analyses and preparation of manuscripts for studies completed during 1998. The Biological Resources Division will initiate one new study in 1999. Biotelemetry will be used to investigate the behavior of sexually mature white sturgeons in The Dalles Reservoir of the Columbia River to determine the effects of short-term dam operations on white sturgeon spawning. The work in 1999 will be a pilot study to develop techniques that will be used in subsequent years.

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APPENDIX C-1

Influence of Externally Attached Transmitters on the Swimming Performance of Juvenile White sturgeon

by

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This manuscript has been accepted for publication as a note in the journal *Transactions of the American Fisheries Society* (American Fisheries Society, Bethesda, Maryland, USA). Reprints should be available by the time this Annual Progress Report is distributed. Therefore, we have elected to not reproduce the text here. Please contact the authors at the address listed above for a reprint of the original journal article.

APPENDIX C-2

Site designation, latitude, longitude, total time sampled, and catch of white sturgeon eggs at sites sampled with artificial substrates in Ice Harbor Reservoir (IH). Sampling occurred from 8 May through 9 July 1997 in Ice Harbor Reservoir. The North American Datum of 1927 (NAD27) was used as the datum for all recorded latitudes and longitudes. The last digit of the site designation represents position in the channel, with 1 through 4 designating 1/4 channel width increments from left to right while facing upstream. Digits preceding the last number represent river miles (RM) to the nearest 0.1 mile from the mouth of the Snake River. When sampling effort exceeded the estimated time from fertilization to hatch for a particular temperature, the effort was recorded as the incubation time. For example, if a substrate was fished for 7 days at a temperature of 17°C, the effort was recorded as the incubation time (137 h) and not 168 h of elapsed time.

Reservoir	Site	Latitude (N)	Longitude (W)	Days sampled	Eggs
IH	3482	46 28.533	118 37.178	54	0
IH	3491	46 29.578	118 37.296	54	0
IH	3573	46 30.145	118 36.776	54	0
IH	3601	46 30.475	118 36.840	54	0
IH	3624	46 30.410	118 36.450	54	0
IH	3634	46 30.492	118 36.415	54	0
IH	3691	46 30.744	118 36.448	54	0
IH	3712	46 31.201	118 35.865	54	0
IH	3741	46 31.400	118 35.739	54	0
IH	3761	46 31.517	118 35.610	54	0
IH	3881	46 32.072	118 34.245	55	0
IH	3921	46 32.156	118 33.997	55	5
IH	3964	46 32.305	118 33.404	55	0
IH	3963	46 32.346	118 33.404	55	0
IH	4004	46 32.654	118 33.188	55	0
IH	4021	46 32.903	118 33.265	54	13
IH	4044	46 33.021	118 32.995	55	0
IH	4051	46 33.273	118 33.044	48	0
IH	4071	46 33.538	118 32.738	48	0

APPENDIX C-3

Site designation, latitude, longitude, total time sampled, and catch of white sturgeon eggs at sites sampled with artificial substrates in Lower Monumental Reservoir (LM). Sampling occurred from 30 April through 10 July 1997 in Lower Monumental Reservoir. The North American Datum of 1927 (NAD27) was used as the datum for all recorded latitudes and longitudes. The last digit of the site designation represents position in the channel, with 1 through 4 designating 1/4 channel width increments from left to right while facing upstream. Digits preceding the last number represent river miles (RM) to the nearest 0.1 mile from the mouth of the Snake River. When sampling effort exceeded the estimated time from fertilization to hatch for a particular temperature, the effort was recorded as the incubation time. For example, if a substrate was fished for 7 days at a temperature of 17 C, the effort was recorded as the incubation time (137 h) and not 168 h of elapsed time.

Reservoir	Site	Latitude (N)	Longitude (W)	Days sampled	Eggs
LM	6974	46 34.412	118 04.445	66	0
LM	6814	46 34.373	118 04.214	63	0
LM	6824	46 34.352	118 03.920	66	0
LM	6844	46 34.380	118 03.678	53	0
LM	6884	46 34.413	118 03.459	66	0
LM	6914	46 34.614	118 02.907	66	0
LM	6944	46 34.782	118 02.625	46	0
LM	6944	46 34.765	118 02.607	44	0
LM	6954	46 34.809	118 02.518	66	0
LM	6964	46 34.828	118 02.377	66	0
LM	6851	46 34.580	118 03.858	63	0
LM	6861	46 34.613	118 03.667	63	0
LM	6871	46 34.631	118 03.540	63	0
LM	6881	46 34.662	118 03.373	63	0
LM	6911	46 34.726	118 03.136	63	0
LM	6931	46 34.838	118 02.874	63	0
LM	6941	46 34.908	118 02.733	63	0
LM	6951	46 34.981	118 02.600	63	0
LM	6951	46 35.036	118 02.641	67	16
LM	6961	46 35.087	118 02.365	67	14
LM	6991	46 35.152	118 02.237	19	0

APPENDIX C-4

Site designation, latitude, longitude, total time sampled, and catch of white sturgeon eggs at sites sampled with artificial substrates in Little Goose Reservoir (LG). Sampling occurred from 6 May through 8 July 1997 in Little Goose Reservoir. The North American Datum of 1927 (NAD27) was used as the datum for all recorded latitudes and longitudes. The last digit of the site designation represents position in the channel, with 1 through 4 designating 1/4 channel width increments from left to right while facing upstream. Digits preceding the last number represent river miles (RM) to the nearest 0.1 mile from the mouth of the Snake River. When sampling effort exceeded the estimated time from fertilization to hatch for a particular temperature, the effort was recorded as the incubation time. For example, if a substrate was fished for 7 days at a temperature of 17 C, the effort was recorded as the incubation time (137 h) and not 168 h of elapsed time.

Reservoir	Site	Latitude (N)	Longitude (W)	Days sampled	Eggs
LG	10014	46 40.590	117 31.736	59	0
LG	10024	46 40.575	117 31.514	59	0
LG	10031	46 40.823	117 31.266	59	0
LG	10042	46 40.820	117 31.062	59	0
LG	10281	46 41.828	117 29.291	59	0
LG	10301	46 41.893	117 29.136	59	0
LG	10381	46 42.123	117 28.127	44	0
LG	10391	46 42.101	117 28.022	61	1
LG	10401	46 42.048	117 27.805	61	2
LG	10421	46 41.936	117 27.600	61	272
LG	10474	46 41.546	117 27.418	61	0
LG	10591	46 40.628	117 26.755	61	0
LG	10594	46 40.538	117 26.976	61	0
LG	10634	46 40.297	117 26.798	42	0
LG	10664	46 40.070	117 26.607	25	4
LG	10684	46 39.893	117 26.455	25	0

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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

Report D

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

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

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February 1999

CONTENTS

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ABSTRACT

In September 1997, the National Marine Fisheries Service (NMFS) sampled juvenile white sturgeon (*Acipenser transmontanus*) in the Columbia River downstream from Bonneville Dam (River Mile (RM) 145). We collected 307 juvenile white sturgeon, including 50 young-of-the-year (YOY), with a 7.9-m (headrope length) semiballoon shrimp trawl between RM 28 and 132. The distribution of juvenile white sturgeon was patchy. The YOY white sturgeon comprised about 16% of the total catch of juvenile white sturgeon. Densities (number/hectare) of YOY white sturgeon at 13 index sampling stations averaged 3.8 fish/hectare during the first survey (2-9 September) and 6.0 fish/hectare during the second survey (15-18 September); the mean for both surveys combined was 4.9 fish/hectare. Densities of YOY white sturgeon at the 13 index trawling stations in mid September 1997 (second survey) were not significantly different ($P > 0.05$) from densities at the same sites in mid to late September 1991, 1993, 1994, 1995, and 1996 ($n = 13$ for each year). However, there was a significant difference ($P < 0.05$) in densities of YOY white sturgeon at the 13 index trawling stations between years if data from two September surveys (early and mid/late) in 1993, 1994, 1995, 1996, and 1997 were used in the analysis ($n = 26$ for each year); the lowest mean density occurred in September 1994. The mean fork length of YOY white sturgeon collected in September 1997 was significantly less than those of YOY collected in September 1993, 1994, and 1995 ($P < 0.05$). Mean lengths of YOY collected in September 1996 and 1997 were not significantly different ($P > 0.05$).

INTRODUCTION

Under an agreement with the Oregon Department of Fish and Wildlife (ODFW), the National Marine Fisheries Service (NMFS) conducted research to describe the reproductive and early life history characteristics of white sturgeon downstream from Bonneville Dam. This reach was used as a control area for Phase I of the White Sturgeon Study (1986-1992) and is being used in a similar manner for Phase II (1992-1997). Data collected in the control area will be used in conjunction with data from upstream impoundments to help determine the effects of the development and operation of the hydroelectric system on white sturgeon spawning and recruitment. The primary goal for 1997 was to estimate the relative success of young-of-the-year (YOY) white sturgeon recruitment in 1997 in the Columbia River downstream from Bonneville Dam. Additionally, I compared catches, geographic distribution, and the mean length of YOY white sturgeon sampled in 1997 to catches, geographic distributions, and mean lengths of YOY in previous years.

METHODS

Juvenile Sampling

A 7.9-m (headrope length) semiballoon shrimp trawl, identical to that used from 1987 through 1996, was used to collect juvenile white sturgeon, including YOY. Mesh size in the trawl was 38 mm (stretched measure) in the body; a 10-mm mesh liner was inserted in the cod end of the net. Shrimp trawl efforts were usually 5 to 6 min in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable were deployed, and the effort was considered ended when 5 to 6 min had elapsed. We estimated the distance the net fished during each sampling effort using a radar range-finder.

To describe juvenile white sturgeon characteristics in 1997, trawling was conducted during two surveys in September at 36 sampling stations established during Phase I of the White Sturgeon Study in the lower Columbia River between River Mile (RM) 28 and 132. The sampling stations were originally selected primarily to determine habitat use by juvenile white sturgeon; no attempt was made to randomly select the stations. In some areas, two or three trawling efforts were completed along parallel transects. Transect 1 was closest to the Washington shore, Transect 2 was the middle transect, and Transect 3 was closest to the Oregon shore. Thirteen of the 36 sampling stations were selected as index sites for estimating YOY white sturgeon densities in the lower Columbia River (Figure 1).

Fishes captured in the shrimp trawls were identified and counted. White sturgeon from each sampling effort were measured (total and fork lengths (mm)) and weighed (g). Small YOY sturgeon (those less than about 150 mm fork length) do not have distinct forks in their tails; therefore I estimated their fork lengths to ensure consistency in data analysis. In previous years, all length comparisons of older juveniles were done using fork lengths, since natural total lengths are much less accurate. On older juvenile sturgeon (those with a fork in their tails), I observed that the distal end of an imaginary line, extended along the lateral row of scutes (before it turns upward) onto the caudal fin, approximated the location of the fork. I routinely examined juvenile white

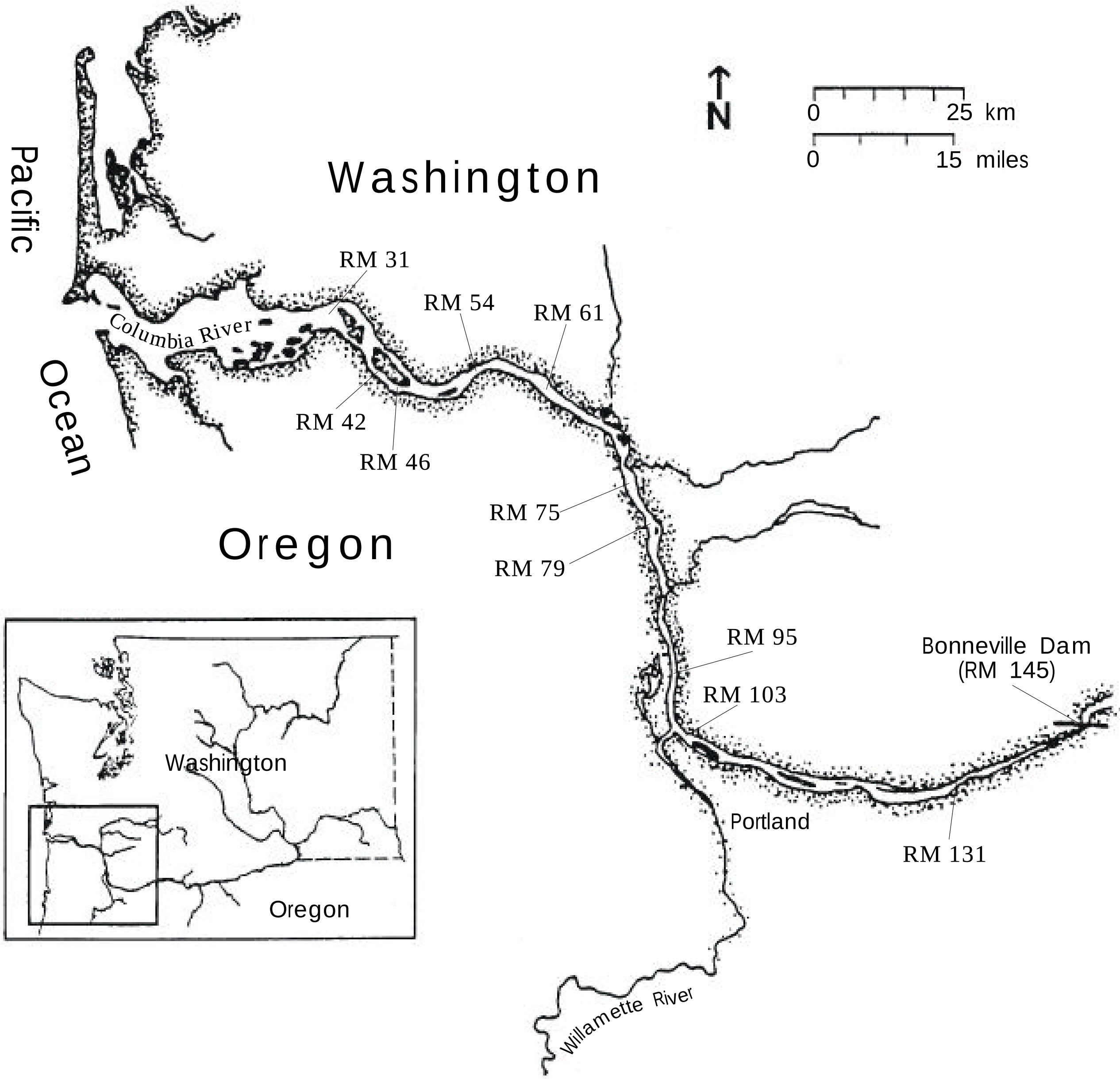

Figure 1. Location of the white sturgeon study area in the Columbia River downstream from Bonneville Dam. The specific locations of the thirteen index trawling stations are shown; at RMs 79, 95, and 131 two stations were sampled. No sampling was done at RM 145.

sturgeon longer than 174 mm fork length for the nematode parasite *Cystoopsis acipenseri* (Chitwood and McIntosh 1950; McCabe 1993). When present, the parasite is encased in blister-like cysts under the skin.

Physical Conditions

The following physical parameters were measured in conjunction with juvenile sturgeon sampling in September 1997: bottom depth (m) (minimum and maximum), bottom-water temperature (°C), and bottom-water turbidity (NTU). Depth was measured with an electronic depth sounder. A Van Dorn water bottle was used to collect water samples just above the bottom. The water temperature of each sample was measured immediately after collection, and a subsample of water was removed and placed in a glass bottle. The turbidity of the sample was determined in the laboratory using a Hach Model 2100A Turbidimeter[1]. All physical and accompanying fish catch data are available upon request from NMFS, Northwest Fisheries Science Center, Point Adams Biological Field Station, P.O. Box 155, Hammond, Oregon 97121.

Data Analyses

Physical and biological data collected during September 1997 were entered into computer files following formats agreed to by the original cooperating agencies involved in the White Sturgeon Study: Biological Resources Division (U.S. Geological Survey), ODFW, NMFS, and the Washington Department of Fish and Wildlife.

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

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

Densities of YOY white sturgeon captured at the 13 index trawling stations in the second survey (15-18 September 1997) were compared to data collected during similar time periods in 1991, 1993, 1994, 1995, and 1996 (n = 13 for each year) using the nonparametric Kruskal-Wallis test (Cruze and Hartzell 1991). In addition, densities of YOY white sturgeon at the 13 index trawling stations from two September surveys (early and mid/late) in 1993, 1994, 1995, 1996, and 1997 were compared (n = 26 for each year); data from 1991 were not included in this analysis because only one complete survey was conducted in September 1991. The mean length of all YOY white sturgeon collected in September 1997 was compared to similar data collected in 1993, 1994, 1995, and 1996 using analysis of variance (ANOVA). The Fisher's Protected Least Significant Difference (FPLSD) multiple comparison procedure was used to compare means in the ANOVA (Petersen 1985).

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

RESULTS

Juvenile Characteristics

During two surveys at 36 sampling stations in September 1997, 307 juvenile white sturgeon were collected between RM 28 and 132. Distribution of juvenile white sturgeon in this section of the river was patchy. The YOY group was the only age group that was easily discernible in a length-frequency histogram, as there was overlap in the lengths of the older age groups (Figure 2). The mean fork length (± SD) and weight (± SD) of 50 YOY white sturgeon collected were 139 mm (± 36 mm) and 22 g (± 18 g), respectively. Variations in the lengths and weights of YOY were considerable--lengths ranged from 77 to 216 mm and weights ranged from 3 to 71 g. The 50 YOY white sturgeon were collected between RM 28 and 103; YOY comprised about 16% of the total catch of juvenile white sturgeon.

Sixty (23%) of 258 juvenile white sturgeon were infected with the nematode parasite *Cystoopsis acipenseri*. The mean fork length of infected fish was 324 mm, with a range from 257 to 456 mm.

Young-of-the-Year Comparisons Among Years

In 1997, densities of YOY white sturgeon at 13 index sampling stations averaged 3.8 fish/hectare during the first survey (2-9 September) and 6.0 fish/hectare during the second survey (15-18 September); the mean for both surveys combined was 4.9 fish/hectare (Table 1). Densities of YOY white sturgeon at 13 index trawling stations in mid September 1997 (second survey) were not significantly different (Kruskal-Wallis, $P = 0.44$) from densities at the same sites in mid to late September 1991, 1993, 1994, 1995, and 1996 ($n = 13$ for each year). No sampling was conducted in September 1992. Densities at the 13 stations averaged 6.7, 9.0, 2.3, 11.0, 11.7, and 6.0 YOY/hectare in 1991, 1993, 1994, 1995, 1996, and 1997, respectively (Table 2). However, there was a significant difference (Kruskal-Wallis, $P = 0.01$) in densities of YOY white sturgeon at the 13 index trawling stations between years if data from two September surveys (early and mid/late) in 1993, 1994, 1995, 1996, and 1997 were used in the analysis ($n = 26$ for each year); the lowest mean density occurred in September 1994.

Young-of-the-year white sturgeon were collected over a smaller geographic area in 1997 than in September 1991, 1993, 1995, and 1996 (includes all sampling data from September of all years). In September 1991, 1993, 1995, and 1996, YOY white sturgeon were collected between RM 28 and 131/132. However, in 1997, YOY white sturgeon were collected only between RM 28 and 103; in 1994, YOY were only collected between RM 61 and 132. In 1997, as in 1991, 1993, 1995, and 1996, the side channel near Goble, Oregon (RM 75), was a productive sampling site for YOY white sturgeon. No YOY white sturgeon were captured at this site in September 1994.

The mean fork length of YOY white sturgeon collected in September 1997 (mean = 139 mm) was significantly less than those of YOY collected in September 1993 (mean = 182 mm), 1994 (mean = 196 mm), and 1995 (mean = 177 mm) (ANOVA, $P = 0.00$; FPLSD). Mean lengths of YOY collected in September 1996 (mean = 147 mm) and 1997 were not significantly different ($P > 0.05$).

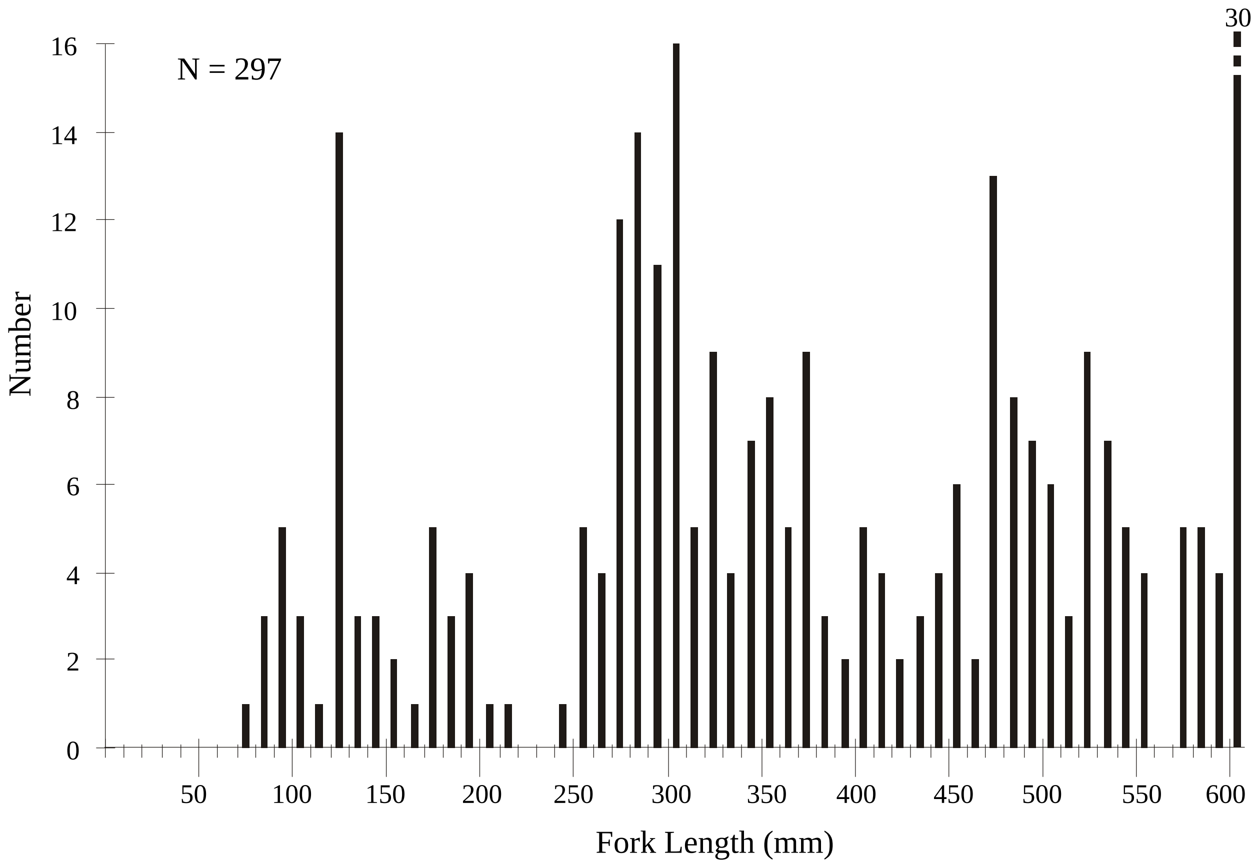

Figure 2. Length-frequency histogram for juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam, 1997. White sturgeon longer than 600 mm are included in the 600-mm interval.

Table 1. Catches of young-of-the-year white sturgeon in September 1997 at 13 sampling stations in the Columbia River downstream from Bonneville Dam. Each value represents the results from one trawling effort. Location is shown in River Mile (RM); in some instances a transect number is shown when parallel trawling efforts were done at the same RM.

Location (RM)	2-9 September		15-18 September	
	Number	Number/hectare	Number	Number/hectare
31	0	0	2	7
42	0	0	0	0
46	1	5	0	0
54	0	0	2	6
61	0	0	0	0
75	6	24	6	23
79-1	1	4	1	4
79-2	2	7	6	23
95-1	1	3	0	0
95-2	0	0	1	4
103	2	7	3	11
131-1	0	0	0	0
131-2	0	0	0	0
Mean	1.0	3.8	1.6	6.0

Table 2. Densities (number/hectare) of young-of-the-year white sturgeon in mid to late September 1991 and 1993-1997 at 13 sampling stations in the Columbia River downstream from Bonneville Dam. Each value represents the results from one trawling effort. Location is shown in River Mile (RM); in some instances a transect number is shown when parallel trawling efforts were done at the same RM.

Location (RM)	1991	1993	1994	1995	1996	1997
31	12	0	0	10	23	7
42	0	0	0	0	5	0
46	0	6	0	4	0	0
54	0	15	0	0	17	6
61	6	5	6	14	0	0
75	48	18	0	77	102	23
79-1	5	35	0	8	0	4
79-2	8	9	0	4	0	23
95-1	4	0	4	0	0	0
95-2	0	0	4	0	0	4
103	0	5	12	26	0	11
131-1	0	15	4	0	0	0
131-2	4	9	0	0	5	0
Mean	6.7	9.0	2.3	11.0	11.7	6.0

DISCUSSION

It is uncertain why YOY white sturgeon were significantly shorter in 1997 than in 1993, 1994, and 1995. Possible causes of the shorter mean length observed in 1997 include one or more of the following: 1) later spawning in 1997, 2) slower growth during the larval and postlarval stages, and 3) unsuccessful recruitment from eggs spawned during the early part of the spawning period. No sampling was conducted for white sturgeon eggs and larvae during the spawning period in 1997. However, the water temperature at Bonneville Dam reached 10°C by 23 April. Spawning of white sturgeon downstream from Bonneville Dam occurs at water temperatures ranging from 10 to 19°C, with the spawning period extending from late April or early May through late June or early July (McCabe and Tracy 1994). In 1997, water temperatures during the spawning period were generally slightly less than those during 1993, 1994, and 1995 (Table 3). The lower water temperatures in 1997 (April-July) may have delayed peak spawning and slowed the growth of white sturgeon larvae and postlarvae. In 1997, river flows throughout the spawning and larval dispersal periods were higher than those during 1993, 1994, and 1995 (Table 3). Food resources for postlarval sturgeon may have been less abundant in 1997 than in the previous years. Possibly, the higher river flows in 1997 reduced the abundance of benthic invertebrates, the primary prey of YOY white sturgeon (Muir et al. 1988), in rearing areas by scouring more benthic invertebrates out of rearing areas than in 1993, 1994, and 1995.

River temperatures during the April-August period in 1996 and 1997 were generally similar; however, river flows were higher in 1997 than in 1996. Similar to data collected in 1997, the mean length of YOY white sturgeon collected in September 1996 was significantly less ($P < 0.05$) than those of YOY collected in September 1993, 1994, and 1995.

Table 3. Summaries of river conditions at Bonneville Dam from April through August, 1993-1997 (U.S. Army Corps of Engineers). Each value is an average for the specific month shown.

Year	April	May	June	July	August
			Water temperature (°C)		
1993	11.4	13.8	16.6	19.0	20.8
1994	10.7	14.7	16.8	20.4	22.0
1995	10.1	13.8	16.9	20.3	20.9
1996	9.4	12.4	15.7	19.7	20.9
1997	9.0	12.3	15.3	19.2	22.1
			Bonneville Dam discharge ($m^3/s \times 1{,}000$)		
1993	4.61	8.45	6.46	4.73	3.41
1994	4.36	6.00	5.52	4.31	2.68
1995	5.28	7.54	8.02	5.72	4.17
1996	9.36	9.94	10.90	7.02	5.35
1997	9.51	12.91	13.68	7.85	5.74

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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

Report E

Quantify physical habitat used by spawning and rearing white sturgeon in the free-flowing portion of the Columbia River between McNary Reservoir and Priest Rapids Dam and in the free-flowing portions of the Snake River between McNary Reservoir and Lower Granite Dam

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

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ACKNOWLEDGMENTS

We would like to acknowledge the effort of our field personnel including Dan Magneson, 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.

ABSTRACT

The U.S. Fish and Wildlife Service initiated data collection for new study areas in both the Columbia and Snake rivers during 1997, and continued data collection in the Snake River downstream from Ice Harbor Dam for white sturgeon (*Acipenser transmontanus*) habitat quantification. Reconnaissance and study design were completed, and data collection was initiated for 43 cross sections in the White Bluffs Island Complex in the Hanford Reach of the Columbia River, and for 12, 10, and 15 cross sections, respectively, in the Lower Monumental, Little Goose, and Lower Granite tailraces in the Snake River. Data collection was also initiated for 10 cross sections around the four islands in the Ice Harbor tailrace. Cross section profile and velocity distribution data were collected at 51 cross sections, and 126 stage-discharge data pairs were collected at 90 cross sections. Data were collected at total river discharges ranging from 3,317 to 9,152 m^3/s in the Columbia River, and 1,528 to 3,379 m^3/s in the Snake River. Approximately 700 total stage-discharge data points, including 177 for the current year, have been collected for calibration of hydraulic models. Cross section profiles, velocity distributions, and stage-discharge data pairs were added to data files for existing cross sections, or used to build new data files for new cross sections. Calibration of hydraulic models for main channel cross sections in the Hanford Reach neared completion. An evaluation of the Columbia River hydrograph for time-series analysis revealed at least two distinct patterns within the period of record. Historically, the hydrograph was seasonal, with a significant spring freshet and low winter flows. During recent years, the hydrograph has become more constant and less seasonal as a result of hydropower and water storage development in the basin. An agreement was made with the Corps of Engineers to use their existing step-backwater models to derive water surface elevations for the habitat assessment in the Snake River study areas. Using the existing models will result in significant cost and time savings over developing new models with empirical data. A review of the project and work conducted over the past four years is presented to assist readers not familiar with previous years work with interpretation of the material presented in this report.

INTRODUCTION

This annual report describes the progress made by the U.S. Fish and Wildlife Service (USFWS) from 1 April 1997 to 31 March 1998 towards completion of our 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. This report also provides a review of work conducted between 1 October 1993 and 31 March 1997, which, together with work completed to date, comprises the entire field data collection effort for the habitat assessment. The habitat assessment was designed to address Objective 2, Task 2.2 from the 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 specific areas:

1) Spawning and rearing habitat in the free-flowing portion 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;

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

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

1) Measurement of horizontal and vertical profiles for cross sections in the White Bluffs Island Complex (WBIC) in the Columbia River, and for cross sections around the islands downstream from Ice Harbor Dam in the Snake River;

2) Measurement of cross section velocity distributions and water surface elevation (stage)-discharge data pairs for the WBIC and all Snake River tailrace areas;

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

4) 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;

5) Hydraulic model calibration and hydraulic modeling for both the Columbia and Snake rivers.

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). Hydraulic and habitat modeling algorithms and other data processing functions have been re-programmed into a user-friendly, menu-driven software package known as Riverine Habitat Simulation (RHABSIM)[1]. RHABSIM is fully compatible with PHABSIM and provides the same capabilities in addition to many enhancements, particularly graphics (Payne 1994). The RHABSIM system was used in place of PHABSIM for data entry, hydraulic model calibration, and hydraulic simulations, and will continue to be used throughout this analysis for hydraulic and habitat modeling. Sampling design, field methods, and data collection protocols are discussed in detail in the 1993, 1994, 1995, and 1996 Annual Reports (Anglin 1995, Anglin 1996, Anglin et al. *In press a*, Anglin et al. *In press b*).

Hydraulic data collection, which began in 1994, was completed during 1996 for main channel sections of the Columbia River between the White Bluffs boat ramp near RM 368 and Priest Rapids Dam (RM 397). Data collection continued for main channel cross sections in the Snake River between McNary Pool (RM 4.5) and Ice Harbor Dam (RM 9.7) (Figure 1).

Hydraulic data collection was initiated in several new areas during 1997. Set-up and data collection began for 43 cross sections in the White Bluffs Island Complex (WBIC) in the Hanford Reach, for 10 cross sections around the islands downstream from Ice Harbor Dam, and for 12, 10, and 15 cross sections in the tailrace areas downstream from Lower Monumental, Little Goose, and Lower Granite dams, respectively. River segmentation and cross section placement for both the main channel segments and the WBIC in the Hanford Reach are shown in Figure 2. River segmentation and cross section placement procedures for the main channel portions of the Reach are discussed in greater detail in the 1994 Annual Report (Anglin 1996), and sampling design and cross section placement for the WBIC are discussed in the 1996 Annual Report (Anglin et al. *In press b*). General locations of the Snake River tailrace study areas are shown in Figure 3. Cross section placement for the tailrace areas (Figures 4 and 5) was determined based on reconnaissance surveys conducted during 1996, and is also discussed in the 1996 Annual Report.

Data Analysis

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 then 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,

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

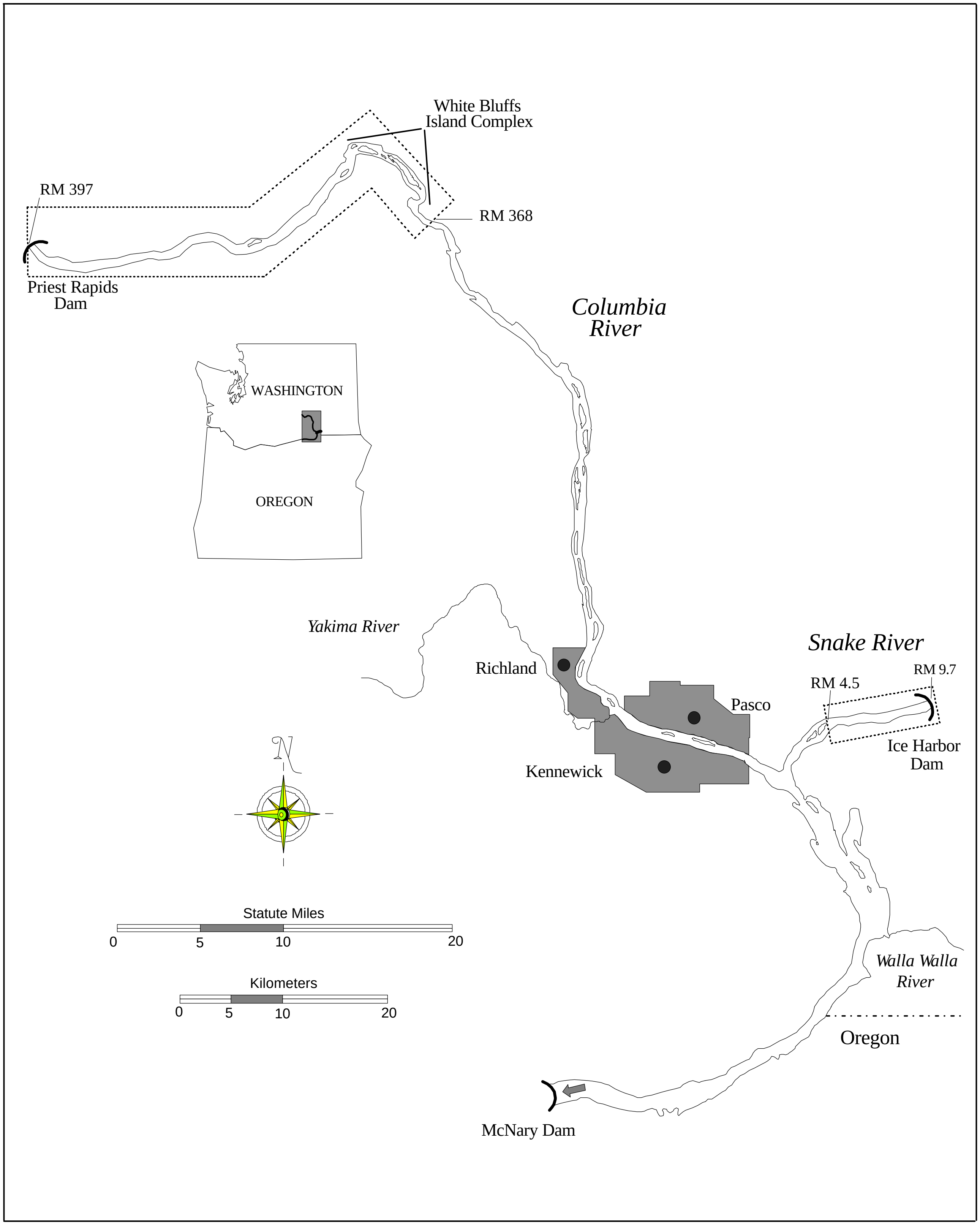


Figure 1. Location of study area between White Bluffs and Priest Rapids Dam on the Columbia River and downstream from Ice Harbor Dam on the Snake River.

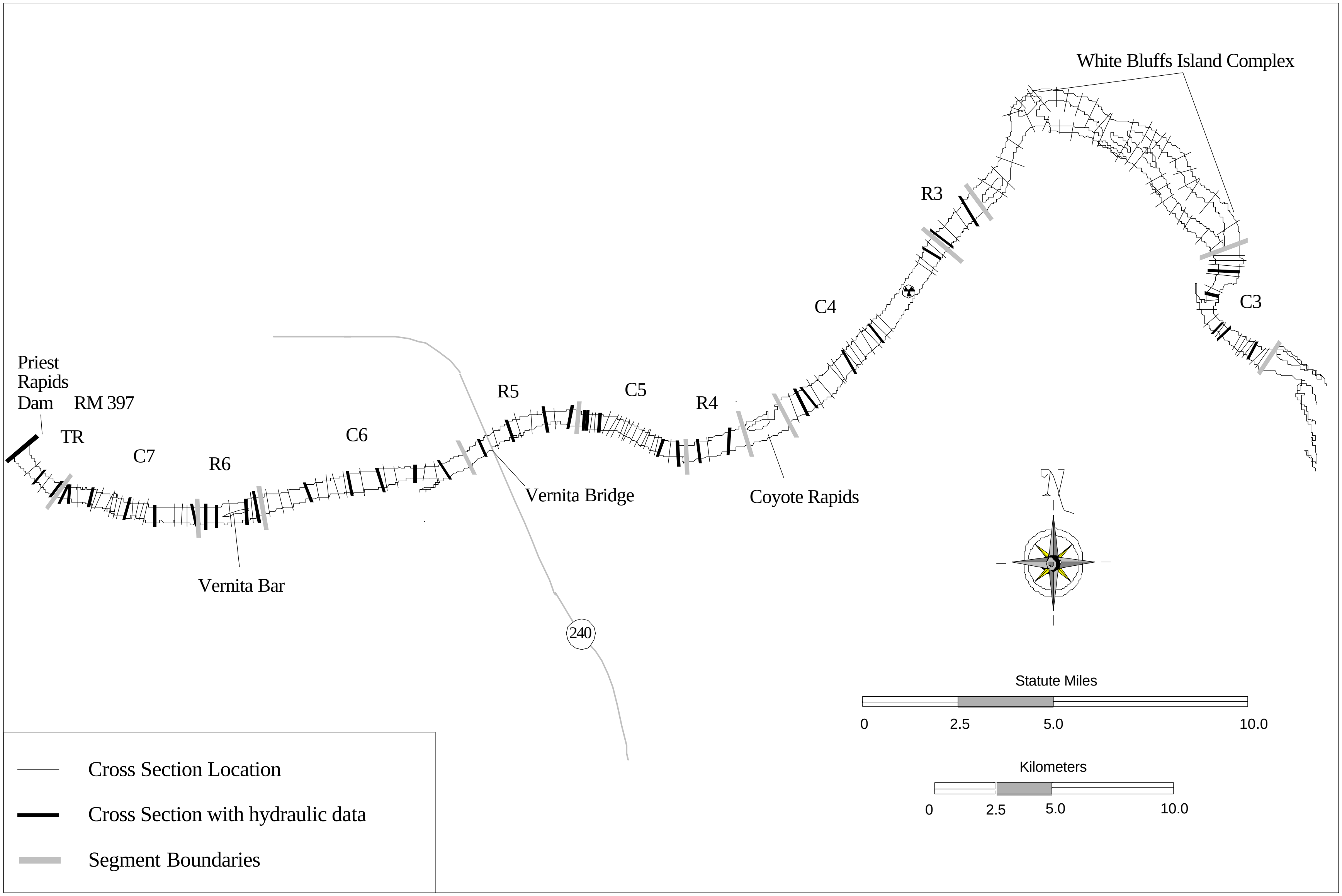


Figure 2. Cross section placement in the Hanford Reach. Hydraulic data for bold cross sections can be found in Figures 8 - 47.

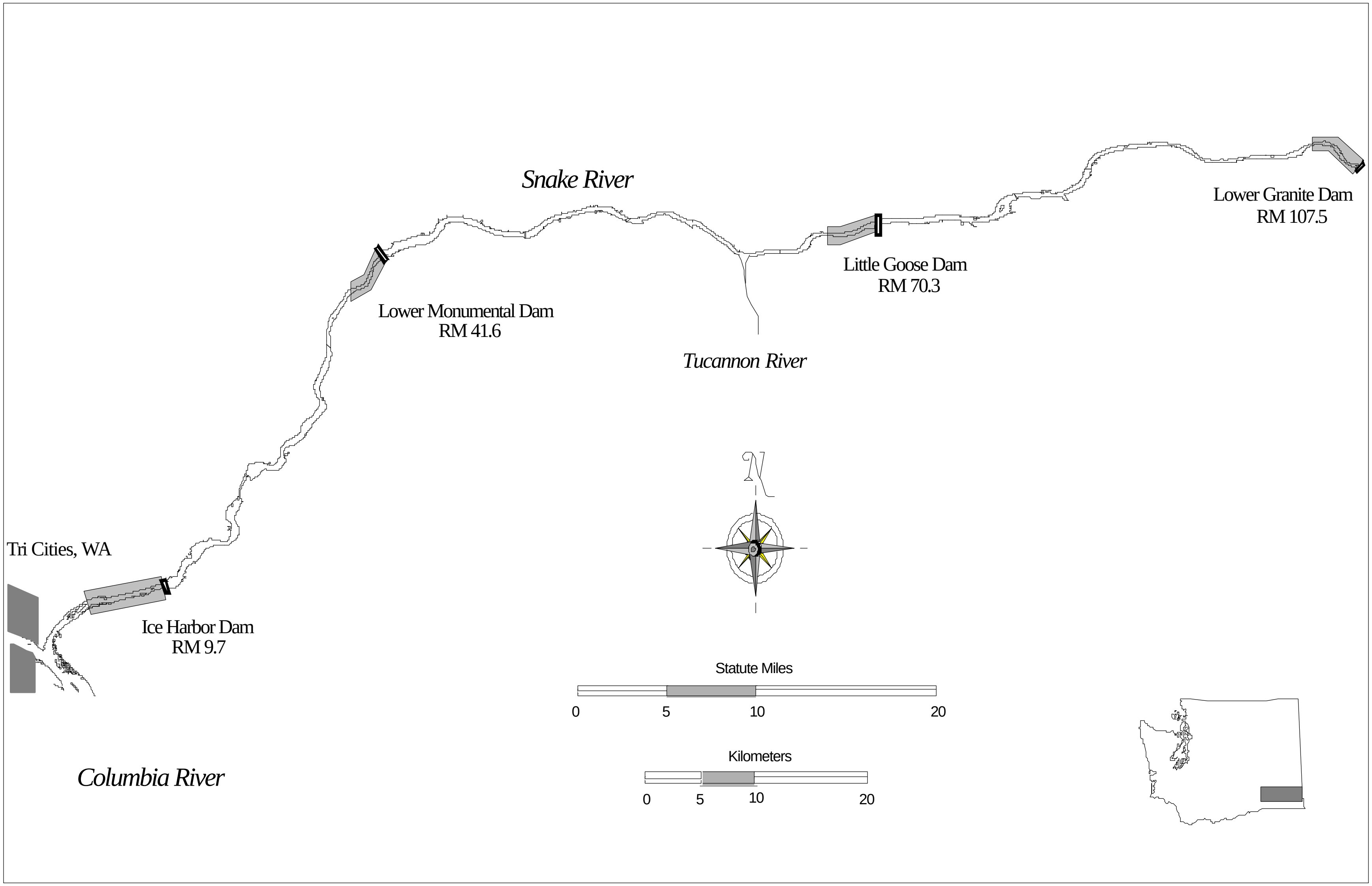


Figure 3. Lower Snake River with tailrace study areas indicated.

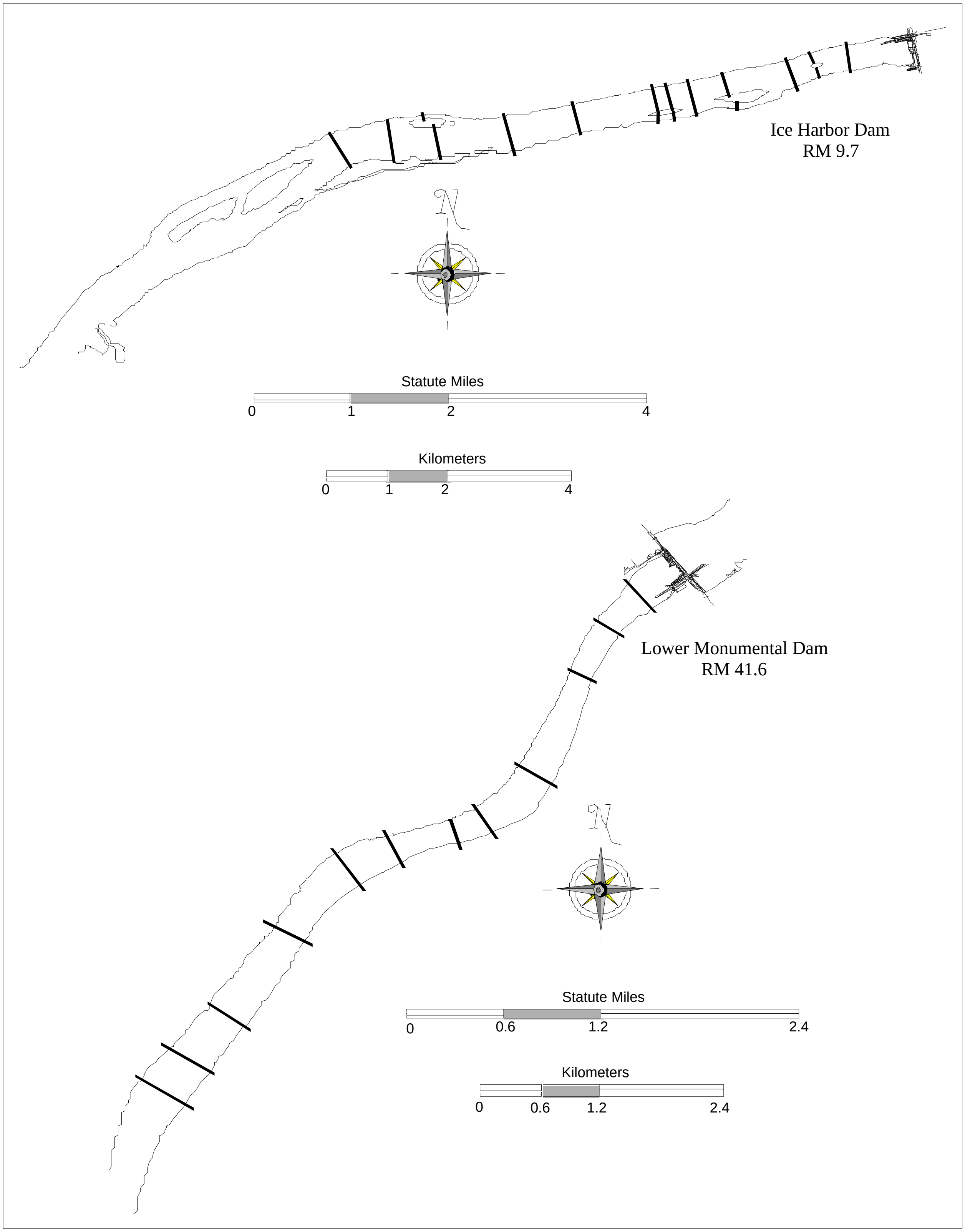


Figure 4. Cross section placement at Ice Harbor and Lower Monumental dams tailraces on the lower Snake River.

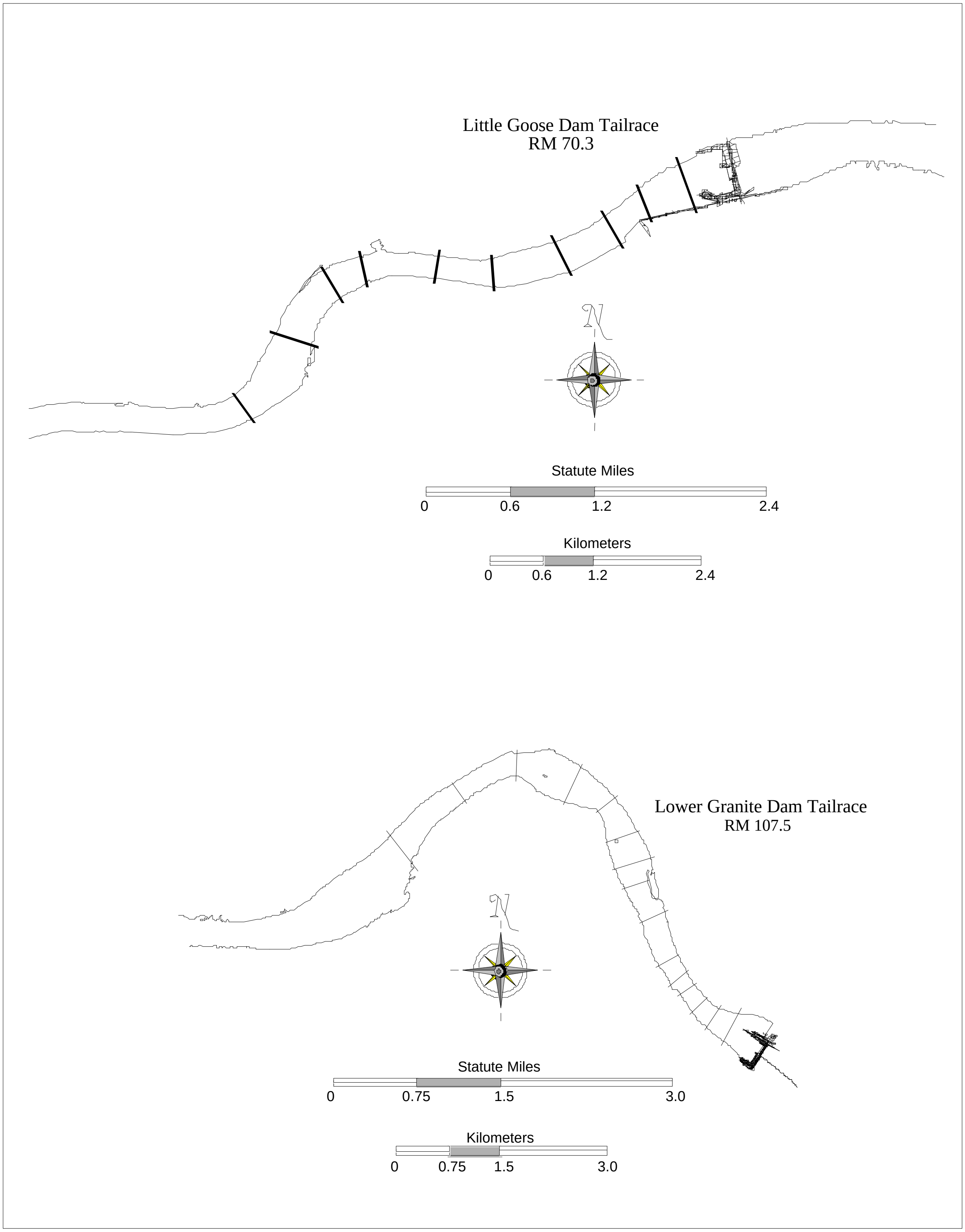


Figure 5. Cross Section placement at Little Goose and lower Granite Dam Tailraces on the Lower Snake River.

hydraulic model calibration, and hydraulic simulations are discussed in the 1996 Annual Report (Anglin et al. *In press* b).

We continued to search for and accumulate data regarding historic and current hydrographs for the Columbia and Snake rivers that will be required for time-series analysis. Mean monthly flows for the Columbia River were examined for different time periods corresponding to various stages of development of the Columbia River hydrosystem. Our goal was to determine whether the hydrograph had been modified by development of the hydrosystem, and, if so, the events and/or time period associated with the modification. Hydrograph data sets were assembled with a minimum duration of 10 years for time periods associated with construction of new flood control, storage, and hydropower generating projects. Initially, data sets were compared visually, and additional analysis was conducted if substantial differences were observed. Additional analysis conducted thus far has consisted of comparisons of frequency distributions for mean annual discharge and total runoff to determine if data sets include representative or similar distributions of water years.

Discussions were initiated with the Walla Walla District of the Corps of Engineers regarding the availability of hydraulic data, specifically water surface elevations, for the tailrace areas downstream from the four lower Snake River dams. We were aware of the existence of tailwater rating curves for Corps projects, however the extent of the available data, in addition to the resolution and accuracy, was not known. The primary issue was one of time and cost efficiency. Based on our experience to date with the Ice Harbor tailrace, the cost and time obligation for development of a water surface model which includes the variable backwater effect from the downstream pool is relatively high. The goal of our discussions with the Corps was to determine whether data were available for our Snake River study areas, and if the resolution and accuracy were sufficient to produce reliable hydraulic simulations for the habitat assessment.

Following completion of hydraulic modeling for each of the study areas, the respective hydraulic simulations will be combined with microhabitat criteria curves for spawning and rearing to convert streamflow into habitat values (weighted usable area-WUA or usable area-UA) for white sturgeon. Microhabitat criteria curves describe the suitability of depth, velocity, substrate, and temperature on a scale from 0.0 to 1.0 for each of the sturgeon lifestages, with 0.0 indicating unsuitable, and 1.0 indicating optimal. Criteria curves which will be used in this habitat assessment for spawning white sturgeon were developed recently in the lower Columbia River, downstream from McNary Dam (Parsley and Beckman 1994). The curves are shown graphically in Figure 6. Criteria curves which will be used for rearing white sturgeon are currently under development by the Biological Resources Division of the U.S. Geological Survey (Report C in this volume).

RESULTS

Field Data Collection

Cross section distance and elevation profiling was completed for the WBIC (43 cross sections), and partially completed for the new Snake River study areas. Velocity distribution surveys were conducted for all 43 cross sections in the WBIC and 8 cross sections around the islands

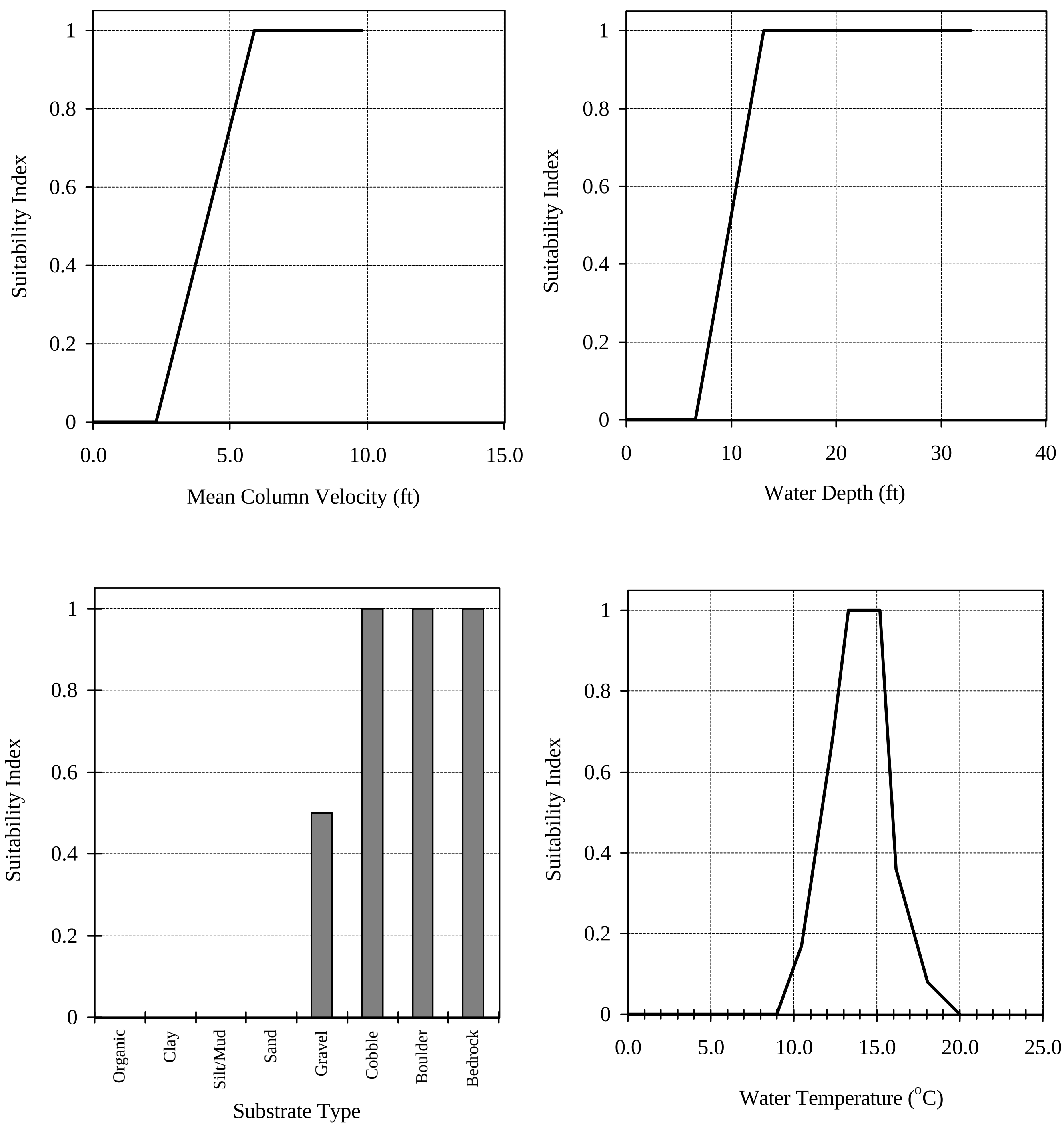


Figure 6. Microhabitat criteria curves indicating the suitability of water velocities, depths, and temperatures, and substrate type for spawning white sturgeon from Parsley and Beckman (1994).

downstream from Ice Harbor Dam in the Snake River. Stage-discharge data collection included 69 data points for the WBIC, 20 data points for the Ice Harbor tailrace islands, and 37 data points for the Lower Monumental, Little Goose, and Lower Granite tailraces. Data were collected at total river discharges ranging from 3,317 to 9,152 m^3/s in the Columbia River, and 1,528 to 3,379 m^3/s in the Snake River. Side-channel (secondary channel around an island) discharges corresponding to total river discharge ranged from 571 to 4,645 m^3/s in the Columbia River (WBIC), and 23 to 402 m^3/s in the Snake River (Ice Harbor tailrace islands). Approximately 700 total stage-discharge data points, including 177 for the current year, have been collected for calibration of hydraulic models.

Data Analysis

Cross section profiles, velocity distributions, and stage-discharge pairs 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. Calibration of hydraulic models for the Hanford Reach (excluding the WBIC) neared completion, and hydraulic simulations were conducted for approximately 75 percent of the cross sections for total river flows ranging from 708 to 14,150 m^3/s.

The initial comparison of 10 year blocks from the Columbia River hydrograph did not reveal any clear pattern of change that could be associated with development of the basin. There appeared to be a trend towards a more consistent pattern across the 12 months of the water year during recent time periods. We reviewed the history of hydroelectric development in the basin and selected time periods associated with development of the larger storage projects for comparison. At least two distinct flow patterns were apparent (Figure 7). The hydrograph appears to have become more constant and less seasonal following construction of the large Canadian storage projects. We will continue to examine various time periods to determine if there have been other changes in the hydrograph associated with development in the basin.

We determined that existing Corps of Engineers backwater curves for McNary Dam and the four lower Snake River projects could provide water surface elevations for our Snake River study areas. A spreadsheet was assembled which delineated the required geographic areas and cross section locations, the range of required elevations for the downstream pool, and the range of Snake River discharges needed for our habitat assessment. Following a review of the spreadsheet by the Corps, we learned that all of the required data could be generated using their Hydrologic Engineering Center's "Water Surface Profiles" computer program (HEC-2). The program uses a step-backwater modeling process based on the conservation of mass and energy. A thorough discussion of this modeling approach can be found in Chow (1959). The Corps agreed to provide the necessary data for a significantly lower cost than would have been required to develop new models with empirical data. A substantial amount of time will also be saved. The accuracy of the data from the Corps models has not been quantified, however, we will use our own measured stage-discharge field data along with the corresponding pool elevations to determine the accuracy of the modeled data.

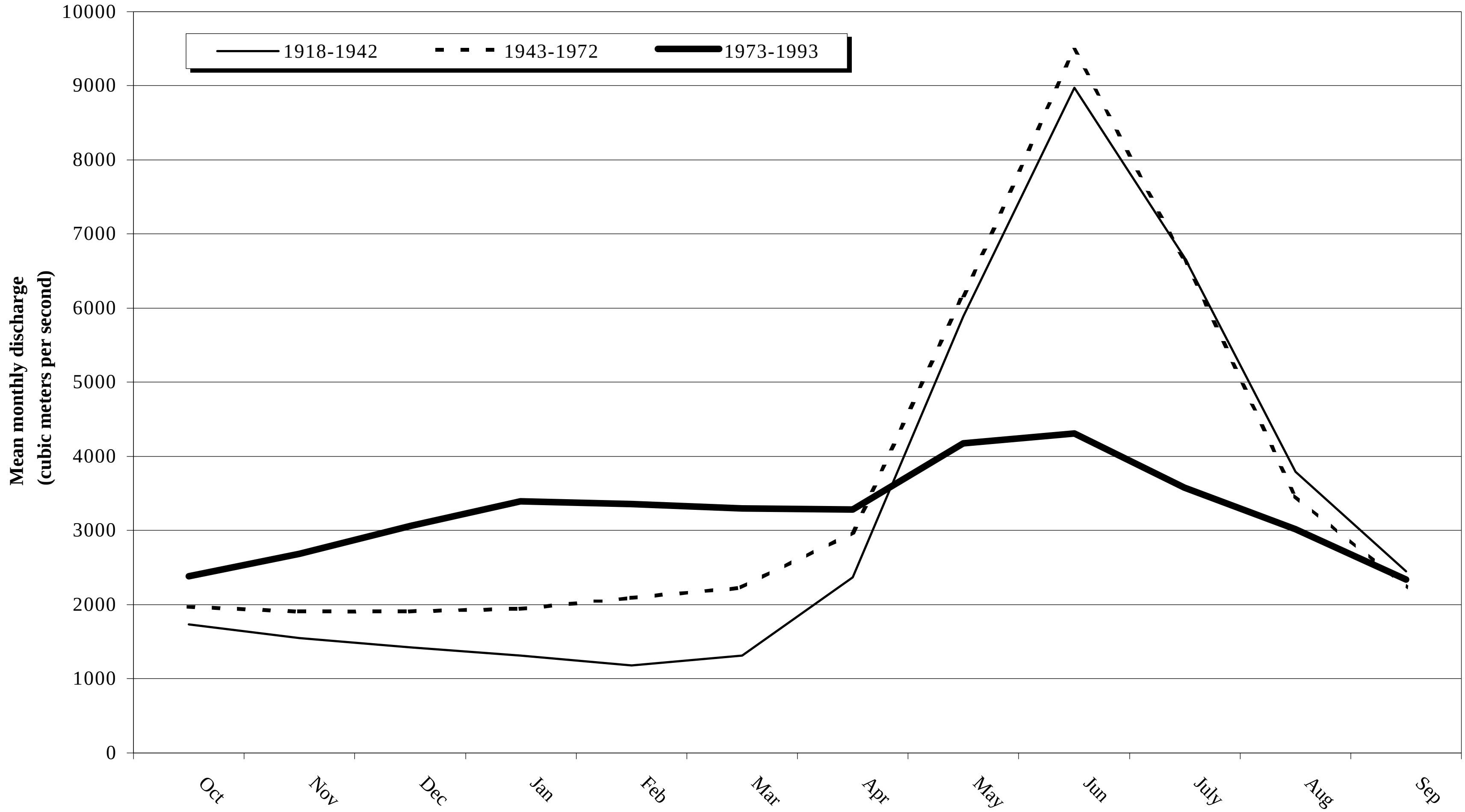


Figure 7. Columbia River hydrograph measured at the Priest Rapids gaging station. Time periods designate pre-Grand Coulee, Grand Coulee to Canadian hydrosystem, and post-Canadian hydrosystem.

DISCUSSION

Field Data Collection

Extensive discussions of field data, field data collection activities, techniques, and protocols have been presented in previous Annual Reports and will not be repeated here. However, following is a review of work conducted over the past four years to provide summary information and perspective on our progress towards completion of the habitat assessment. The purpose of the review is to provide sufficient background on the project to assist readers not familiar with previous years work with interpretation of the material presented in this report. Table 1 provides a brief description of the data collection and analysis tasks which have been completed, and corresponding time periods for the work since the study began.

Habitat Assessment Review

The study was initiated in October 1993 with several reconnaissance surveys to the Hanford Reach and to the Snake River downstream from Ice Harbor Dam. Significant effort was expended to overcome new challenges associated with the size of the Columbia and Snake rivers. Characterization of hydraulic and habitat conditions for determination of study design was our first challenge. Hydraulic, habitat, and substrate characters that can be readily observed or determined in small to mid-size streams are not apparent in larger rivers at a level of detail necessary to determine sampling design and effort. We also found a wide range of variation in channel morphology in the Reach. As a result, we conducted a sensitivity analysis (January-May 1994) to determine the level of effort required to obtain a representative sub-sample of hydraulic conditions (Anglin 1995). A complete three point data set was collected, modeled, and habitat was analyzed for 40 cross sections in the Hanford Reach. Based on the analysis, a stratified random sampling design was used to determine and mark the locations for 102 cross sections in the Hanford Reach upstream from the WBIC, and 20 cross sections downstream from the WBIC. Channel morphology in the Snake River was more uniform and predictable, and cross sections were selected to be representative of the habitat and hydraulic conditions that were present in the tailrace area downstream from Ice Harbor Dam.

Development of a data collection protocol that would enable us to accurately and efficiently collect the field data required to build and calibrate hydraulic models and predict habitat with a reasonable degree of confidence was our second challenge. State-of-the-art acoustic equipment (ADCP) was obtained through cooperative efforts initially, and eventually through acquisition by BPA, and protocols were developed which enabled us to collect cross section profiles and velocity distributions quickly and efficiently. We also acquired GPS receivers and electronic surveying equipment that increased our efficiency and automated geo-spatial referencing for all of our data.

During the remainder of FY1994, we collected profiles, velocity distributions, and stage-discharge data points for the Hanford Reach and lower Snake River study areas (Anglin 1996). We planned to accumulate at least four stage-discharge data pairs for each cross section in the Hanford Reach, ranging from approximately 1,415 m^3/s to 7,075 m^3/s, to enable modeling of flows ranging from approximately 708 m^3/s to 16,980 m^3/s. Snake River data collection was planned for flows

Table 1. Review of tasks conducted for the white sturgeon habitat assessment, 1993-1998. Key: **IHR**-Ice Harbor; **LMN**-Lower Monumental; **LGS**-Little Goose; **LGR**-Lower Granite; **TR**-tailrace; **MC**-main channel; **Hanford R.**-Hanford Reach.

TIME PERIOD	TASK	LOCATION
Oct-Dec 1993	•Reconnaissance and study design.	Hanford Reach Snake R., IHR-TR
Jan-May 1994	•Sensitivity analysis, complete study design.	Hanford Reach Snake R., IHR-TR
May-Sep 1994	•Mark 67 cross sections, stratified random design. •Mark 7 cross sections, representative design. •Develop data collection, data processing protocol. •Data collection: Profiles, velocity distributions (67). •Data collection: Profiles, velocity distributions (7). •Data collection: Stage-discharge data pairs (131).	Hanford R.-MC Snake R., IHR-TR Hanford R.-MC Snake R., IHR-TR Hanford R. (124); IHR-TR (7)
Oct 1994-July 1995	•Contract lapse.	N/A
Aug-Sep 1995	•Mark 55 cross sections, stratified random design. •Data collection: Stage-discharge data pairs (56).	Hanford R.-MC
Oct-Dec 1995	•Data collection: Stage-discharge data pairs (3). •Data analysis: Velocity distribution and profile data reduction and entry (74).	Snake R., IHR-TR Hanford R. (67); IHR-TR (7)
Jan-June 1996	•Data collection: Velocity distributions (55). •Data collection: Stage-discharge data pairs (127). •Data analysis: Velocity distribution and profile data reduction and entry (55).	Hanford R.-MC Hanford R. (120); IHR-TR (7) Hanford R.-MC
July-Sep 1996	•Data collection: Stage-discharge data pairs (77). •Data collection: Cross section substrate (129).	Hanford R. (70); IHR-TR (7) Hanford R. (122); IHR-TR (7)
Oct-Dec 1996	•Reconnaissance and study design. •Data analysis: Stage-discharge and substrate data reduction and entry (complete to date).	LMN, LGS, LGR-TR's Hanford R.-MC Snake R., IHR-TR
Jan-Mar 1997	•Reconnaissance and study design. •Mark 43 cross sections, representative design. •Mark 37 cross sections, representative design. •Data analysis: Hydraulic model calibration.	WBIC LMN, LGS, LGR-TR's Hanford R.-MC
Apr-Sep 1997	•Mark 10 cross sections, representative design. •Data collection: Velocity distributions (8). •Data collection: Stage-discharge data pairs (20). •Data collection: Velocity distributions (43). •Data collection: Stage-discharge data pairs (69). •Data collection: Stage-discharge data pairs (37).	IHR-TR-Islands WBIC LMN, LGS, LGR-TR's
Oct-Dec 1997	•Data analysis: Velocity distribution and profile data reduction and entry (51). •Data analysis: Stage-discharge data reduction, entry. •Data analysis: Hydraulic model calibration.	WBIC (43) IHR-TR-Islands (8) WBIC; All Snake R. TR's Hanford R.-MC; IHR-TR
Jan-Mar 1998	•Data analysis: Hydraulic model calibration, flow modeling. •Data analysis: Step-backwater curves-Corps of Engineers.	Hanford R.-MC IHR-TR LMN, LGS, LGR-TR's IHR-TR, Islands

ranging from approximately 283 m^3/s to 5,660 m^3/s for modeling of flows ranging from approximately 142 m^3/s to 11,320 m^3/s. A sufficient number of data points were required to adequately describe the backwater effect from the downstream pool for Snake River study areas.

Budget constraints in FY1995 left us without a contract for much of the fiscal year. The result was approximately two months of functional work during August-September 1995. All remaining cross sections were staked on both sides of the river, and low flow data points were collected for most of the remaining Hanford Reach cross sections (Anglin et al. *In press a*). Our primary emphasis during the first quarter of FY1996 was data reduction and entry, along with some additional stage-discharge data collection. The contract lapse a year earlier had not allowed sufficient time to process the large volume of field data that had been collected up to that point.

Field data collection was our primary activity during winter and spring of 1996 (January-June). High river flows allowed us to collect data points up to 8,490 m^3/s for much of the Hanford Reach study area. Velocity distribution work was completed and stage-discharge work was nearly completed for the Hanford Reach by the end of June 1996, with the exception of the WBIC. Data collection for the Ice Harbor tailrace area in the Snake River also continued during this time period.

Stage-discharge data collection and substrate characterization were our primary tasks for the remainder of FY1996 (July-September). Stage-discharge data collection was completed for Hanford Reach cross sections. Approximately 500 data points consisting of river stage, discharge, and velocity distribution were accumulated for cross sections in the Reach, excluding the WBIC (Anglin et al. *In press b*). Development of the protocol for substrate data collection, and fabrication of deployment equipment for our underwater video camera were followed by data collection during July-August 1996. This task was completed for the Hanford Reach, and the Ice Harbor tailrace. Substrate was characterized at approximately 1,200 locations using the video equipment, and at approximately 1,000 bank point locations by direct observation.

Hydraulic and substrate data reduction and entry were completed for all existing data during the first quarter of FY1997 (October-December 1996). We also conducted reconnaissance surveys of the tailrace areas at Lower Monumental, Little Goose, and Lower Granite dams to determine study design for those areas (Anglin et al. *In press b*).

Field work conducted during spring and summer of FY1997 was focused on the WBIC and lower Snake River tailraces, including the islands in the Ice Harbor tailrace. Reconnaissance surveys were completed, and cross section locations were selected and marked during January-March 1997. We also began calibration of hydraulic models for Hanford Reach cross sections. Velocity distribution data were collected for all 43 cross sections in the WBIC, and 8 of 10 cross sections around the Ice Harbor tailrace islands from April-September of 1997. A total of 126 stage-discharge data points were collected for the WBIC and Snake River study areas. Additional details for this work are presented in this report.

Our primary tasks during the first and second quarters of FY1998 (October 1997-March 1998) were completion of data reduction and entry for work conducted in the WBIC and Snake River, hydraulic model calibration and modeling for the Hanford Reach cross sections, excluding the WBIC, and discussions with the Corps of Engineers regarding availability of water surface elevation data for the lower Snake River. Additional details for this work are presented in this report.

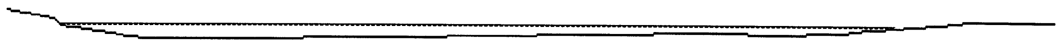
Data Analysis

Hydraulic model calibration has been efficient and water surface models and velocity simulations are working extremely well in most cases. Cross section profiles, substrate characteristics, and hydraulic data are shown in Figures 8 through 47 for several cross sections in each river segment in the Hanford Reach. Cross sections were chosen to illustrate the range of variation in hydraulic and physical parameters within each segment. Cross section locations are indicated in Figure 2.

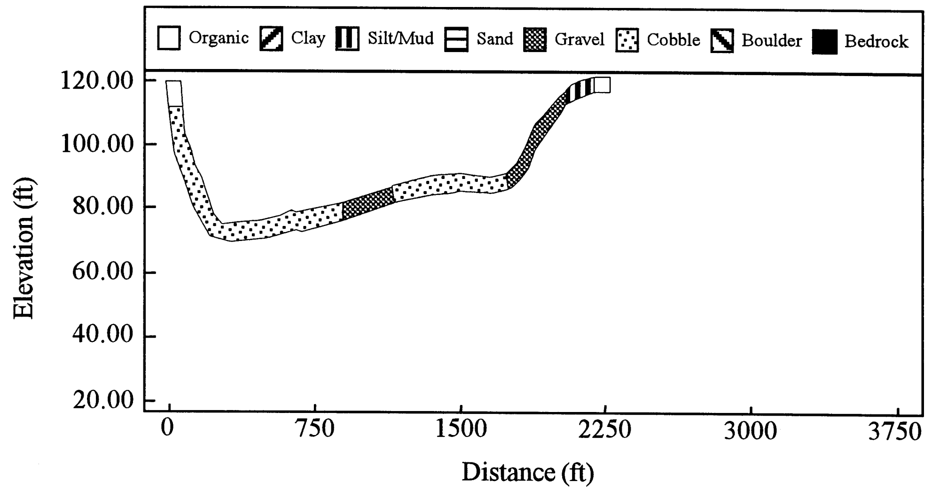
Plans for 1998

The USFWS plans to complete hydraulic data collection and substrate characterization for the WBIC and Snake River tailrace areas during spring and summer of 1998. Approximately 250 data points (stage, discharge, velocities) have been collected to date for these areas. Data reduction and entry should be complete, and significant progress is planned towards completion of hydraulic modeling for most areas. Work will continue on hydrographs to be used for the habitat time series analysis, and habitat modeling will proceed as time permits.

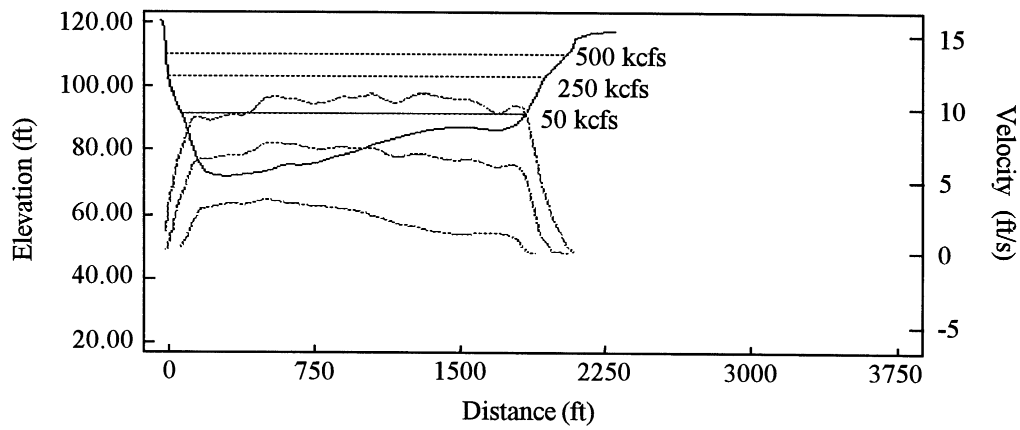
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

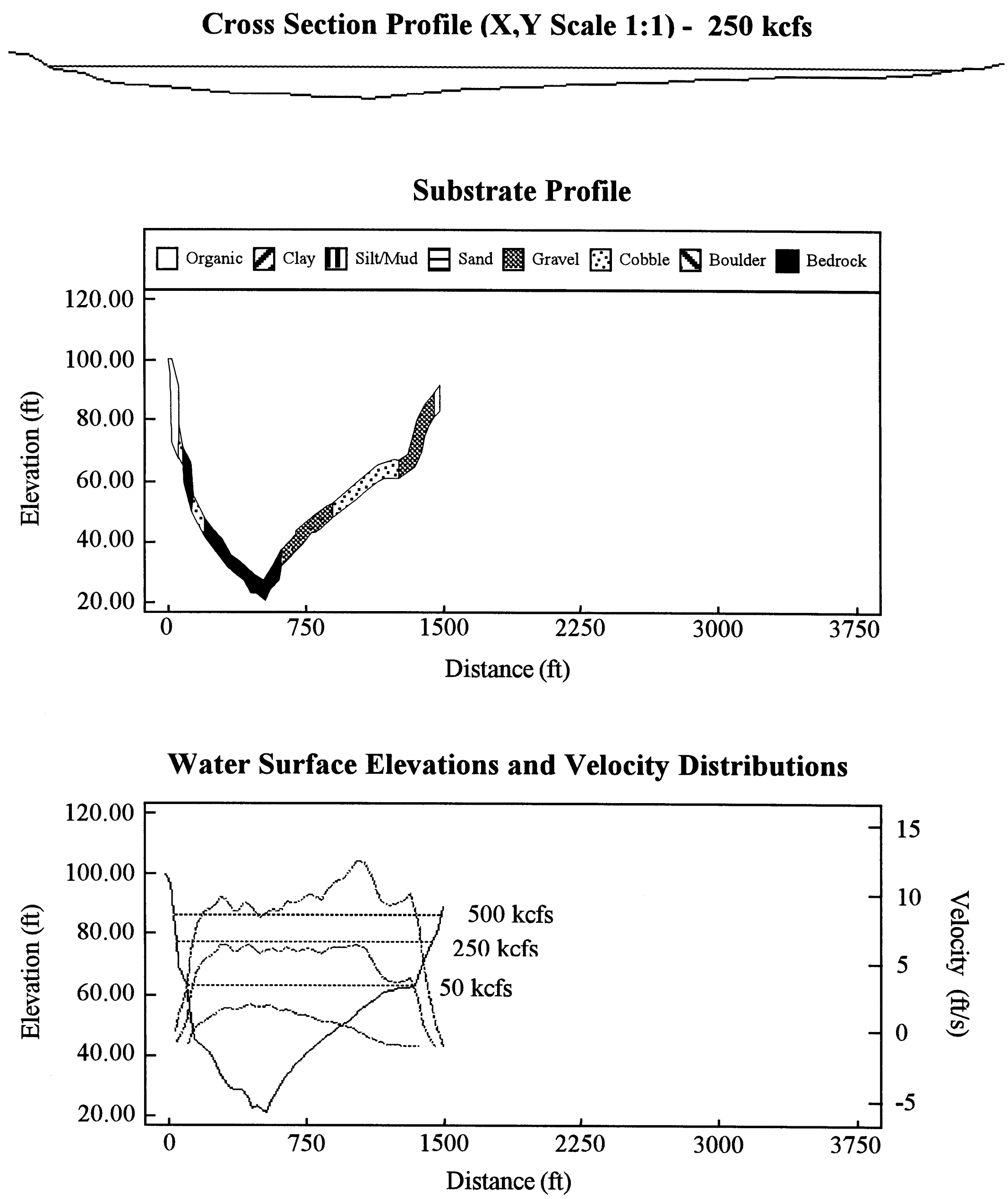


Water Surface Elevations and Velocity Distributions



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1650.50	18432.71	0.00	3.50	2.10	20.00	11.17
250	1803.11	39725.23	0.10	7.30	5.20	32.30	22.03
500	1921.73	53505.50	0.90	10.50	8.30	39.60	27.84

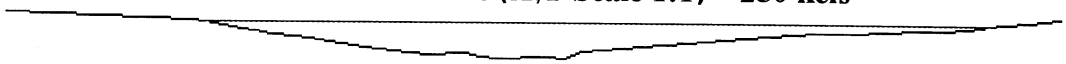
Figure 8. Cross section profile, substrate and hydraulic modeling data for segment C3 Cross Section 3.



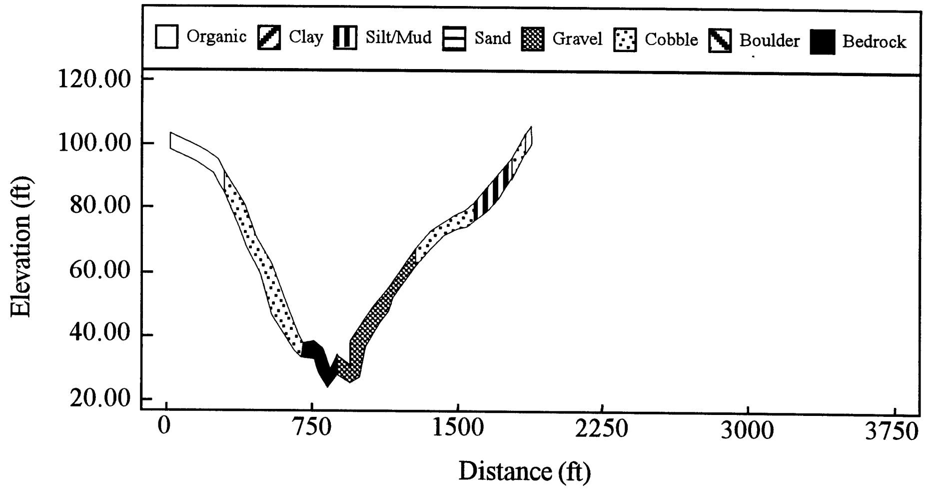
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1264.11	24416.29	0.00	2.60	1.60	40.70	19.32
250	1428.40	43488.16	0.40	6.70	5.10	54.70	30.45
500	1493.15	55794.30	1.20	12.10	8.20	63.10	37.37

Figure 9. Cross section profile, substrate and hydraulic modeling data for segment C3 Cross Section 8.

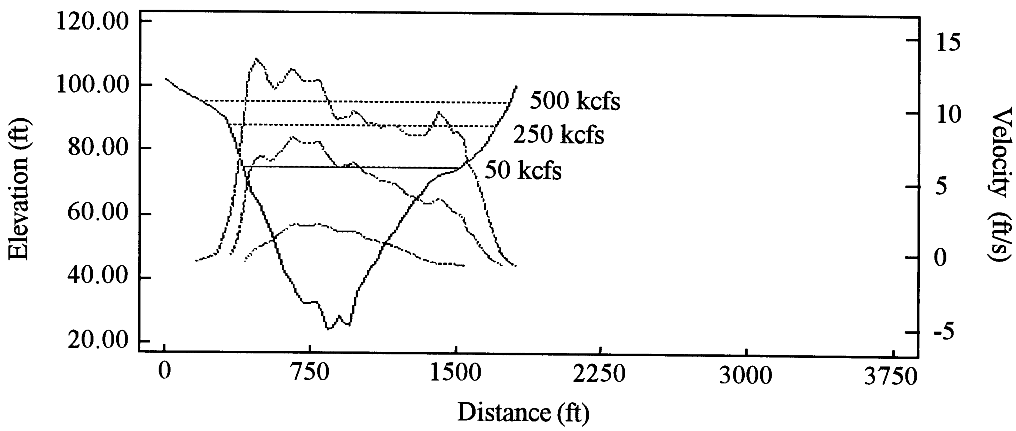
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

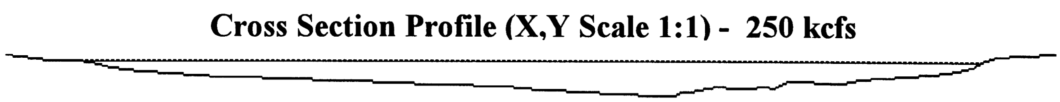


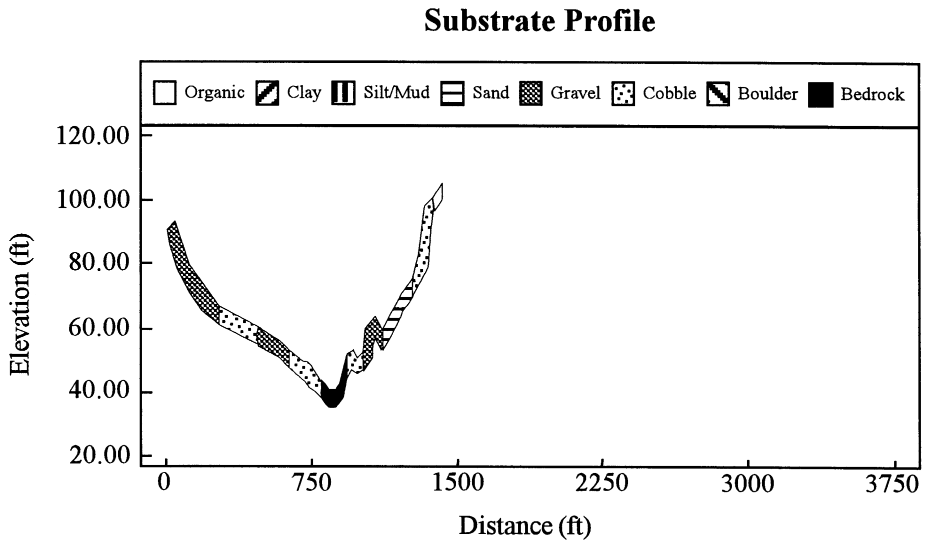
Water Surface Elevations and Velocity Distributions

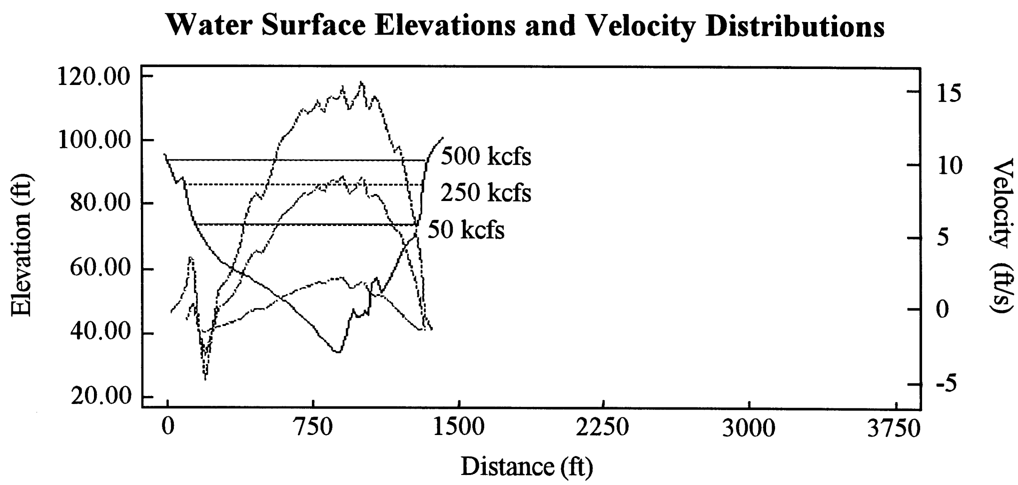


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1050.20	26357.48	0.00	2.50	1.40	50.80	25.10
250	1288.00	41435.23	0.80	7.90	5.10	63.60	32.17
500	1495.96	51900.47	0.20	12.80	8.50	71.20	34.69

Figure 10. Cross section profile, substrate and hydraulic modeling data for segment C3 Cross Section 10.





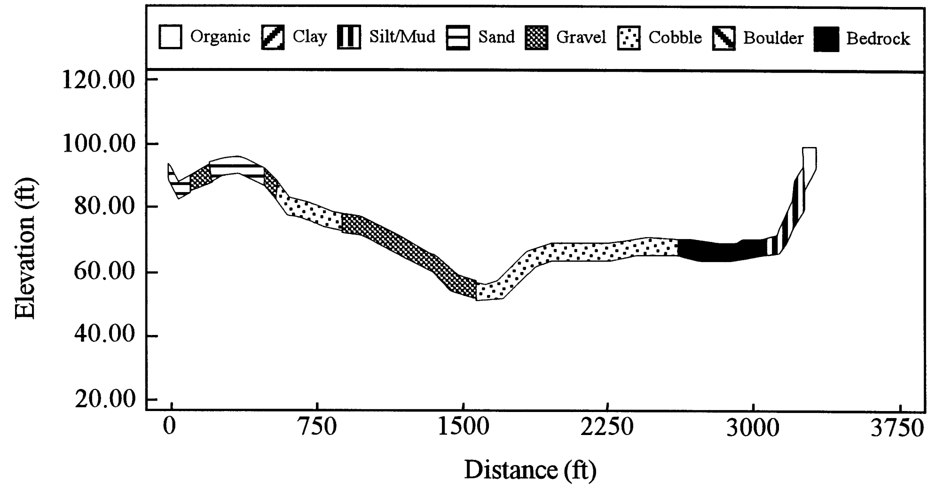


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1163.36	23180.73	-0.20	3.30	1.90	38.40	19.93
250	1252.02	38065.42	-1.70	6.10	6.10	50.70	30.40
500	1366.60	47658.02	-3.40	15.70	9.80	58.00	34.87

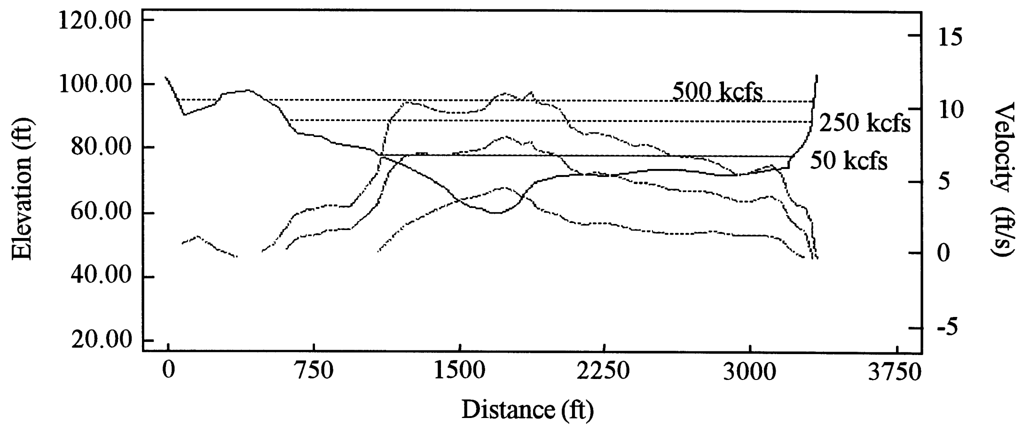
Figure 11. Cross section profile, substrate and hydraulic modeling data for segment C3 Cross Section 14.

Cross Section Profile (X,Y Scale 1:1) - 250 kcfs

Substrate Profile



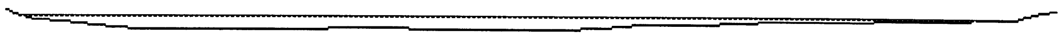
Water Surface Elevations and Velocity Distributions



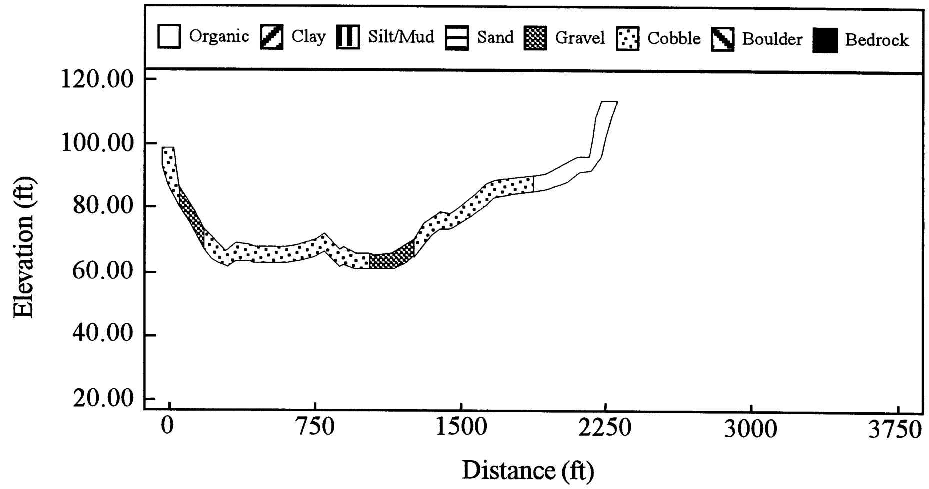
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	2164.35	16827.91	0.40	4.70	2.50	18.80	7.78
250	2755.25	45484.64	0.40	8.10	4.90	30.20	30.20
500	3085.53	65238.01	0.40	11.10	6.50	37.00	37.00

Figure 12. Cross section profile, substrate and hydraulic modeling data for segment C3 Cross Section 17.

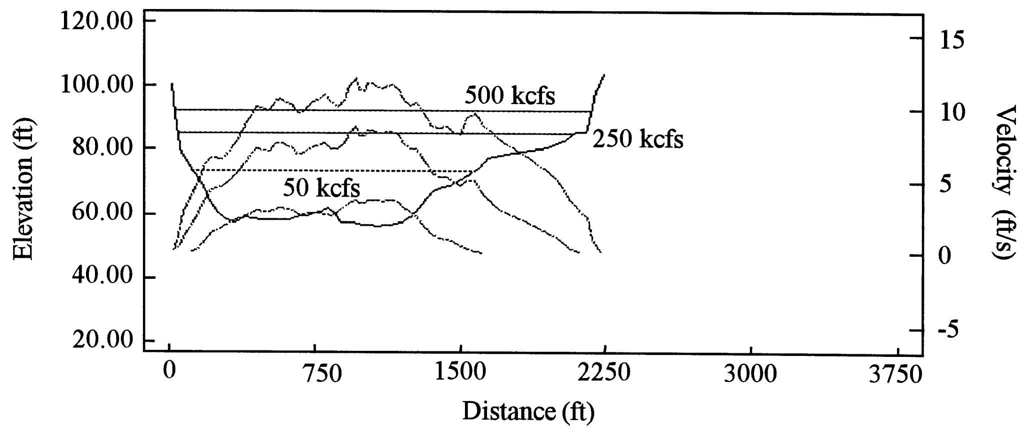
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

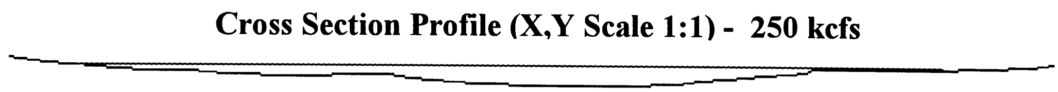


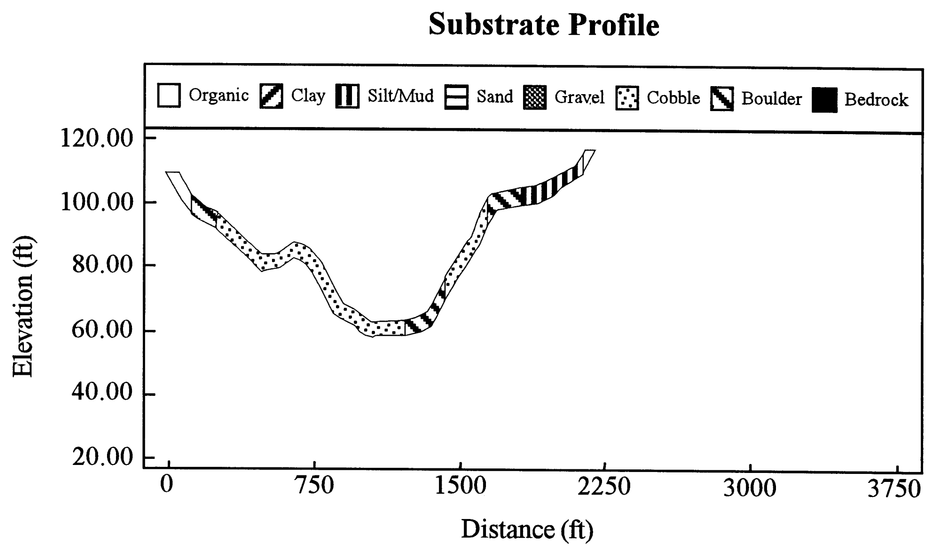
Water Surface Elevations and Velocity Distributions

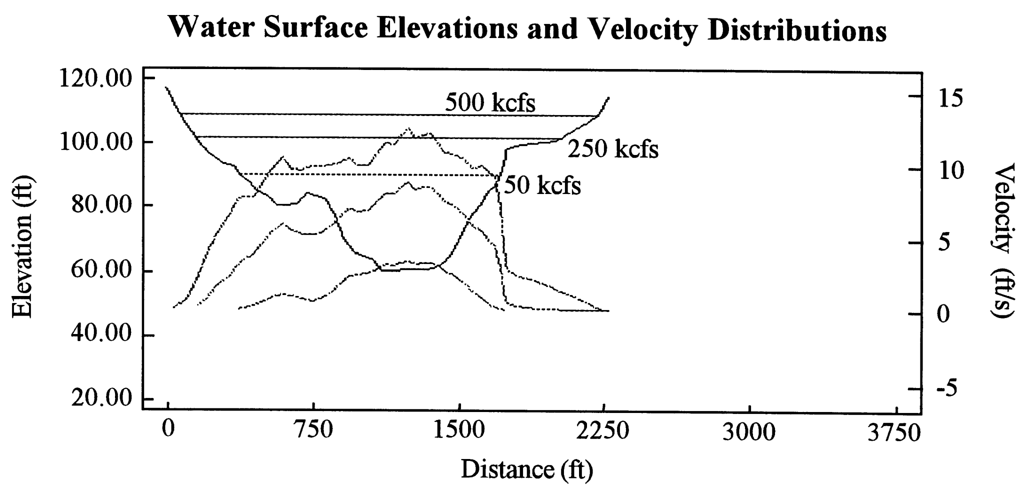


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1493.84	19387.96	0.10	3.50	2.30	18.20	12.98
250	2090.55	41276.06	0.50	8.50	5.70	30.40	19.74
500	2206.05	57712.75	0.10	11.80	8.10	38.00	26.16

Figure 13. Cross section profile, substrate and hydraulic modeling data for segment C4 Cross Section 2.



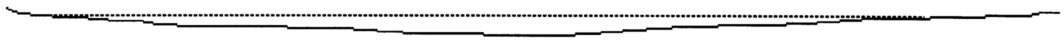




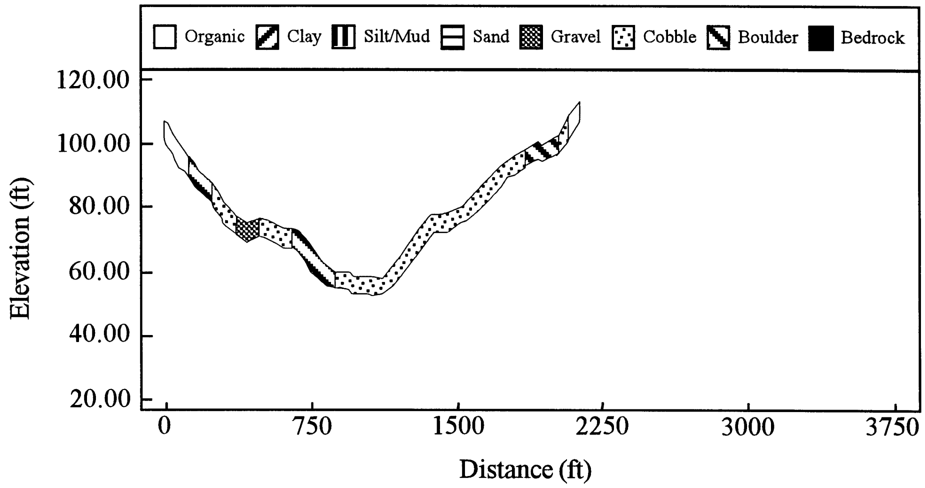
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1299.47	22551.00	0.00	3.30	1.60	31.00	17.35
250	1841.26	41012.97	0.00	8.60	4.70	43.40	22.27
500	2104.44	55442.92	0.00	12.30	7.70	50.70	26.35

Figure 14. Cross section profile, substrate and hydraulic modeling data for segment C4 Cross Section 7.

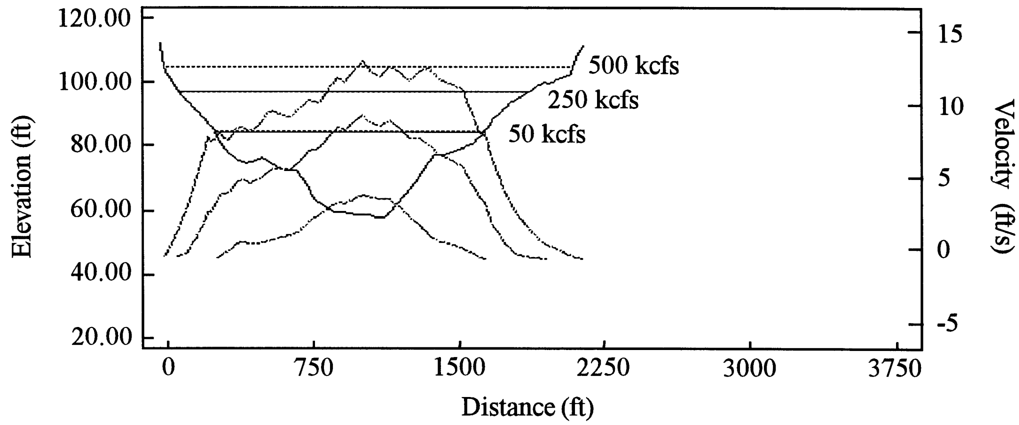
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



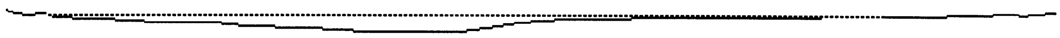
Water Surface Elevations and Velocity Distributions



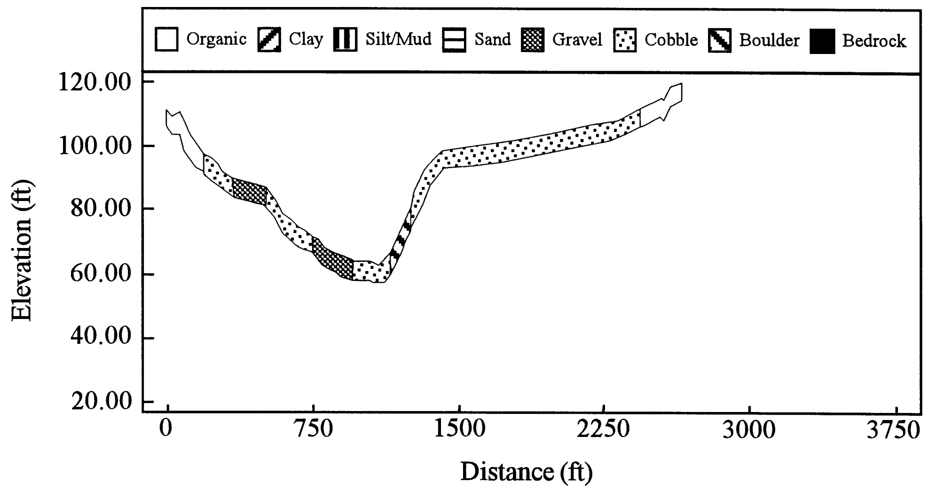
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1308.74	18833.37	0.00	4.00	1.70	26.60	14.39
250	1707.83	37821.95	0.10	9.00	5.00	39.40	22.15
500	1988.45	52012.57	0.10	12.40	7.70	46.90	26.16

Figure 15. Cross section profile, substrate and hydraulic modeling data for segment C4 Cross Section 13.

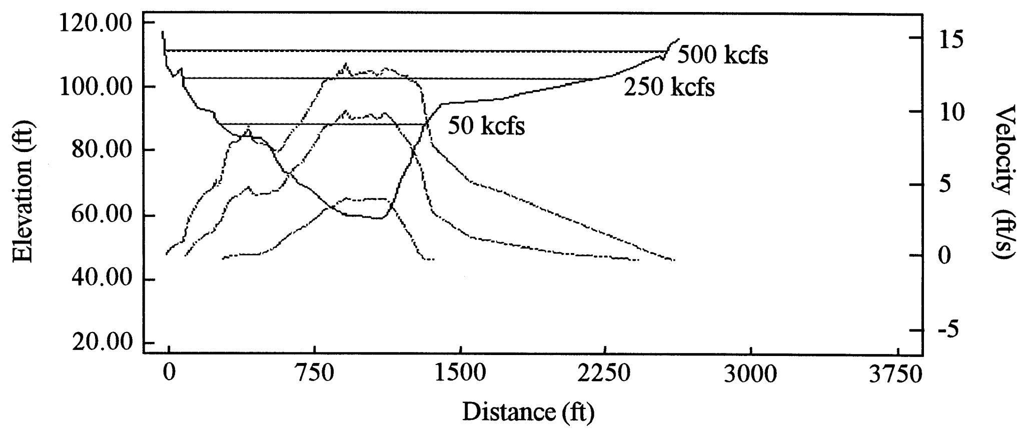
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

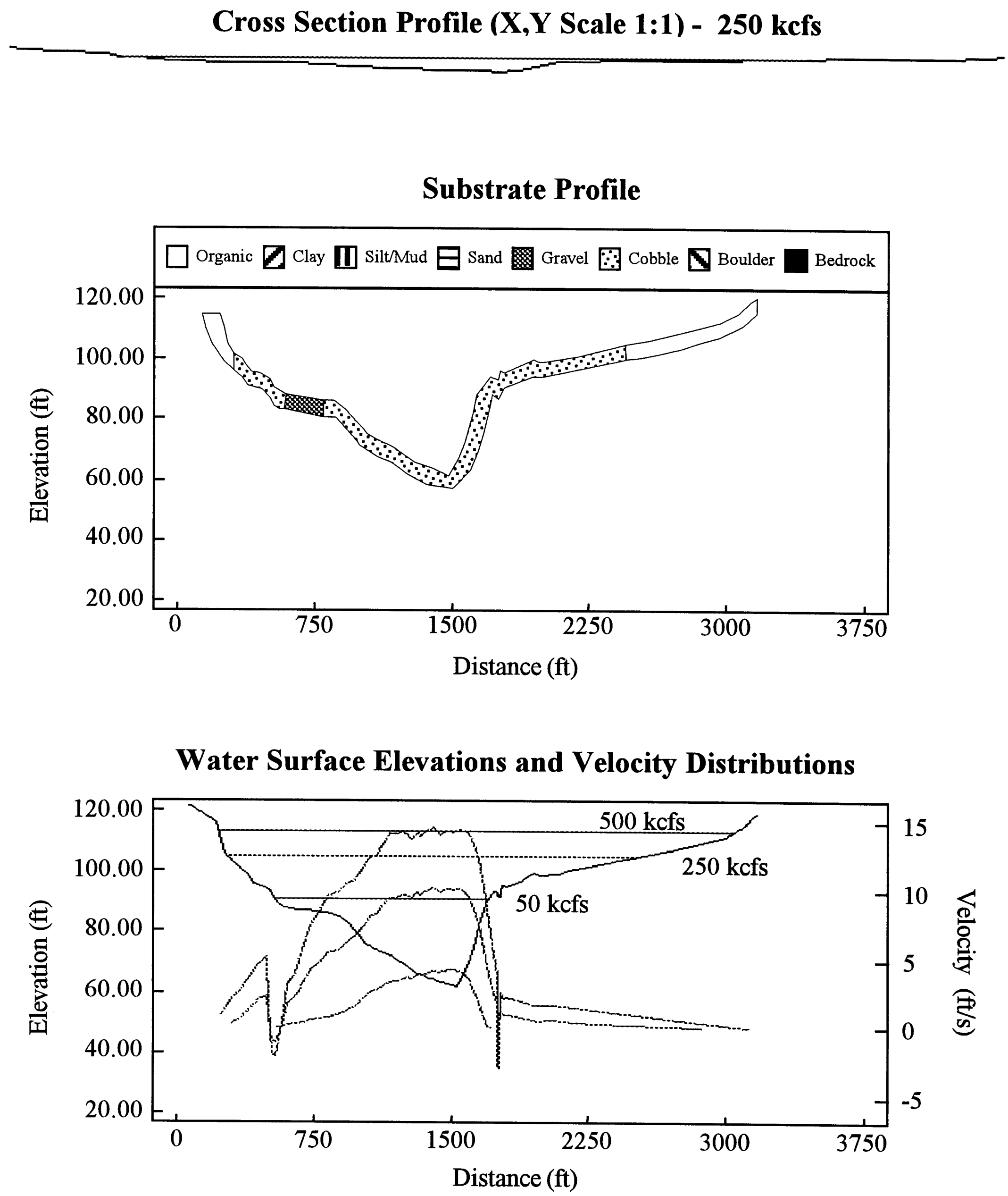


Water Surface Elevations and Velocity Distributions



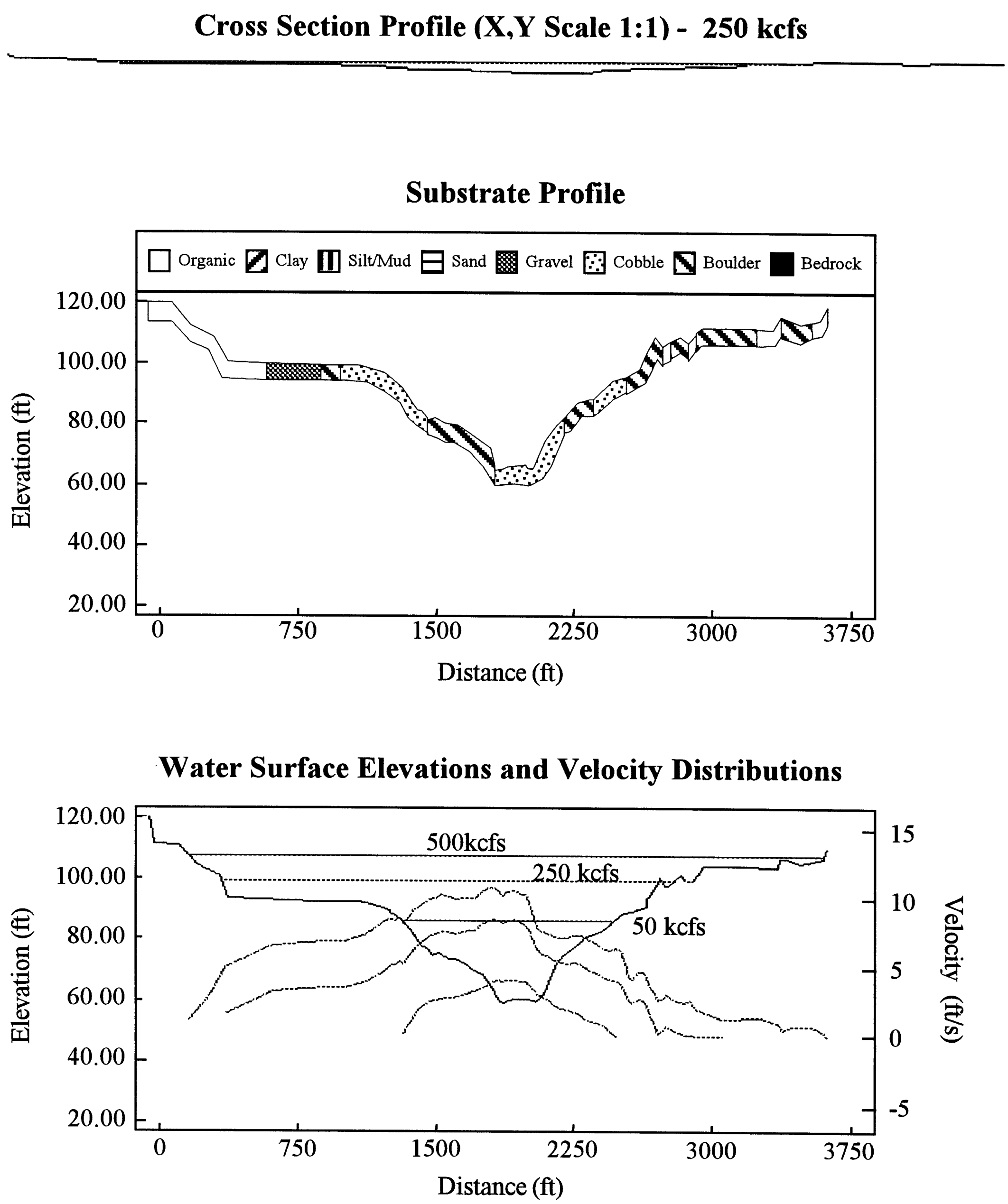
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1045.81	17549.28	0.00	3.90	2.20	29.50	16.78
250	2118.25	39376.45	0.10	9.50	5.90	44.20	18.59
500	2569.00	60517.93	0.10	12.50	8.20	53.10	23.56

Figure 16. Cross section profile, substrate and hydraulic modeling data for segment C4 Cross Section 18.



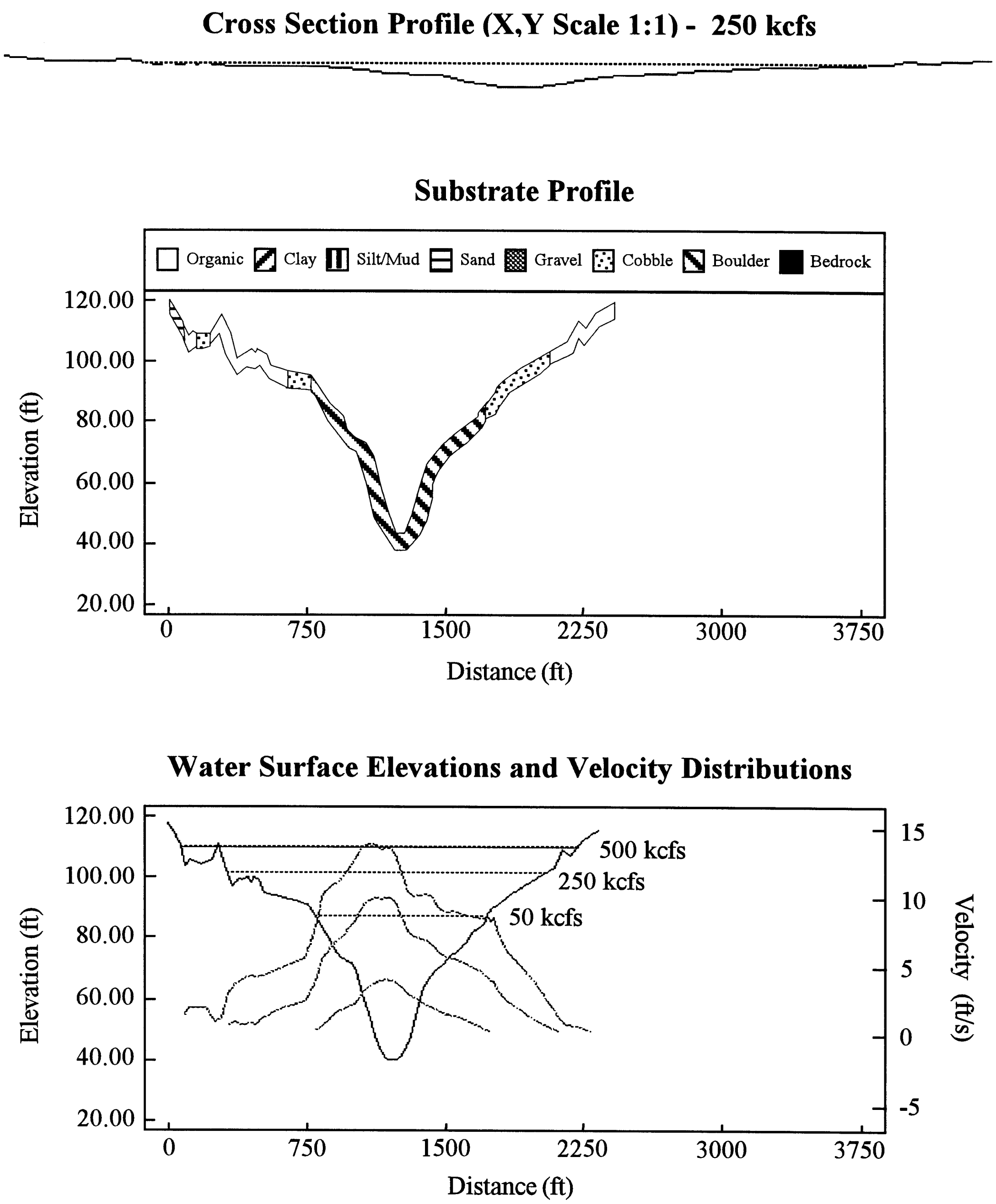
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1114.37	16724.21	-0.10	4.00	2.50	29.80	15.01
250	2146.04	38938.06	-1.60	9.70	4.40	44.20	18.14
500	2682.61	60237.07	-3.20	13.90	6.70	52.90	22.45

Figure 17. Cross section profile, substrate and hydraulic modeling data for segment C4 Cross Section 19.



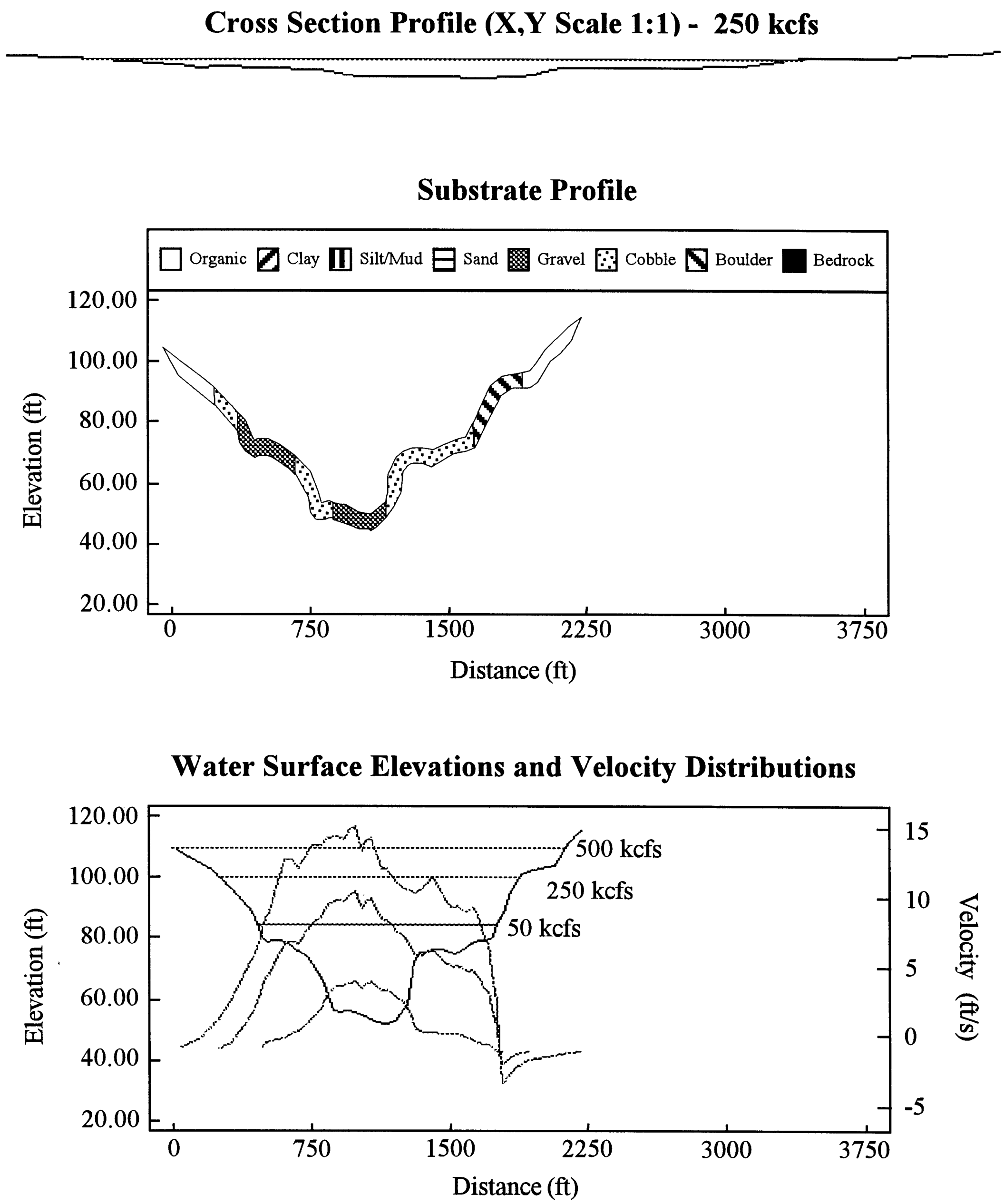
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1123.12	16780.81	0.10	3.90	2.50	28.20	14.94
250	2449.28	42361.14	0.00	8.30	4.90	42.30	17.30
500	3394.52	66501.54	0.40	10.50	6.50	50.70	19.59

Figure 18. Cross section profile, substrate and hydraulic modeling data for segment C5 Cross Section 1.



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	956.67	20978.84	0.00	3.40	1.80	47.70	21.93
250	1780.24	40378.79	0.30	9.20	4.50	62.40	22.68
500	2209.29	57786.06	0.10	12.90	7.00	71.20	26.16

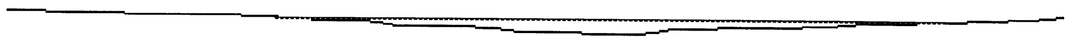
Figure 19. Cross section profile, substrate and hydraulic modeling data for segment C5 Cross Section 3.



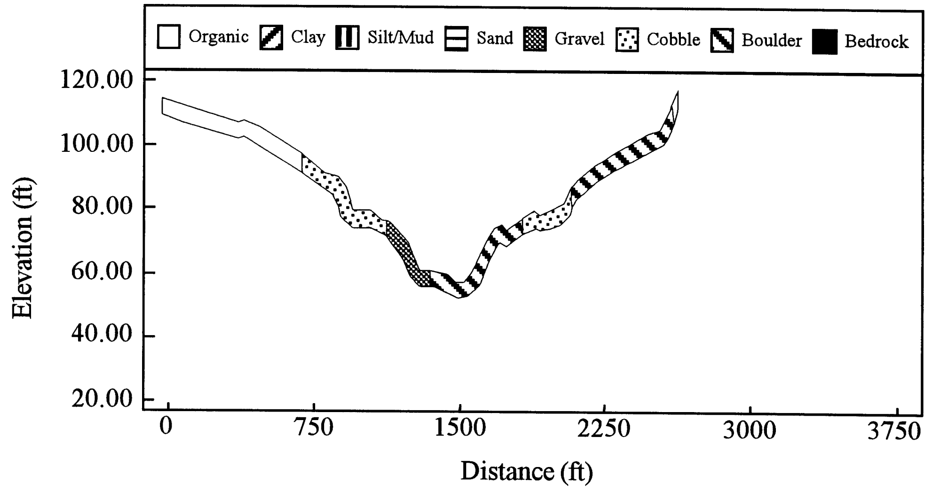
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1232.48	16042.46	0.00	4.50	1.90	28.30	13.02
250	1573.19	38448.84	-0.90	9.30	5.30	44.50	24.44
500	2067.89	56639.04	-1.90	12.80	7.30	54.20	27.39

Figure 20. Cross section profile, substrate and hydraulic modeling data for segment C5 Cross Section 17.

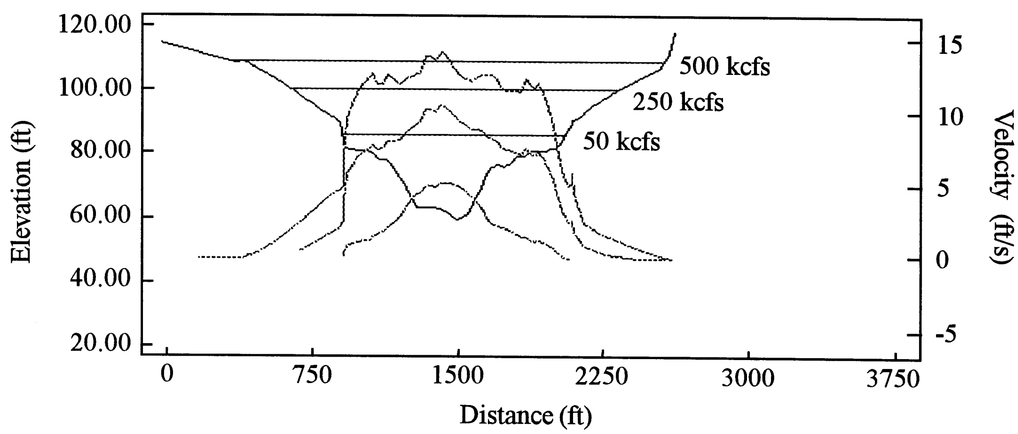
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

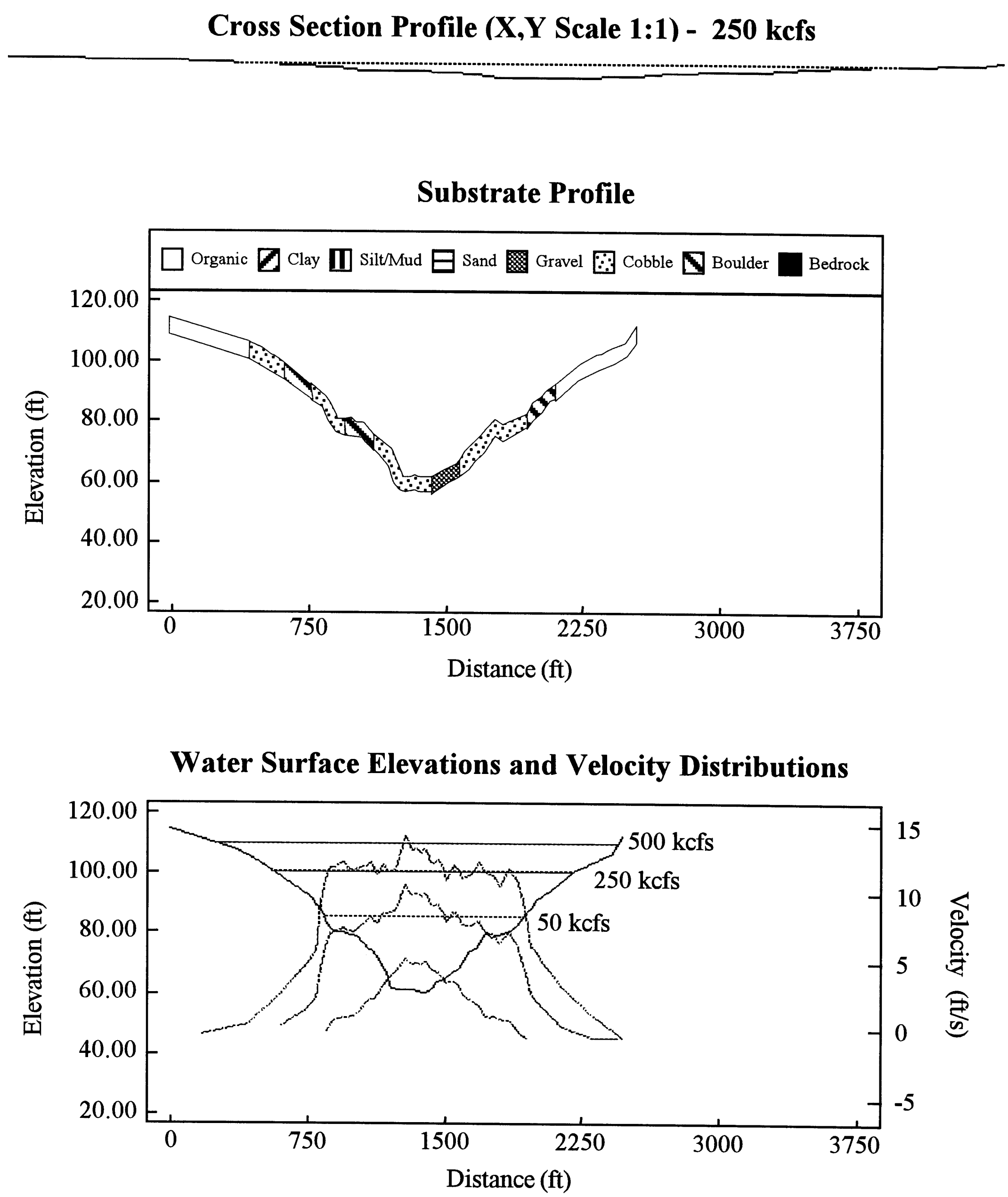


Water Surface Elevations and Velocity Distributions



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1142.70	14605.70	0.10	4.90	2.40	27.00	12.78
250	1678.77	34767.63	0.00	10.10	6.00	41.80	20.71
500	2197.30	51990.36	0.00	13.70	8.80	50.80	23.66

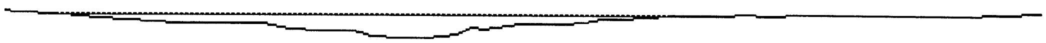
Figure 21. Cross section profile, substrate and hydraulic modeling data for segment C5 Cross Section 19.



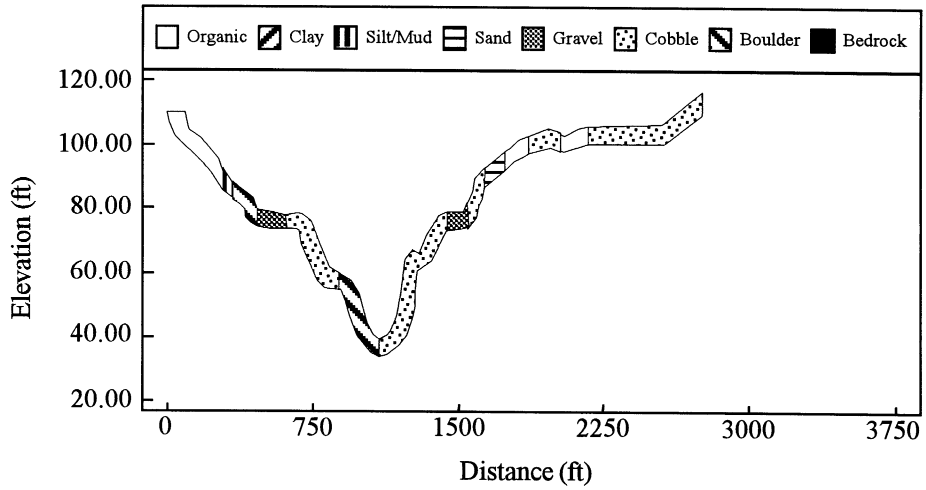
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1104.64	14261.52	0.30	5.40	2.80	24.60	12.91
250	1686.46	34545.36	0.00	10.40	6.60	39.50	20.48
500	2238.29	52127.75	0.30	13.70	9.50	48.40	23.29

Figure 22. Cross section profile, substrate and hydraulic modeling data for segment C5 Cross Section 20.

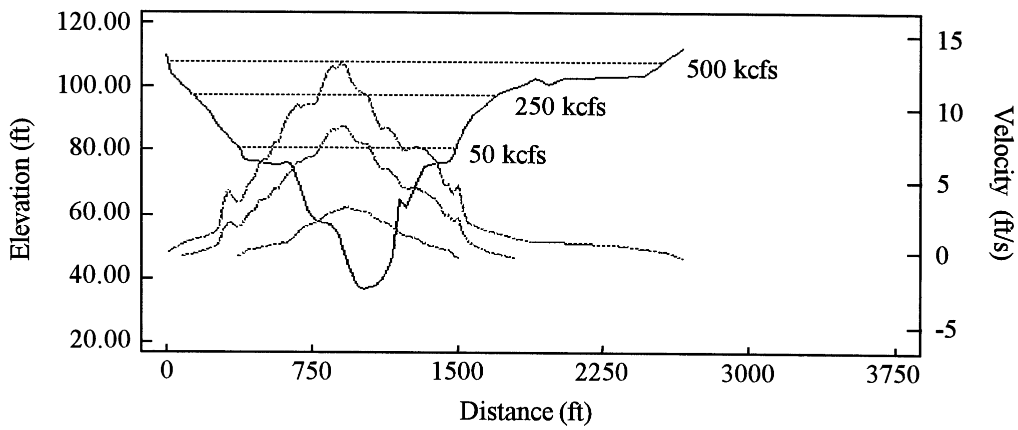
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



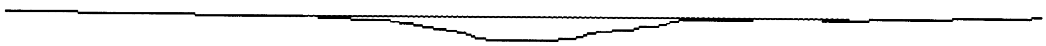
Water Surface Elevations and Velocity Distributions



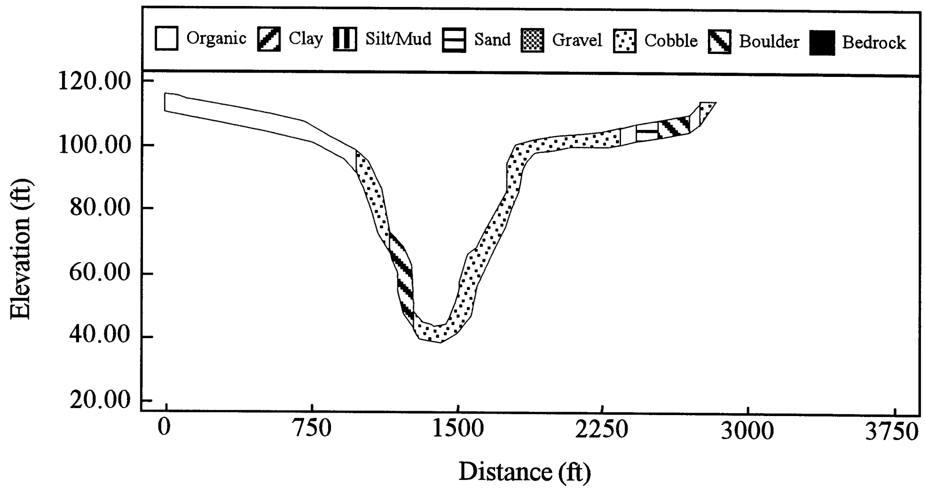
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1127.82	21210.87	0.00	3.40	1.50	45.87	18.81
250	1597.13	44664.07	0.10	9.00	4.30	63.41	27.97
500	2584.23	67281.84	0.50	13.20	6.10	74.07	26.04

Figure 23. Cross section profile, substrate and hydraulic modeling data for segment C6 Cross Section 1.

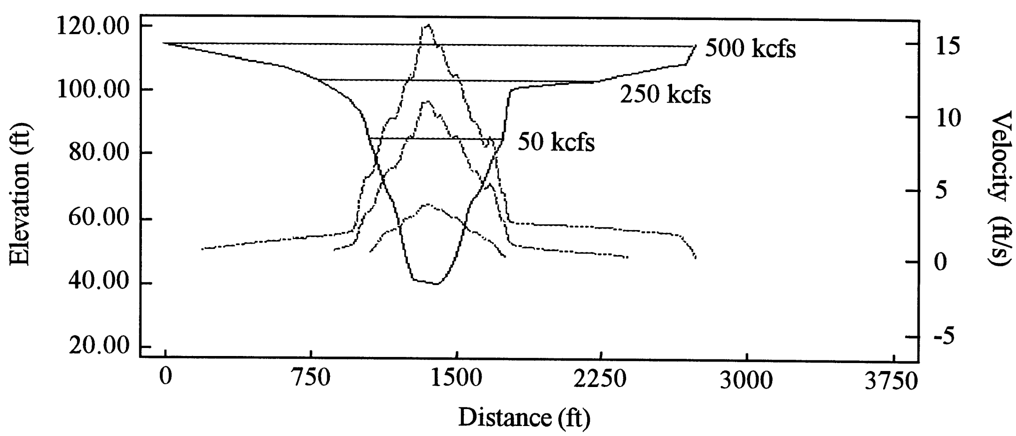
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



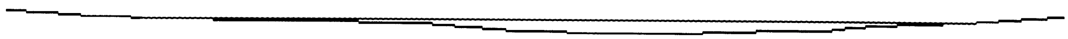
Water Surface Elevations and Velocity Distributions



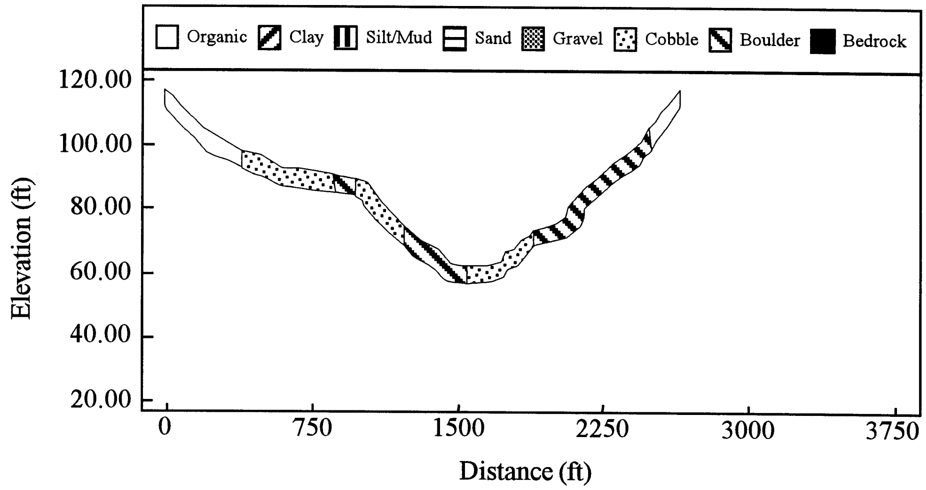
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	701.95	19418.14	0.30	3.50	2.10	46.99	27.66
250	1476.24	35431.99	0.30	10.60	5.40	65.93	24.00
500	2793.21	60594.80	0.80	15.80	7.80	77.47	21.69

Figure 24. Cross section profile, substrate and hydraulic modeling data for segment C6 Cross Section 4.

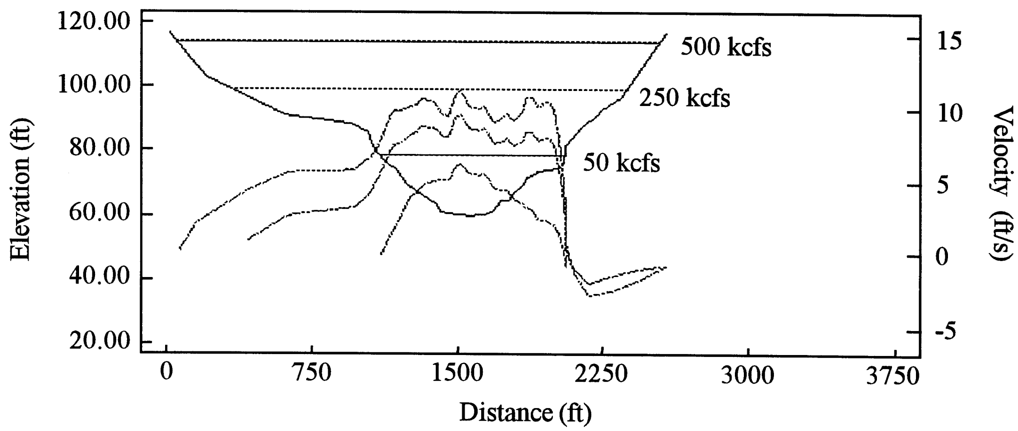
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



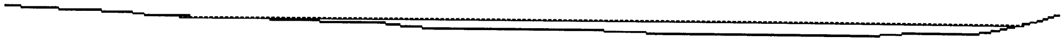
Water Surface Elevations and Velocity Distributions



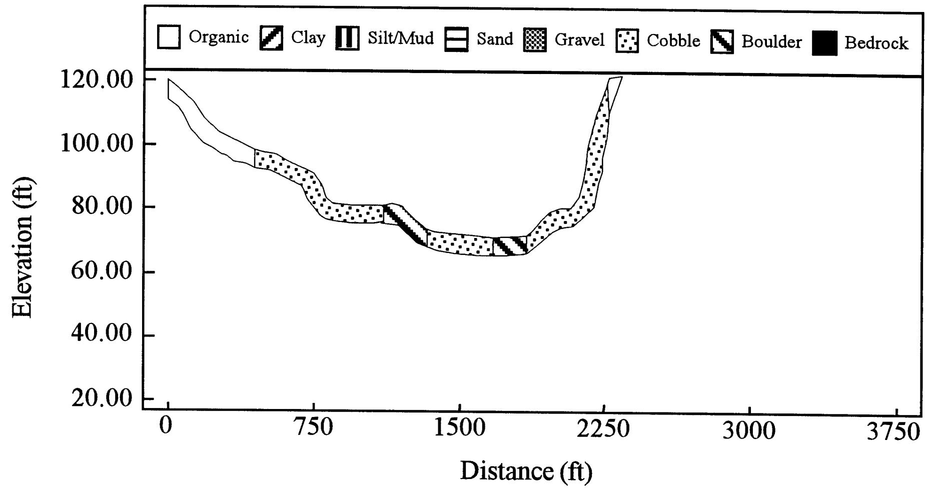
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	967.66	10515.27	0.80	6.10	4.10	18.04	10.87
250	2061.53	38488.02	-1.10	9.10	6.20	37.78	18.67
500	2524.07	71365.75	-1.80	10.50	7.40	51.95	28.27

Figure 25. Cross section profile, substrate and hydraulic modeling data for segment C6 Cross Section 7.

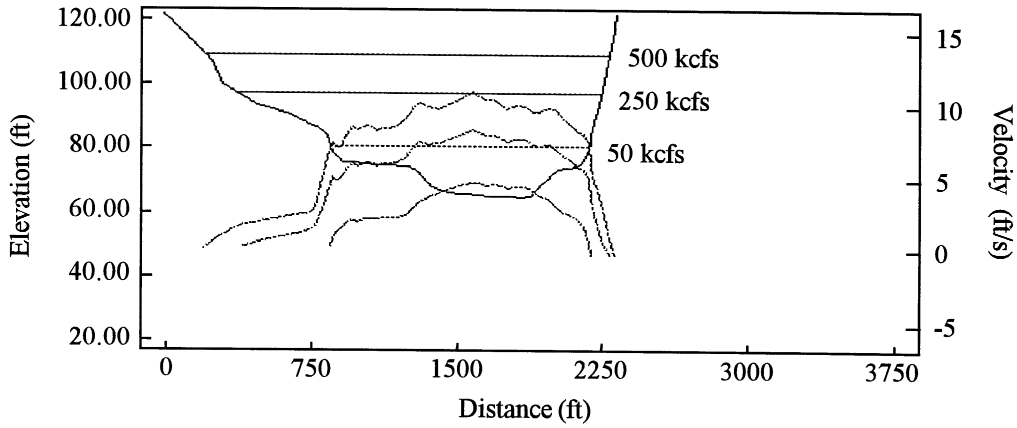
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



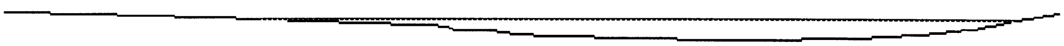
Water Surface Elevations and Velocity Distributions



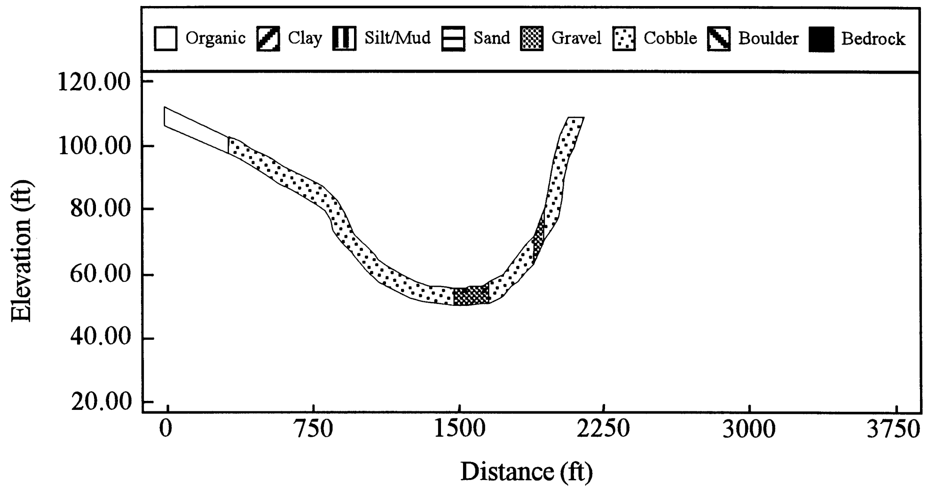
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1326.63	13594.40	0.90	4.60	3.00	16.34	10.25
250	1873.78	39975.96	0.80	7.90	5.30	33.36	21.33
500	2063.92	63736.88	0.60	10.30	7.10	45.36	30.88

Figure 26. Cross section profile, substrate and hydraulic modeling data for segment C6 Cross Section 9.

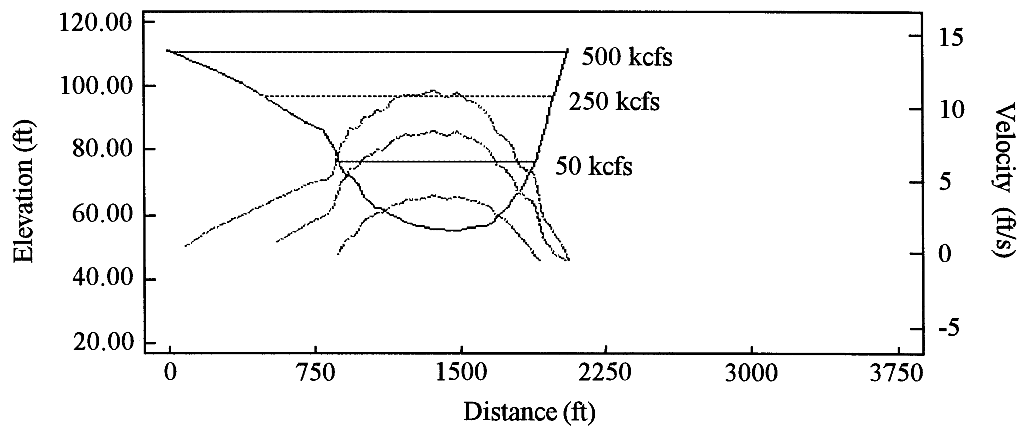
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

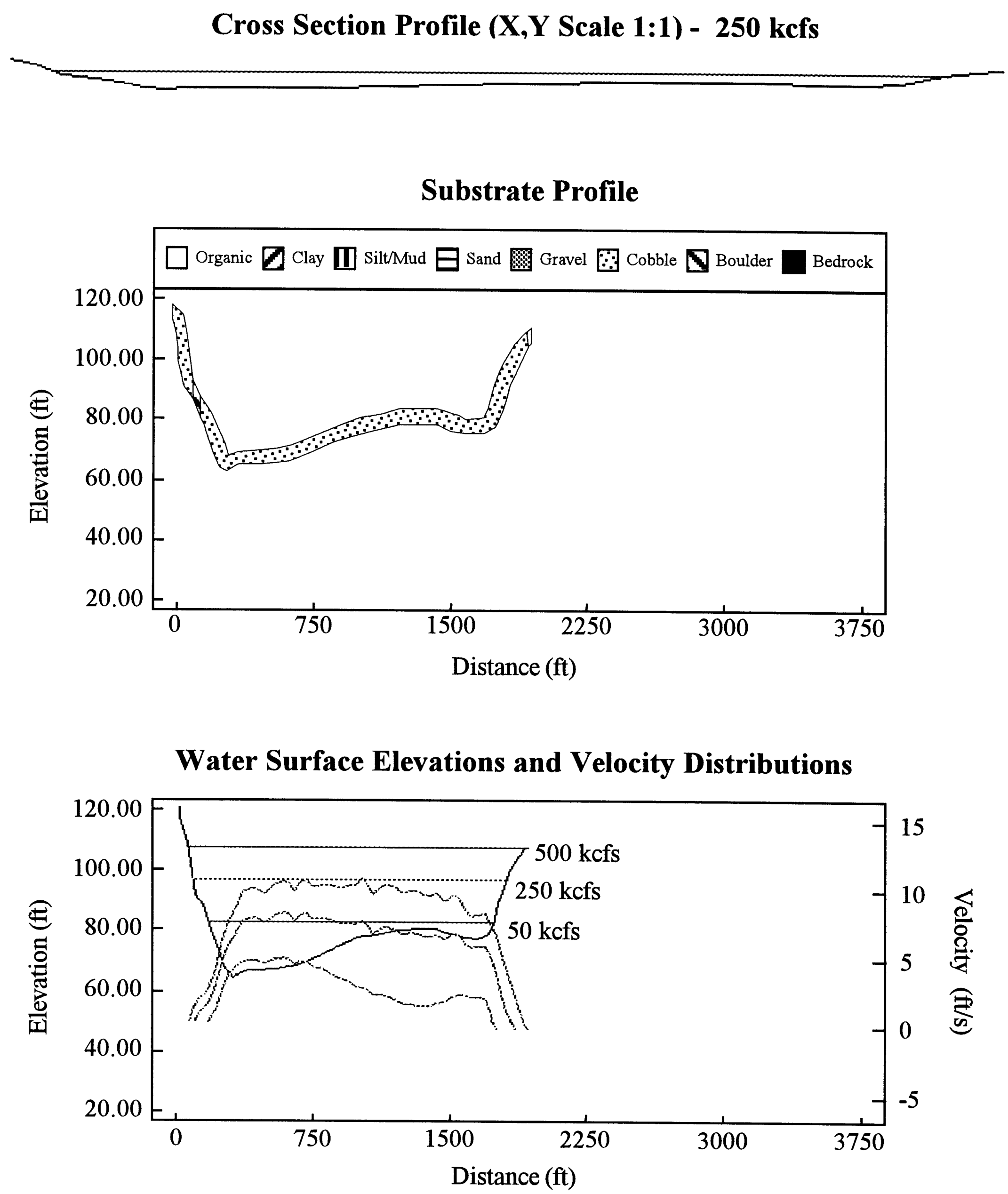


Water Surface Elevations and Velocity Distributions



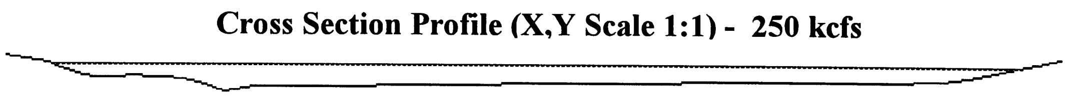
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1012.12	15304.45	0.40	3.90	2.80	21.02	15.12
250	1479.54	39442.32	0.70	8.00	5.80	41.22	26.66
500	2030.03	63558.69	1.10	10.50	7.60	55.09	31.31

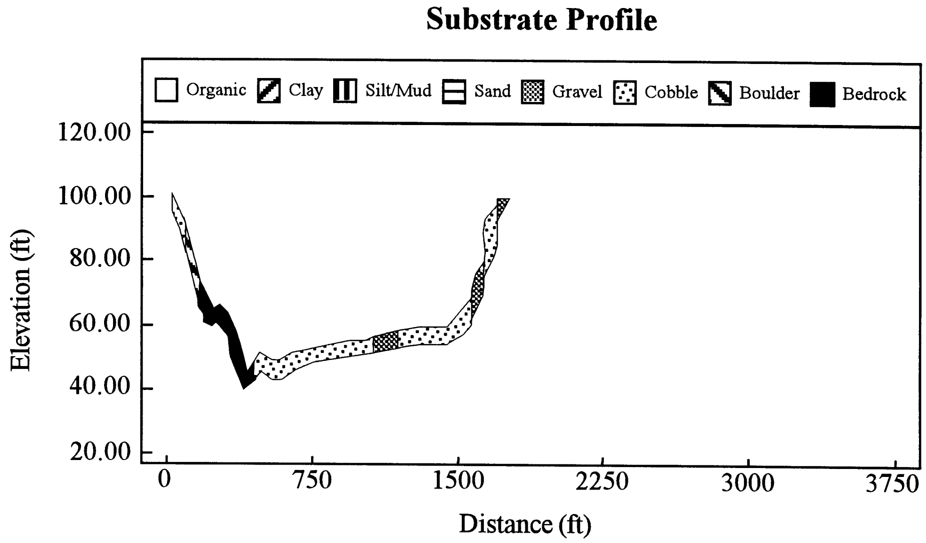
Figure 27. Cross section profile, substrate and hydraulic modeling data for segment C6 Cross Section 14.

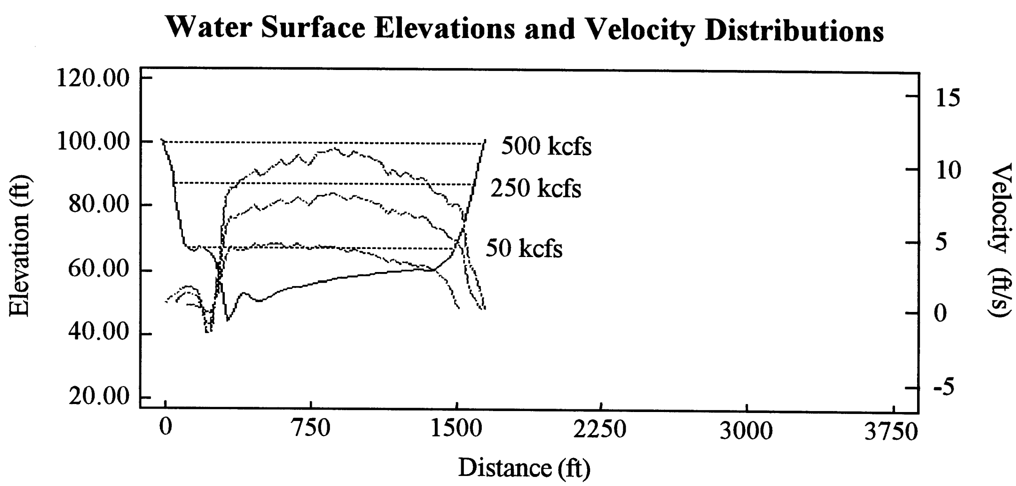


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1588.18	13415.95	0.50	4.90	3.00	19.00	8.45
250	1747.76	37967.93	0.90	8.20	6.30	33.71	21.72
500	1884.75	57764.55	0.20	10.60	8.10	44.68	30.65

Figure 28. Cross section profile, substrate and hydraulic modeling data for segment C7 Cross Section 1.



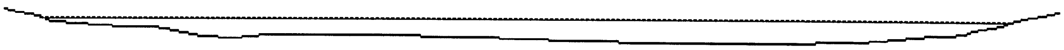




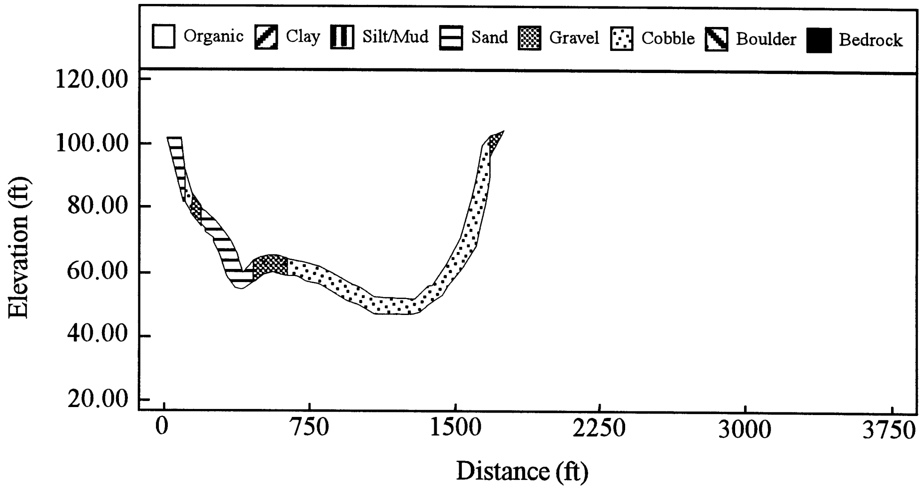
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1340.02	13802.31	-0.30	4.30	3.00	24.27	10.30
250	1512.65	43280.33	-1.20	7.50	5.20	44.67	28.61
500	1628.90	64259.74	-1.80	10.50	7.10	58.08	39.45

Figure 29. Cross section profile, substrate and hydraulic modeling data for segment C7 Cross Section 5.

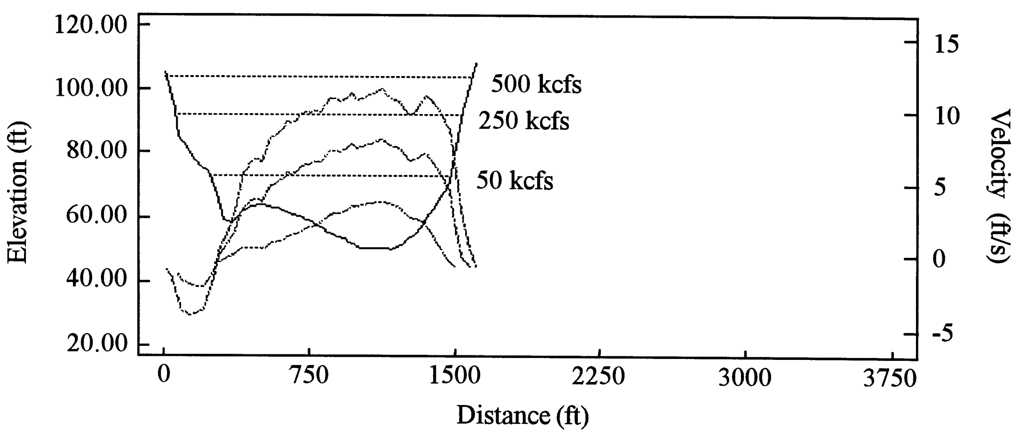
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

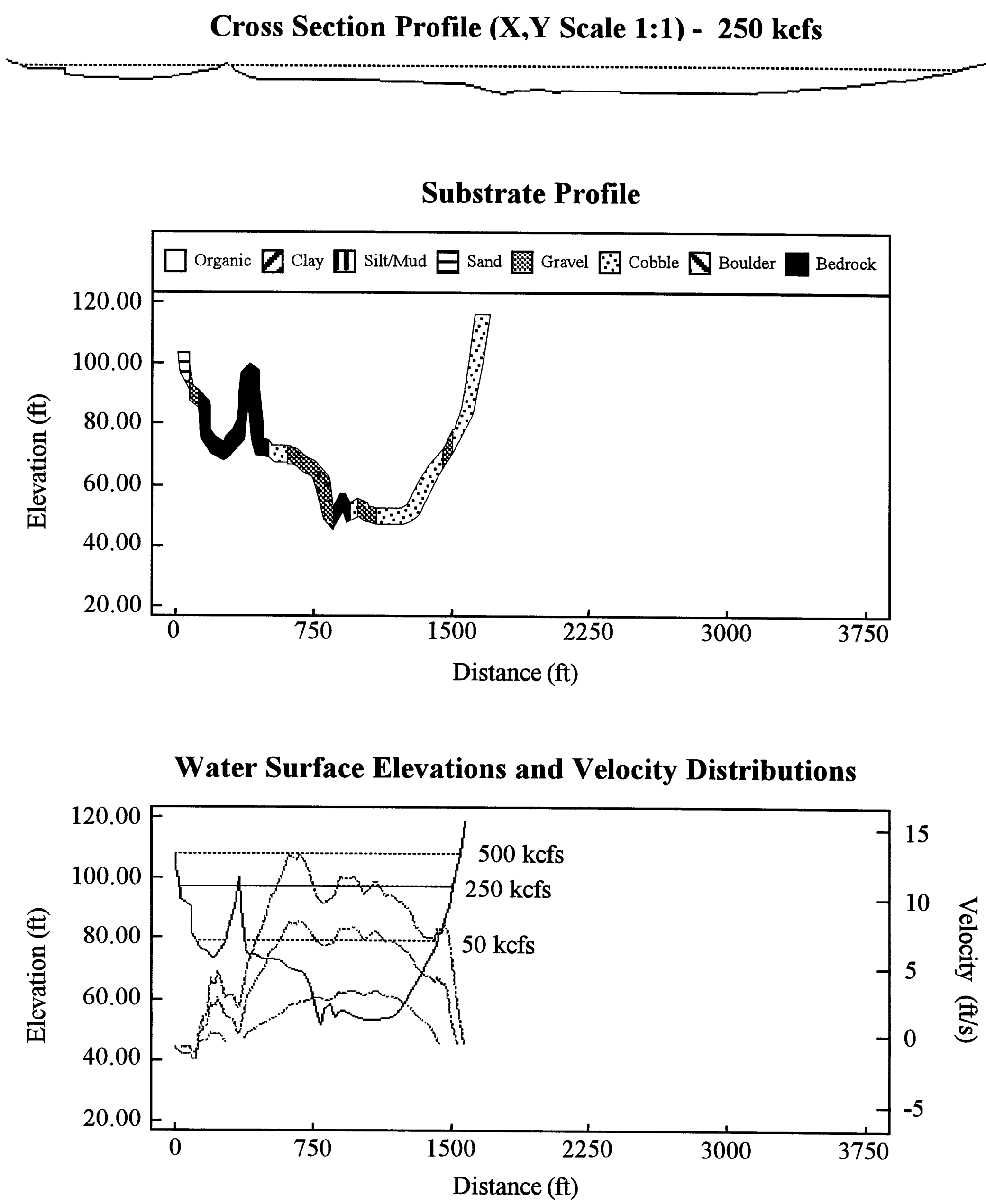


Water Surface Elevations and Velocity Distributions



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1264.21	18602.99	0.10	4.00	2.20	22.69	14.72
250	1508.22	45374.48	-1.30	8.00	5.00	41.62	30.08
500	1610.73	64712.48	-3.00	11.20	7.20	54.04	40.18

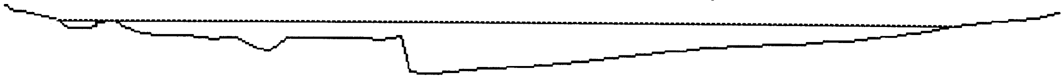
Figure 30. Cross section profile, substrate and hydraulic modeling data for segment C7 Cross Section 10.



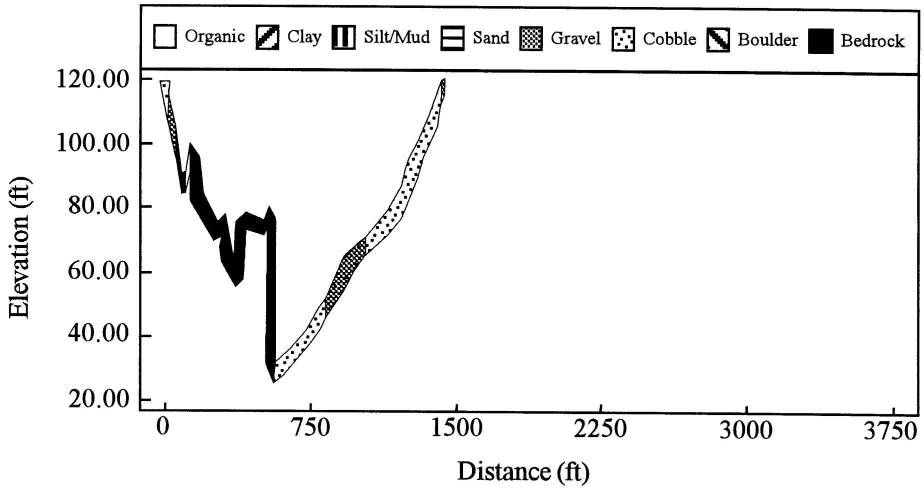
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1213.71	17927.57	0.10	3.50	1.90	28.29	14.77
250	1492.15	42307.94	-0.60	8.20	4.60	46.20	28.35
500	1567.29	59000.38	-1.00	12.70	6.80	57.06	37.64

Figure 31. Cross section profile, substrate and hydraulic modeling data for segment C7 Cross Section 17.

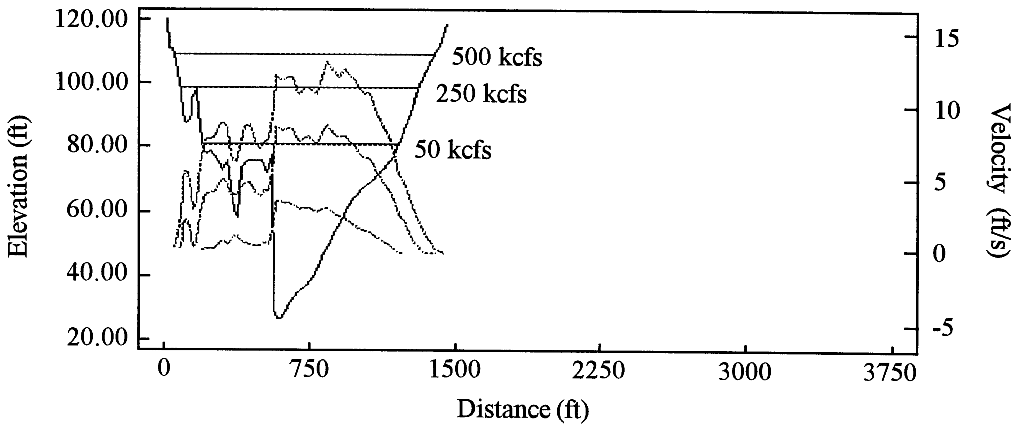
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

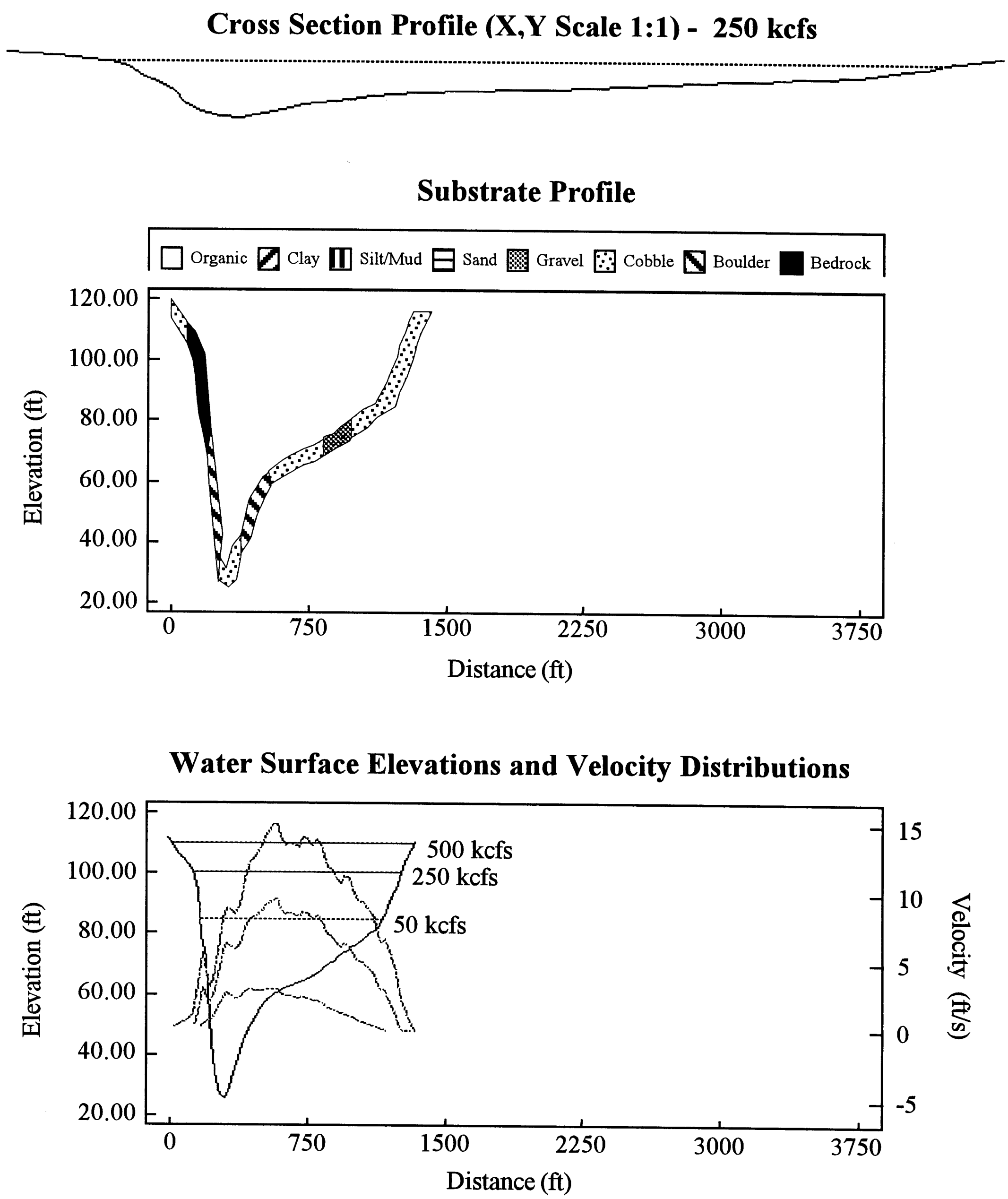


Water Surface Elevations and Velocity Distributions



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1003.57	21138.91	0.10	3.30	1.50	55.59	21.06
250	1213.78	40863.42	0.00	8.20	4.70	73.43	33.67
500	1336,65	54800.04	0.40	12.20	7.80	84.38	41.00

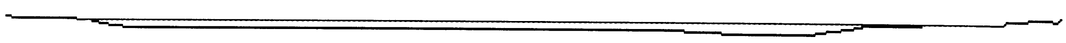
Figure 32. Cross section profile, substrate and hydraulic modeling data for segment C7 Cross Section 19.



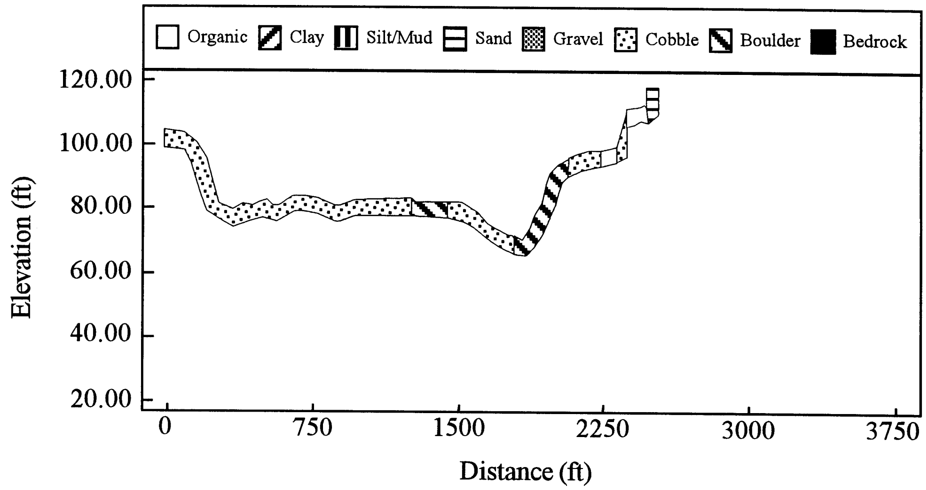
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	949.27	23594.23	0.10	2.90	1.70	61.69	24.86
250	1080.44	40020.95	0.00	9.20	5.50	77.86	37.04
500	1260.72	51453.10	0.30	14.60	8.60	87.66	40.81

Figure 33. Cross section profile, substrate and hydraulic modeling data for segment C7 Cross Section 20.

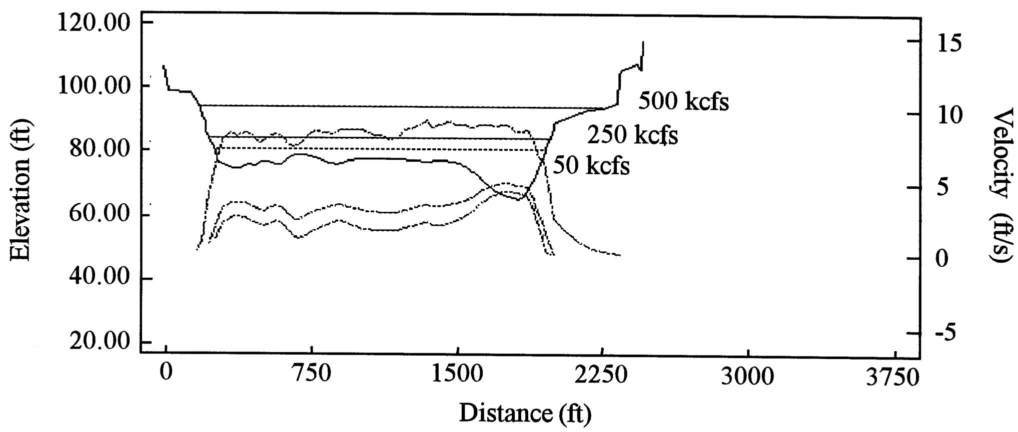
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



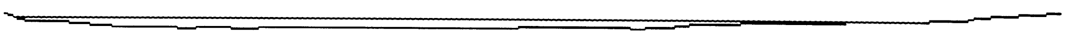
Water Surface Elevations and Velocity Distributions



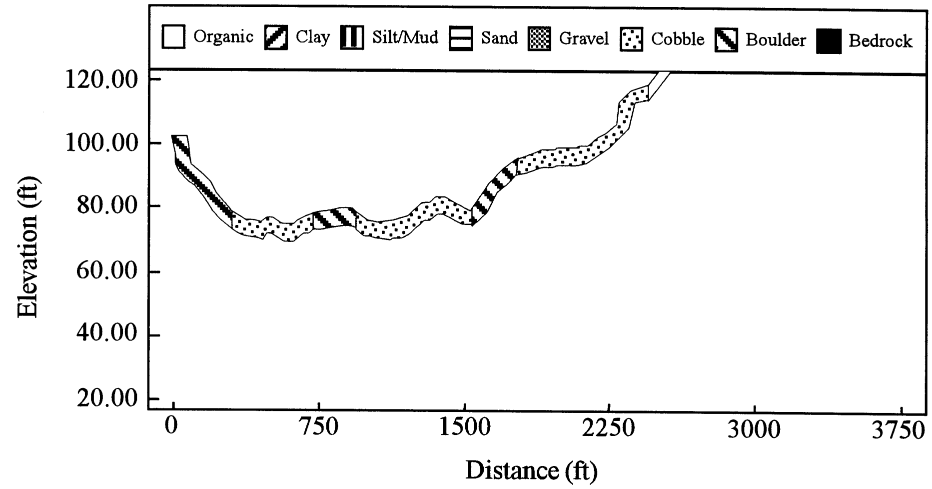
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1778.71	15135.54	1.00	4.50	3.00	18.70	8.51
250	2112.32	33869.13	0.10	8.60	6.50	28.70	16.03
500	2354.48	46924.86	0.50	13.10	9.60	34.60	19.93

Figure 34. Cross section profile, substrate and hydraulic modeling data for segment R3 Cross Section 1.

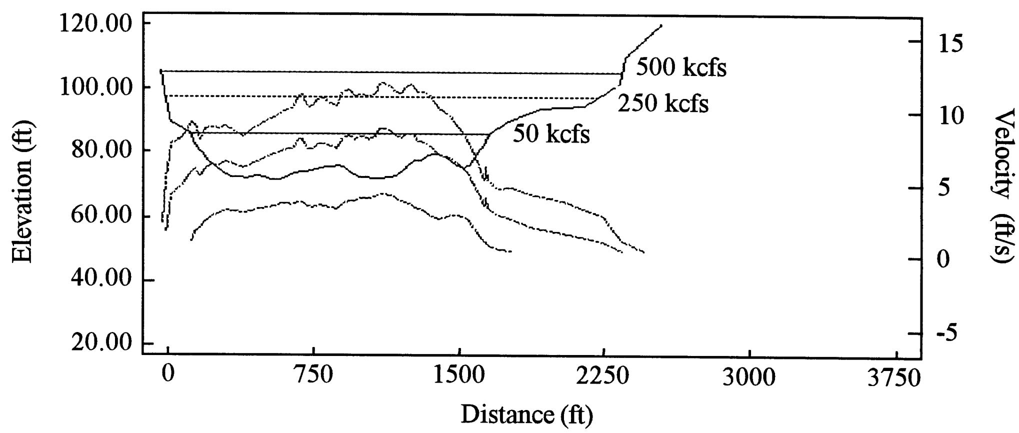
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

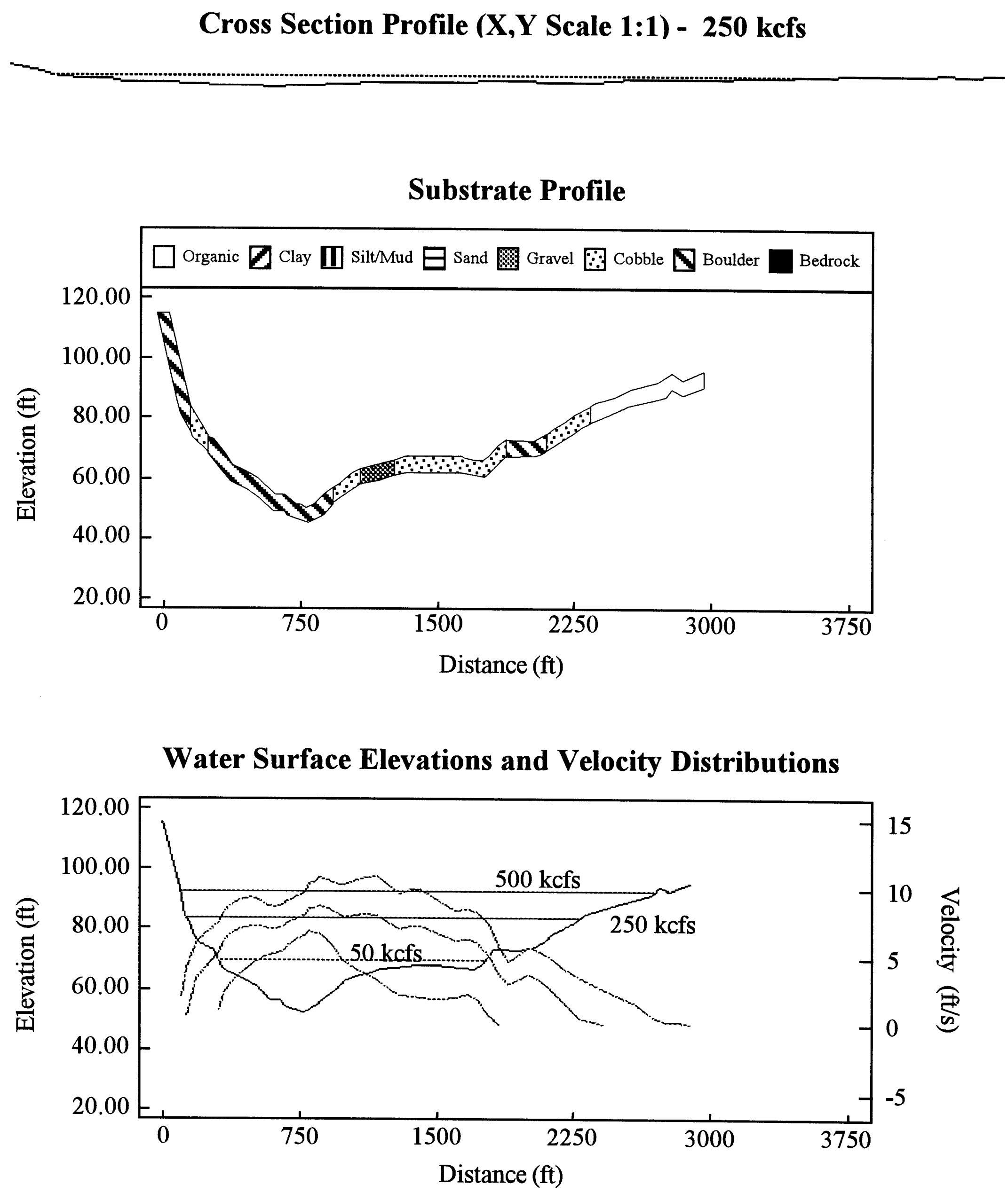


Water Surface Elevations and Velocity Distributions



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1542.17	17214.32	0.10	3.80	2.60	15.14	11.16
250	2231.58	40617.58	1.10	8.20	5.80	27.66	18.20
500	2370.97	59655.84	1.40	11.30	8.30	35.87	25.16

Figure 35. Cross section profile, substrate and hydraulic modeling data for segment R3 Cross Section 4.

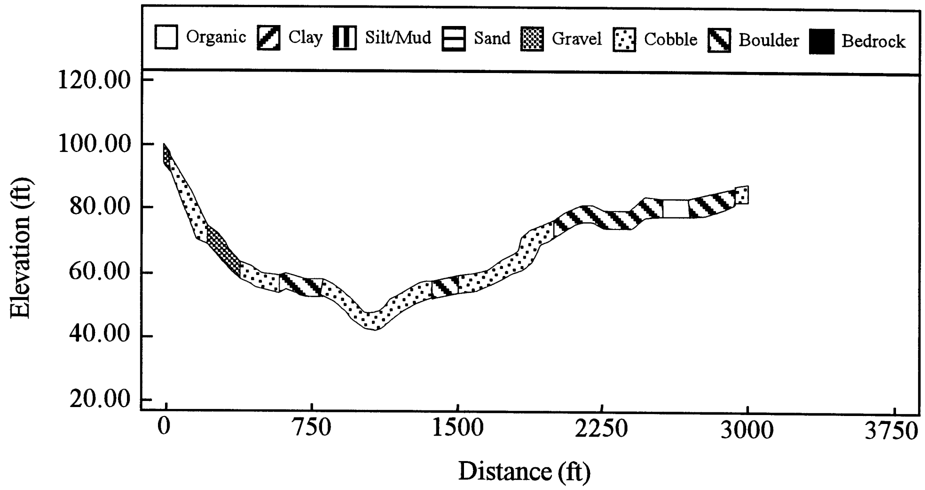


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1451.62	10396.87	1.20	6.70	4.20	18.81	7.16
250	2141.52	38029.46	0.90	8.50	6.00	33.82	17.76
500	2604.85	61019.45	0.30	10.50	7.60	43.45	23.43

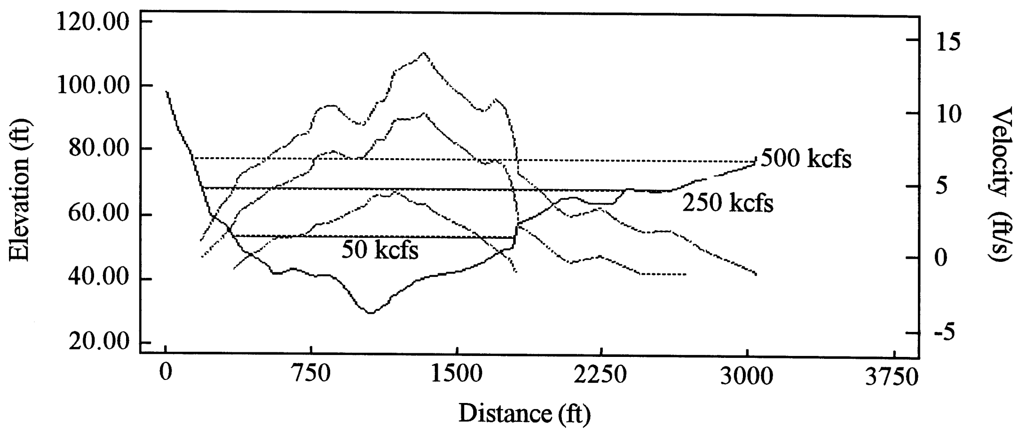
Figure 36. Cross section profile, substrate and hydraulic modeling data for segment R4 Cross Section 1.

Cross Section Profile (X,Y Scale 1:1) - 250 kcfs

Substrate Profile

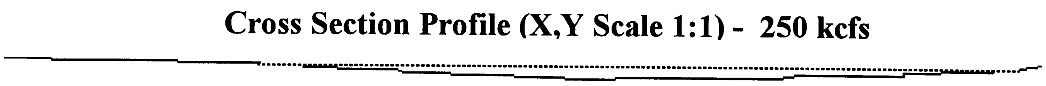


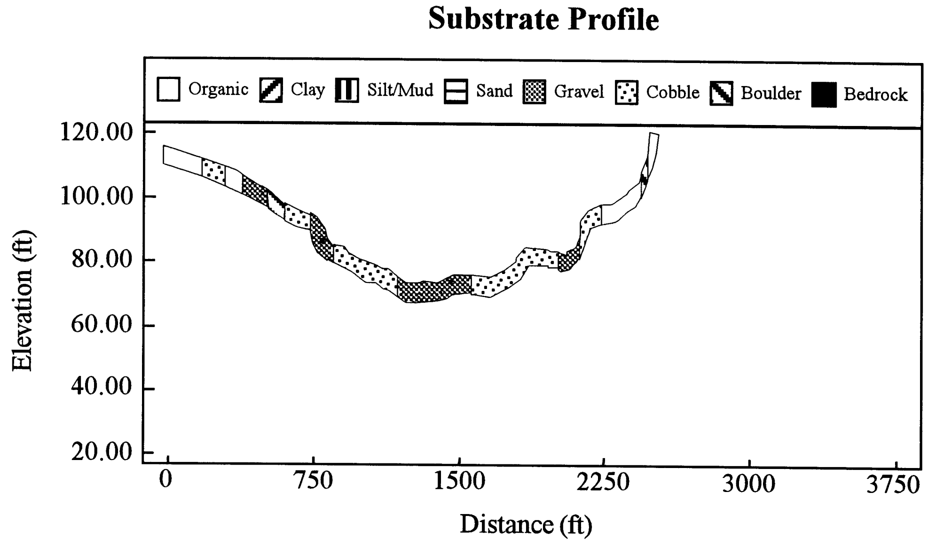
Water Surface Elevations and Velocity Distributions

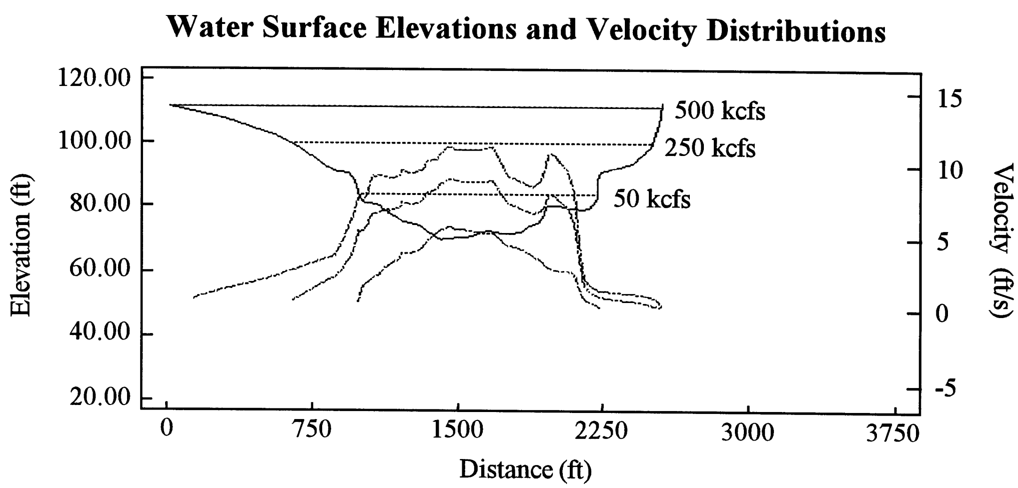


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1429.71	15725.02	0.10	4.60	2.70	21.73	11.00
250	2258.91	39816.84	0.10	9.20	5.50	35.79	17.63
500	2855.63	62353.50	0.20	12.70	7.60	44.36	21.84

Figure 37. Cross section profile, substrate and hydraulic modeling data for segment R4 Cross Section 3.





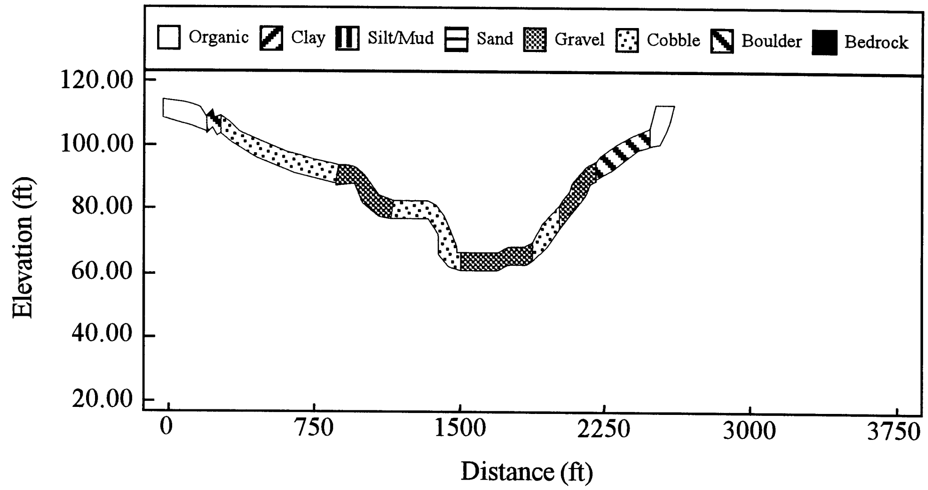


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1258.28	11978.35	0.20	5.50	3.40	15.49	9.52
250	1902.50	38847.74	0.20	8.90	6.00	33.20	20.42
500	2583.19	67269.92	0.20	11.20	7.40	46.11	26.04

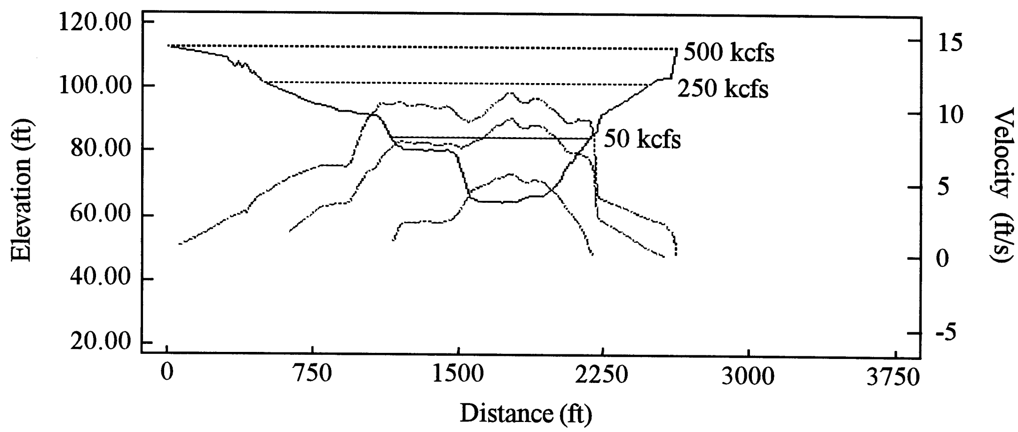
Figure 38. Cross section profile, substrate and hydraulic modeling data for segment R5 Cross Section 1.

Cross Section Profile (X,Y Scale 1:1) - 250 kcfs

Substrate Profile

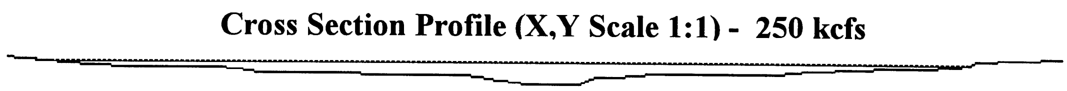


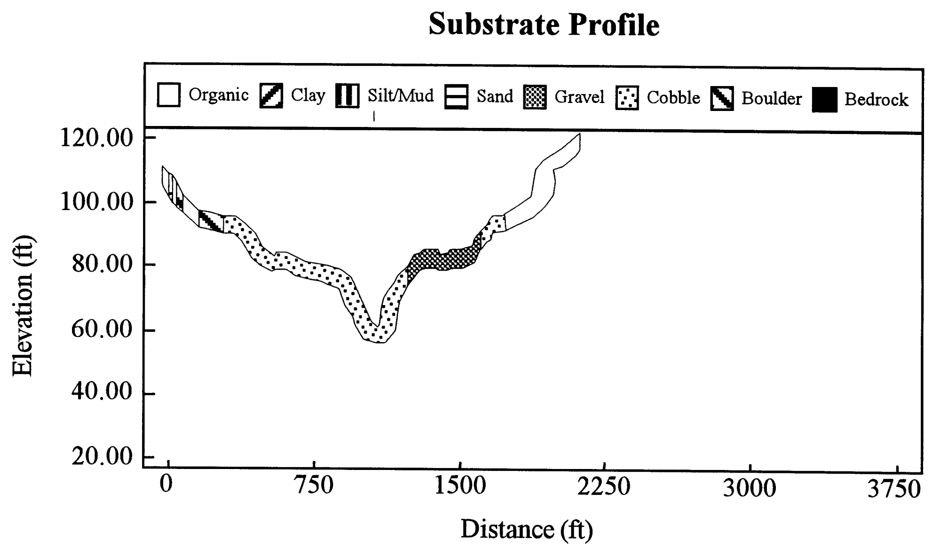
Water Surface Elevations and Velocity Distributions

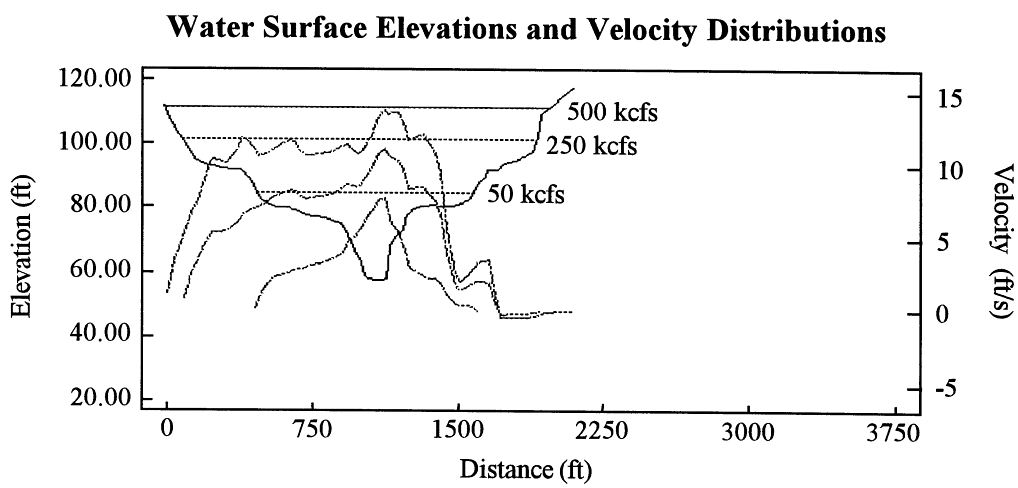


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1028.78	12073.34	0.40	5.20	3.50	20.59	11.74
250	1986.19	36881.55	0.70	8.70	6.30	38.00	18.57
500	2610.59	62791.14	0.40	10.50	7.20	49.47	24.05

Figure 39. Cross section profile, substrate and hydraulic modeling data for segment R5 Cross Section 3.

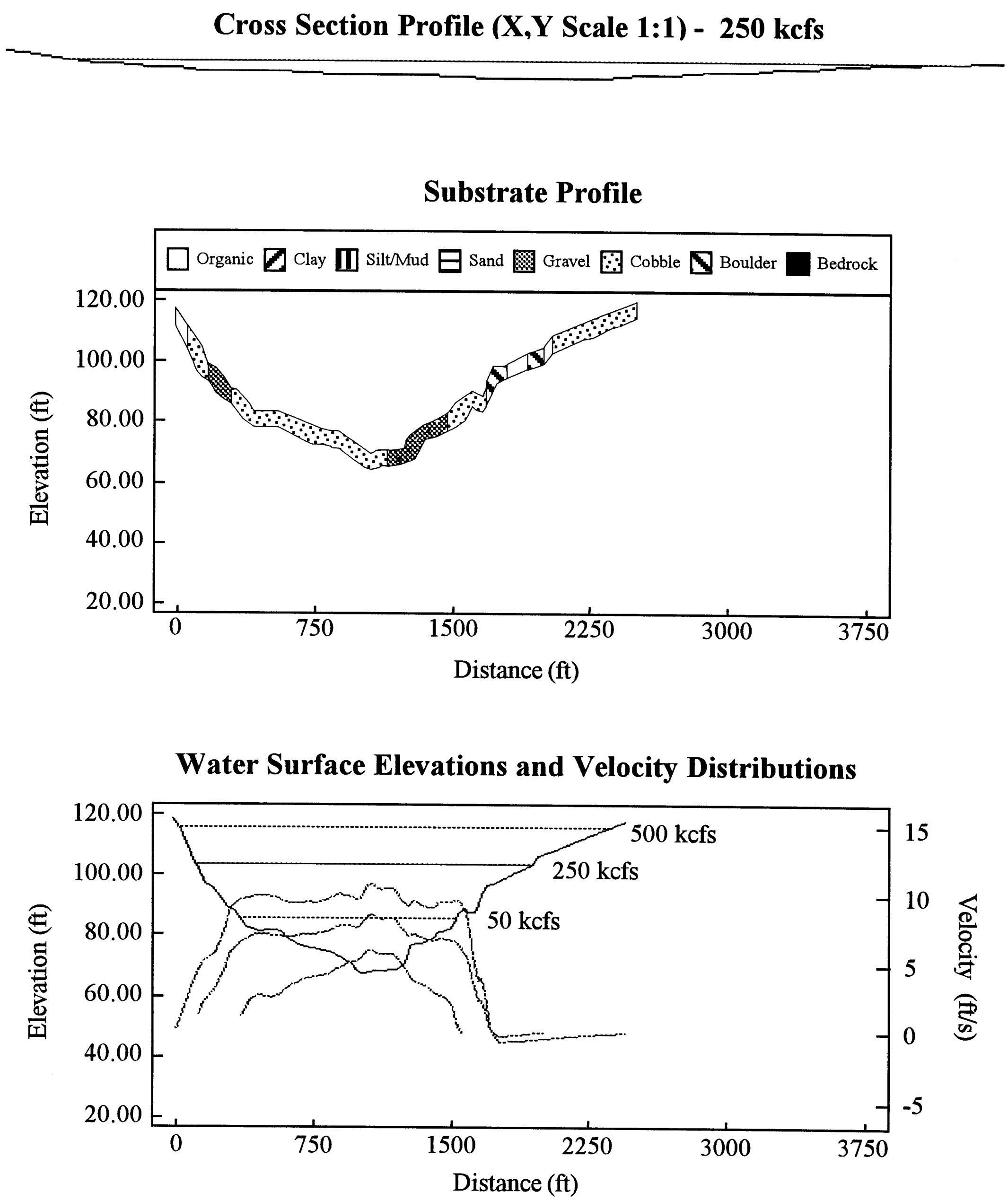






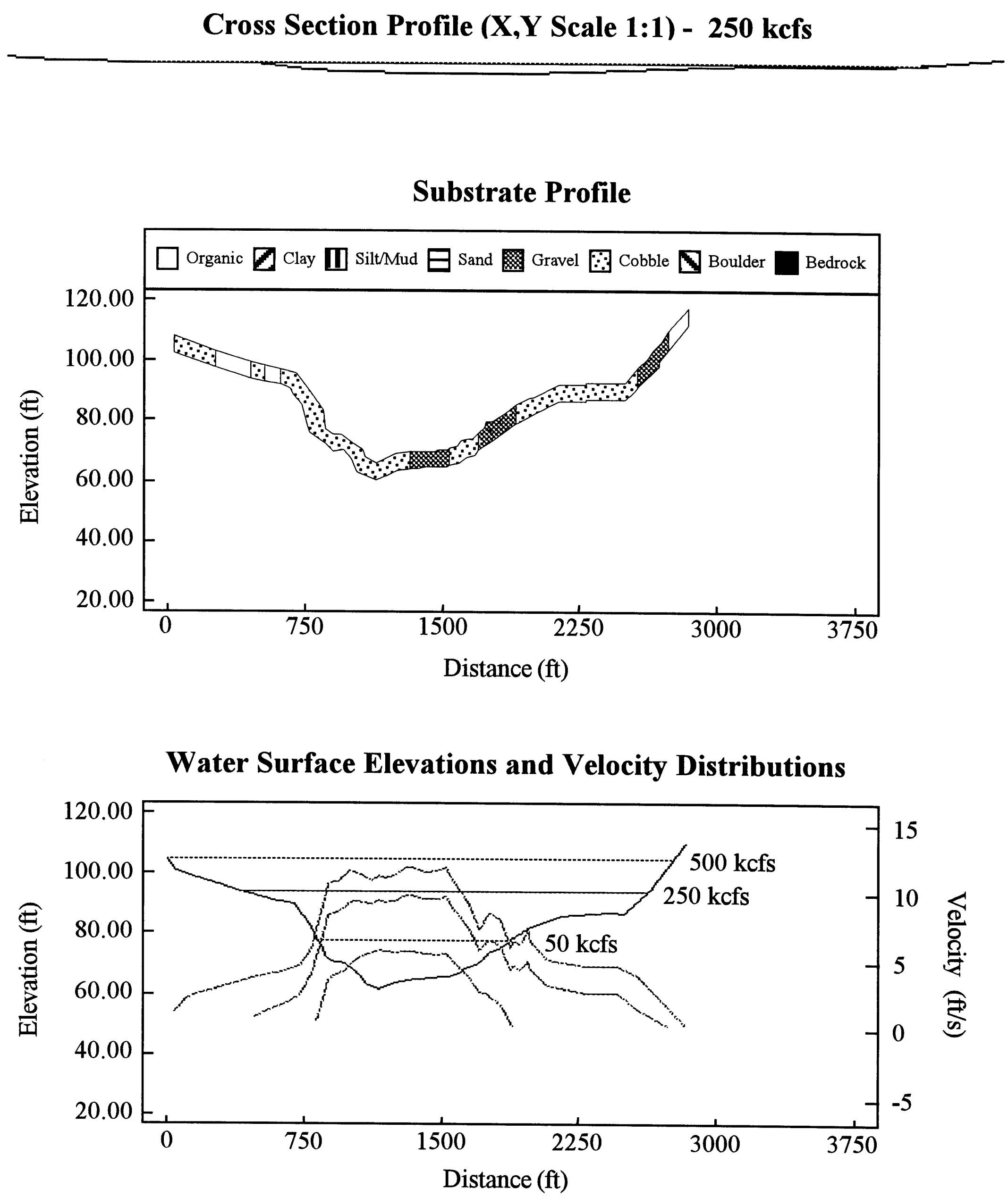
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1128.22	11074.20	0.20	7.40	3.20	28.35	9.82
250	1846.64	36662.21	-0.23	10.60	5.80	45.40	19.85
500	2001.39	56614.58	-0.50	13.20	7.90	55.98	28.29

Figure 40. Cross section profile, substrate and hydraulic modeling data for segment R5 Cross Section 6.



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1108.46	11548.78	1.50	5.80	3.80	19.23	10.42
250	1726.93	38083.48	-0.30	8.30	5.70	38.06	22.05
500	2208.50	63324.89	0.40	10.50	7.30	51.07	28.67

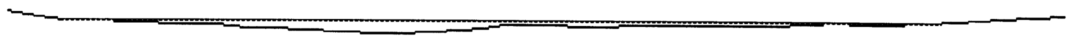
Figure 41. Cross section profile, substrate and hydraulic modeling data for segment R5 Cross Section 8.



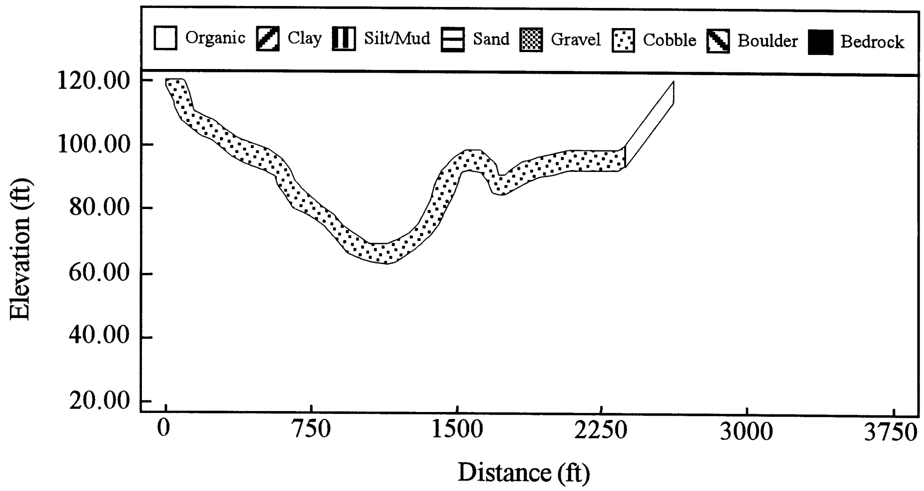
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1019.16	11005.48	0.40	5.50	3.60	17.27	10.80
250	2130.49	36354.79	0.95	9.40	6.00	34.20	17.06
500	2653.63	64914.60	1.60	11.40	7.40	45.89	24.46

Figure 42. Cross section profile, substrate and hydraulic modeling data for segment R6 Cross Section 1.

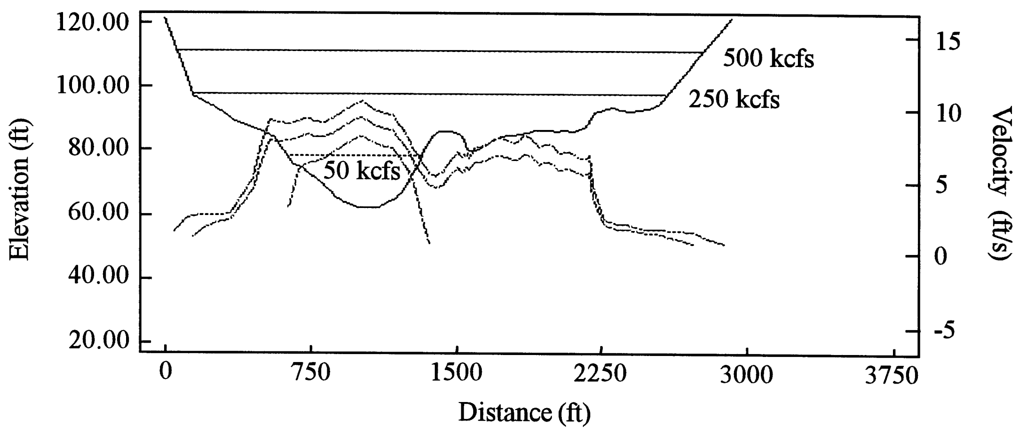
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



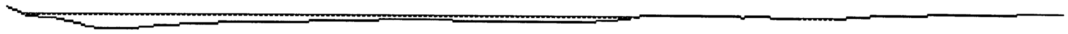
Water Surface Elevations and Velocity Distributions



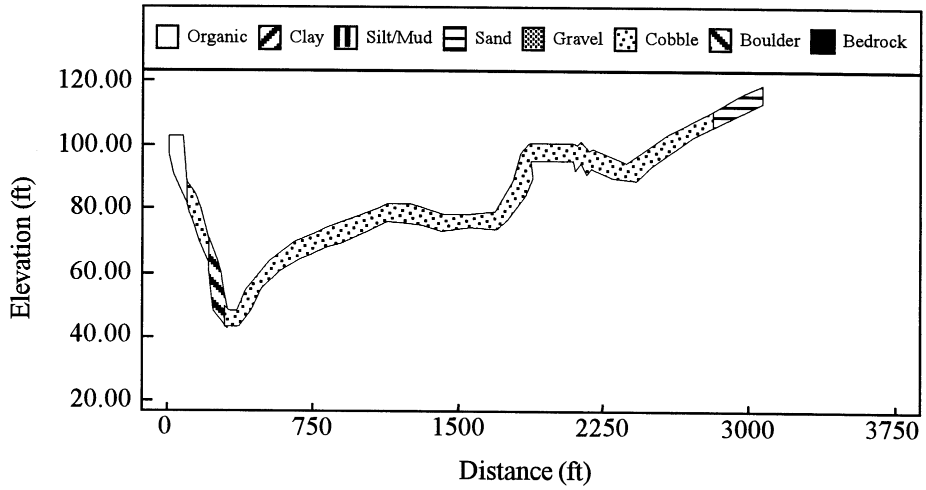
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	714.41	8063.06	3.20	7.30	5.80	17.63	11.29
250	2476.47	40909.76	0.60	8.60	4.80	38.02	16.52
500	2759.02	79962.32	0.70	9.70	5.50	52.93	28.98

Figure 43. Cross section profile, substrate and hydraulic modeling data for segment R6 Cross Section 3.

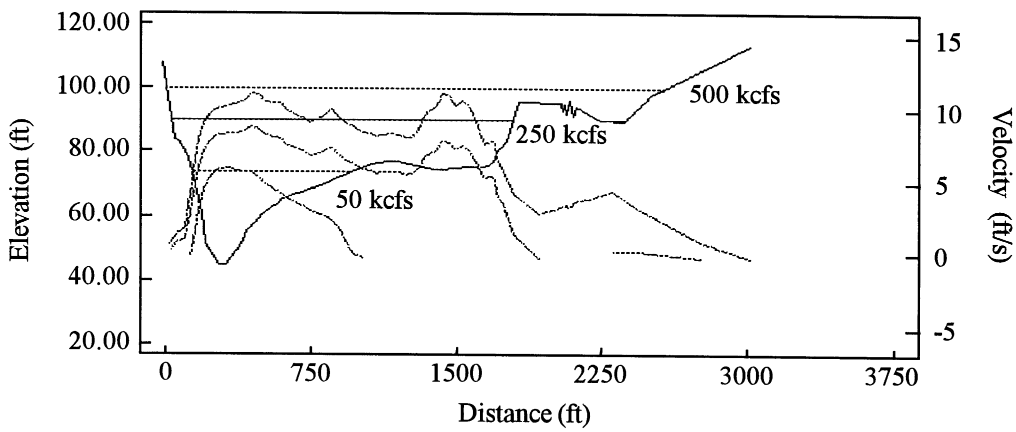
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile

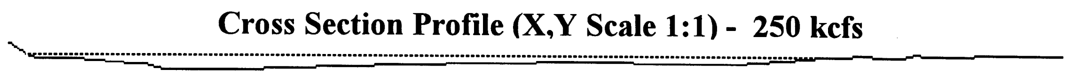


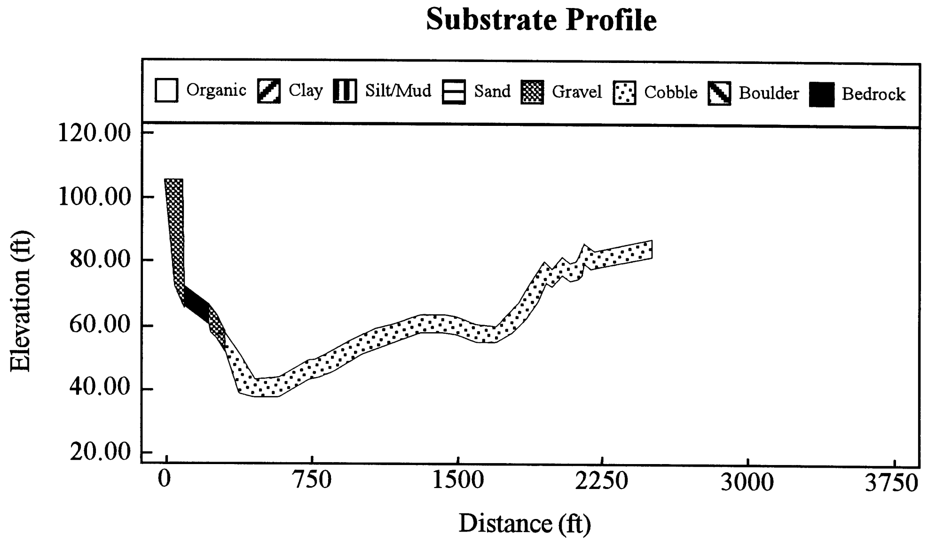
Water Surface Elevations and Velocity Distributions

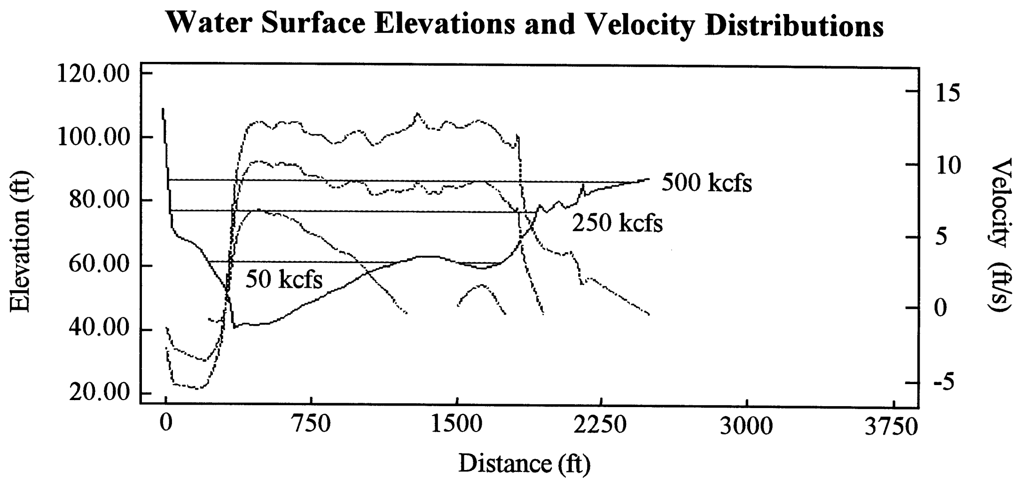


Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	817.75	10198.53	0.20	5.80	3.80	29.67	12.47
250	1860.51	36681.67	0.90	8.50	5.90	46.58	19.72
500	2555.51	59729.75	1.60	11.10	7.30	56.86	23.37

Figure 44. Cross section profile, substrate and hydraulic modeling data for segment R6 Cross Section 5.



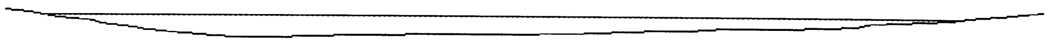




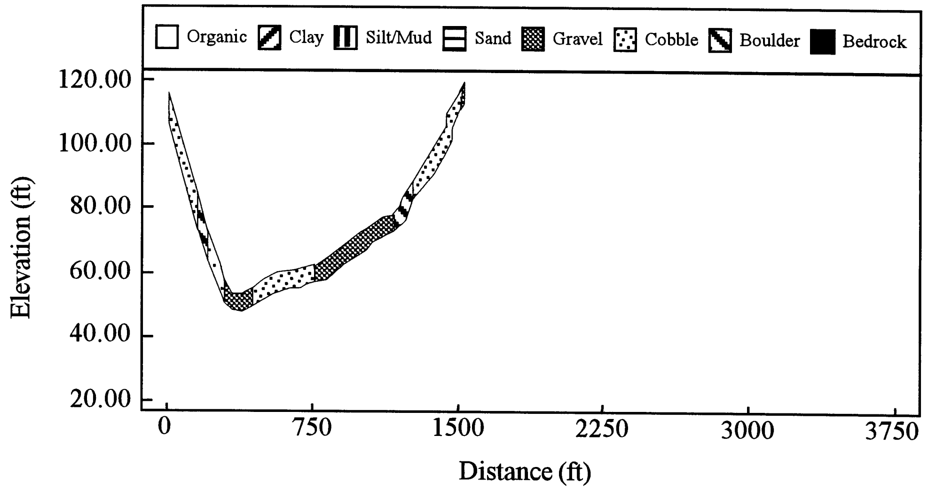
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1197.11	10503.76	-0.70	6.30	3.30	20.12	8.77
250	1845.37	36255.11	-3.10	9.40	6.30	35.48	19.65
500	2287.11	56607.00	-5.00	13.00	8.20	45.29	24.75

Figure 45. Cross section profile, substrate and hydraulic modeling data for segment R6 Cross Section 6.

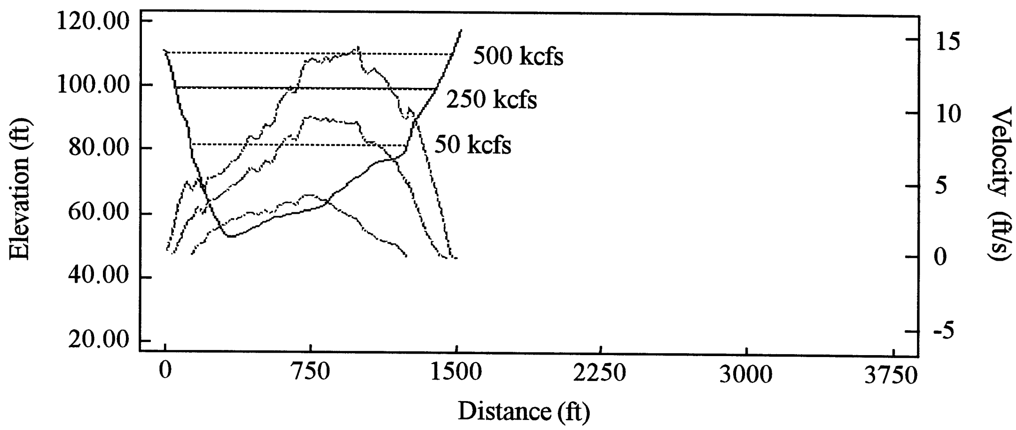
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



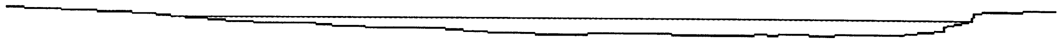
Water Surface Elevations and Velocity Distributions



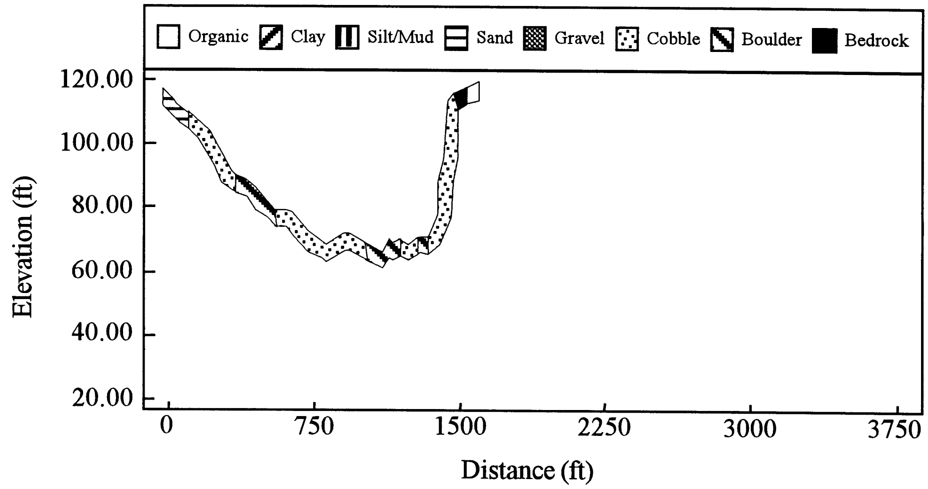
Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	1060.21	18254.96	0.20	4.00	2.30	29.60	17.22
250	1284.48	39522.38	0.20	9.20	5.70	47.90	30.77
500	1413.36	54549.61	0.00	14.20	8.40	59.10	38.60

Figure 46. Cross section profile, substrate and hydraulic modeling data for segment TR Cross Section 1.

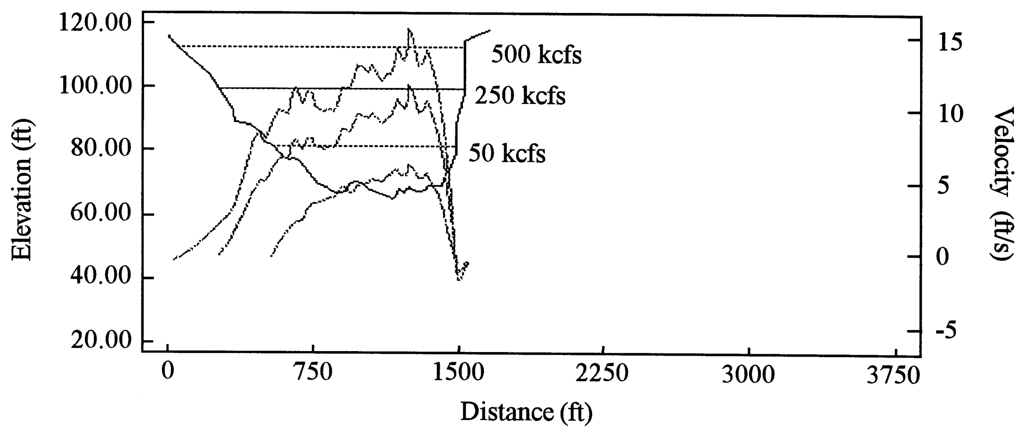
Cross Section Profile (X,Y Scale 1:1) - 250 kcfs



Substrate Profile



Water Surface Elevations and Velocity Distributions



Discharge (kcfs)	Width (ft)	Area (ft^2)	Velocity (ft/s)			Depth (ft)	
			Min	Max	Mean	Max	Mean
50	934.27	10316.29	0.10	6.60	4.50	16.90	11.04
250	1243.88	30688.18	-0.80	11.90	7.50	35.40	24.67
500	1450.06	48335.21	-1.30	15.70	9.90	48.60	33.33

Figure 47. Cross section profile, substrate and hydraulic modeling data for segment TR Cross Section 3.

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

ANNUAL PROGRESS REPORT

APRIL 1997 - MARCH 1998

REPORT F

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: Work to (1) help estimate survival of transplanted wild white sturgeon collected downstream of Bonneville Dam and transported to and released into The Dalles Reservoir, and (2) assist with the update of life history parameters and population dynamics in The Dalles Reservoir.

Prepared By:

Blaine L. Parker

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February 1999

CONTENTS

ACKNOWLEDGMENTS

My sincere appreciation goes to the following Yakama Indian Nation fisheries technicians; Chuck Gardee, James Kiona, and Al McConville who worked closely with tribal fishers during fish capture, tagging, and data collection. Tribal fishers Robert Brigham, Evans Lewis, Jr., and Baptist Lumley, Sr. and their crews were industrious and knowledgeable, reaching the marking objective in approximately five weeks. Tom Rein, John North, and Ruth Farr from the Oregon Department of Fish and Wildlife for their excellent support in project planning, data entry and analysis. Mike Wakeland provided valuable project coordination and field assistance throughout the year.

ABSTRACT

I report on work conducted in The Dalles Reservoir during December 1996 and January 1997 in fiscal year 1997. My efforts focused on two objectives associated with white sturgeon in The Dalles Reservoir (TDR). The first objective was to assist the Oregon Department of Fish and Wildlife (ODFW) with an estimate of survival of transplanted wild white sturgeon collected downstream of Bonneville Dam and transported to and released into TDR. I contracted with experienced tribal sturgeon fishers to capture and mark sturgeon, and recorded data using fisheries technicians from the Yakama Indian Nation (YIN). The second objective was to capture, mark, and release several thousand white sturgeon of all sizes to assist with the update of life history parameters and population dynamics in The Dalles Reservoir white sturgeon population. In five weeks of sampling in December 1996 and January 1997 fishers set 771 overnight gill net sets and 11 overnight setline sets catching 3,747 white sturgeon of all sizes, 2,278 were between 70-166 fork length. Trawl and haul recaptures constituted approximately 21% (N=776) of the all sized sturgeon catch. Technicians applied 1,789 passive integrated transponder (PIT) tags and 1,578 wire-core spaghetti tags to white sturgeon between 70 – 166 fork length. Gonad samples and pectoral fin sections were not collected during the marking effort

INTRODUCTION

This annual report details work conducted by the Columbia River Inter-Tribal Fish Commission (CRITFC) during the Fiscal Year 1997, which runs from October 1996 through September 1997. The CRITFC subcontracted to the Oregon Department of Fish and Wildlife (ODFW), which in turn contracted to the Bonneville Power Administration (BPA) white sturgeon *Acipenser transmontanus* research project 86-50. The CRITFC was responsible for portions of Objective 1, which reads; 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. My work this past year focused on two objectives. The first objective was to cooperate with the ODFW in the evaluation of 1994-1995 sturgeon transplants into The Dalles Reservoir (TDR) by using contracted tribal fishers to recapture the transplanted fish and confirm their presence in the reservoir. The second objective was to assist ODFW with the periodic stock assessment of the indigenous TDR white sturgeon population. I report on catch, marking, and distribution of transplanted and indigenous white sturgeon. Survival estimates of the transplanted sturgeon and population parameters of the population assessment studies are cooperatively reported in North et al. (this report).

METHODS

Three tribal fishers, their crews, and three Yakama Indian Nation (YIN) fisheries technicians sampled white sturgeon in The Dalles Reservoir (TDR) in December 1996 for a three week period ending just prior to Christmas (Figure 1). High water and increased turbidity curtailed sampling until the third week in January 1997. Sampling was concluded the fourth week of January 1997.

Fishers targeted areas throughout the entire reservoir that were most productive based on personal experience and recent catches. This strategy was not random, with 60% and 63% of the commercial and experimental gillnet effort downstream of Miller Island (Table 1; Figure1). This effort though not random or systematic, did span most of the reservoir. This effort combined with the migratory nature of white sturgeon provided for adequate distribution of marked fish over the next several months prior to the follow up evaluation by ODFW and WDFW (North et al. this report).

Tribal fishers used both commercial gill nets (N= 548 sets) and experimental gill nets (N= 223 sets) to sample the population, throughout the reservoir. Some setlines were also used, but in a very limited fashion (N=11 sets). All gears were fished overnight, although poor weather conditions sometimes extended the soak period to 48 h or even 72 h on occasion.

Commercial gill nets varied with regard to mesh material, length, and mesh size, but all nets were fished in a consistent manner, set on the river bottom and anchored in place. Nets ranged in length from 61m to 121m. Stretched mesh sizes ranged from 17.8 cm to 25.4 cm, although most nets used either 20.3 cm or 25.4 cm stretched mesh.

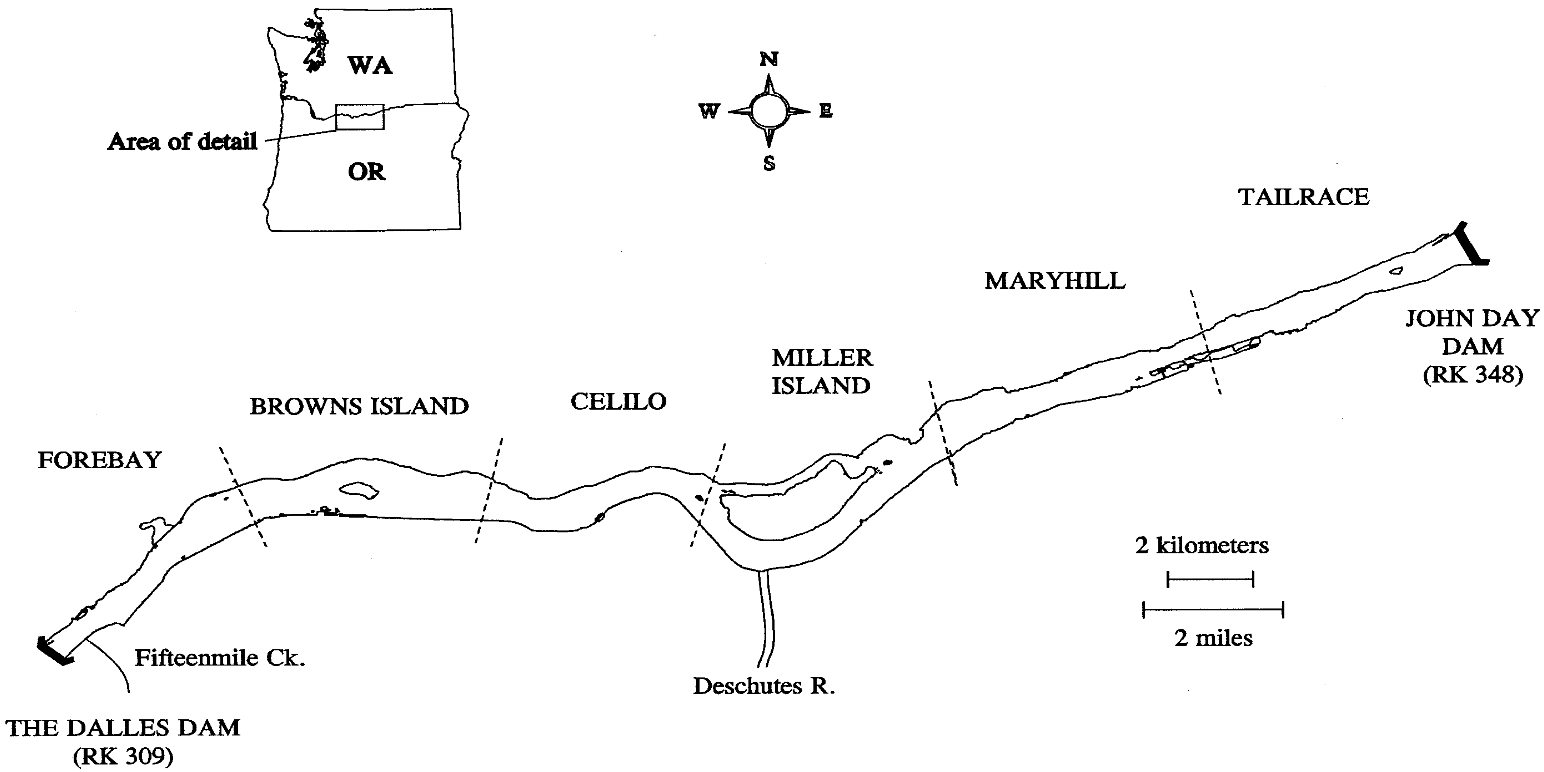

Figure 1. The Columbia River between The Dalles and John Day dams. Sampling section boundaries are indicated by dashed lines. The scale is approximate.

Table 1. Sampling effort (number of gill net and setline sets) for white sturgeon (all lengths) in The Dalles Reservoir during December 1996 and January 1997. A "-" indicates that sampling was not conducted.

Gear and year Week	Sampling section[a]							
	1	2	3	4	5	6	7	All
Commercial gill nets 1996-1997								
49	2	64	4	31	-	-	-	101
50	18	92	10	14	2	1	-	137
51	-	64	22	23	20	19	1	149
4	-	46	11	12	-	7	1	77
5	2	62	-	3	6	10	1	84
Total	22	328	47	83	28	37	3	548
Experimental gill nets 1996-1997								
49	-	35	7	4	-	-	-	46
50	-	50	-	1	-	-	-	51
51	-	19	25	2	-	6	-	52
4	-	12	13	3	-	8	-	36
5	1	25	4	-	3	5	-	38
Total	1	141	49	10	3	19	-	223
Setlines 1997								
5	2	1	2	-	-	4	2	11
Total	2	1	2	-	-	4	2	11

[a] Sampling sections: 1 = The Dalles Dam forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = John Day Dam tailrace, 7 = John Day Dam Boat restricted zone.

The second gill net type was an experimental gill net that was approximately 91 m with six alternating panels of 10.2 cm and 15.2 cm stretched mesh. Experimental gill nets were used to ensure that the smaller trawl and haul sturgeon (<100cm FL) would be adequately represented in the sample. Four of these experimental gill nets were issued to each fisher to include with their commercial gill net sets.

In addition to gill nets, some setlines were also used. Setline lengths were variable and ranged from 122 m to 183 m in length. Fishers used J-style hooks, sizes 10/0 to 12/0, 40-50 hooks per line baited with salmon pieces.

Captured white sturgeon were examined for tags and tag scars, scute scars, pectoral fin scars, scanned for Passive Integrated Transponders (PIT) tags, and measured to the nearest cm fork length (FL). All length data reported and discussed in the text are FL unless otherwise noted. White sturgeon greater than 30 cm FL, but less than 79cm, received a PIT tag if not previously tagged. The PIT tag was injected under the bony plates dorsal and posterior to the head. Upon PIT tag confirmation, the second left lateral scute was removed as a permanent marked to indicate the presence of the PIT tag. White sturgeon greater than 79 cm FL also received a wire-core spaghetti tag if they did not already have an external tag. The spaghetti tag was applied in the anterior portion of the dorsal fin, with the insertion point approximately 1 cm ventral of where the dorsal fin rays insert into the body of the fish. Generally, a distinct horizontal line denotes this fin ray insertion line.

During December 1996, the seventh left lateral scute was removed as a secondary mark to indicate that the fish was tagged or marked in 1996. In January 1997, the seventh right lateral scute was removed for the same purpose. White sturgeon less than 30 cm FL were scute marked for recapture purposes, although these fish were not included in the population estimation as they were not fully recruited to setline gear. Recaptures of white sturgeon tagged from previous sampling efforts were weighed to the nearest 0.1 kg on a hand-held spring balance. Non-salmonid fish species other than white sturgeon captured during our sampling efforts were noted, but not enumerated. Salmonid species were enumerated and condition at release was recorded.

Statistical comparisons were made on catch rates of white sturgeon caught in the commercial and experimental gillnets for white sturgeon of all sizes. Statistical differences ($P < 0.05$) in catch rates were evaluated on transformed catch-per-set data [Log_e (catch+1)]. Differences in the mean size of white sturgeon captured with commercial and experimental gill nets were also made using analysis of variance (ANOVA) and Tukey's studentized range test.

RESULTS

Catch

Fishers caught 3,747 white sturgeon (16 to 281 cm) (Table 2). Commercial gill net sets caught 1,987 (19-280 cm FL) white sturgeon and 1,755 (16-262 cm FL) white sturgeon were caught in experimental gill nets (Table 2). The mean catch rate of the commercial gill nets ranged from a low of 0.0 fish per set to 7.7 fish per set, compared with 2.0 and 12.2 fish per set for experimental gill nets, respectively (Table 3). Catch rates averaged 3.6 fish per set with commercial gill nets (CPUE range 0.0 to 4.6) and 7.9 fish per set with experimental gillnets (CPUE range 2.0 to 12.2) (Table 3). Significant differences existed between log-transformed catch rates of commercial and experimental gill nets in TDR (df=1, 769; F= 139.19; r= 0.153; P< 0.001).

The commercial gill nets caught more larger white sturgeon (> 100cm FL) than the experimental gill nets, 26.4% versus 3.7% (Table 4; Figure 2). Conversely, the catch

Table 2. Catches of white sturgeon (all lengths) with gill nets and setlines in The Dalles Reservoir during December 1996 and January 1997. A "-" indicates that sampling was not conducted.

Gear and year Week	Sampling section[a] 1	2	3	4	5	6	7	All
Commercial gill nets 1996-1997								
49	0	443	12	104	-	-	-	559
50	49	313	39	20	10	0	0	431
51	-	247	61	15	11	39	0	373
4	-	246	19	29	-	52	5	351
5	6	182	-	1	5	79	0	273
Total	55	1,431	131	169	26	170	5	1,987
Experimental gill nets 1996-1997								
49	-	447	56	25	-	-	-	528
50	-	391	-	3	-	-	-	394
51	-	158	175	2	-	43	-	378
4	-	41	48	18	-	115	-	222
5	2	146	35	-	6	44	-	233
Total	2	1,183	314	48	6	202	-	1,755
Setlines 1997								
5	0	0	1	-	-	1	3	5
Total	0	0	1	-	-	1	3	5

[a] Sampling sections: 1 = The Dalles Dam forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = John Day Dam tailrace, 7 = John Day Dam Boat restricted zone.

rate of smaller white sturgeon (< 100 cm FL) was higher in the experimental gill nets than the commercial gill nets, 96.3% versus 73.6% (Table 4; Figure 2). White sturgeon less than 40 cm FL constituted a substantial portion of the smaller white sturgeon in the experimental gill nets (Table 4). The majority of these fish were considered to be young of year (YOY) white sturgeon (<33cm FL) (Figure 2).

The mean length of white sturgeon caught with the experimental gill nets was significantly (df = 1, 3740; p <0.001) less than the mean length of white sturgeon caught

Table 3. Mean catch of white sturgeon (all lengths) with gill nets and setlines in The Dalles Reservoir during December 1996 and January 1997. A "-" indicates that sampling was not conducted.

Gear and year / Month	Sampling section[a]							
	1	2	3	4	5	6	7	All
Commercial gill nets 1996-1997								
December	2.5	4.6	3.1	2.0	1.0	1.9	0.0	3.5
January	3.0	4.0	1.7	2.0	0.8	7.7	2.5	3.8
Total	2.5	4.4	2.7	2.0	0.9	4.7	2.5	3.6
Experimental gill nets 1996-1997								
December	-	9.6	7.2	4.3	-	7.2	-	8.7
January	2.0	5.1	4.9	6.0	2.0	12.2	-	6.1
Total	2.0	8.4	6.4	4.8	2.0	10.6	-	7.9
Setlines 1997								
January	0.0	0.0	0.5	-	-	0.25	1.5	0.5
Total	0.0	0.0	0.5	-	-	0.25	1.5	0.5

[a] Sampling sections: 1 = The Dalles Dam forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = John Day Dam tailrace, 7 = John Day Dam Boat restricted zone.

with commercial gill net gear, 51.3 cm and 87.7 cm, respectively. The ODFW setline catch was significantly larger at 90.6 cm (df = 1, 4,444; $p < 0.001$) than the CRITFC commercial gill net catch.

Distribution

Tribal fishers captured white sturgeon in throughout TDR (Table 2), although 70% of all sturgeon collected were taken in Section 2 (Browns Island) in lower portion of the reservoir with mean catch rates of 4.4 and 8.4 for commercial and experimental gill nets, respectively (Figure 1; Table 2). The highest catch rates were recorded for Section 6 near John Day Dam with other sections (Figure 1; Table 2)

Marking and Mark Recovery

Tribal fishers marked 2,290 white sturgeon of all sizes and recaptured 161 white sturgeon by the end of the sampling period. As reported by North et al. (this report) our within year PIT retention was 98% (103-256 days at large) and 95% (119-251 days at large) for fish marked with wire core spaghetti tags.

Table 4. Catches of white sturgeon by fork length (cm) interval with commercial and experimental gill nets in The Dalles Reservoir, December 1996 and January 1997. Setline catches are not included due to the low number of fish (N=5). A "-" indicates sampling was not conducted.

Gear type	Sampling section[a]							
Fork interval	1	2	3	4	5	6	7	Total
Commercial								
≤20	0	4	0	0	0	0	0	4
21-40	9	135	5	2	2	3	0	156
41-60	0	10	0	27	4	16	0	57
61-80	5	174	22	74	5	35	3	318
81-100	20	721	61	38	6	81	0	927
101-120	19	365	41	27	6	34	2	494
121-140	1	16	1	1	3	0	0	22
141-160	0	1	0	0	0	0	0	1
161-180	0	3	0	0	0	0	0	3
181-200	0	0	0	0	0	0	0	0
201-220	0	2	1	0	0	0	0	3
221-240	0	0	0	0	0	1	0	1
>241	1	0	0	0	0	0	0	1
Total	55	1,431	131	169	26	170	5	1,987
Percent	2.7	72.1	6.6	8.5	1.3	8.6	0.3	100
Net sets	22	328	47	83	28	37	3	548
Experimental								
≤20	0	22	11	0	0	1	-	34
21-40	1	658	145	7	6	24	-	841
41-60	0	46	30	11	0	69	-	156
61-80	0	213	80	22	0	86	-	401
81-100	0	192	39	7	0	20	-	258
101-120	1	49	7	1	0	2	-	60
121-140	0	2	2	0	0	0	-	4
141-160	0	0	0	0	0	0	-	0
161-180	0	0	0	0	0	0	-	0
181-200	0	0	0	0	0	0	-	0
201-220	0	0	0	0	0	0	-	0
221-240	0	0	0	0	0	0	-	0
>241	0	1	0	0	0	0	-	1
Total	2	1,183	314	48	6	202	-	1,755
Percent	0.1	67.4	17.9	2.7	0.3	11.5	-	100
Setline sets	1	141	49	10	3	19	-	223

[a] Sampling sections: 1 = The Dalles Dam forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = John Day Dam tailrace, 7 = John Day Dam Boat restricted zone.

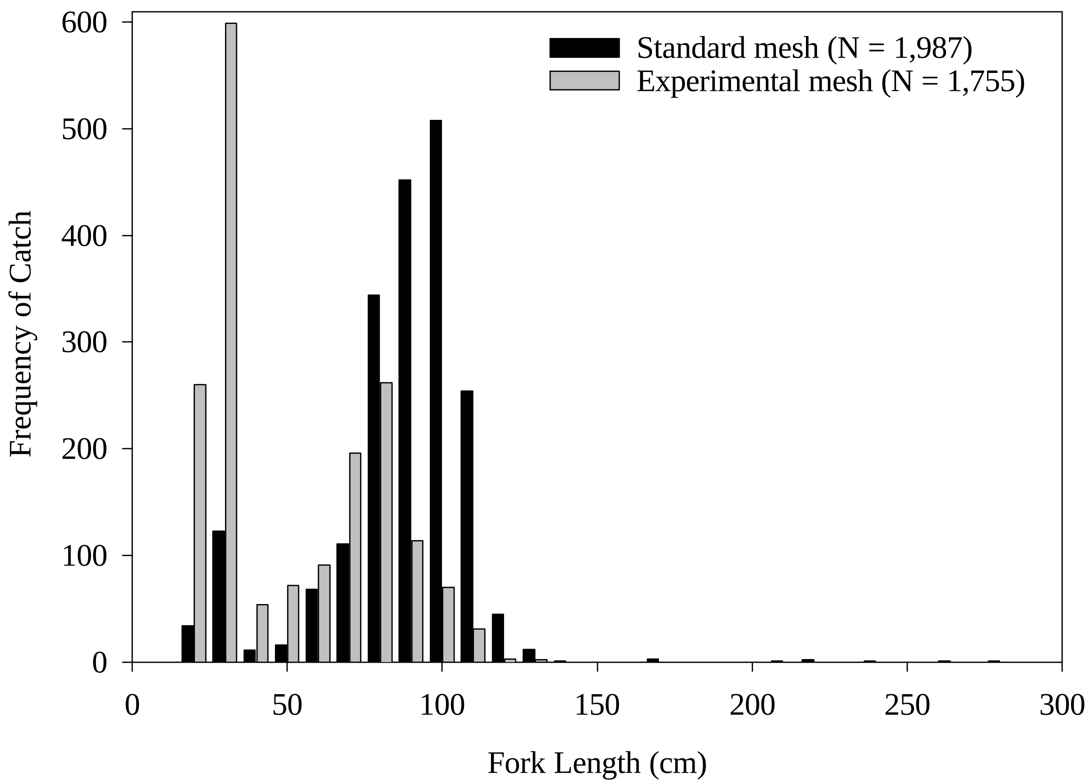

Figure 2. Frequency of catch of white sturgeon collected with gill nets by Columbia River Inter Tribal Fish Commision in The Dalles Reservoir, December 1996 through January 1997.

Incidental Catch

Additional fish species besides white sturgeon were captured with in experimental gill nets and commercial gill nets. Suckers *Catostomus sp*., channel catfish *Ictalurus punctatus*, northern pikeminnow *Ptychocheilus oregonensis*, and walleye *Stizostedion vitreum* were caught during the sampling period. A single steelhead trout *Oncorhyncus mykiss* was caught during our sampling and released alive. All incidentally caught fish were returned to the river.

DISCUSSION

Tagging efforts in TDR by CRITFC and tribal fishers was the second dual state/tribal population assessment. The combined marking effort allowed for a greater number of potential recaptures and thus tighter confidence limits around the population estimate. As discussed in North et. al., it is unclear what factors are operating to create the substantial upward population shifts in both John Day and The Dalles reservoirs.

This represents the second time in 2 years that the paired strategy of a CRITFC and ODFW joint effort has resulted in a substantial white sturgeon population increase. As discussed in North et al. (this report), it is unclear what is operating with regard to these substantive population changes, the effect of paired co-management efforts or subtle changes in gear deployment and baits by ODFW. Regardless, I concur with ODFW that the effort has resulted in a more precise population estimate than those generated in previous years. I also concur that appropriate increases should be made with regard to existing harvest guidelines to allow for increased exploitation of this more robust population, but not at the rate that occurred in the late 1980's.

The other key element that was noted during the sampling effort was the relative ease of capture of young of year white sturgeon in our experimental gill nets. I believe that a unique opportunity exists to use this gear to annually monitor reproductive success of all Zone 6 white sturgeon populations. Currently only the Bonneville Reservoir has been and is being monitored in such a fashion by staff from the National Biological Service. This monitoring is conducted by bottom trawling, a time consuming, expensive, and labor intensive process that does not lend itself to uneven underwater topography. Unfortunately, many areas of TDR and John Day Reservoir are not suitable for trawling, but would be easily sampled with overnight gill net sets. I will request that this technology be more closely examined as a possible strategy for annual recruitment sampling in the future.

PLANS FOR 1998

In 1998 I plan to assess sturgeon harvest by tribal subsistence fishers using hook and line gear during the non-commercial fishing season. Some concern has raised that since this fishery is not formally monitored using a standardized count and angler survey process, many fish are being harvested that are going unrecorded against the subsistence guideline. I will coordinate with Washington Department of Fish and Wildlife (WDFW) staff on this project and report the findings in my 1998 report.

REFERENCES

North, J. A., L. C. Burner, and R. A. Farr. 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 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.