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

ANNUAL PROGRESS REPORT

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CONTENTS

EXECUTIVE SUMMARY

We report on progress from April 1994 through March 1995 of research on white sturgeon in the lower Columbia River.

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

This report describes activities conducted during the third year of this contract's second phase. Information was collected, analyzed, and evaluated on subadult and adult life histories, population dynamics, quantity and quality of habitat, and production enhancement strategies. Abstracts at the beginning of Reports A through E.

REPORT A

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

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

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ABSTRACT

We report on work performed from April 1994 to March 1995 to determine the life history and population dynamics of white sturgeon ***Acipenser transmontanus*** in the Columbia River between Bonneville and John Day dams. We set 604 and 428 set lines in Bonneville and The Dalles reservoirs and caught 2,226 and 1,338 white sturgeon. We tagged 1 500 and 1,081 fish that were 70 - 166 cm fork length and estimated the abundance of those'fish was 35,200 and 9,700 respectively. We recaptured 20 and 41 of these tagged fish. White sturgeon moved widely within the reservoirs during the five months of this study, and in The Dalles Reservoir fish tended to move upstream. However long-term recovery of tags showed that few tagged fish left the reservoirs (6% of tag recoveries since 1987), and that nearly all reservoir emigration was downstream. We collected 621 fin-ray samples from white sturgeon < 110 cm fork length, and collected eggs from 17 fish. These samples will contribute to our age and reproduction data bases. Mean relative weight was higher than previously reported for white sturgeon populations in these reservoirs. Snout/head length ratios classified by 20-cm fork length intervals were not significantly different among Bonneville Reservoir, The Dalles Reservoir, and the area of the Columbia and Snake rivers upstream from McNary Dam and downstream from Priest Rapids and Ice Harbor dams.

INTRODUCTION

In 1986, the Bonneville Power Administration (BPA) funded a 6-year study of white sturgeon ***Acipenser transmontanus*** in the Columbia River below McNary Dam. The study addressed objectives of a research program implementation plan developed in response to the 1987 Fish and Wildlife Program measure 903(e)(l). Phase I of this research was completed in 1992. In 1993, BPA extended funding for continued white sturgeon research in this study area and above McNary Dam. In this report we describe our activities and results from April 1994 through March 1995, summarizing progress toward study objectives and intermediate results that we will use to estimate the productivity of white sturgeon in Bonneville and The Dalles reservoirs. Sampling in 1994 was designed to tag fish for estimates of abundance and exploitation, to collect individual growth data, and to collect gonad tissue samples that will contribute to our understanding of reproductive potential and will be useful in assessing bioaccumulation of toxins.

Results of the October 1993 feasibility evaluation of transplant supplementation will be reported in DeVore et al. (In Review). A summary of collection and transportation methods effort, catch, and number of juvenile white sturgeon transported from below Bonneville Dam to The Dalles Reservoir in October and November 1994 will be presented with our report of activities and results for April 1995 through March 1996.

The White Sturgeon Management Framework Plan for the Columbia River between Bonneville and McNary dams (Zone 6) will be presented as a separate document (DeVore et al. In Review).

METHODS

We sampled white sturgeon in Bonneville and The Dalles reservoirs from mid April through. early September 1994 to estimate population statistics (Figure 1). We divided Bonneville Reservoir into eight sampling sections, approximately 9.5-km long. The Dalles Reservoir was divided into six sections, about 6.5~km long. Results for the boat restricted zones (BRZs) adjacent to and immediately downstream from The Dalles and John Day dams are reported separately from other sections in each pool because the BRZs were unique habitats and were less than 1 km long.

We distributed setline sampling effort equally among and within sections to obtain a representative sample of the populations. We divided the field season into three, 7-week sampling periods. All sections were sampled in each period, except the BRZ in The Dalles Reservoir, where spill prevented sampling in some periods (Table 1).

Setlines were our primary sampling gear because they provide the greatest catch rate and are less size selective than other gears (Elliott and Beamesderfer 1990). We set 604 setlines in Bonneville Reservoir and 428 in The Dalles Reservoir. Setlines were fished overnight for 14.2 to 32.2 hours (average 22.8 hours). Depth of sets ranged from 1.5 to 41.3 m. We used 12/O, 14/O, and 16/O hooks baited with pieces of Pacific lamprey ***Lumpetra tridentata.*** Each line had 40 hooks.

Gill nets, similar to those described by Elliott and Beamesderfer (1990), were used in BRZs downstream from The Dalles and John Day dams to increase our catch of white sturgeon < 80 cm fork length. We set four gill nets in Bonneville Reservoir and eight in The Dalles Reservoir. Gill nets were fished 0.75 to 1.05 hours (average 0.95 hours).

We measured fork length (cm) and weight (0.1 kg) of each white sturgeon captured and examined all fish for tags, tag scars, fin marks, scute marks, and missing barbels (a mark used in 1987 and 1988). Most white sturgeon were tagged with a passive integrated transponder (PIT) tag injected under the armor of the head near the dorsal midline. In mid season we ran short of PIT tags and some fish (> 79 cm) were marked with a spaghetti tag instead. The

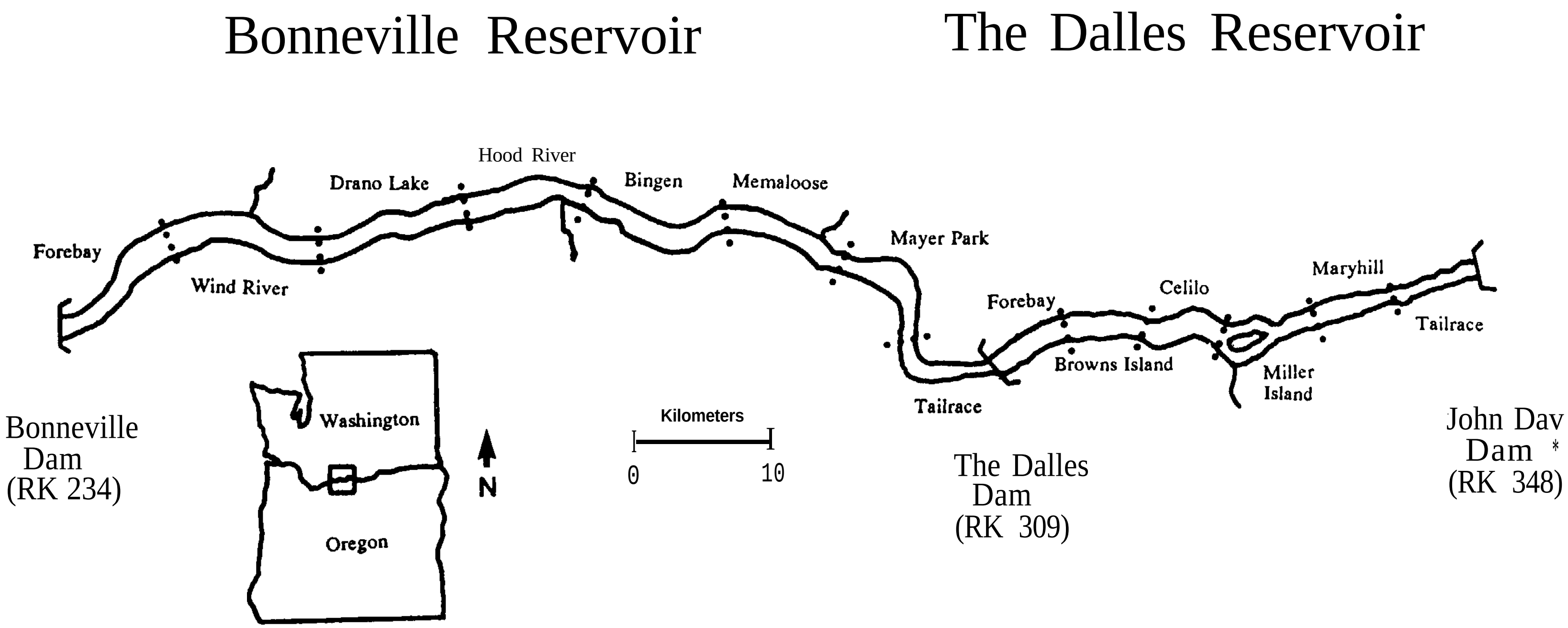

Figure 1. Columbia River from Bonneville Dam to John Day Dam. Sampling area boundaries are indicated by. .‘s.

Table 1. Sampling effort (number of setline sets) for white sturgeon in Bonneville and The Dalles reservoirs, April through September, 1994.

Reservoir, Weekofyear	Location[a]									
	1	2	3	4	5	6	7	8	9	Total
Bonneville:										
15	0	0	0	0	0	10	2	0	0	12
18	0	0	0	0	24	22	0	0	0	46
19	0	0	21	22	0	0	0	0	0	
20	0	0	0	0	0	0	24	19	5	43 48
21	23	24	0	0	0	0	0	0	0	47
26	0	0	0	0	27	27	0	0	0	54
27	27	27	0	0	0	0	0	0	0	54
28	0	0	27	27	0	0	0	0	0	
29	0	0	0	0	0	0	24	9	9	54 42
33	0	0	0	0	28	26	0	0	0	54
34	27	27	0	0	0	0	0	0	0	54
35	0	0	27	27	0	0	0	0	0	54
36	0	0	0	0	0	0	24	6	12	42
Total	77	78	75	76	79	85	74	34	26	604
The Dalles:										
16	0	0	23	24	0	0	0			47
17	22	22	0	0	0	0	0			44
22	0	0	0	0	24	24	0			48
23	0	0	22	24	0	0	0			46
24	24	24	0	0	0	0	0			48
25	0	0	0	0	23	23	0			46
30	0	0	24	23	0	0	0			47
31	25	26	0	0	0	0	0			51
32	0	0	0	0	27	15	9			51
Total	71	72	69	71	74	62	9		-	428

[a] In Bonneville reservoir: 1 = Forebay, 2 = Wind River, 3 = Drano Lake, 4 = Hood River, 5 = Bingen, 6 = Memaloose, 7 = Mayer Park, 8 = Tailrace, 9 = The Dalles Dam boat restricted zone (BRZ). In The Dalles reservoir: 1 = Forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = Tailrace, 7 = John Day Dam BRZ.

spaghetti tag was placed near the posterior end of the dorsal fin about 2.5 cm beneath the fin insertion. All untagged white sturgeon > 79 cm were tagged with a molded nylon-tipped dart tag placed near the anterior origin of the dorsal fin and about 2.5 cm beneath the fin insertion (Gutherz et al. 1990; North et al. 1995). We removed the fifth left lateral scute as a secondary mark to identify year of capture if all tags were shed or lost. The second left lateral scute was removed to identify PIT tagged fish (Rien et al. 1994). Pectoral fin-ray sections were collected from white sturgeon < 95 cm long in Bonneville Reservoir and < 110 cm long in The Dalles Reservoir to determine age.

We injected 1,930 white sturgeon in Bonneville Reservoir (< 95 cm or > 154 cm) and 1,186 in The Dalles Reservoir (< 110 cm or > 154 cm) with oxytetracycline (OTC) to validate our age interpretations from fin-ray sections using fish we recapture in future years. We injected 100 mg/ml OTC into the red muscle under the dorsal scutes immediately posterior to the head. Doses were adjusted such that each fish received about 25 mg/kg of body weight (McFarlane and Beamish 1987; Rien and Beamesderfer 1994). We removed the second right lateral scute from OTC injected fish to identify injected white sturgeon at recapture. We collected fin-ray samples from recaptured white sturgeon injected with OTC prior to 1994.

We surgically examined the gonads of white sturgeon longer than 154 cm to determine sex and collected samples from female fish following procedures outlined in Beamesderfer et al. (1989). In the laboratory we measured egg diameters and classified them to five developmental stages (Chapman 1989; North et al. 1992). The stages were: 1) early vitellogenic, 2) late vitellogenic, 3) ripe, 4) post spawning (spent), 5) previtellogenic with attritic oocytes, and 6) previtellogenic. Fish in stages 3 and 4 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 2 or more years after capture.

We took an additional egg sample from some females that will be used to examine levels of polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls. If mature or maturing eggs were observed, we removed up to 30 g of eggs using a 200 cc disposable syringe. The eggs were transferred to an uncontaminated glass jar and frozen for storage. Toxin analyses will be conducted by a commercial laboratory once we have collected more than 10 ovary samples.

Distribution of white sturgeon was examined by comparing setline catch rate among sampling sections. We examined recoveries of white sturgeon tagged since 1987 among years and reservoirs to describe the extent and direction of reservoir emigration.

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

Paired samples of fork length and weight were used to calculate regressions for both reservoirs. Relative weights (W_r) were used to estimate the condition of white sturgeon captured (Beamesderfer 1993). Wr values were compared between reservoirs and among 20-cm fork length intervals using analyses of variance (ANOVA), (SAS 1988a; 1988b).

We examined snout dimorphism by calculating the ratio of head to snout length from white sturgeon (Crass and Gray 1982; North et al. 1995). Head length (mm) was measured as the linear distance from the dorsal insertion of the opercle to the anterior tip of the snout. Snout length (mm) was measured as the linear distance from the anterior orbit of the eye to the anterior tip of the snout (Scott and Crossman 1973; North et al. 1995). We also classified snout type as long, short, or unknown using subjective criteria. For each reservoir, we calculated linear regressions of head length versus snout length, and of fork length versus head/snout length ratio (Zar 1984). We used ANOVA to compare mean head/snout length ratio among snout types. We used 1994 data and head/snout length ratio data collected in

1993 from above McNary Dam (North et al. 1995) to compare mean head/snout length ratio among areas of the Columbia River and 20-cm fork length intervals.

Abundance was estimated for each reservoir for fish 70 - 166 cm using a modified Schnabel multiple mark-recapture estimator (Ricker 1975). Mark-recapture samples were grouped by sampling periods and we accounted for harvested fish observed during recreational fisheries (James et al. 1995). Fish that had lost tags were identified from secondary marks. We expanded the size range of the estimate using gear vulnerability and observed length frequency (Beamesderfer and Rieman 1988; Beamesderfer et al. 1995).

RESULTS

Catch

We caught 2,226 white sturgeon with setlines in Bonneville Reservoir (3.69 per set) and 1,338 white sturgeon in The Dalles Reservoir (3.13 per set, Table 2). Setlines captured white sturgeon 37 - 268 cm long (Figures 2A and 3A). We caught 134 white sturgeon in Bonneville Reservoir with gill nets (34.00 per set) and 22 in The Dalles Reservoir (2.75 per set, Table 3). Gill nets captured sturgeon 22 - 109 cm long (Figures 2A and 3A).

Marking and Mark Recovery

In Bonneville Reservoir we tagged 2,332 white sturgeon, of which 1,500 (70 - 166 cm) were used to estimate abundance. We applied 1,944 PIT tags, 1,012 dart tags, **and 384** spaghetti tags. We recaptured 20 of the fish (70 - 166 cm) tagged in 1994 (Table 4). Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) personnel recovered one sturgeon tagged this year while sampling recreational fisheries in Bonneville Reservoir (James et al. 1995). Recreational anglers voluntarily reported harvesting three sturgeon tagged this year.

In The Dalles Reservoir we tagged 1,312 white sturgeon, of which 1,081 (70 - 166 cm) were used to estimate abundance. We applied 1,300 PIT tags, 8 11 dart tags, and 8 spaghetti tags. We recaptured 41 of the fish (70 - 166 cm) tagged in 1994. No white sturgeon tagged this year were observed while sampling recreational fisheries in the Dalles Reservoir (James et al. 1995). Recreational anglers voluntarily reported harvesting one sturgeon tagged this year.

The 1994 commercial fishery in the reservoirs occurred prior to field sampling so we did not receive any voluntary or insample tag recoveries from this source.

We estimated the abundance of 70 - 166 cm white sturgeon to be 35,200 fish in Bonneville Reservoir and 9,700 fish in The Dalles Reservoir (Table 5).

The retention rate of PIT tags was approximately 97%. The retention rate of dart tags was approximately 85 % (Table 6).

Distribution and Movement

Setline catch rates within sections were variable among months, but were generally higher after May (Table 7). Setline catch rates generally increased moving upstream from dam forebays and were highest in tailrace BRZs.

We captured white sturgeon in all reservoir sections and we often recaptured fish in areas other than where they were released, particularly in The Dalles Reservoir where most movement was upstream (Table 8). Since 1987 we have tagged 9,323 white sturgeon in areas above Bonneville Dam. We have recovered 1,162 tagged fish during sampling and from sport and commercial fishers. Of these, 661 fish (57%) were recovered l-7 years after the initial tagging, and 68 fish (6%) were recovered in areas downstream from the initial tagging reservoir. Only two tagged white sturgeon have been recovered in areas upstream from the reservoir they were tagged in (Table 9).

Table 2. Catches of white sturgeon (all lengths) with setlines in Bonneville and The Dalles -reservoirs, April through September, 1994.

Reservoir, Weekofyear	Location[a]									
	1	2	3	4	5	6	7	8	9	Total
Bonneville:										
15						42	5	-	-	47
18			3;	74	55-	61-	-	-	-	116
19										
20	-	-	-	-	-	-			-	106
21	25	47	-	-	-	-	112-	54-	9	175
26	-	-								
27	40	115	-	=	164	115	=	=	-	279 155
28	-	124	94	-	-	-	-	-	-	218
29						-	123	47	87	257
33	11	87	-	-	124-	124-	=	=	-	248
34									-	98
35		-	110	132	-				-	242
36						-	124	24	65	213
Total	76	249	266	300	343	342	364	125	161	2,226
The Dalles:	-									
16	31	38	80-	69-	-	-	-	-	-	149
17							-	-	-	69
22					54	5;	-	-	-	105
23		-								
24	28	75	60-	75-	-	-	-	-	-	135 103
25					50	147	-	-	-	197
30	20	61	57-	94-	-	-	-	-	-	151
31								-	-	81
32				-	110	9;	143	-	-	348
Total	79	174	197	238	214	293	143	-	-	1,338

[a] In Bonneville reservoir: 1 = Forebay, 2 = Wind River, 3 = Drano Lake, 4 = Hood River, 5 = Bingen, 6 = Memaloose, 7 = Mayer Park, 8 = Tailrace, 9 = The Dalles Dam boat restricted zone (BRZ). In The Dalles reservoir: 1 = Forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = Tailrace, 7 = John Day Dam BRZ.

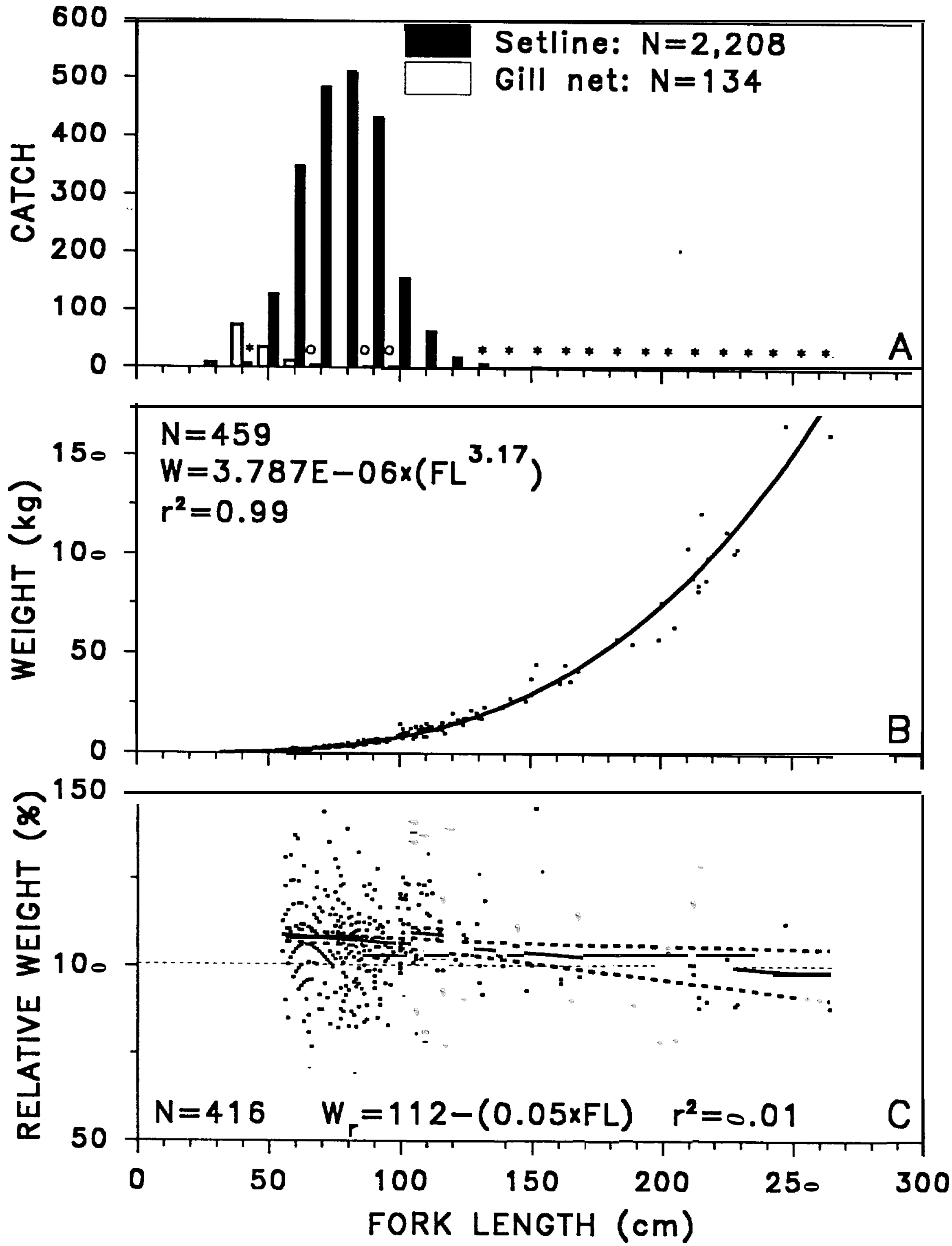

Figure 2. Length and weight information for white sturgeon collected in Bonneville Reservoir, April through September, 1994: A) Frequency of catch. Length increments with fewer than 10 fish are indicated by an "o" for gill nets and an "*" for setlines. B) Length-weight relationship. C) Relative weight by fork length.

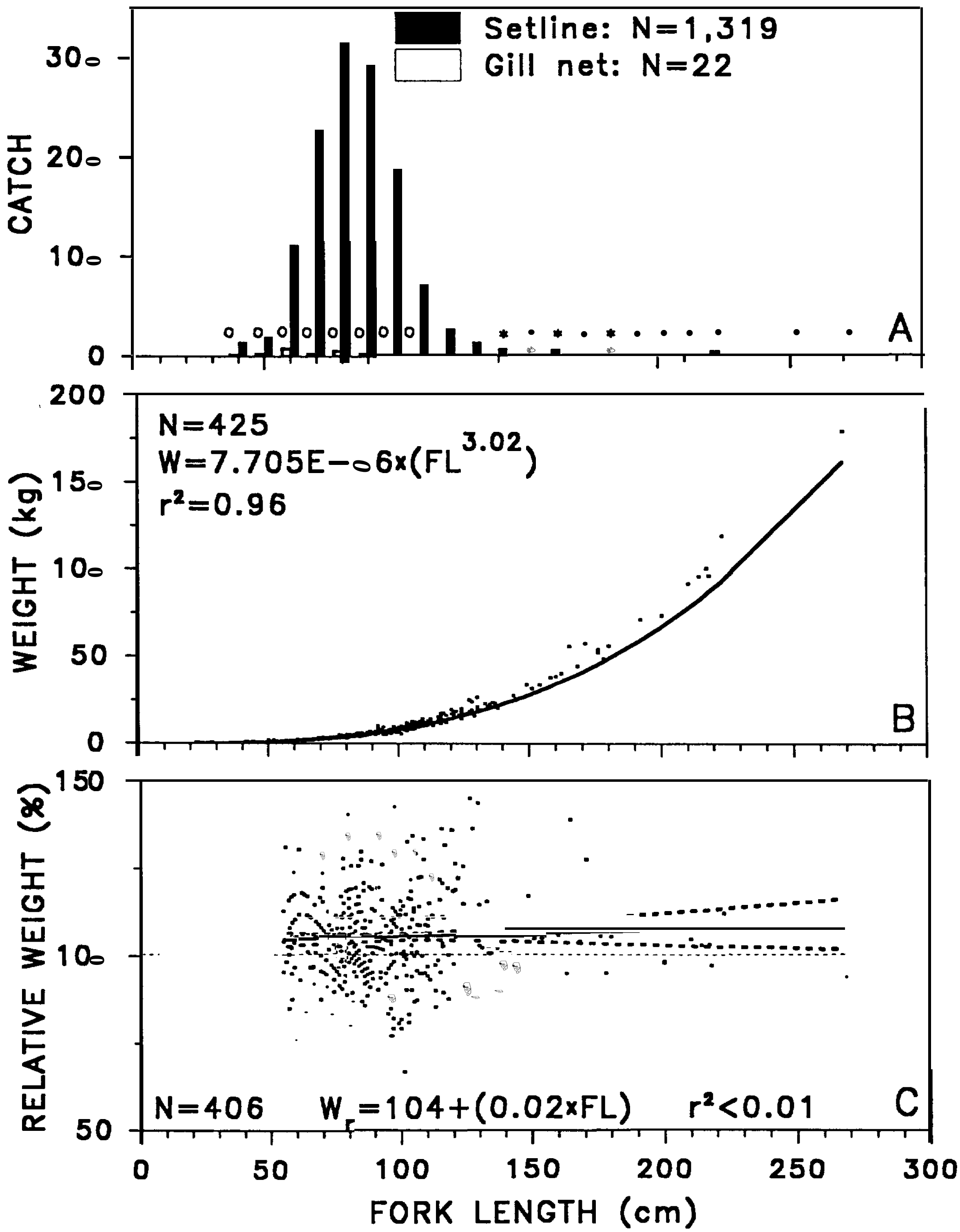

Figure 3. Length and weight information for white sturgeon collected in The Dalles Reservoir, April through September, 1994: A) Frequency of catch. Length increments with fewer than 10 fish are indicated by an "o" for gill nets and an "*" for setlines. B) Length-weight relationship. C) Relative weight by fork length.

Table 3. Sampling effort (number of gill net sets), catch, and catch per set of white sturgeon in Bonneville and The Dalles reservoirs, April through September, 1994.

Reservoir, Week of year	Effort[a]	Catch	Catch per net
Bonneville:			
29	3	3	1.00
36	1	131	131.00
The Dalles:			
22	3	4	
25	2	1	0.50 1.33
32	3	17	5.67

[a] Gill nets were set for about one hour.

Table 4. Mark and recapture data for white sturgeon 70 - 166 cm fork length captured with setlines and gill nets and recovered from surveyed recreational anglers in 1994.

Reservoir, period	Number caught	Number marked[a]	Number recaptured	Number removed[b] Unmarked	Number removed[b] Marked	Number of marks at large
Bonneville:						
4/11-6/5	292	287	0	24		0
6/6-7/24	668	655	6	74	1	286
7/25-9/11	581	558	14	96	1	938
Total	1,541	1,500	20	194	2	
The Dalles:						
4/18-6/5	252	251	0	2		0
6/6-7/24	391	385	5	12	-	251
7/25-9/11	489	445	36	2	1	635
Total	1,132	1,081	41	16	1	

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

[b] Includes observed harvest by recreational fisheries sampled by Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife personnel.

Table 5. Abundance of white sturgeon based on mark-recapture estimates ($\tilde{N}$ for fish 70-166 cm) in Bonneville and The Dalles reservoirs, 1994. Confidence intervals (95%) are in parentheses.

$\tilde{N}$	Fork lengths (cm)[a] 54-81	82-109	110-166	≥167	Σ
		Bonneville Reservoir			
35,200 (24,800 - 66,000)	31,300	18,300	1,500	900	52,000
		The Dalles Reservoir			
9,700 (7,500 - 14,000)	5,800	5,700	800	300	19,100

[a] Correspond to total lengths of 24-35, 36-47, 48-72, and ≥72 inches.

Table 6. Number of marked white sturgeon recaptured with setlines and gill nets in Bonneville and The Dalles reservoirs, April through September, 1994.

Mark type, retention[a]	Number recaptured
Nylon-tipped dart tag	
Retained	39
Lost	7
Passive Integrated Transponder tag	
Retained	77
Lost	2

[a] We determined tag loss from marks and tag scars on sturgeon at recapture.

Table 7. Mean catch per setline day (40 hooks) by month and for all months combined for white sturgeon in Bonneville and The Dalles reservoirs, April through September, 1994.

Reservoir, month[b]	Location[a]								
	1	2	3	4	5	6	7	8	9
Bonneville:									
April	-	-	-		-	4.20	2.50	-	
May	1.00	1.96	1.52	3.36	2.29	2.77	4.67	2.84	1.80
June	1.48	4.26	4.59	3.48	6.07	4.26			
July							5.12	5.22	9.67
August	0.41	3.22	4.07	4.89	4.43	4.77		-	-
September							5.17	4.00	5.42
All months	0.99	3.19	3.55	3.95	4.34	4.02	4.92	3.68	6.19
The Dalles:									
April	1.41	1.73	3.48	2.87			-	-	-
May					2.25	2.12	-	-	-
June	1.17	3.12	2.73	3.12	2.17	6.39	-	-	-
July								-	-
August	0.80	2.35	2.37-	4.09-	4.07	6.33	15.89	-	-
All months	1.11	2.42	2.86	3.35	2.89	4.73	15.89	-	-

[a] In Bonneville reservoir: 1 = Forebay, 2 = Wind River, 3 = Drano Lake, 4 = Hood River, 5 = Bingen, 6 = Memaloose, 7 = Mayer Park, 8 = Tailrace, 9 = The Dalles Dam boat restricted zone (BRZ). In The Dalles reservoir: 1 = Forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = Tailrace, 7 = John Day Dam BRZ.

[b] Months: April = weeks 15 through 17, May = weeks 18 through 22, June = weeks 23 through 26, July = weeks 27 through 30, August = weeks 31 through 35, September = week 36.

Table 8. Number of white sturgeon (all lengths) marked and recovered by location in Bonneville and The Dalles reservoirs, April through September, 1994. Boat-restricted zone (BRZ).

Reservoir, tagging location	Number tagged	Recapture location								
		1	2	3	4	5	6	7	8	9
Bonneville:										
1. Forebay	76		2							
2. Wind River	249									
3. Drano Lake	266									
4. Hood River	299		1		1					
5. Bingen	342					1				
6. Memaloose	336						4		1	
7. Mayer Park	357							6		
8. Tailrace	122							1	2	1
9. The Dalles BRZ	285									10
Total	2,332	0	3	0	1	1	4	7	3	11
The Dalles:										
1. Forebay	78	1	1	1	1				-	-
2. Browns Island	171		3		1			2	-	-
3. Celilo	195		1	2					-	-
4. Miller Island	235				2	3	2	2	-	-
5. Maryhill	201					4	2	2	-	-
6. Tailrace	279					1	10	3	-	-
7. John Day BRZ	153							4	-	-
Total	1,312	1	5	3	4	8	14	13	-	-

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

Table 9. Summary of white sturgeon tagged in each reservoir and the numbers and locations of recaptures, 1987-1994, Columbia River. Recoveries are from field sampling, commercial fisheries, angler creel, and volunteer angler returns.

Tag reservoir:		McNary	John Day			The Dalles						Bonneville				
Year tagged:		93	89	90	91	87	88	89	91	93	94	88	89	91	93	94
Number tagged:		156	21	516	85	830	1,281	147	379	7	811	417	2,514	1,141	8	1,010
Recapture Location	**Year**															
McNary Reservoir	93	6														
	94	4														
John Day Reservoir	87					1										
	90		3	35												
	91			29												
	93			7	1				1							
	94	21	1	2												
				4	1											
The Dalles Reservoir	87					69										
	88					86	115									
	89					16	58	3								
	91					6	15	1								
	92		1	1		13	24	4	7							
						3	7	1	5							
	93			1		1	7	1	9							
	94			3		3	6	6	15		30					
Bonneville Reservoir	88											2				
	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
Lower Columbia River	87					1										
	89											3				
	90											1	4			
	91												1			
	92												7	2		
	93									1			3	1		
	94						1						1	5		

To **claify** trends, this table is not zero-filled.

Age, Growth, and Morphometry

We collected 621 fin-ray samples which were classified by reservoir and 20-cm fork length interval and mounted for age determination. Assigned ages ranged from 1 to 25 in Bonneville Reservoir and from 4 to 22 in The Dalles Reservoir (Tables 10 **and** 11). We collected 164 fin-ray samples from white sturgeon injected with OTC prior to 1994. These samples will be used to corroborate results of age validation previously reported (Rien and Beamesderfer 1994). An age-frequency table of McNary Reach white sturgeon collected during 1993 stock assessment work is presented in Appendix A-3. This table was omitted in a previous report (North et al. 1995).

Paired samples of fork length and weight were sufficient to calculate reservoir specific regressions with high degrees of confidence (Figures 2B and 3B). Mean Wr was 107 in Bonneville Reservoir and 105 in The Dalles Reservoir (Figures 2C and 3C). ANOVA (type III sum of squares) showed that mean Wr did not vary significantly between reservoirs (df = **1, 821;** F = 0.81; P = 0.37). However comparisons of mean Wr among 20-cm fork length size classes showed significant variation (df = 11, 82 1; F = 2.02; P = **0.02),** as did comparisons between reservoirs categorized by 20-cm fork length size classes (df = 10, 821; F = 2.19; P = 0.02). Reservoir specific linear regressions of fork length on Wr had very poor coefficients of correlation, but the slope was negative in Bonneville and positive in The Dalles .

Head to snout length ratios were calculated for 313 and 329 white sturgeon from Bonneville and The Dalles reservoirs. Snout lengths were positively correlated with head lengths (Figure 4A and 4B). Correlations of head/snout length ratios with fork lengths were weak, with positive slopes (Figures 4C and 4D). Two-way ANOVA (type III sum of squares) showed that mean head/snout length ratios, classified by 20-cm fork length intervals, did not vary significantly among Bonneville Reservoir, The Dalles Reservoir, and the McNary Reach (df = 2, 807; F = 0.89; P = 0.41). Mean head/snout length ratio was significantly different among snout type categories (df = 2; F = 83.70; P $\leq$ 0.01).

Reproduction

We surgically examined 27 and 20 white sturgeon in Bonneville and The Dalles reservoirs. Bonneville Reservoir fish were classified: 11 female (3 ripe, 3 early vitellogenic, 2 late vitellogenic, 2 previtellogenic, and 1 sample was lost), 11 male, and 5 undetermined. The Dalles Reservoir fish were classified: 7 female (2 ripe, 4 early vitellogenic, and 1 previtellogenic), 11 male, and 2 undetermined.

We collected egg samples for toxin analyses from five female white sturgeon. These samples were permanently labeled and stored with three existing samples.

DISCUSSION

Our sampling effort in 1994 provided data that allowed us to estimate abundance, and describe length frequencies in Bonneville and The Dalles reservoirs. This material will enable us **to** report on changes in these parameters since 1989 in Bonneville Reservoir and 1988 in The Dalles Reservoir.

We first began using dart tags in 1993 and liked the ease of application, and the sheath which protects the numbers from wear. However, this year's retention rate was poor compared to vinyl spaghetti tags and Carlin tags which we previously evaluated (North et al. 1995). We observed that some tags were lost because of broken monofilament, and that some were lost when the entire dart head was expelled. On some recaptures that had retained the dart tag, the tissue was inflamed around the dart head. However, many dart tag wounds had completely healed, a condition rarely observed for vinyl spaghetti tags or Carlin tags. We will

Table 10. Age-length frequency distribution for white sturgeon < 100 cm fork length collected in Bonneville Reservoir, Columbia River, 1994.

Age	Fork length interval (cm) 20-39	40-59	60-79	80-99	Mean	STD	N
1	4				34.8	2.2	4
2	12				37.0	2.0	12
3	5				37.2	1.3	5
4	2				37.0	—	2
5		1			59.0	—	1
6	1	2	2		54.2	11.4	5
7		3	3		59.3	6.4	6
8		7	3		58.9	4.6	10
9		5	7	1	64.3	10.1	13
10		4	8		63.0	7.1	12
11		3	11	4	69.4	9.6	18
12		1	4	3	75.8	14.8	8
13		1	2	4	77.6	11.2	7
14			2	4	81.8	8.0	6
15			3	1	74.3	4.9	4
16			3		70.0	7.0	3
17			3	3	77.3	13.3	6
18			2		78.0	—	2
19			1	2	82.3	11.6	3
20			1	4	87.0	5.5	5
21			2		70.0	5.7	2
22			1		73.0	—	1
23			1	1	79.0	7.1	2
24			1	1	79.5	6.4	2
25			3		73.0	7.0	3
N	24	27	63	28	64.5	16.5	142

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

Table 11. Age-length frequency distribution for white sturgeon < 110 cm fork length collected in The Dalles Reservoir, Columbia River, 1994.

Age	Fork length interval (cm) 40-59	60-79	80-99	100-109	Mean	STD	N
4	2				47.0	7.1	2
5					–		0
6	2				56.0	2.8	2
7	2	1			61.7	7.2	3
8	5	5	1		66.5	9.6	11
9	4	2	4	1	74.1	15.3	11
10	7	11	5	2	71.2	15.3	25
11	4	5	6	7	83.8	18.2	22
12		3	6	5	90.4	12.7	14
13	1		7	4	89.5	14.2	12
14			3	4	97.7	8.9	7
15			1	3	102.5	4.9	4
16				1	107.0	–	1
17				1	108.0	–	1
18			1	1	96.5	10.6	2
19				1	109.0		1
20					–	–	0
21				1	106.0		1
22				2	104.5	5.0	2
N	27	27	34	33	81.2	18.6	121

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

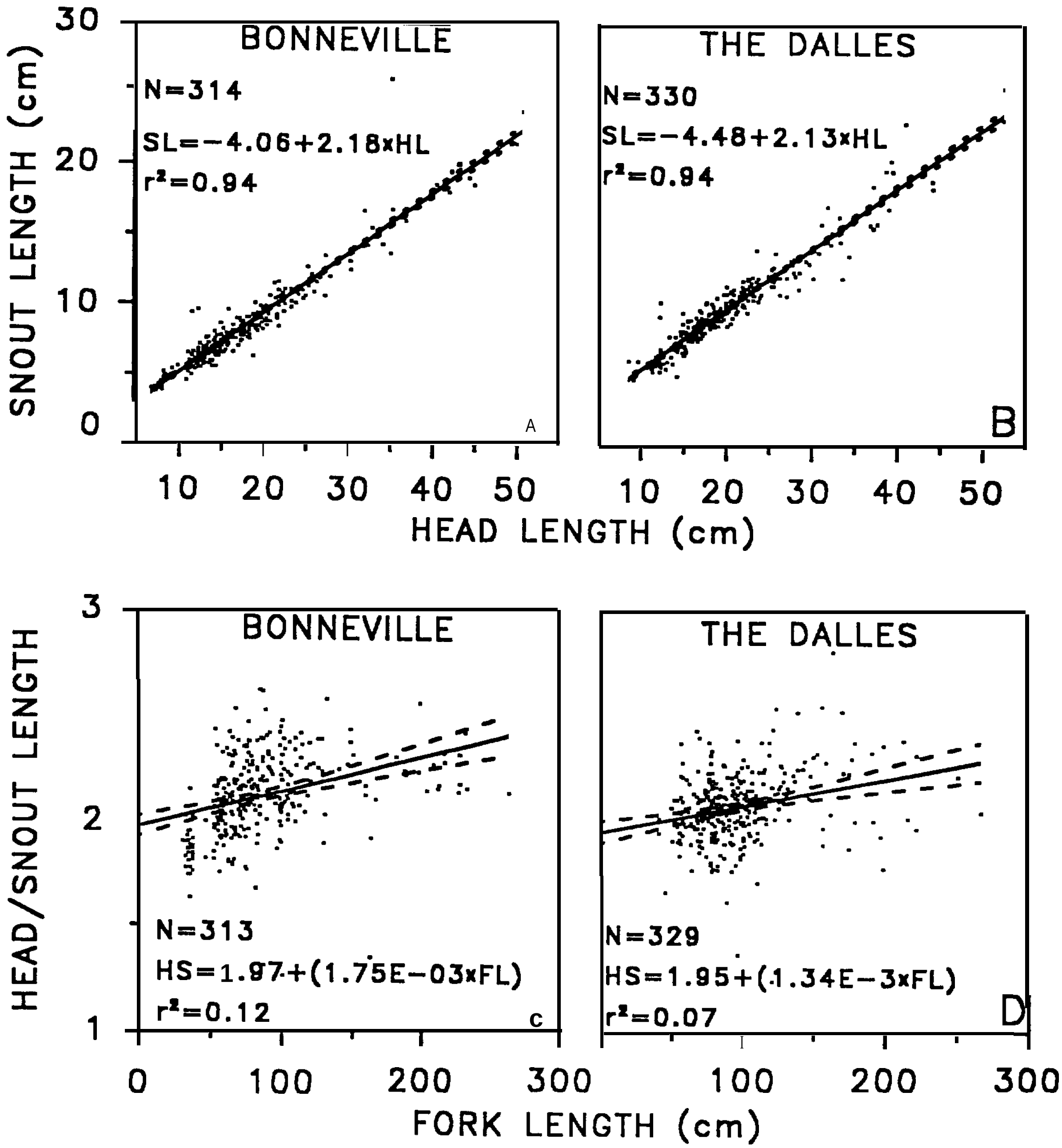

Figure 4. Snout length versus head length (A and B) and head/snout length ratios versus fork length (C and D) of white sturgeon collected in Bonneville and The Dalles reservoirs, April through September, 1994.

use dart tags again in 1995, but we intend to cleanse them with Chlorhexidine to reduce infection.

The 1994 PIT tag retention rate was high and we will continue using this tag and evaluate its long-term retention rate. None of the recaptured fish were infected at the tag injection site. We observed two possible losses this year, unfortunately one fish was never dart tagged and the other lost the dart tag, which precluded verification of application. Since the random tag number sequences complicate recording of field data, a hand-held computer would expedite processing and accuracy of data.

Mean relative weights of white sturgeon were higher in both reservoirs in 1994 than reported by Beamesderfer (1993). In Bonneville Reservoir, where relative weight tends to decrease with increasing length, this finding may reflect increased catches of small white sturgeon more than improved condition. Regardless, this year's sampling corroborates earlier observations that conditions of subadult and adult white sturgeon in Bonneville and The Dalles reservoirs are less than those reported for white sturgeon in the Columbia River below Bonneville Dam (Beamesderfer and Rien 1992; Beamesderfer et al. 1995).

After analyzing head and snout length data collected in 1993 (North et al. 1995), we speculated that the ratio of these two measures may not describe the "long" and "short" snout shapes that we and other white sturgeon researchers have noted (Crass and Gray 1982). However, there were significant differences in mean head/snout length ratio among groups of fish classified by snout type. We take this as evidence that the ratio does quantify the characteristic. Our examination of head shape has not provided evidence of significant differences in this characteristic among three areas of the Columbia River.

Egg samples collected and staged in 1994 will contribute to our understanding of the white sturgeon reproductive cycle in the Columbia River. Specifically they will contribute to our data base which will be used to describe the duration of the resting and egg development stages, and will provide an estimate of spawning frequency by age (Welch and Beamesderfer 1992).

1995 Activities

We will return to the McNary Reach to collect mark and recapture data that will allow us to estimate abundance, condition, describe length frequency, and productivity of the white sturgeon population in that area. Additional egg samples will be collected for use in estimating duration and frequency of spawning. We will attempt to use gill nets to increase the number of small (< 80 cm) white sturgeon we sample to provide evidence to supplement recruitment information being collected by National Biological Service.

We will continue collecting ovary samples for toxin analysis during 1995 and 1996 field sampling and from commercial fisheries. Laboratory analysis is currently scheduled to occur after September, 1996.

In 1995 we will summarize field data collected during transplant supplementation activities in October - November 1994, including short-term survival, and capture rates. We will also investigate methods for evaluating effects of handling and capture techniques to isolate sources of stress and reduce mortality of transferred white sturgeon.

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Appendix A-l. Catch with setlines and gill nets in Bonneville and The Dalles reservoirs, April through September 1994.

Reservoir, Species	Setline		Gill net	
	Live	Dead	Live	Dead
Bonneville,				
American shad *(Alosa sapidissima)*	0	0	0	2
Bridgelip sucker *(Catostomus columbianus)*	0	0	1	0
Channel catfish *(Ictalurus punctatus)*	5	0	0	1
Largescale sucker *(Catostomus macrocheilus)*	0	0	6	0
Northern squawfish *(Ptychocheilus oregonensis)*	7	0	0	0
Peamouth *(Mylocheilus caurinus)*	0	1	0	0
Smallmouth bass *(Micropterus dolomieu)*	0	0	3	0
Steelhead *(Oncorhynchus mykiss)*	0	0	1	1
Walleye *(Stizostedion vitreum)*	0	0	0	1
White sturgeon *(Acipenser transmontanus)*	2,226	0	132	2
The Dalles,				
American shad *(Alosa sapidissima)*	0	0	3	0
Bridgelip sucker *(Catostomus columbianus)*	0	0	2	0
Channel catfish *(Ictalurus punctatus)*	1	0	2	0
Largescale sucker *(Catostomus macrocheilus)*	0	0	6	3
Northern squawfish *(Ptychocheilus oregonensis)*	2	2	1	0
Peamouth *(Mylocheilus caurinus)*	0	0	8	0
Smallmouth bass *(Micropterus dolomieu)*	0	0	0	4
S teelhead *(Oncorhynchus mykiss)*	0	0	1	1
Walleye *(Stizostedion vitreum)*	0	0	4	10
White sturgeon *(Acipenser transmontanus)*	1,338	0	22	0

Appendix A-2. Gonad developmental stage of white sturgeon collected from the Columbia River between Bonneville and Priest Rapids dams, 1987-94. Recoveries are from field sampling, commercial fisheries, and angler creel.

Reservoir, length group (cm)	Developmental stage[a]						Expected spawning year[b]	
	1	2	3	4	5	6	Year captured	Year after capture
Bonneville:								
80- 99	3	1	2	0	2	170	2	4
100-119	37	8	7	0	13	444	7	45
120-139	2	1	3	0	1	77	3	3
140-159	1	0	1	0	0	11	1	1
160-179	1	1	0	0	0	3	0	2
180-199	2	1	1	0	0	3	1	3
200-219	3	6	2	0	1	3	2	9
>219	7	10	5	2	2	2	5	17
The Dalles:								
80-99	0	0	0	0	0	14	0	0
100-119	4	1	0	0	0	240	0	0
120-139	5	3	0	0	3	198	0	8
140-159	12	5	4	0	2	90	4	17
160-179	6	5	1	0	1	16	1	11
180-199	3	2	0	0	1	3	0	5
200-219	5	1	2	0	0	1	2	6
>219	5	1	2	0	0	2	2	6
John Day:								
80-99	0	0	0	0	0	9	0	0
110-119	0	0	0	0	0	81	0	0
120-139	2	1	0	0	0	43	0	3
140-159	1	0	2	0	5	22	2	1
160-179	1	1	1	0	0	2	1	2
180-199	2	0	0	0	0	1	0	2
200-219	2	0	0	0	0	2	0	2
>219	3	0	1	0	0	0	1	3

(More)

[a] 1 = Early vitellogenic, 2 = Late vitellogenic, 3 = Ripe, 4 = Spent, 5 = Previtellogenic with oocytes, and 6 = Previtellogenic.

[b] Fish in stages 3 and 4 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 2 or more years after capture.

Appendix A-2 (continued). Gonad developmental stage of white sturgeon collected from the Columbia River between Bonneville and Priest Rapids dams, 1987-94. Recoveries are from field sampling, commercial fisheries, and angler creel.

Reservoir, length group (cm)	Developmental stage[a]						Expected spawning year[b]	
	1	2	3	4	5	6	Year captured	Year after capture
McNary:								
80-99	0	0	0	0	0	0	0	0
110-119	0	0	0	0	0	0	0	0
120-139	0	0	0	0	0	0	0	0
140-159	0	1	0	0	0	0	0	1
160-179	0	0	0	0	0	0	0	0
180-199	0	0	0	0	0	1	0	0
200-219	0	0	0	0	0	1	0	0
>219	0	0	0	0	0	1	0	0
Unknown:	2							
80-99	0	0	0	0	0	0	0	2
110-l 19		1	1	0	0	31	1	1
120-139	1	2	2	0	0	11	2	2
140-159	0	1	1	0	0	4	1	2
160-179		0	0	0	0	1	0	0
180-199	0	0	0	0	0	0	0	0
200-2 19	0	0	0	0	0	0	0	0
>219	0	1	1	0	0	0	1	1

a 1 = Early vitellogenic, 2 = Late vitellogenic, 3 = Ripe, 4 = Spent, 5 = Previtellogenic with oocytes, and 6 = Previtellogenic.

b Fish in stages 3 and 4 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 2 or more years after capture.

Appendix A-3. Age-length frequency distribution for white sturgeon collected in the McNary Reach of the Columbia River, 1993.

	Fork length interval (cm)										
Age	40-59	60-79	80-99	100-119	120-139	140-159	160-179	> 179	Mean	STD	N
6	1								49.0	-	1
7		1							63.0	-	1
8	1								50.0	-	1
9	1	2		1					78.7	21.3	4
10		8	3	1					78.5	11.5	12
11		3	3	3					84.7	16.4	9
12		2	2	2		1			96.7	28.4	7
13		8	2	2					79.6	15.3	12
14		1	4	2					90.4	13.7	7
15			4	1	3	1			109.7	23.1	9
16		2		3	1	1			108.0	23.7	7
17		1	1		2				106.7	24.8	4
18		2	3		1	1	1		106.9	34.1	8
19			1	2	1	4			129.0	24.1	8
20				2	1	1			125.5	23.1	4
21			2	1		1	1		120.0	37.9	5
22			3	3					99.7	8.8	6
23				2			1		135.7	36.7	3
24				2		1			122.7	26.5	3
25				1	2	1			130.3	21.3	4
26			1	1	2		1		126.4	25.7	5
27			1	1	1	2			127.4	23.2	5
28				1			1		142.0	38.2	2
29									-		0
30+								5	217.8	12.8	5
N	3	30	30	31	14	14	5	5	107.1	36.3	132

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

REPORT B

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

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

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CONTENTS

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ABSTRACT

The Washington Department of Fish and Wildlife (WDFW) conducted a census of the 1994 recreational fisheries on the Columbia River from Bonneville Dam upstream to Priest Rapids Dam and on the Snake River upstream to Ice Harbor Dam to estimate white sturgeon ***Acipenser transmontunus*** harvest. Harvest and biological data were collected as a component of white sturgeon stock assessment work conducted by the Oregon Department of Fish and Wildlife (ODFW). Harvest monitoring was also used to evaluate the success of managing fisheries to protect and enhance white sturgeon populations between Bonneville and McNary dams (Zone 6 of the Columbia River).

Zone 6 recreational fisheries are managed by WDFW and ODFW with the direction of the Sturgeon Management Task Force (SMTF). The SMTF established 1994 recreational fishery harvest guidelines of 1,350 fish for Bonneville Reservoir, 100 fish for The Dalles Reservoir, and 100 fish for John Day Reservoir. Harvest exceeded the guidelines in 1993, therefore, the states further restricted the fishery in 1994 by adopting a 107 cm (42 in) minimum and 168 cm (66 in) maximum size limit regulation for Bonneville Reservoir. Anglers fishing upstream from The Dalles Dam were allowed a daily bag limit of one fish 122-168 cm (48-66 in). A ten fish annual bag limit was adopted for all waters within each state.

The states closed the Zone 6 recreational fishery to the retention of white sturgeon 16 September through 3 1 December, 1994 when harvest was projected to exceed the guidelines. Catches increased the month preceding closure and harvest exceeded the guidelines. We estimated 2,169 white sturgeon were harvested from Bonneville Reservoir by anglers making an estimated 13,15 1 trips for March through October 1994. Anglers targeting sturgeon comprised 63% of an estimated 20,991 total trips. Anglers made an estimated 4,987 trips (22% of total trips) for white sturgeon in The Dalles Reservoir, with an estimated harvest of 151 fish. We estimated anglers harvested 231 white sturgeon from John Day Reservoir during 10,081 trips (31% of total trips). An estimated 386 white sturgeon were harvested from McNary Reservoir by anglers making an estimated 7,562 trips April through October 1994 (10% of total trips).

Treaty Indian commercial fishers landed 1,176 white sturgeon from Bonneville Reservoir (1,250 fish guideline) during winter gillnet and setline fisheries, 309 from The Dalles Reservoir (300 fish guideline), and 117 from John Day Reservoir (100 fish guideline). Fall gillnet fisheries were closed to the sale of sturgeon. The Columbia River Inter-Tribal Fish Commission (CRITFC) and the Yakama Indian Nation estimated an additional 650 fish were harvested during subsistence fisheries.

The SMTF reviewed updated information provided by ODFW on the status of white sturgeon stocks in Bonneville and The Dalles reservoirs, and concluded conditions had not changed enough to warrant new guidelines. Washington and Oregon adopted a set season for retention of sturgeon (1 January through 30 June 1995) combined with catch and release during the remainder of the year for the 1995 Zone 6 recreational fisheries.

A comprehensive strategic framework plan for managing Zone 6 sturgeon populations was drafted. This plan, involving WDFW, CRITFC, and ODFW has been reviewed by the SMTF and will be presented as a separate document.

INTRODUCTION

This annual report describes work completed by the Washington Department of Fish and Wildlife (WDFW) and the Columbia River Inter-Tribal Fish Commission (CRITFC) as part of the Bonneville Power Administration (BPA) white sturgeon ***Acipenser transmontanus*** research project 86-50. The WDFW and CRITFC are responsible for portions of tasks related to Objective 1: to experimentally implement and evaluate the success of selected measures to protect and enhance white sturgeon populations and mitigate for effects of the hydropower system on the productivity of white sturgeon in the Columbia River downstream from McNary Dam. Tasks identified for this objective include evaluation of annual management plans that closely monitor and regulate sturgeon fisheries to maintain exploitation at optimum sustainable rates, and development of a strategic framework plan to guide white sturgeon management and enhancement efforts for the Columbia River between Bonneville and McNary dams (Zone 6 of the Columbia River).

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. Tasks identified for this objective include providing the Oregon Department of Fish and Wildlife (ODFW) with biological and harvest data collected from the recreational fishery upstream from McNary Dam and providing white sturgeon egg developmental stage and larval age data for samples collected by the National Biological Service (NBS) and the National Marine Fisheries Service (NMFS).

Specific activities are reported for the period March 1994 through March 1995 include: 1) analysis of egg and larval samples collected downstream from Bonneville Dam by NMFS and upstream from Bonneville Dam by NBS, 2) surveying the March through October recreational fishery in Zone 6 of the Columbia River and the April through October recreational fishery between McNary and Priest Rapids dams on the Columbia River and downstream from Ice Harbor Dam on the Snake River, 3) monitoring Zone 6 Treaty Indian commercial fishery landings of white sturgeon, and 4) preparation of a strategic framework plan for management of white sturgeon populations in Zone 6 of the Columbia River.

METHODS

Egg and Larval Analysis

White sturgeon eggs and larvae were collected downstream from Bonneville Dam by NMFS. A thorough discussion of sampling gear and techniques is presented by NMFS in REPORT D of this document. Egg and larval samples upstream from Bonneville Dam were collected by NBS and a description of collection techniques and gear is presented by NBS in REPORT C. White sturgeon eggs and larvae in the samples were enumerated, aged, and preserved in 20 % methanol. Eggs were staged and larvae aged according to Beer (1981). Spawning dates were back-calculated using the methods of Wang et al. (1985).

Recreational Fishery Census

The 1994 recreational fishery census was conducted in Bonneville, The Dalles, and John Day reservoirs from March through October (Figure 1). Only the area from McNary Dam downstream to Arlington, Oregon, was censused in John Day Reservoir. The census above McNary Dam covered the Columbia River upstream to Priest Rapids Dam and the Snake River upstream to Ice Harbor Dam from April through October.

The 1994 census was built upon extensive angler census work conducted on Bonneville Reservoir from 1988-1990, The Dalles Reservoir from 1987-1989, and John Day Reservoir from 1989-1991 (Hale and James 1993). Sampling was conducted by two full-time creel checkers hired by ODFW, three full-time checkers hired by WDFW, four creel checkers from WDFW's Hanford Reach anadromous salmonid sampling program, two staff from the WDFW Columbia River Anadromous Fish Division office, and personnel operating two WDFW northern squawfish ***Pty chocheilus oregonensis*** sport reward registration stations.

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

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

Indices of angler pressure were established at popular fishing locations and vantage points in each reservoir. These index areas were similar to the areas used since 1987 (with the exception of McNary Reservoir) with some minor changes (Appendix B-l). Counts were made of all bank anglers and recreational fishing boats within each index area. Boat trailers instead of boats were counted at two ramps in the Hanford Reach of the Columbia River. Average numbers of anglers per boat were determined from angler interviews.

Angling pressure within index areas was counted in two ways. First, during one weekday and one weekend day per week counts were made every four hours between dawn and dusk. Second, single once-through counts were made during the remainder of the week (Appendix Table B-l. 1). The hour of the first count on dawn to dusk days was randomly scheduled to start between 0600 and 0900 hours with additional counts repeated every four hours until dark. Since each count represented four hours of angling effort, the counts were multiplied by four and summed to obtain the day's total angling effort (e,). The average daily effort ($\bar{e}_T$) and the average 1000 to 1300 count ($\bar{e}_2$) for dawn to dusk days were calculated for each month. The single once-through counts were randomly scheduled to start between 1000 and 1300 hours. Total angling effort for a single count day was obtained by multiplying the single count by the ratio ($\bar{e}_T / \bar{e}_2$). On days without counts, $\bar{e}_T$ was used. Daily estimates were summed to obtain monthly totals.

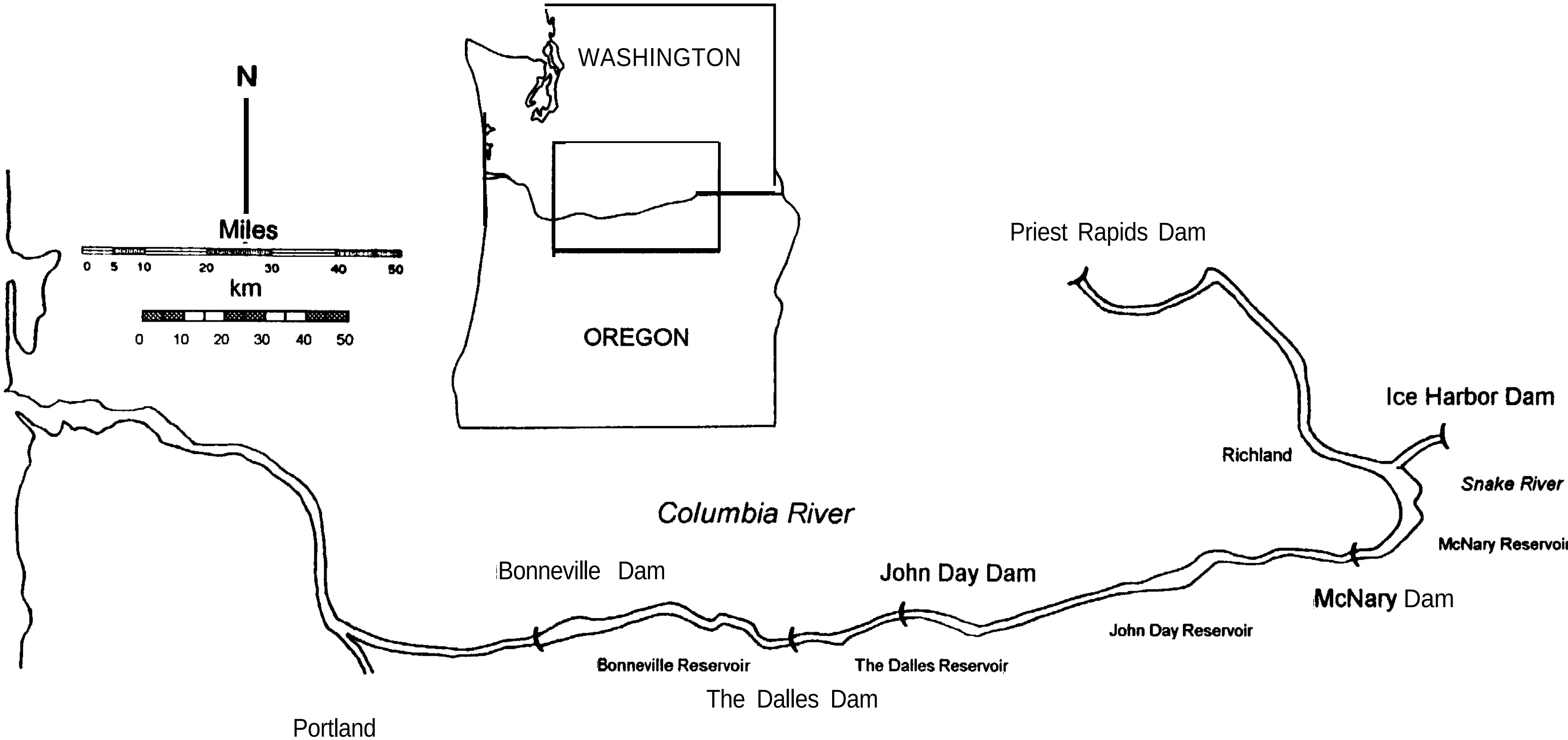

Figure 1. Location of the recreational fishery census between Bonneville and Priest Rapids dams on the Columbia River and downstream from Ice Harbor Dam on the Snake River,

Index area pressure estimates were expanded to reservoir estimates using aerial survey data. Bonneville Reservoir was aerially surveyed six times a month from July through October. Prior to July, index to non-index pressure distribution patterns were obtained from 1988-1990 aerial surveys. The Dalles Reservoir was not aerially surveyed. Index to non-index angling pressure patterns were obtained from 1987-1989 aerial surveys. John Day and McNary reservoirs were aerially surveyed five times a month from April through October.

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

WDFW samplers operating northern squawfish sport reward check stations assisted us by interviewing a portion of the non-registered anglers exiting those ramps. We incorporated the length data they collected in our white sturgeon length frequencies. Personnel from ODFW's District Office in The Dalles, Oregon sampled mainstem Columbia River salmonid anglers exiting the Heritage Park ramp at the mouth of the Deschutes River. They provided sampling summaries and harvest estimates which we incorporated into our salmonid harvest estimates for The Dalles Reservoir. Anglers participating in walleye and bass tournaments were not sampled. Summaries of catch and effort provided by tournament operators were used instead.

Effort and catch data were stratified by angling method (bank/boat), reservoir subsection (Appendix B-l), and weekend and weekday type to account for differential catch and sampling rates. Harvest and angling effort estimates were derived monthly. Harvest estimates were calculated by multiplying the observed catch per hour for each angling method within a reservoir subsection by the total estimated effort for each angling method for that subsection. Annual harvest estimates were extrapolated from census period estimates by applying monthly harvest proportions based on 1987-1993 Oregon and Washington sturgeon catch record card reports.

White sturgeon harvest by bank anglers in The Dalles, John Day, and McNary reservoirs was calculated differently because 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 1994 boat harvest per angler hour rate to estimate 1994 bank harvest per angler hour. The 1994 bank harvest rate was then applied to the 1994 estimate of bank angling effort for sturgeon. Since this was the first year McNary Reservoir was censused, prior year's catch rate data for John Day Reservoir were used.

We described angling success as harvest-per-unit-of-effort (HPUE) with angler trip as the unit of effort. We examined catch rate trends between years by comparing 1994 average catch of legal size fish per angler hour (CPUE) to prior years data using the nonparametric Mann-Whitney U-test (SAS 1988). We used kept and released legal size fish from the boat fishery because of 1991 changes to the daily bag and legal minimum/maximum size limits. Catch per angler hour data were first tested for normality by computing the Shapiro-Wilk statistic (W) using the SAS (1988) univariate procedure.

Treaty Indian Commercial and Subsistence Harvest

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

RESULTS

Egg and Larval Analysis

The results of the egg and larval analysis for samples collected downstream from Bonneville Dam are presented by NMFS in REPORT D. The NBS presents results of the egg and larval analysis of samples collected upstream from Bonneville Dam in REPORT C.

Recreational Fishery Census

Bonneville Reservoir

Washington and Oregon anglers fished an estimated 116,697 hours (20,991 trips) in Bonneville Reservoir from March through October (Table 1). Angling effort for sturgeon comprised 63 % (13,151 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 3,062 (15 %) for anadromous salmonids, 181 (1%) for American shad ***Alosa sapidissima, 797 (4%)*** for walleye, 2,782 (13%) for bass, 539 (3%) for northern squawfish, 401 (2%) for other resident fish, and 78 (< 1%) for anglers participating in tournaments.

Anglers harvested an estimated 2,169 white sturgeon in Bonneville Reservoir from March through October (Table 2). The fishery for white sturgeon encompassed the entire reservoir and was comprised of similar numbers of bank and boat anglers. Angling effort for white sturgeon was consistently strong throughout the census, peaking in July with 2,920 trips (Table 3). Peak catches occurred July through mid-September (Table 3). The average harvest per trip was 0.13 for bank anglers and 0.21 for boat anglers. Harvest rates improved each month throughout the census period, peaking in September at 0.38 fish/trip. Approximately 10% of the estimated bank

Table 1. Combined Washington and Oregon recreational fishery angling effort estimates for Bonneville, The Dalles, and John Day reservoirs, March through October 1994, and McNary Reservoir, April through October 1994.

Species,	Bonneville		The Dalles		John Day		McNary	
Bank/Boat	Hours	Trips	Hours	Trips	Hours	Trips	Hours	Trips
Sturgeon								
Bank	44,171	7,822	30,059	3,124	18,073	3,221	20,918	2,660
Boat	30.419	5,329	9.437	1,863	40,556	6,860	28,584	4,902
Total	74,590	13,151	39,496	4,987	58,629	10,081	49,502	7,562
Salmonid								
Bank	15,719	2,017	4,816	474	3,503	766	60,525	9,424
Boat	5,300	1,045	34,543	6,088	2,018	429	202,925	31,702
Total	21,019	3,062	39,359	6,562	5,521	1,195	263,450	41,126
Shad								
Bank	648	165	8,225	1,172	19	4	938	305
Boat	47	16	148	46	441	74	573	138
Total	695	181	8,373	1,218	460	78	1,511	443
Walleye								
Bank	0	0	822	140	41	7	93	22
Boat	3,854	797	31,434	5,295	53,178	9,079	2,639	542
Total	3,854	797	32,256	5,435	53,219	9,086	2,732	564
Bass								
Bank	3,478	821	3,126	763	7,789	1,862	11,074	3,437
Boat	8,397	1.961	4,009	927	31,792	6.103	58,294	12,606
Total	11,875	2,782	7,135	1,690	39,581	7,965	69,368	16,043
Squawfish								
Bank	1,227	255	948	176	121	20	1,755	319
Boat	1,405	284	5,670	1,204	173	50	14,452	1,932
Total	2,632	539	6,618	1,380	294	70	16,207	2,251
Other								
Bank	815	261	4,254	845	7,758	1,849	28,850	5,605
Boat	429	140	591	149	5,230	1,162	13,340	2,656
Total	1,244	401	4,845	994	12,988	3,011	42,190	8,261
Tournament								
Bank	0	0	0	0	0	0	0	0
Boat	788	78	633	64	9,891	1,064	4,201	474
Total	788	78	633	64	9,891	1,064	4,201	474
Total								
Bank	66,058	11,341	52,250	6,694	37,304	7,729	124,153	21,772
Boat	50,639	9,650	86,465	15,636	143.279	24,821	325,008	54.952
Total	116,697	20,991	138,715	22,330	180,583	32,550	449,161	76,724

Table 2. Combined Washington and Oregon recreational fishery harvest and catch and release estimates for Bonneville, The Dalles, and John Day reservoirs, March through October 1994, and McNary Reservoir, April through October 1994.

Species	Bonneville	The Dalles	John Day	McNary
White sturgeon				
Legals kept	2,169	151	231	386
Sublegals released	19,387	4,505	5,131	2,661
Legals released	718	9	73	277
Oversize released	197	79	269	328
Total	22,471	4,744	5,704	3,652
Chinook salmon				
Adults kept	81	87	28	5,543
Jacks kept	10	17	17	1,531
Total kept	91	104	45	7,074
Released	495	1,030	0	138
Coho salmon				
Adults kept	339	0	14	0
Jacks kept	16	0	0	0
Total	355	0	14	0
Steelhead				
Kept	147	998	185	2,213
Released	69	302	50	347
American shad				
Kept	326	2,945	0	237
Released	47	355	105	95
Walleye				
Kept	206	1,972	2,484	65
Released	984	9,781	2,137	36
Bass				
Kept	1,739	1,828	5,659	10,575
Released	6,804	4,533	21,265	22,828
Northern squawfish kept	4,248	7,559	846	16,510
Other resident fish kept	135	230	2,590	10,100

Table 3. Estimates of recreational fishery angler trips for white sturgeon, white sturgeon harvest, and harvest per angler trip for Bonneville, The Dalles and John Day reservoirs, March through October 1994, and McNary Reservoir, April through October 1994.

Month Method	Bonneville Trips	HPUE	Harvest	The Dalles Trips	HPUE	Harvest
March						
Bank	1,142	0.08	86	86	0.00	0
Boat	427	0.04	16	30	0.00	0
Total	1,569	0.07	102	116	0.00	0
April						
Bank	734	0.08	57	166	0.00	0
Boat	432	0.11	48	115	0.02	2
Total	1,166	0.09	105	281	0.01	2
May						
Bank	808	0.06	51	462	0.00	0
Boat	663	0.13	88	113	0.00	0
Total	1,471	0.09	139	575	0.00	0
June						
Bank	1,075	0.08	85	1,084	0.03	35
Boat	900	0.19	174	738	0.05	34
Total	1,975	0.13	259	1,822	0.04	69
July						
Bank	1,716	0.16	279	695	0.05	38
Boat	1,204	0.16	193	454	0.08	36
Total	2,920	0.16	472	1,149	0.06	74
August						
Bank	1,369	0.18	241	434	0.01	6
Boat	1,106	0.33	360	210	0.00	0
Total	2,475	0.24	601	644	0.01	6
September						
Bank	802	0.31	252 [a]	175	0.00	0
Boat	498	0.48	239 [a]	78	0.00	0
Total	1,300	0.38	491	253	0.00	0
October						
Bank	176	0.00	0	22	0.00	0
Boat	99	0.00	0	125	0.00	0
Total	275	0.00	0	147	0.00	0
Combined						
Bank	7,822	0.13	1,051	3,124	0.03	79
Boat	5,329	0.21	1,118	1,863	0.04	72
Total	13,151	0.16	2,169	4,987	0.03	151

continued

Table 3. Continued.

Month Method	John Day Trips	John Day HPUE	John Day Harvest	McNary Trips	McNary HPUE	McNary Harvest
March						
Bank	465	0.02	7			
Boat	306	0.01	4			
Total	771	0.01	11			
April						
Bank	319	0.02	5	96	0.07	7
Boat	326	0.01	3	142	0.09	13
Total	645	0.01	8	238	0.08	20
May						
Bank	386	0.02	6	747	0.02	12
Boat	662	0.03	18	382	0.02	8
Total	1,048	0.02	24	1,129	0.02	20
June						
Bank	337	0.01	5	455	0.04	19
Boat	882	0.05	47	866	0.05	46
Total	1,219	0.04	52	1,321	0.05	65
July						
Bank	1,150	0.01	16	694	0.05	33
Boat	2,025	0.04	82	1,524	0.06	92
Total	3,175	0.03	98	2,218	0.06	125
August						
Bank	368	0.01	5	505	0.03	14
Boat	1,368	0.01	12	1,404	0.03	49
Total	1,736	0.01	17	1,909	0.03	63
September						
Bank	188	0.02	3	119	0.08	10
Boat	1,236	0.01	18	470	0.11	52
Total	1,424	0.01	21	589	0.11	62
October						
Bank	8	0.00	0	44	0.16	7
Boat	55	0.00	0	114	0.21	24
Total	63	0.00	0	158	0.20	31
Combined						
Bank	3,221	0.01	47	2,660	0.04	102
Boat	6,860	0.03	184	4,902	0.06	284
Total	10,081	0.02	231	7,562	0.05	386

[a] ***Closed to the retention of white sturgeon 16 September through 31 December 1994.***

effort (angler hours) and 14% of the estimated boat effort for white sturgeon during the census period were accounted for by the 2,121 sturgeon anglers interviewed (Table 4).

Anglers fished with a daily bag limit regulation allowing one fish 107 to < 122 cm (42 to < 48 in) and one fish 122-168 cm (48-66 in) that resulted in anglers releasing 25% of the reported catch of legal size fish. The percentage sublegal (< 107 cm, < 42 in), legal (107-168 cm, 42-66 in, both kept and released) and oversize (> 168 cm, > 66 in) sturgeon in the sampled catch was 86 %, 13 % and 1% respectively (Table 4). Length frequencies of white sturgeon measured in the creel are presented in Table 5.

Approximately 10% of the 1 March through 3 1 October estimated recreational harvest of white sturgeon from Bonneville Reservoir was examined for marked fish (Table 6). Two 1994 ODFW marked white sturgeon and seven white sturgeon marked by ODFW during previous studies were observed.

The census period estimate expanded to an annual harvest estimate of 2,223 white sturgeon (Table 7). Harvest per trip of 107-168 cm (42-66 in) fish has improved each year since 1992 (Table 8).

The Dalles Reservoir

Washington and Oregon anglers fished an estimated 138,715 hours (22,330 trips) in The Dalles Reservoir from March through October 1994 (Table 1). Angling effort for sturgeon comprised 22% (4,987 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 6,562 (29%) for anadromous salmonids, 1,218 (5 %) for American shad, 5,435 (24%) for walleye, 1,690 (8%) for bass, 1,380 (6%) for northern squawfish, 994 (4%) for other resident fish, and 64 (< 1%) for anglers participating in tournaments.

The recreational fishery for white sturgeon extended from the John Day Dam tailrace downstream to Miller Island, with some additional effort along the Washington shore downstream from the railroad bridge and out of The Dalles Dam and Avery, Washington boat ramps. More sturgeon anglers fished from the bank than from boats. An estimated 15 1 white sturgeon were harvested during the census period (Table 2) which was expanded to an annual estimate of 154 sturgeon (Table 7). The white sturgeon catch was highest in June and July (Table 3). The average harvest per trip was 0.03 for bank anglers and 0.04 for boat anglers targeting sturgeon (Table 3). Harvest per boat angler trip of 122-168 cm (48-66 in) fish was higher in 1994 than in 1992 and 1993 though HPUE remained below the rates measured in 1987 and 1988 (Table 8). Approximately 16% of the estimated bank effort (angler hours) and 13% of the estimated boat effort for sturgeon was accounted for by the 1,203 sturgeon anglers interviewed (Table 4).

The percentage sublegal (< 122 cm, < 48 in), legal (122-168 cm, 48-66 in) and oversize (> 168 cm, > 66 in) sturgeon in the sampled catch was 95 %, 3 % and 2% respectively (Table 4). The length distribution of the sampled catch is presented in Table 5.

Table 4. Numbers of sturgeon anglers interviewed and numbers of kept and released white sturgeon reported during sampling of recreational fisheries in Bonneville, The Dalles and John Day reservoirs, March-October 1994, and McNary Reservoir, April-October, 1994.

Reservoir, Method/Month	Anglers checked	Hours fished	Sublegal	Legal released	Legal kept	Oversize
Bonneville						
Bank						
March	234	659	91	0	9	0
April	231	597	91	0	8	0
May	183	446	94	0	6	0
June	183	662	100	0	9	1
July	232	1,005	244	1	32	0
August	202	600	145	1	18	0
September	89	338	108	8	22	0
October	24	48	19	8	0	0
Boat						
March	53	248	53	0	2	0
April	58	288	107	0	5	0
May	132	589	305	1	15	4
June	180	1,188	309	25	44	24
July	126	815	239	6	20	5
August	149	870	302	15	44	1
September	41	227	108	13	20	1
October	4	22	0	0	0	0
Combined total	2,121	8,602	2,315	78	254	36
The Dalles						
Bank						
March	62	171	0	0	0	0
April	98	380	20	0	0	0
May	131	699	46	0	0	3
June	255	1,337	53	0	5	5
July	189	1,059	121	0	6	1
August	147	749	61	0	1	0
September	56	273	19	0	0	0
October	10	79	4	1	0	0
Boat						
March	15	63	32	0	0	0
April	44	201	82	0	1	1
May	25	95	19	0	0	0
June	52	321	75	0	3	0
July	78	343	74	1	5	2
August	26	140	49	0	0	0
September	10	54	8	0	0	0
October	5	32	17	0	0	0
Combined total	1,203	5,996	680	2	21	12

continued

Table 4. Continued.

Reservoir, Method/Month	Anglers checked	Hours fished	Sublegal	Legal released	Legal kept	Oversize
John Day						
Bank						
March	85	200	8	0	0	0
April	93	214	13	0	0	0
May	89	251	3	0	2	1
June	178	790	28	0	3	4
July	226	755	23	0	0	0
August	95	332	3	0	0	1
September	31	83	4	0	0	0
October	5	9	0	0	0	0
Boat						
March	44	209	11	0	1	0
April	101	568	73	0	1	5
May	117	632	88	1	3	16
June	111	628	54	2	5	4
July	206	1,308	166	4	9	5
August	166	1,039	169	1	2	4
September	76	400	19	0	2	1
October	9	55	7	1	0	0
Combined total	1,632	7,473	669	9	28	41
McNary						
Bank						
March	--	--	--	--	--	--
April	39	70	2	0	0	0
May	141	415	7	1	1	0
June	121	392	9	0	2	1
July	136	561	9	0	0	3
August	92	324	4	0	1	0
September	34	114	3	0	0	0
October	12	43	0	0	0	0
Boat						
March	--	--	--	--	--	--
April	14	63	2	0	1	0
May	52	272	4	0	1	0
June	152	859	31	7	9	2
July	142	873	48	7	9	9
August	143	813	61	8	6	6
September	65	403	103	5	9	9
October	29	180	23	5	8	12
Combined total	1,172	3,848	306	33	47	42

Table 5. Length frequencies of harvested white sturgeon measured during sampling of recreational fisheries in Bonneville, The Dalles, and John Day reservoirs, March through October 1994, and McNary Reservoir, April through October 1994. Not all sampled fish were measured. Includes out-of-sample fish (prior days catch and northern squawfish check station samples) excluded from Table 4.

Total length (cm)	Bonneville	The Dalles	John Day	McNary	Total length (cm)	Bonnevill	The Dalles	John Day	McNary
100					140	3	1	2	1
101					141	1	1		1
102	1				142		2		1
103					143			2	3
104					144			1	
105	3				145				
106	3				146	2			
107	18				147	2			1
108	16				148		1		2
109	15				149	2		1	
110	10				150			1	1
111	16				151				1
112	21				152			2	1
113	13				153				
114	10				154				1
115	18		1		155	1			1
116	2		1	1	156		1	1	1
117	9				157				
118	10				158	1		1	
119	7				159				
120	4	1		1	160	1			
121	7	1	2	2	161		1	1	1
122	4		3	2	162		1	1	1
123	7	1			163			1	
124	11	2	4	1	164		1		1
125	4	3	2	2	165		1		
126	3	2	2	3	166				1
127	4	1		2	167				1
128		1	3	1	168				
129	2		2		169				
130	3		4	4	170				1
131	1	1		4	171			2	
132	2	3	1		172				
133			1		173			1	
134	1		1		174				
135	1		2	3	175				1
136		1		2	176				1
137	1				177				1
138	1		1	1					
139	1		1	1	Total	242	27	48	54

Table 6. Numbers of marked and unmarked white sturgeon observed in the examined recreational fishery harvest for Bonneville, The Dalles, John Day, and McNary reservoirs, 1994. Released marked catch reported during interviews and prior days marked harvest and catch volunteered by anglers is also presented. Some harvest reported during interviews was not examined for marks. Northern squawfish check station interview data are incorporated.

Reservoir, Period	Recovery method	Proportion of harvest examined	Non-marked, kept	1994 mark Kept	1994 mark Released	Pre- 1994 mark Kept	Pre- 1994 mark Released
Bonneville							
3/1 - 10/31	Insample	0.095	198	74787 dart 75037 dart	a	B060849 JD 70761 JD 70448 scar/scute scar/scute scar/scute scar/scute	B062568 B062568 a
	Volunteer			73771 dart	73863 dart	TD 52872	0
The Dalles							
3/1 - 10/31	Insample	0.126	16	scar/scute	b	JD 70045 scar/barbel	b
	Volunteer			74838 dart d	73672 dart 74460 dart c	JD 70497 d	c
John Day							
3/1 - 10/31	Insample	0.186	41	0	e	JD 70831 JD 70934	e
	Volunteer			0	0	0	0
McNary							
4/1 - 10/3 1	Insample	0.120	46	0	0	0	0
	Volunteer			0	0	0	0

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

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

[c] *Information on another five marked white sturgeon caught and released was volunteered to WDFW by anglers.*

[d] *One marked white sturgeon was reported harvested without the interviewed angler recording the tag number or scute mark pattern.*

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

Table 7. Estimated census period and annual recreational fishery harvest of white sturgeon by reservoir from Zone 6 of the Columbia River, 1987 through 1994.

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

[a] ***No sampling conducted.***

Table 8. Angling effort, harvest, and harvest per angler trip of white sturgeon within common size classes from recreational fisheries in Zone 6 of the Columbia River, 1987 through 1994.

Reservoir, Year	Period	Bank anglers			Boat anglers		
		Trips	Harvest	HPUE	Trips	Harvest	HPUE
Bonneville (42 - 66 inches)							
1987	-- a						
1988	Mar-Ott	5,653	630	0.111	4,776	814	0.170
1989	Mar-Ott	8,028	1,516	0.189	5,792	1,265	0.218
1990	Mar-Ott	7,213	850	0.118	7,349	1,247	0.170
1991	--b						
1992	Apr-Ott	5,340	473	0.089	3,210	393	0.122
1993	Mar-Ott	7,599	976	0.128	6,747	1,058	0.157
1994	Mar-Ott	7,822	1,051	0.134	5,329	1,118	0.210
The Dalles (48 - 66 inches)							
1987	Jun-Ott	5,019	465	0.093	3,618	339	0.094
1988	Mar-Ott	5,043	247	0.049	2,566	163	0.064
1989	Mar-Ott	3,659	118	0.032	1,760	98	0.055
1990	--a						
1991	--b						
1992	Apr-Ott	1,500	67	0.045	1,090	30	0.028
1993	Mar-Ott	2,058	46	0.023	1,902	61	0.032
1994	Mar-Ott	3,124	79	0.025	1,863	72	0.039
John Day (48 - 66 inches)							
1987	-- a						
1988	--a						
1989	May-Jul	3,572	22	0.006	3,401	34	0.010
1990	Mar-Dee	3,806	35	0.009	3,063	86	0.028
1991	Apr-Sep	1,977	35	0.018	2,463	72	0.029
1992	May-Ott	1,760	23	0.013	-- b		
1993	Mar-Ott	3,208	48	0.015	4,466	94	0.021
1994	Mar-Ott	3,221	47	0.015	6,860	184	0.027

[a] ***Not sampled.***
[b] ***Sample insufficient to provide reliable estimate of angler trips.***

Approximately 13 % of the 1 March through 3 1 October estimated recreational harvest of white sturgeon from The Dalles Reservoir was examined for marked fish (Table 6). One 1994 ODFW marked white sturgeon and two white sturgeon marked by ODFW during previous studies were observed.

John Day Reservoir

Washington and Oregon anglers fished an estimated 180,583 hours (32,550 trips) in John Day Reservoir from March through October (Table 1). Angling effort for sturgeon comprised 31% (10,081 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 1,195 (4 %) for anadromous salmonids, 78 (< 1%) for American shad, 9,086 (28%) for walleye, 7,965 (24%) for bass, 70 (< 1%) for northern squawfish, 3,011 (9%) for other resident fish, and 1,064 (3%) for tournament anglers.

The recreational fishery for white sturgeon was concentrated from McNary Dam downstream to Irrigon, Oregon with some additional boat effort upstream from Boardman, Oregon, and at Crow Butte Island. Anglers harvested an estimated 231 white sturgeon during the sample period and catches were highest in July (Table 3). The census period estimate expanded to an annual harvest estimate of 234 white sturgeon (Table 7). The average harvest per trip was 0.01 for bank anglers and 0.03 for boat anglers (Table 3). Harvest per trip of 122-168 cm (48-66 in) fish has remained relatively stable since 1990 (Table 8). Approximately 15% of the estimated bank effort (angler hours) and 12% of the estimated boat effort for sturgeon was accounted for by the 1,632 sturgeon anglers interviewed (Table 4).

The percentage sublegal (< 122 cm, < 48 in), legal (122-168 cm, 48-66 in) and oversize (> 168 cm, > 66 in) sturgeon in the reported catch was 90%, 5 % and 5% respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5.

Approximately 19% of the 1 March through 31 October estimated recreational harvest of white sturgeon from John Day Reservoir was examined for marked fish (Table 6). No 1994 ODFW marked white sturgeon were observed, however two sturgeon marked by ODFW during previous studies were observed.

McNary Reservoir

Anglers fished an estimated 449,161 hours (76,724 trips) in McNary Reservoir from April through October 1994 (Table 1). Angling effort for sturgeon comprised 10% (7,562 trips) of the total estimated effort. The number of angler trips estimated by target species were as follows: 41,126 (53 %) for anadromous salmonids, 443 (< 1%) for American shad, 564 (1%) for walleye, 16,043 (21%) for bass, 2,251 (3 %) for northern squawfish, 8,261 (11%) for other resident fish, and 474 (< 1%) for tournament anglers.

Anglers fished for white sturgeon throughout the impounded and the free flowing reaches of the Columbia River. The Columbia River from the wooden powerline towers at the Old

Hanford townsite upstream to Vernita Bridge was open to sturgeon angling 16 June through 22 October. There was minor angling effort for sturgeon in the Snake River downstream from Ice Harbor Dam. Anglers harvested an estimated 386 white sturgeon April through October with highest catches in July (Table 3). The census period estimate expanded to an annual harvest estimate of 403 sturgeon. The average harvest per trip was 0.04 for bank anglers and 0.06 for boat anglers (Table 3). Approximately 9% of the estimated bank effort (angler hours) and 12% of the estimated boat effort for sturgeon were accounted for by the 1,172 sturgeon anglers interviewed (Table 4).

The percentage sublegal (< 122 cm, < 48 in), legal (122-168 cm, 48-66 in) and oversize (> 168 cm, > 66 in) sturgeon in the reported catch was 71%, 19% and 10% respectively (Table 4). The length distribution of the sampled harvest is presented in Table 5.

Approximately 12% of the April through October estimated recreational harvest of white sturgeon from McNary Reservoir was examined for marked fish (Table 6). No ODFW marked white sturgeon were observed.

Treaty Indian Commercial and Subsistence Harvest

Preliminary 1994 treaty Indian commercial harvest estimates for Zone 6 were 1,176 white sturgeon from Bonneville Reservoir, 309 white sturgeon from The Dalles Reservoir and 117 white sturgeon from John Day Reservoir (Table 9). Most of the harvest came from the winter gillnet fishery (1,519 fish). The remainder (83 fish) came from the winter setline fishery. The tribes elected to close the fall gillnet fishery to the sale of sturgeon. The Treaty Indian Zone 6 subsistence white sturgeon harvest was estimated by CRITFC and YIN at 650 fish (Table 9) (ODFW and WDFW 1995).

Strategic Framework Plan

The strategic framework management plan was drafted by WDFW, CRITFC, and ODFW and presented to the SMTF for comment on 4 December 1994. A section of the plan detailing recommendations for Zone 6 white sturgeon management was submitted to the SMTF for review and adoption on 16 March 1995. The plan is in revision and will be presented later as a separate document.

Table 9. Harvest guidelines and estimated harvest of white sturgeon by reservoir in Zone 6 of the Columbia River, 199 1 through 1994.

Fishery	Year	Bonneville	The Dalles	John Day	Unknown	Total
Non-Indian recreational	Guideline	1,350	100	100		1,550
	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
Indian commercial	Guideline	1,250	300	100		1,650
	1991	999	457	39	0	1,495
	1992	1,146	431	23	0	1,600
	1993	1,415	579	12	0	2,006
	1994 [a]	1,176	309	117	0	1,602
Combined fisheries	Guideline [b]	2,600	400	200		3,200
	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 [a]	3,399	463	351	0	4,213
Indian subsistence	Expectation [b]	--	--	--	--	300
	1991	-- [c]	-- [c]	-- [c]	-- [c]	-- [c]
	1992	89	-- [c]	-- [c]	119	208
	1993	146	31	30	56	263
	1994 [a]	290	197	163	0	650

[a] ***Preliminary.***

[b] ***The 300 fish Treaty Indian subsistence harvest expectation was initiated in 1994 and was not reservoir specific.***

[c] ***Not available.***

DISCUSSION

Recreational Fishery Census

Harvest management of Columbia River white sturgeon fisheries during 1994 was coordinated through the SMTF, consisting of representatives from WDFW, ODFW, and the Columbia River Treaty Indian tribes. The SMTF recommended 1994 harvest guidelines of 1,350 recreational and 1,250 commercial white sturgeon from Bonneville Reservoir, 100 recreational and 300 commercial from The Dalles Reservoir, and 100 recreational and 100 commercial from John Day Reservoir (WDF and ODFW 1993). Recreational white sturgeon harvest had exceeded the guidelines in all years since 1991 despite a series of regulatory harvest reduction plans implemented from 1988 through 1993 (Appendix Table B-1.2). The states further restricted the 1994 fishery by adopting a 107 cm (42 in) minimum and 168 cm (66 in) maximum size limit regulation for Bonneville Reservoir. A 10 fish annual bag limit for all three reservoirs was also adopted.

We were asked by fishery managers to provide periodic updates of estimated 1994 white sturgeon harvest and to project future monthly harvest. Using March through July data, we projected that the recreational sturgeon harvest would exceed the combined pool guideline in September. As a result the states closed the Zone 6 recreational fishery to the retention of sturgeon from 16 September through 31 December 1994. Catch and release fishing for sturgeon was allowed to continue during the closure. Harvest rates continued to climb during the weeks preceding the closure and estimated total harvest surpassed our projections.

The joint WDFW/ODFW staff conducted several public workshops in the fall of 1994 to determine how to shape future sport fishing regulations in the three reservoirs without having emergency closures. Opinions expressed were diverse, however anglers were against area closures and favored a season structure if necessary. After considering the 1994 fishery results and preliminary updates of stock status for the Bonneville and The Dalles reservoir populations, the SMTF directed that the 1991-1994 harvest guidelines remain in effect for 1995. On 27 January 1995 Washington and Oregon adopted a 1 January through 30 June season for retention of sturgeon and allowed catch and release angling opportunity during the remainder of the year in Zone 6. We projected that this season would maintain recreational harvest within SMTF guidelines and minimize the possibility of emergency in-season closures.

Fishery managers relied on 1987-1991 estimates of white sturgeon stock status to prepare for 1994 Zone 6 management. The status of the white sturgeon stocks in Bonneville and The Dalles reservoirs was updated by ODFW in 1994 while status of the John Day Reservoir population was scheduled to be updated in 1996. In the interim between stock status updates fishery managers have had to rely on recreational fishery CPUE for annual indices of stock status. Based on recreational fishery CPUE trends, the stocks of legal size white sturgeon in Bonneville and John Day reservoirs appeared relatively stable while numbers of older age fish in The Dalles Reservoir continued to decline.

The ODFW reported a slight increase in 122-183 cm (48-72 in) abundance in Bonneville Reservoir from 1,200 fish in 1989 to 1,500 fish 1994 (REPORT A of this document). This increase was also evidenced by improved CPUE in the recreational fishery. The catch of 122-168 cm (48-66 in) white sturgeon (both kept and released fish) per boat angler hour in 1994 (0.012) was significantly greater than the 0.006 (p = 0.009) measured in 1989. The catch per bank angler hour was not significantly different between years (p = 0.611). Harvest per angler trip in Bonneville Reservoir increased dramatically near the end of the 1994 census, peaking at 0.31 fish/trip for bank anglers and 0.48 fish/trip for boat anglers during the first two weeks of September before the closure went into effect. Sublegal fish initially spared from harvest by the new 107 cm (42 in) minimum size limit likely recruited to the fishery during the year, although the proportion of 107-l 14 cm (42-45 in) fish in the sampled harvest did not change from March through July vs. August and September.

The ODFW reported a decline in 122-183 cm (48-72 in) white sturgeon abundance in The Dalles Reservoir from 2,000 fish in 1988 to 800 fish in 1994 (REPORT A). We observed a reduction in estimated recreational fishery harvest per angler trip over this period (Table 3) although we did not find a significant difference in 1988 vs. 1994 catch per boat angler hour. The catch of 122-152 cm (48-60 in) fish per boat angler hour was 0.006 in 1988 and 0.004 in 1994 (p = 0.523) and the catch of the larger 152-168 cm (60-66 in) fish per boat angler hour was 0.004 in 1988 and 0.003 in 1994 (p = 0.511). We expected recruitment to 122 cm (48 in) to increase along with an increase in 122-152 cm (48-60 in) CPUE beginning in the mid-1990's due to savings gained from implementing the 122 cm (48 in) minimum size limit in 1991 and limiting harvest to the conservative guidelines in place since 1992. Abundance in this size class apparently remains depressed due to the excessive harvest of the 1980's. The CPUE trends of these larger, older aged fish are important since a reduction in their numbers equates to a reduction in broodstock escapement.

The estimated harvest of 122-168 cm (48-66 in) white sturgeon per boat angler trip from John Day Reservoir has remained relatively stable since 1990 (Table 3). Harvest of 152-168 cm (60-66 in) fish per boat angler trip in 1994 (0.004) was the same as that measured in 1990, indicating little change in the 122-168 cm (48-66 in) population. The expectation of improved recruitment to 122 cm (48 in) and concern over depressed broodstock escapement applies to the John Day Reservoir population. We expect to see improved recreational fishery CPUE once savings from recent management actions has had time to work through the population, however we still remain concerned about adequate escapement into the broodstock population.

We achieved slightly higher sampling rates in 1994 than in 1993 with the help of one additional full-time creel checker. Sampling rates for 1994 bank fisheries improved in all three reservoirs. Sampling rates for 1994 boat sturgeon fisheries in The Dalles Reservoir doubled from those attained in 1993. Combined bank and boat sampling rates were similar to the rates achieved from 1987 through 1991 but were still below the 20% target. Next season we intend to shift some sampling effort from counting angling pressure and spend more time at ramps interviewing boat anglers.

We began the 1994 census uncertain whether we could adequately sample the one fish daily bag limit fishery in The Dalles and John Day reservoirs. Samplers encountered both the successful and the unsuccessful boat angler returning to ramps but successful bank anglers could leave prior to being interviewed, thereby skewing the creel check to unsuccessful anglers. In-season management needs required that we estimate both boat and bank white sturgeon harvest. Our in-season estimates of white sturgeon harvest by bank anglers in The Dalles and John Day reservoirs appeared to reasonably represent actual harvest. Estimates of bank angler HPUE based on 1994 boat angler HPUE and historic bank to boat HPUE relationships were similar to observed 1994 bank angler HPUE. Many sturgeon bank anglers fished in groups and most successful anglers appeared to have remained with the group for the duration of the trip providing an equal chance of being sampled.

Treaty Indian Commercial and Subsistence Harvest

The Treaty Indian Zone 6 1994 commercial fishery harvest remained within the combined pool harvest guideline established by the SMTF. Pool specific harvest guidelines for The Dalles and John Day reservoirs were reached before the end of the winter gillnet season. Harvest from Bonneville Reservoir was still below the pool specific guideline at the end of the winter gillnet season, however the Tribes elected not to continue the setline fishery or allow sales of sturgeon during the fall gillnet season. The estimated Treaty Indian subsistence harvest (650) was greater than in previous years and was more than double the 300 fish guideline recommended for 1994.

Plans for 1995

The WDFW and CRITFC plan to assist ODFW with their stock assessment work in McNary Reservoir, finalize the strategic framework plan for managing Zone 6 white sturgeon populations, stage white sturgeon egg and larvae samples collected by NBS and NMFS, and participate in the trial transport program conducted by ODFW. In addition CRITFC plans to continue collecting and analyzing data from the on-board monitoring project during the 1995 Zone 6 commercial sturgeon fisheries in conjunction with the Yakama Indian Nation fisheries staff. The WDFW also plans to continue monitoring 1995-1996 Zone 6 recreational and Treaty Indian commercial fisheries.

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APPENDIX El

Angler Pressure Count Index Areas and Reservoir Subsection Stratifications

<u>Index Areas</u>

Bonneville Reservoir

Boat

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

West of Cooks Landing' [Rkm 257.5 (RM 160.0)] upstream to Drano Lake [Rkm 262.3 (RM 163 .O)].

West of Spring Creek Hatchery [Rkm 267.3 (RM 166.0)] upstream to Mosier, OR (Rkm 282.6 [RM 175.51).

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

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

Bank

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

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

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

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

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

The Dalles Reservoir

Boat

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

Bank

The Washington shore east of Maryhill, WA [Rkm 340.7 (RM 211.6)] upstream to the base of John Day Dam [Rkm 347.0 (RM 215.5)].

The Oregon shore east of Rufus, OR [Rkm 344.9 (RM 214.2)] upstream to John Day Dam [Rkm 347.2 (RM 215.6)].

John Day Reservoir

Boat

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

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

Bank

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

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

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

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

McNary Reservoir

Boat

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

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

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

Trailers

Ringold ramp [Rkm 571.2 (RM 355.0)].

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

Bank

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

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

The east shore at Ringold [Rkm 571.2 (RM 355.0)].

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

Reservoir Subsections

Bonneville Reservoir

Boat

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

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

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

Bank

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

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

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

The Dalles Reservoir

Boat and Bank

Sect-3 The. Dalles Dam [Rkm 308.4 (RM 191.5)] upstream to the railroad bridge at Celilo [Rkm 323.8 (RM 201. 1)] .

Sect-2 The railroad bridge [Rkm 323.8 (RM 201. 1)] upstream to the Hwy . 97 bridge at Biggs [Rkm 336.7 (RM 209.1)].

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

John Day Reservoir

Boat and Bank

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

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

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

McNary Reservoir

Boat

Sect-5 McNary Dam [Rkm 470.4 (292. 1)] upstream to approximately Hat Rock State Park [Rkm 475.5 (RM 295.5)].

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

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

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

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

Bank

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

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

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

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

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

Appendix Table B- 1.1. Numbers of days angling effort was counted on Bonneville, The Dalles, and John Day reservoirs, March through October 1994, and on McNary Reservoir, April through October 1994.

Reservoir, Count type	March	April	May	June	July	August	September	October	Total
Bonneville									
Flight	***0***	***0***	***0***	***0***	6	**8**	4	5	23
Dawn-Dusk index	7	8	10	9	8	8	8	6	64
Single index	17	15	6	5	6	6	4	6	65
The Dalles									
Flight	0	0	0	0	0	0	0	0	0
Dawn-Dusk index	8	11	8	8	9	8	7	7	66
Single index	13	12	11	5	5	7	4	8	65
John Day									
Flight	0	5	5	4	5	5	6	4	34
Dawn-Dusk index	8	8	9	9	9	7	8	8	66
Single index	16	16	11	10	11	**11**	8	11	94
McNary									
Flight		5	5	4	5	5	6	4	34
Dawn-Dusk index McNary Pool		6	9	9	9	7	8	9	57
Single Index McNary Pool		4	7	6	7	11	5	4	44
Hanford Reach		11	**12**	**11**	**10**	**12**	20	30	106

Appendix Table B-l .2. Recreational fishery sturgeon regulations for Zone 6 of the Columbia River, 1987-1994.

Year	Daily bag limit	Size limit	Other
1987	2	36" min 72" max	Oregon - Sturgeon catch record and 30 fish annual bag limit since 1986. Washington - No gaffing of sturgeon.
1988	2	40" min 72" max	Washington - Sturgeon catch record required. Size limit increase effective April 30, 1988.
1989	2	40" min 72" max	Washington - Annual limit 15 fish.
1990	2	40" min 72" max	Oregon - Annual limit 15 fish, no gaffing of sturgeon. Oregon and Washington - Single point barbless hooks.
1991	l/l	40" min 72" max	Oregon and Washington - Bag limit changed to 1 fish less than 48" and 1 fish ≥ 48" (l/l regulation) for waters downstream of The Dalles Dam.
	1	48" min 66" max	Oregon and Washington - Size limit change effective April 16, 1991 for waters upstream of The Dalles Dam.
1992	l/l	40" min 72" max	Oregon - No change from 1991 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 60" max	Washington - Size limit change effective April 16, 1992 for waters downstream of The Dalles Dam.
	1	48" min 60" max	Washington - Size limit change effective April 16, 1992 for waters upstream of The Dalles Dam.
1993	l/l	40" min 72" max	Oregon - No change from 1991 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.
	l/l	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	l/l	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 3 1.

REPORT C

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

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

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CONTENTS

CONTENTS (continued)

ACKNOWLEDGEMENTS

We thank all who provided comments on earlier drafts of this report. We also wish to thank Lance G. Beckman, who retired during 1994, for imparting his wisdom and knowledge for the betterment of this cooperative project. Thanks are also extended to those who assisted in the recovery of the boat that sank.

ABSTRACT

The National Biological Service documented spawning by white sturgeon in the Columbia River downstream from Priest Rapids Dam and in the Snake River downstream from Ice Harbor Dam in 1994. However, no young-of-year white sturgeon were captured within the McNary Pool. Bottom trawling in the Bonneville Pool resulted in the capture of 11 young of year, indicating that spawning occurred downstream from The Dalles Dam.

The annual indices for spawning habitat downstream from Bonneville, The Dalles, John Day, and McNary dams were close to the ten year averages for the four spawning areas. Efforts to quantify the amount of spawning and rearing habitats for white sturgeon in the McNary Pool were continued.

INTRODUCTION

This annual report describes the progress of the National Biological Service's (previously the National Biological Survey) Columbia River Research Laboratory from 1 April 1994 through 3 1 March 1995 towards meeting the objectives of Bonneville Power Administration's Project 86-50. The primary goals of the National Biological Service under this project are to investigate the reproduction and early life history of white sturgeon in the Columbia River downstream from Priest Rapids Dam and in the Snake River downstream from Ice Harbor Dam (Figure 1). Our tasks for this period were to:

Estimate the timing of white sturgeon spawning in the Columbia River between McNary and Priest Rapids dams and in the Snake River downstream from Ice Harbor Dam.

Determine if recruitment of white sturgeon young of year occurred in the McNary and Bonneville pools.

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

Begin to quantify spawning and rearing habitat for white sturgeon in McNary Pool.

Capture juvenile white sturgeon from the Columbia River downstream from Bonneville Dam with bottom trawls to assist the Oregon Department of Fish and Wildlife (ODFW) in evaluating supplementation strategies.

METHODS

Field and analytical techniques were similar to those used in previous years. We sampled the Snake River downstream from Ice Harbor Dam twice weekly for white sturgeon eggs and larvae with D-shaped plankton nets (Parsley et al. 1993) and artificial substrates (McCabe and Beckman 1990) from 2 May to 5 July. Generally, one day elapsed before we resampled this tailrace. We sampled for white sturgeon eggs and larvae in the Columbia River downstream from Priest Rapids Dam with two vessels; one fished D-shaped plankton nets once weekly from 3 May through 20 July at five to seven locations encompassing statute river miles (RM) 343 to 357. The other vessel fished a beam trawl (Palmer et al. 1988) at seven sites twice weekly on consecutive days, and artificial substrates at two sites between RM 370 and 396. This vessel operated from

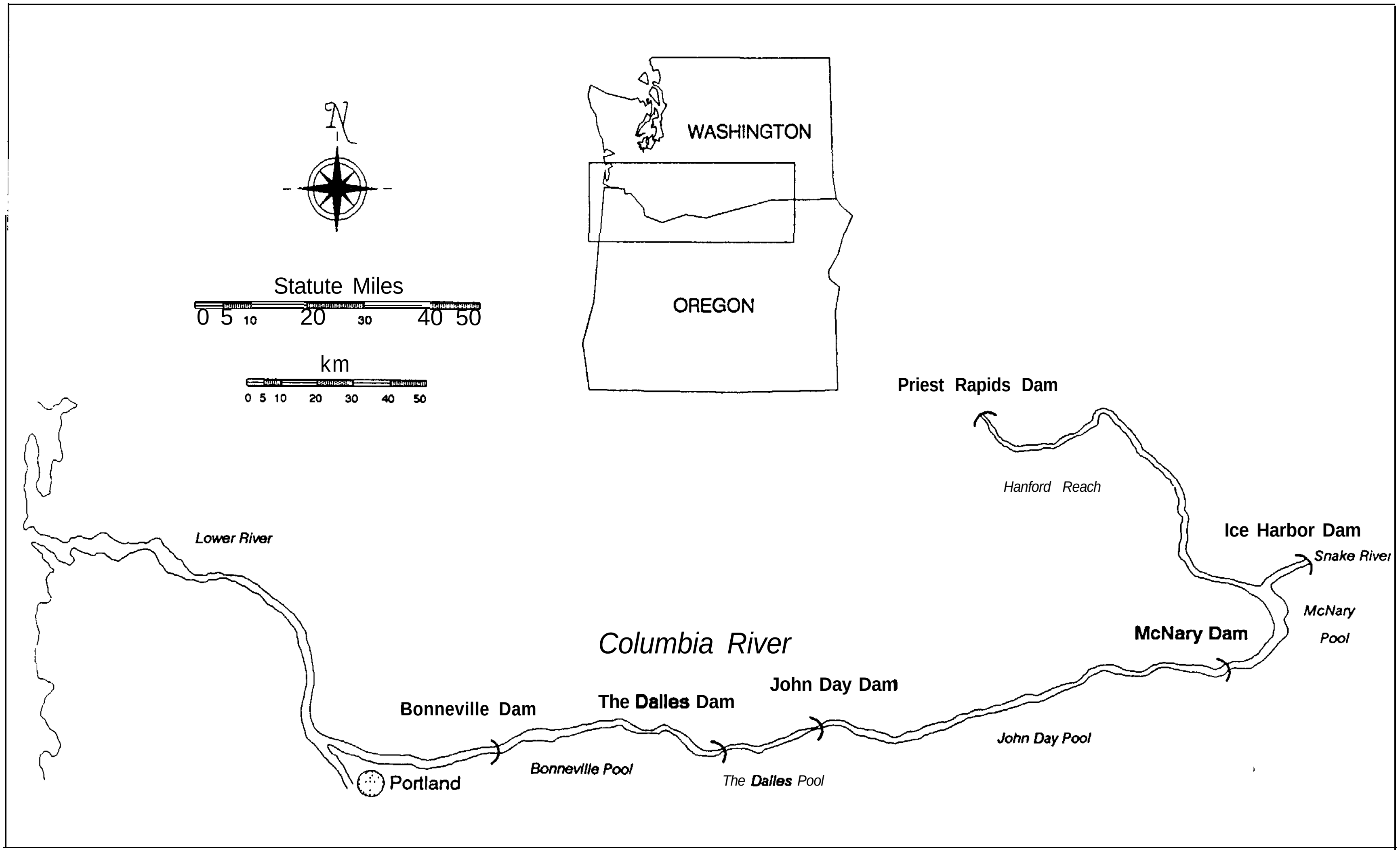

Figure 1. Location of study area between Bonneville and Priest Rapids dams on the Columbia River and downstream from Ice Harbor Dam on the Snake River.

7 June until 22 June when it accidently sank[1]. We reduced sampling in the Snake River after 22 June to one day each week through 5 July to continue sampling in the Columbia River downstream from Priest Rapids Dam with a second vessel.

Sample sites were designated with a code indicating statute river mile and relative position across the river channel. The last digit of the site designation represents position in the channel, with 0 and 5 designating backwater areas and 1 through 4 designating 1/4 channel width increments from left to right while facing upstream, Digits preceding the last number represent 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).

Collections containing white sturgeon eggs or larvae or those collections that were too large to sort in the field were preserved in a solution of 10% unbuffered formalin tinted with the biological stain phloxine B for sorting in the laboratory. Larval white sturgeon were measured to the nearest 0.1 mm total length (TL) and weighed to the nearest 0.001 g White sturgeon eggs and larvae were assigned developmental stages based on criteria described by Beer (1981), and dates on which spawning occurred were estimated by back-calculating the time of fertilization from the relations developed by Wang et al. (1985) with the water temperature on the day the eggs were collected.

We used a 6.2-m high-rise shrimp trawl fished on the bottom to capture juvenile white sturgeon (Palmer et al. 1988; Parsley et al. 1989). We fished this gear once weekly from 1 September to 28 September at five sites in the McNary Pool and twice weekly on consecutive days from 23 August to 27 September at six sites in the Bonneville Pool. We measured fork length (FL) and TL to the nearest mm on all young-of-year white sturgeon and FL on all other juvenile white sturgeon and weighed each on a Pescola[2] hanging scale. In general, young-of-year white sturgeon were weighed to the nearest 1 or 5 g, and larger juveniles were weighed to the nearest 10 g.

We also fished the high-rise trawl (minus the fine-mesh cod liner) to capture juvenile white sturgeon from the Columbia River downstream from Bonneville Dam for transplanting into The Dalles Pool. Report A (ODFW this volume) describes the latter task more thoroughly.

Catch per unit effort (CPUE) of white sturgeon was calculated when appropriate for a particular task, and was expressed as number caught/l5 min for the beam trawl, number caught/hectare with the high-rise trawl, and number caught/1,000 m^3 of water sampled with the D-shaped plankton nets. Only efforts from the period when water temperatures were between 12 and 19°C were used in calculations of egg CPUE. Larval CPUE was calculated using only

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[1] This vessel sank when the beam trawl became entangled on the bottom in 3-4 m of water with water velocities exceeding 2 m/s. The vessel was recovered and placed back in service. Planning and operations for future sampling efforts will strive to prevent this from reoccurring.

[2] The mention of trade names does not imply endorsement by the National Biological Service.

efforts from the period when water temperatures were between 12 and 20 °C. Young-of-year and juvenile CPUEs were calculated using all efforts with the high-rise trawl.

Habitat descriptors calculated, measured, or obtained were river discharge, water temperature, water velocity, water depth, and weighted usable spawning habitat. Mean daily discharge records for The Dalles, John Day, McNary, Priest Rapids, and Ice Harbor dams were obtained for April through July, 1994 from the Fish Passage Center. Water temperatures were recorded every two hours with Ryan Tempmentor thermographs placed on the river bottom at RM's 190.8, 214.3, 290.6 and 353.0 in the Columbia River, and at RM 6.3 in the Snake River. Water temperatures were also measured with a digital thermometer prior to most sampling efforts.

Water velocities were measured prior to most efforts made with the beam trawl and D-shaped plankton nets. Mean water column velocity (an average of the velocities measured at 0.2 and 0.8 of the total depth) and bottom velocity (measured 0.4 m above the bottom) were measured with a cable suspended Price type "AA" sensor connected to a Swoffer Instruments Model 2200 direct reading current velocity meter.

We used the methods and data described in Parsley and Beckman (1994) to model the availability of spawning habitat for white sturgeons downstream from McNary Dam, and began collecting data in cooperation with the U.S. Fish and Wildlife Service (USFWS Report E this volume) that will allow these methods to be used to quantify spawning and rearing habitat in the McNary Pool.

RESULTS

Egg and Larva Sampling

White sturgeon spawned in the Snake River downstream from Ice Harbor Dam and in the Columbia River downstream from Priest Rapids Dam. We collected only three eggs and three larvae in the Snake River downstream from Ice Harbor Dam, and only nine eggs and two larvae in the Columbia River downstream from Priest Rapids Dam.

Snake River

We sampled for white sturgeon eggs and larvae at a number of sites in the Snake River downstream from Ice Harbor Dam (Appendix C-l). We collected two well-developed eggs (closure of the neural tube) from the Snake River on 3 1 May at RM 5.6 and 6.0, and one dead fungused egg on 6 June at RM 6.3 (Table 1). The two viable eggs were collected when the water temperature was 13.7°C, the water depth was 7.3 m at both sites, the mean column water velocities were 1.46 and 1.48 m/s, and the velocities near the bottom were 0.91 and 1.13 m/s.

Table 1. Total number and catch per 1,000 m^3 of water sampled of white sturgeon eggs and larvae collected with the D-shaped plankton nets in the Snake River below Ice Harbor Dam from 2 May to 5 July 1994.

Site	Total number of eggs		Dead and fungused eggs			Larvae	
	Number	Catch/ 1,000 m^3	Number	Percent of total catch	Catch/ 1,000 m^3	Number	Catch/ 1,000 m^3
561	1	0.08	0	0.00	0.00	0	0.00
601	1	0.20	0	0.00	0.00	1	0.20
631	1	0.30	1	100	0.30	2	0.59
Total	3	0.14	1	33	0.05	3	0.14

Two one-day-old larvae were collected on 6 June, one at RM 6.0 and one at RM 6.3 (Table 1). One larva was 13.3 mm TL and weighed 0.023 g. The other larva was 13.5 mm TL and weighed 0.030 g. These larvae were collected when the water temperature was 15.4°C, the water depths were 7.0 m at both sites, the mean column water velocities were 0.81 and 0.91 m/s, and the velocities near the bottom were 0.30 and 0.85 m/s. One badly-damaged larva was collected on 15 June at RM 6.3. The water temperature was 16.1 "C, the depth was 7.0 m, the mean column water velocity was 0.58 m/s, and the velocity near the bottom was 0.30 m/s.

All white sturgeon eggs and larvae from the Snake River were collected from within the dredged navigation channel that runs along the northern shore of the river. Sampling did occur upstream from RM 6.3 but no white sturgeon eggs or larvae were collected there. Sampling also occurred outside of the dredged channel (Appendix C-l). We used artificial substrates at two sites (533 and 63 1) but collected no white sturgeon eggs with them.

We estimated that spawning in the Snake River occurred on 28 May and also sometime in early June by back-calculating spawning dates from the viable eggs and the three larvae collected. Water temperatures in the Snake River were optimal for white sturgeon spawning (14 - 17 ° C; Wang et al. 1985) during 17 - 24 May and 3 - 2 1 June. River discharges fell precipitously from a mean daily high of 2,660 m^3/s on 11 May to a low of 508 m^3/s on 1 July (Figure 2).

Columbia River

We sampled for white sturgeon eggs and larvae at numerous locations in the Columbia River downstream from Priest Rapids Dam (Appendix C-2, Appendix C-3). We collected nine white sturgeon eggs and two larvae from the Columbia River downstream from Priest Rapids Dam. The nine eggs were collected with the beam trawl on 21 June at five sites between river miles 370.0 and 396.3, and were at various stages of development (Table 2). Water temperatures were 15.1 to 15.3°C, depths were 7.6 to 18.9 m, mean water column velocities ranged from 1.80 to 2.70 m/s, and velocities near the bottom ranged from 1.04 to 1.71 m/s. Two larvae were collected with the plankton nets at two sites. One post-hatch larva collected on 30 June at RM 370.0 was 11.3 mm TL and weighed 0.023 g. The water temperature was 16.3°C, the depth was 8.5 m, the mean column and near bottom water velocities were 1.97 and 1.16 m/s. One one-day post-hatch larva collected on 12 July at RM 396.0 was 11.4 mm TL and weighed 0.024 g. The water temperature was 17.4°C, the depth was 4.0 m, and the mean column and near bottom water velocities were 1.25 and 0.98 m/s.

Spawning by white sturgeon in the free-flowing Columbia River occurred on at least four days. From the developmental stages of the eggs collected, we estimate that these eggs were spawned on 18, 20, and 21 June. The post-hatch larva collected on 30 June was spawned on about 21 June, but the one-day post-hatch larva collected on 12 July was spawned around 4 July. Spawning occurred between Priest Rapids dam (RM 397.1) and RM 396.3, and may have occurred between RMs 388.8 and 396.3. Spawning also occurred between RMs 370.0 and 376.3. This latter spawning area is suspected because we collected a newly-spawned egg at RM 370.0, but collected no white sturgeon eggs upstream at RMs 376.3 and 381.7 (Table 2).

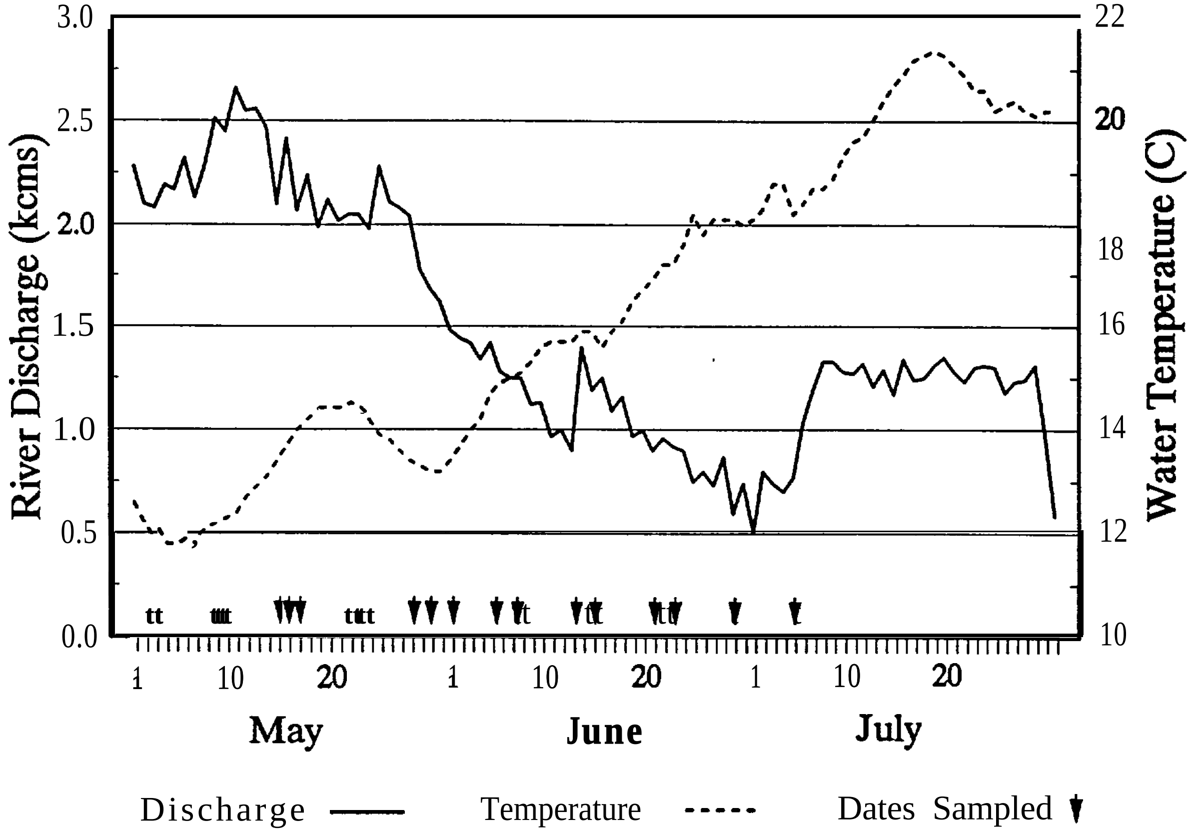

Figure 2. Mean daily discharges (x 1,000), water temperatures ("C), and dates on which sampling occurred for white sturgeon eggs and larvae in the Snake River downstream from Ice Harbor Dam during May through July 1994.

Table 2. The distribution of sampling efforts with the beam trawl and catch of white sturgeon eggs on 21 June 1994 in the Columbia River downstream fi-om Priest Rapids Dam. The water temperature was 15.1 - 15.3°C. Developmental stages are from Beer (1981). Priest Rapids Dam is at river mile 397.

Site	Number of eggs collected	Developmental stage	Depth (m)	Mean column velocity (m/s)	Near-bottom velocity (m/s)
39633	2	closure of the neural tube, elongation of the pronephros	10.0	2.70	1.58
39582	4	late cleavage, early epithelial, closure of the neural tube	19.2	2.21	1.46
39433	1	early epithelial	7.6	1.80	1.04
38883	1	early epithelial	18.9	2.10	1.52
38173	0		10.7	2.27	1.86
37634	0		17.4	2.13	1.52
37003	1	changing pigmentation	11.3	2.36	1.71

Water temperatures in the Columbia River were optimal for white sturgeon spawning from 17 June to 8 July. River discharges were quite variable during these dates; mean daily discharges ranged from a high of 4,717 m^3/s to a low of 2,728 m^3/s. The peak of the annual hydrograph occurred before water temperatures became optimal for spawning and occurred on 14 June with a mean daily discharge of 5,153 m^3/s (Figure 3).

Juvenile Sampling

McNary Pool

No juvenile white sturgeon were captured with the high-rise bottom trawl in the McNary Pool. We trawled at five sites once each week for five weeks beginning 1 September (Appendix C-4). Three young-of-year white sturgeon were collected from two of these sites during 1993 (Counihan et al. 1995).

Bonneville Pool

We captured 29 juvenile white sturgeon with the high-rise trawl during our sampling in the Bonneville Pool. Eleven of these juveniles were young of year. Young-of-year white sturgeon were captured at four of six sites trawled and older white sturgeon were captured at five of the six sites trawled (Table 3). Young of year were first captured on 7 September and were 150 - 250 mm FL and 22 - 100 g. The other juvenile white sturgeon captured were 334 - 854 mm FL and 230 - 5,000 g.

Densities of white sturgeon estimated from catches with the bottom trawl varied from 0 to 1.63 young of year per hectare at the six sites and densities for all juveniles ranged from 0 to 3.24 fish per hectare at the sites (Table 4). Density for all sites combined was 0.57 young of year per hectare and 1.5 1 fish per hectare for all juvenile white sturgeon.

Catch of Other Fish Species

The pooled data for all sites in Bonneville Pool showed that prickly sculpins were most abundant in our catches, followed by sandrollers, peamouths, and redside shiners (Table 5). In the McNary Pool yellow perch were most abundant in our pooled catches, followed by sandrollers, prickly sculpins, and channel catfish. However, 99% of the yellow perch were captured at one site. No redside shiners were captured in McNary Pool, but they were abundant in the Bonneville Pool. No common carp were captured in the Bonneville Pool, but they were abundant in McNary Pool.

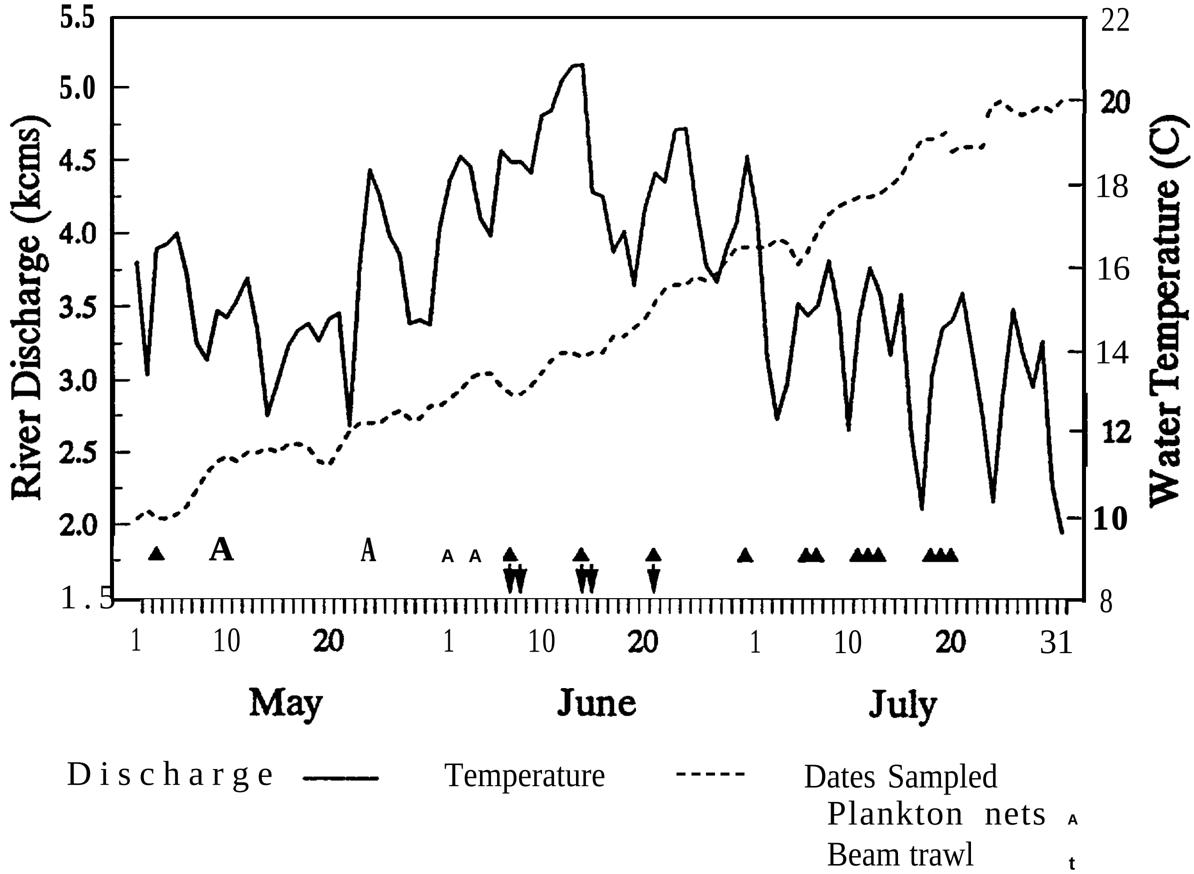

Figure 3. Mean daily discharges (x 1,000), water temperatures ("C), and dates on which sampling occurred for white sturgeon eggs and larvae in the Columbia River from river mile 343.6 to Priest Rapids Dam during May through July 1994.

Table 3. Number of juvenile white sturgeon caught with a high-rise bottom trawl in Bonneville Pool during 1994. Numbers in parentheses are the number of young of year present in the total catch ofjuvenile white sturgeon.

	Date												
	August				September								
Site	23	24	29	30	7	8	12	13	20	21	26	27	Site totals
15734	0	0	1	0	0	0	0	0	0	0	0	0	1
15951	0	1	0	0	1(1)	0	0	2(2)	0	0	1	0	5(3)
17063	0	0	1	1	0	0	0	1(1)	1(1)	2(2)	1(1)	0	7(5)
17374	0	0	0	0	0	0	0	0	0	0	0	0	0
17911	1	0	0	0	0	2	0	1(1)	0	0	0	0	4(1)
18531	2	4	0	1	0	0	0	0	1	1	2(1)	1(1)	12(2)
Daily totals	3	5	2	2	1(1)	2	0	4(4)	2(1)	3(2)	4(2)	1(1)	29(11)

Table 4. Number and average catch per hectare (CPHA) of young-of-year and juvenile white sturgeon captured with the high-rise bottom trawl from 23 August through 27 September 1994 at six trawling sites in Bonneville Pool.

	Young of year		Juveniles	
Site	Number	CPHA	Number	CPHA
15734	0	0.00	1	0.31
15951	3	0.97	5	1.62
17063	5	1.63	7	2.28
17374	0	0.00	0	0.00
17911	1	0.33	4	1.32
18531	2	0.54	12	3.24
Pooled mean		0.57		1.51

Table 5. Number and catch per hectare (CPHA) of fishes other than white sturgeon captured with the high-rise bottom trawl from 23 August through 27 September 1994 at trawling sites in Bonneville and McNary pools.

Species		Bonneville Pool		McNary Pool	
		No.	CPHA	No.	CPHA
American shad	*Alosa sapidissima*	108	5.6	91	11.8
Lake whitefish	*Coregonus clupeaformis*	0	0	2	0.3
Mountain whitefish	*Prosopium williamsoni*	0	0	1	0.1
Chinook salmon	*Oncorhynchus tshawytscha*	1	<0.1	0	0
Common carp	*Cyprinus carpio*	0	0	71	9.2
Chiselmouth	*Acrocheilus alutaceus*	1	<0.1	2	0.3
Longnose dace	*Rhinichthys cataractae*	0	0	1	0.1
Redside shiner	*Richardsonius balteatus*	219	11.4	0	0
Peamouth	*Mylocheilus caurinus*	295	15.4	61	7.9
Largescale sucker	*Catostomus macrocheilus*	1	<0.1	38	4.9
Bridgelip sucker	*Catostomus columbianus*	0	0	3	0.4
Channel catfish	*Ictalurus punctatus*	4	0.2	95	12.3
Sandroller	*Percopsis transmontana*	753	39.3	367	47.6
Smallmouth bass	*Micropterus dolomieui*	1	a . 1	2	0.3
Black crappie	*Pomoxis nigromaculatus*	0	0	1	0.1
White crappie	*Pomoxis annularis*	0	0	1	0.1
Walleye	*Stizostedion vitreum*	2	0.1	0	0
Yellow perch	*Perca flavescens*	0	0	481	62.3
Prickly sculpin	*Cottus asper*	1,250	65.2	267	34.6

Availability of Spawning Habitat

Phase 1 Study Area

Monthly estimates of the index of white sturgeon spawning habitat (temperature conditioned weighted usable area) for 1994 are similar to the 1 O-year averages for each spawning area (Figure 4, Appendix C-5). The availability of spawning habitat was greatest during May in all areas. The annual mean composite indices of spawning habitat for 1994 were within one standard deviation of the IO-year averages for the spawning areas (Figure 5, Appendix C-5).

McNary Pool

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

Supplementation Strategies

We provided five days of bottom trawling for juvenile white sturgeon for the ODFW downstream from Bonneville Dam. See Report A (ODFW) within, this volume for further information on this task.

DISCUSSION

We were able to estimate the onset of spawning by white sturgeon in the Columbia River downstream from Priest Rapids Dam and in the Snake River downstream from Ice Harbor Dam, but subsequent collections of white sturgeon eggs and larvae were too low in either river to estimate the duration of the spawning period. We believe two factors contributed to these low catches: limited spawning by white sturgeon, and insufficient sampling to detect the patchy spatial and temporal distributions of spawning within the large areas in which spawning may have occurred.

The start of spawning in the Snake River downstream from Ice Harbor Dam was followed by a decline in river discharge (Figure 2) that may have altered the physical environment enough to curtail spawning by white sturgeon. Swift water velocities are important for spawning white sturgeon (parsley and Beckman 1994). Water velocities over known spawning areas in the Snake River declined with the drop in river discharge. On 3 1 May, the mean column velocity at site 561 was 1.49 m/s. The velocity at this site fell to less than 1 .O m/s by 6 June, velocities remained lower than those that have been defined as optimum for spawning white sturgeon (Parsley and Beckman 1994) throughout the time period when water temperatures were suitable for spawning (Table 6).

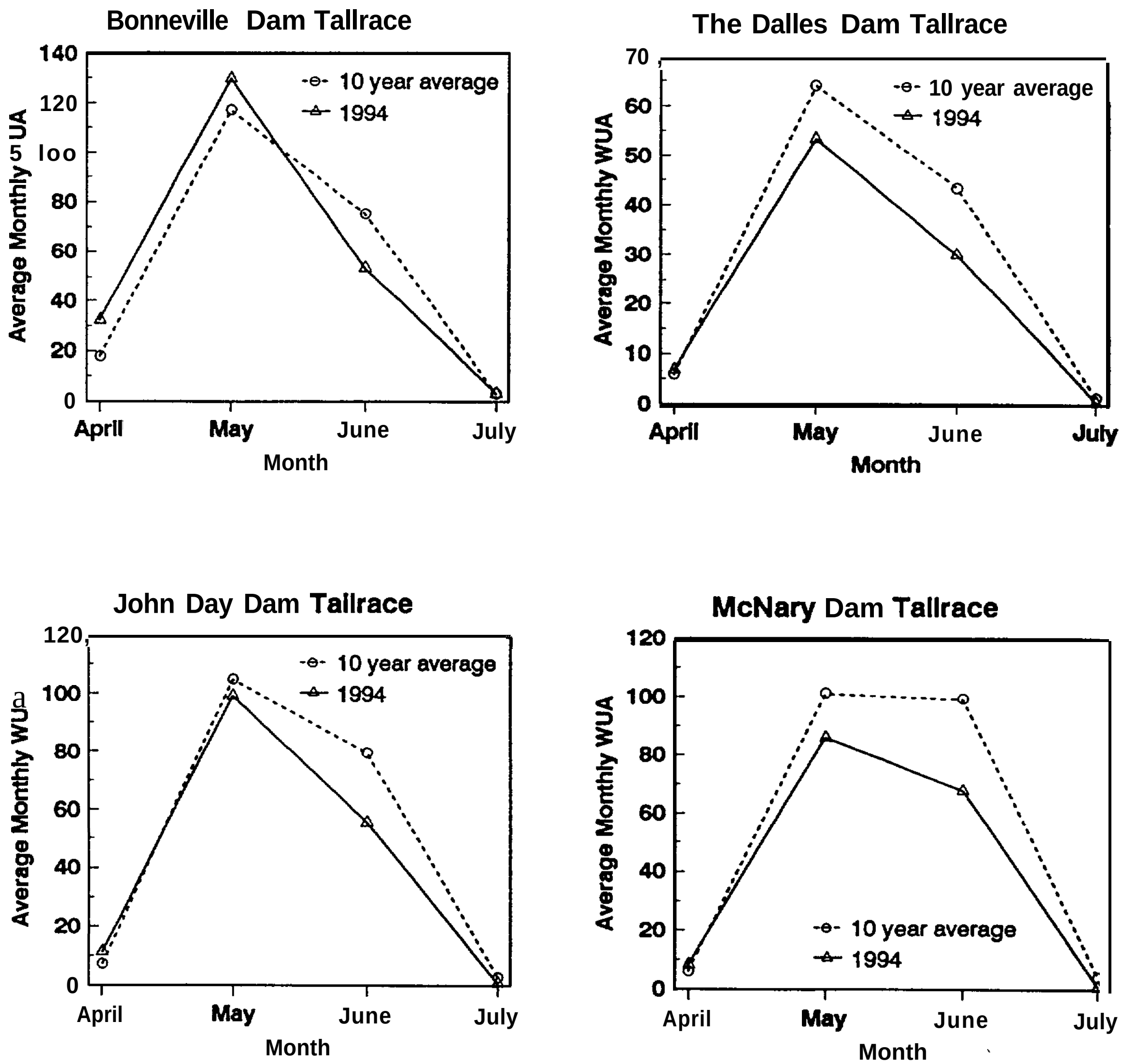

Figure 4. Mean monthly indices of spawning habitat (weighted usable area (WUA)) for white sturgeon during 1994 and the lo-year averages of the monthly indices for the four spawning areas that have been modeled (Parsley and Beckman 1994).

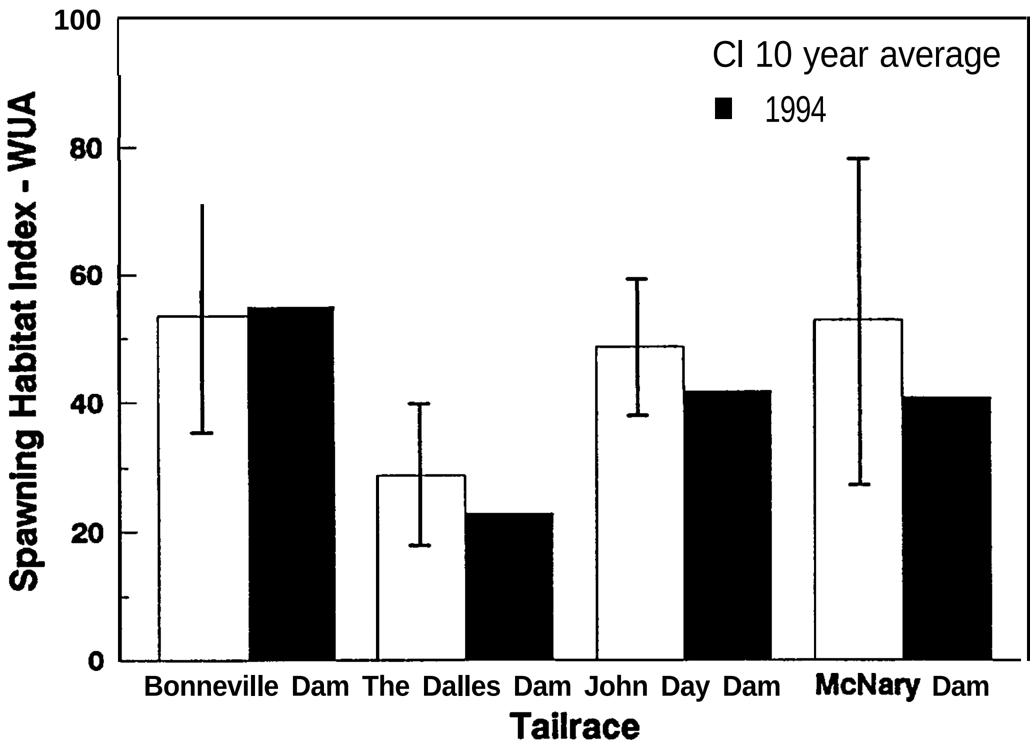

Figure 5. Annual mean composite index of white sturgeon spawning habitat (weighted usable area (WUA)) for each of the four dam tailraces that have been modeled. Shown are the indices for 1994 and the lo-year averages. The vertical lines within the bars for the lo-year averages depict ± one standard deviation.

Table 6. Mean column water velocities measured at site 561 in the Snake River, a known spawning area for white sturgeon, during 1994. Mean column velocities were measured only once during each day and may have been measured at a discharge different from the mean daily discharge measured at Ice Harbor Dam.

Date	Mean column velocity (m/s)	Mean daily discharge (m^3/s)
2 May	1.34	2,100
9 May	1.30	2,510
11 May	1.49	2,660
16 May	1.34	2,420
17 May	1.40	2,070
23 May	1.33	2,050
25 May	1.36	2,280
31 May	1.49	1,620
2 June	1.13	1,440
6 June	0.84	1,280
8 June	0.84	1,250
15 June	0.50	1,190
20 June	0.78	1,000
22 June	0.70	960
28 June	0.41	870
5 July	0.59	770

Estimating the timing of spawning and determining the spatial distribution of spawning locations requires two sampling protocols. Estimating the timing of spawning demands that sample sites encompass locations where eggs will be collected and that sampling occur at a temporal fkequency capable of detecting sporadic spawning. Estimating the location of spawning demands that sample sites be spatially and temporally discrete to identify all spawning sites over time, thus sampling will probably occur at sites where spawning may never happen - a contradiction to the protocol for an efficient sampling program to estimate the timing of spawning.

Achieving these two tasks at the same time required a more intense sampling effort than we were able to put forth in 1994. The logistics of sampling for white sturgeon eggs (the 30-min duration of each sampling effort, pre- and post-sample data processing, and travel time between sample sites in the free-flowing reach) limited the number of efforts we were able to conduct each day, and thus constrained our ability to adequately sample the patchy spatial and temporal distributions of spawning by white sturgeon. Safety concerns generally precluded us from sampling with nets in some areas that may have been used for spawning (although not always, ergo a sunken boat); however, we did sample adjacent to or downstream from many potential spawning areas. These constraints, coupled with the unknown efficiency of the nets used to collect eggs, require that considerable effort be expended to meet the two objectives.

Bottom trawling in the Bonneville Pool revealed that spawning by white sturgeon and recruitment to young of year occurred in this pool. The 12 white sturgeon caught during the four days of trawling in August were older than young of year, whereas 11 of the 17 white sturgeon caught during the month of September were young of year. The higher catches of young of year during September could indicate that the vulnerability of young-of-year white sturgeon to the bottom trawl increased with age or that the fish moved into the areas where our trawling sites were located.

The lack ofjuvenile white sturgeon from the trawling conducted within the McNary Pool is puzzling. The zero catch may be a result of poor recruitment or perhaps the trawling sites were not used by juvenile white sturgeon. We did capture three young-of-year white sturgeon during 1993 from two of the sites sampled in 1994 (Counihan et al. 1995), but have not captured an older juvenile white sturgeon with the bottom trawl from this pool.

The indices of the availability of white sturgeon spawning habitat for the four spawning areas that have been modeled were near the IO-year averages for each area. Estimates of the indices of spawning habitat are available only for the past 10 years, and the average for this period should not be construed as representative for a longer time period. The index for each area provides information on the effects of hydropower operations within the Columbia River Basin on the physical microhabitat for spawning white sturgeon because it incorporates backwater effects caused by the impoundments and changes to the river hydrograph and water temperatures as a result of upriver storage. These results do not imply that spawning and subsequent recruitment to young of year were similar to a 10 year average. Other factors such as brood stock abundance, periodicity of spawning by adult white sturgeon, and environmental conditions before and after the spawning season may also affect spawning and recruitment.

The National Biological Service has several objectives to meet in 1995. They include:

1. Evaluate white sturgeon spawning and recruitment downstream from The Dalles Dam under recommended flows and project operations. This will be done with assistance from the National Marine Fisheries Service.

2. Refine habitat definitions used for spawning and rearing that were derived during phase 1. Estimate the habitat available for spawning and rearing in the lower river, Bonneville Pool, The Dalles Pool, John Day Pool, and McNary Pool, including the free-flowing reach downstream from Priest Rapids Dam and the Snake River downstream from Ice Harbor Dam.

3. Describe the reproductive and early life history characteristics of white sturgeon in McNary Pool.

We will investigate how hydropower operations affect white sturgeon spawning downstream from The Dalles Dam. The National Marine Fisheries Service will provide assistance with this sampling for six weeks during May and June. The analysis will examine the effects of changes in river discharge, temperatures, degree-days, flow-days, and other variables on the timing and duration of the spawning. The timing, duration, and magnitude of spawning will be estimated from catches of eggs from the D-shaped plankton nets. Sampling will occur during daylight and at night.

Bottom trawling for juvenile white sturgeon will be done during August and September. The goal of the trawliig efforts will be to enable the calculation of an index of abundance that can be used to compare relative year class strength among years for the Bonneville Pool.

The evaluation of habitat for white sturgeon spawning and rearing in the McNary Pool study area will continue. Substrates within the pool will be mapped, and cartographic modeling with a Geographic Information System will be used to determine areas of suitable habitat based on water depths and substrate. We will continue to assist the USFWS with its efforts to determine the amount of spawning and rearing habitat within the free-flowing reaches downstream from Priest Rapids and Ice Harbor dams. The indices of spawning habitat for the spawning areas located downstream from Bonneville, The Dalles, John Day, and McNary dams will be derived from 1995 river discharges and temperatures.

We will continue to investigate the early life history of white sturgeon in the McNary Pool study area. Sampling for white sturgeon eggs and larvae downstream from Priest Rapids and Ice Harbor dams will be done, but the efforts will focus on estimating the timing of spawning and will not investigate the spatial distribution of spawning sites. This will allow us to more precisely estimate the spawning period. We will employ artificial substrates (McCabe and Beckman 1990) to collect eggs and use the D-shaped plankton nets to collect eggs and larvae. This sampling will occur in areas where we have collected eggs in previous years.

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APPENDIX C-l

The location, total time sampled, volume of water sampled, and catch/1,000 m^3 of white sturgeon eggs and larvae at sites sampled with the D-shaped plankton nets in the Snake River downstream from Ice Harbor Dam. Sampling occurred from 2 May through 5 July 1994. Three white sturgeon eggs and three larvae were collected; one egg was dead and covered with fungus.

			Catch/l ,000 m^3	
Site	Minutes sampled	Volume sampled (m^3)	Eggs	Larvae
374	60	227	0	0
452	60	743	0	0
494	60	485	0	0
522	60	458	0	0
523	960	6,367	0	0
524	600	6,215	0	0
561	960	12,788	0.08	0
591	60	787	0	0
601	420	5,043	0.20	0.20
603	60	645	0	0
612	240	3,334	0	0
613	60	760	0	0
621	120	1,532	0	0
631	420	3,380	0.30	0.59
632	60	952	0	0
641	60	587	0	0
651	300	3,651	0	0
681	120	1,557	0	0
682	60	848	0	0
702	60	833	0	0
721	60	641	0	0
731	60	1,287	0	0

Appendix C-l continued.

Site	Minutes sampled	Volume sampled (m^3)	Catch/l ,000 m^3 Eggs	Larvae
781	60	1,211	0	0
791	180	2,764	0	0
792	60	1,244	0	0
851	60	1,212	0	0
852	60	995	0	0
861	120	1,859	0	0
862	60	1,132	0	0
881	60	722	0	0
931	180	2,185	0	0
933	60	561	0	0
942	60	669	0	0
943	60	158	0	0
Total	5,940	67,832		

APPENDIX C-2

The location, total time sampled, volume of water sampled, and catch/1,000 m^3 of white sturgeon eggs and larvae at sites sampled with the D-shaped plankton nets in the Columbia River downstream from Priest Rapids Dam. Sampling occurred from 3 May through 20 June 1994.

Site	Minutes sampled	Volume sampled (m^3)	Catch/1,000 m^3 Eggs	Catch/1,000 m^3 Larvae
34361	120	763	0	0
34371	420	4,259	0	0
34374	60	237	0	0
34741	60	1,083	0	0
34752	112	2,667	0	0
34753	180	3,681	0	0
34754	120	2,159	0	0
34861	60	1,405	0	0
34873	60	819	0	0
34874	180	3,017	0	0
34884	60	584	0	0
34894	60	508	0	0
35101	60	1,089	0	0
35102	60	1,629	0	0
35112	60	959	0	0
35121	120	2,112	0	0
35181	120	2,929	0	0
35201	60	1,312	0	0
35213	60	1,255	0	0
35543	120	2,688	0	0
35544	240	3,317	0	0
35554	60	609	0	0
35582	60	837	0	0

Appendix C-2 continued.

Site	Minutes sampled	Volume sampled (m^3)	Catch/1,000m^3 Eggs	Larvae
35701	60	384	0	0
35711	180	1,244	0	0
35713	120	1,477	0	0
35714	120	1,413	0	0
35721	60	366	0	0
35724	180	1,677	0	0
35743	60	874	0	0
35753	60	895	0	0
3 7004	180	3,214	0	0.08
37014	60	1,093	0	0
38151	60	1,023	0	0
38191	120	2,102	0	0
38192	120	1,469	0	0
38861	120	1,359	0	0
3 8874	120	2,174	0	0
39004	180	2,322	0	0
39104	120	2,233	0	0
39401	120	1,667	0	0
39511	60	949	0	0
3953 1	60	714	0	0
39563	60	789	0	0
39574	60	374	0	0
39604	120	1,987	0	0.50
39611	60	811	0	0
39614	60	849	0	0
39621	60	893	0	0

Appendix C-2 continued.

Site	Minutes sampled	Volume sampled (m^3)	Catch/1,000m^3 Eggs	Larvae
3963 1	60	998	0	0
39634	60	1,166	0	0
Total	5,212	76,431		

APPENDIX C-3

The location, total time sampled, and the catch/l 5 min of white sturgeon eggs and larvae at sites sampled with the beam trawl in the Columbia River downstream from Priest Rapids Dam. Sampling occurred from 7 June through 21 June 1994. None of the eggs collected were visibly infected with fungus.

		Catch/15 min	
Site	Minutes sampled	Eggs	Larvae
3 7003	150	0.10	0
37634	90	0.00	0
38173	150	0.00	0
38472	60	0.00	0
38883	150	0.10	0
39433	90	0.17	0
39582	150	0.40	0
39633	150	0.20	0
Total	990		
Pooled mean		0.14	0

APPENDIX C-4

The location, total time sampled, total area sampled, and catch/hectare at sites sampled with the high-rise bottom trawl in the Columbia River between McNary and Priest Rapids dams. Sampling occurred once weekly at these sites during 1 - 28 September 1994.

Site	Total time sampled (min)	Area sampled (hectares)	Number of juvenile white sturgeon collected	Catch/hectare
30712	50	1.38	0	0
30934	50	1.46	0	0
31193	50	1.45	0	0
31254	50	1.24	0	0
3 1432	50	1.35	0	0
Total	250	6.88	0	0

APPENDIX C-5

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

Bonneville Dam Tailrace

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

APPENDIX C-S continued.

The Dalles Dam Tailrace										
Month	Year									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
April	6.70	4.97	4.32	2.06	11.98	10.89	1.85	7.07	1.65	6.77
May	54.77	58.36	72.81	42.60	89.10	46.63	61.90	51.49	109.77	53.49
June	22.76	30.94	17.18	26.49	26.83	112.71	107.84	6.13	55.80	30.20
July	0.05	0.14	0.01	0.11	0.28	4.48	5.92	0.00	2.45	0.48
Sum	84.28	94.4 1	94.32	71.26	128.19	174.71	177.51	64.69	169.67	90.94
Annual mean	21.17	23.69	23.79	17.87	32.25	43.38	44.20	16.33	42.64	22.81
Standard deviation	27.74	37.45	34.19	24.32	40.24	52.24	51.39	22.64	58.23	24.23
Coef. var	1.31	1.58	1.44	1.36	1.25	1.20	1.16	1.39	1.37	1.06

APPENDIX C-5 continued.

John Day Dam Tailrace

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

APPENDIX C-5 continued.

McNary Dam Tailrace

Month	Year									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
April	12.70	3.36	3.57	0.91	9.99	11.26	2.07	6.23	1.48	8 22
May	92.46	99.49	102.39	43.73	114.66	81.20	105.19	81.37	205.26	86.00
June	56.47	138.72	27.46	25.00	59.62	247.90	228.9 1	16.47	124.67	67.54
July	0.06	0.17	0.00	0.00	0.05	15.73	20.77	0.00	4.87	0.72
Sum	161.69	241.74	133.42	69.64	184.32	356.09	356.94	104.07	336.28	162.48
Annual mean	40.52	60.26	33.65	17.48	46.27	88.36	88.80	26.26	84.42	40.67
Standard deviation	54.48	103.89	55.68	29.85	59.60	115.08	104.21	38.94	117.56	45.51
Chef. var	1.34	1.72	1.65	1.71	1.29	1.30	1.17	1.48	1.39	1.12

REPORT D

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

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

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CONTENTS

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ABSTRACT

During 1994, the National Marine Fisheries Service sampled white sturgeon (*Acipenser transmontanus*) eggs, larvae, and juveniles in the Columbia River downstream from Bonneville Dam (River Mile (RM) 145). A total of 2,175 white sturgeon eggs was collected with plankton nets and artificial substrates between RM 120 and 145. Viable white sturgeon eggs were collected first on 19 April, and last on 5 July. The sampling site near Ives Island (RM 143) was used as the primary index station to monitor white sturgeon spawning throughout the season. Between **19** April and 5 July, white sturgeon egg densities near Ives Island (in plankton nets) ranged from 0.0 to 58.4 eggs/l,000 m^3 of water sampled, with the highest density on 23 May. Based on egg collections, I estimated that white sturgeon spawned on at least 40 days in 1994, beginning on 18 April and ending on 5 July, Spawning was estimated to have occurred at Bonneville Dam discharges (mean hourly discharge by day) ranging from 3,713 to 6,594 m^3/s, and water temperatures ranging from 11 to 17°C. A total of 42 white sturgeon larvae was collected in plankton nets between RM 120 and 145. Larvae were first collected on 3 May, and last collected on 20 June. Densities of larvae near Ives Island ranged from 0.0 to 4.6 larvae/l,000 m^3 of water sampled.

In September 1994, 183 juvenile white sturgeon were collected with a 7.9-m (headrope length) semiballoon shrimp trawl between RM 3 1 and 132 in the Columbia River downstream from Bonneville Dam. Distributions of juvenile white sturgeon were patchy; not only were there differences in catches among different areas of the river, but also differences in catches between parallel transects within the same area. We collected 19 young-of-the-year (YOY) white sturgeon between RM 61 and 132; YOY comprised about 10% of the total catch of juvenile white sturgeon. Densities of YOY white sturgeon at 13 index sampling stations averaged 0.6 fish/hectare during the first survey (l-9 September) and 2.3 fish/hectare during the second survey (19-22 September); the mean for both surveys combined was 1.4 fish/hectare.

INTRODUCTION

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

Specific research goals for 1994 were 1) to determine the timing of spawning in the Columbia River downstream from Bonneville Dam; 2) to estimate the effects of river flow, water velocity, and water temperature on white sturgeon spawning; 3) to estimate the success of young-of-the-year (YOY) white sturgeon recruitment in 1994; and 4) to collect juvenile white sturgeon in selected areas of the Columbia River downstream from Bonneville Dam for an ODFW evaluation on the feasibility of transporting juvenile white sturgeon from fully-seeded habitats (e.g., the river downstream from Bonneville Dam) to under-seeded habitats upstream from The Dalles Dam. This report describes progress on NMFS studies from March 1994 to March 1995.

METHODS

Egg and Larval Sampling

From mid-April through early July 1994, NMFS sampled weekly for white sturgeon eggs and larvae in the Columbia River downstream from Bonneville Dam. A D-ring plankton net was used to collect white sturgeon eggs and larvae. This net was 0.8 m wide at the bottom of the mouth opening and was constructed of 7.9-mesh/cm nylon marquisette netting (Kreitman 1983); the open area of the net was about 0.3 m^2. Depending upon the water velocity, two to six lead weights (4.5 or 9.1 kg each) were attached to two corners of the net frame to hold the net on the river bottom. A digital flow meter (General Oceanics Model 2030') was suspended in the mouth of the net to estimate the water volume sampled. Typically, two plankton nets were fished simultaneously for about 30 min from an anchored 12.2-m research vessel. The nets were fished once a day at each sampling station.

Artificial substrates constructed of latex-coated animal hair were also used to collect white

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

sturgeon eggs. Substrates were cut into 76- by 91-cm sections and secured to an angle iron frame. Two sections of artificial substrate were placed back to back in each frame. Because two pieces were used in each frame, it made no difference which side of the frame rested on the river bottom. Two short sections of cable were used to attach the frame to an anchor, which held the substrate and frame in place on the bottom. A buoy line was attached to the anchor to allow retrieval of the substrate, frame, and anchor. Substrates were generally retrieved and examined weekly for eggs. When small numbers of white sturgeon eggs (< 20) were present on the substrates, the eggs were removed and the original substrates were redeployed. When larger numbers of eggs were present, new artificial substrates were deployed in place of the original substrates.

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

White sturgeon eggs and larvae were fixed in an approximately 4% buffered formaldehyde solution and transferred to WDFW for determinations of egg and larval developmental stages.

Juvenile Sampling

A 7.9-m (headrope length) semiballoon shrimp trawl, identical to that used from 1987 through 1993, was used to collect juvenile white sturgeon, including YOY. Mesh size in the trawl was 38 mm (stretched measure) in the body; a 1 O-mm mesh liner was inserted in the cod end of the net. Shrimp trawl efforts were normally 5 to 7 min in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable were deployed, and the effort was considered ended when 5 to 7 min had elapsed. We estimated the distance the net fished during each sampling effort using a radar range-finder.

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

Fishes captured in the shrimp trawls were identified and counted. White sturgeon from each sampling effort were generally measured (total and fork lengths (mm)) and weighed (g). Other fish species collected were released. I routinely examined juvenile white sturgeon for the

Table 1. Numbers of sampling efforts for white sturgeon eggs, larvae, and juveniles in the Columbia River downstream from Bonneville Dam, 1994. Plankton nets and artificial substrates were used to collect eggs, plankton nets were used to collect larvae, and a shrimp trawl was used to collect juveniles. When two plankton nets were fished simultaneously, the data were combined and considered as one sampling effort. Location is shown in River Miles (RM).

Location	Apr	May	Jun	Jul	Aug	Sep	Total
			Plankton net				
RM 120-122	4	8	10	4	0	0	26
RM 139-140	4	10	8	4	0	0	26
RM 143-145	4	10	8	4	0	0	26
			Artificial substrate				
RM 143	3	8	6	3	0	0	20
			Shrimp trawl				
RM 28-60	0	0	0	0	0	22	22
RM 61-90	0	0	0	0	0	29	29
RM 91-120	0	0	0	0	0	14	14
RM 121-132	0	0	0	0	0	16	16

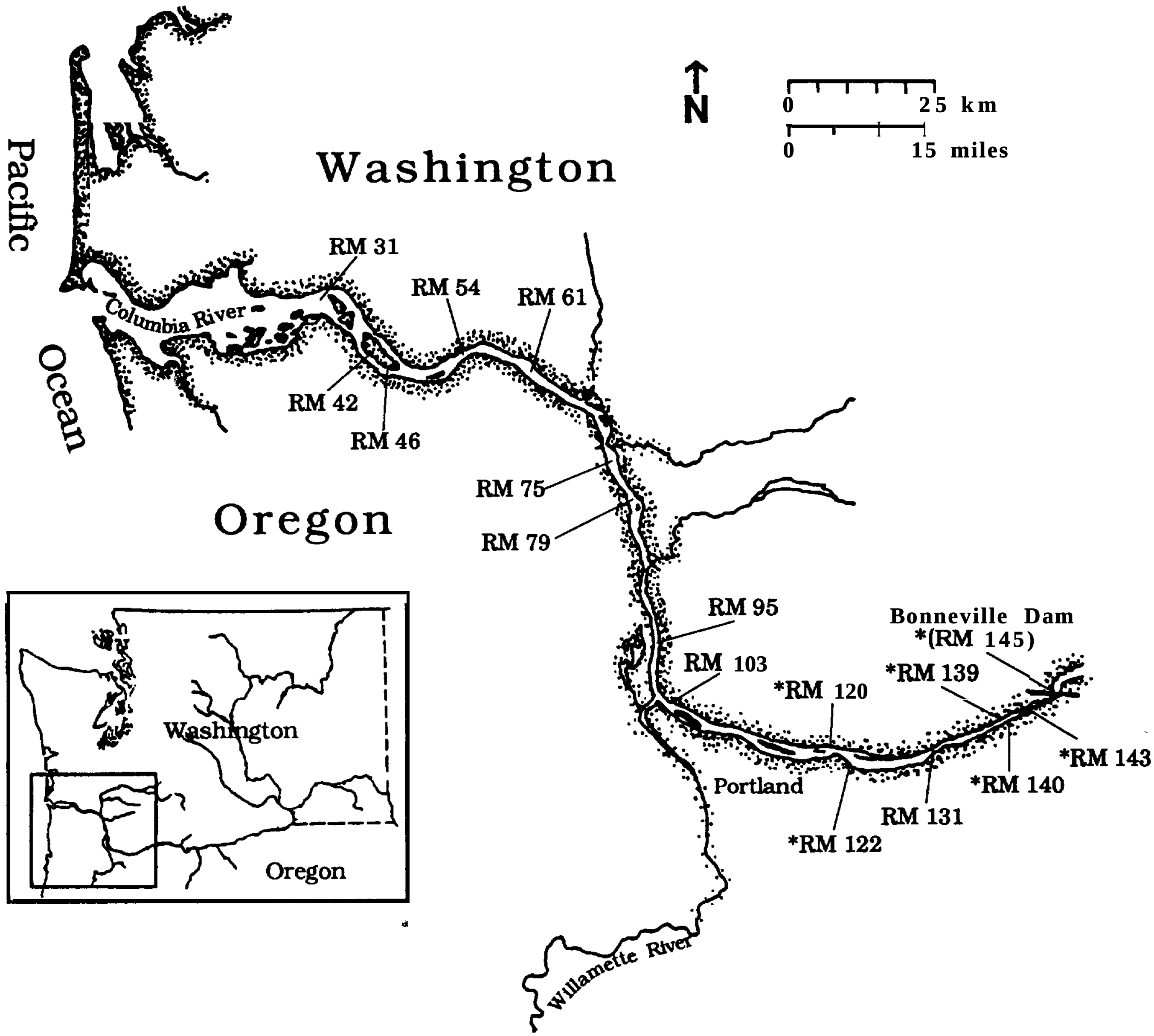

Figure 1. Locations of white sturgeon sampling stations in the Columbia River downstream from Bonneville Dam, Stations at RMs preceded by asterisks were sampled with plankton nets. Thirteen index trawling stations were sampled at RMs not preceded by asterisks; at RMs 79, 95, and 13 1 two stations were sampled. All index trawling stations were sampled with a shrimp trawl.

nematode parasite ***Cystoopsis acipenseri*** (Chitwood and McIntosh 1950; McCabe 1993). When present, the parasite is encased in blister-like cysts under the skin.

From 18 October to 10 November, NMFS collected juvenile white sturgeon between RM 13 1 and 132 for ODFW with the 7.9-m shrimp trawl described above. The ODFW is evaluating the feasibility of collecting juvenile white sturgeon in the Columbia River downstream from Bonneville Dam and transporting them to impoundments upstream from The Dalles Dam (see Report A for further details and results of the ODFW study).

Physical Conditions

The following physical parameters were measured in conjunction with biological sampling: bottom depth (m) (minimum and maximum); bottom-water temperature (“C); bottom-water turbidity (NTU); and water velocities at 0.2 of the total depth, 0.8 of the total depth, and about 0.6 m above the bottom. Mean water-column velocity was calculated by averaging water velocities measured at 0.2 and 0.8 of the total depth (Buchanan and Somers 1969). Water velocities were measured only during egg and larval sampling. Depth was measured with electronic depth sounders, and velocity with a Price Type “AA” current meter attached to a 45.4-kg lead fish. A Van Dom 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 within 4 days after collection.

Data Analyses

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

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

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

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

RESULTS

Egg and Larval Sampling

In 1994, 2,175 white sturgeon eggs were collected between RM 120 and 145 (Table 2); 403 eggs were collected with plankton nets and 1,772 eggs were collected with artificial substrates. Viable white sturgeon eggs were first collected on 19 April near Ives Island (RM 143) and were last collected on 5 July at RM 140 and near Ives Island. In 1994, less than 2% of white sturgeon eggs collected in plankton nets were infected with fungus; fungal infection indicated infertile or dead eggs (Table 2).

The sampling station near Ives Island was used as the primary index station to monitor white sturgeon spawning during 1994 (Table 3). White sturgeon eggs were collected at this station on 8 of the 13 sampling days from 19 April to 12 July. The abundance (density) of white sturgeon eggs at Ives Island was highest on 23 May (58.4 eggs/l,000 m^3). At Ives Island, stage 2 (freshly fertilized) eggs represented 91% of the total eggs collected in plankton nets and were collected on 6 of the 8 sampling days when eggs were collected at this location (Table 4). Stage 2 eggs were first collected on 19 April and last collected on 23 May.

In areas downstream from Ives Island, only 10% of the total eggs collected in plankton nets were stage 2 eggs (Table 4). One stage 2 egg was also collected in a plankton net upstream from Ives Island, representing 4% of the total eggs collected in plankton nets in this area. These data suggest that spawning intensity was greater in the area near or just upstream from Ives Island than in the other areas sampled.

Artificial substrates placed along Ives Island and just upstream from Ives Island collected white sturgeon eggs. Total egg collections using substrates at these stations were 1,730 eggs for Ives Island and 42 eggs for the site just upstream from Ives Island.

Based on back calculations using the developmental stages of eggs, I estimated spawning began on 18 April and ended on 5 July. During this period, spawning was estimated to have occurred on at least 40 days: 10 days in late April, 18 days in May, 8 days in June, and 4 days in July. Spawning was estimated to have occurred at water temperatures ranging from 11 to 17°C and Bonneville Dam discharges (mean hourly discharge by day) ranging from 3,713 to 6,594 m^3/s (Figure 2). Water temperatures at Bonneville Dam sometimes differed by about 1°C from those at the egg sampling stations.

Table 2. Numbers of white sturgeon eggs and larvae collected in the Columbia River downstream from Bonneville Dam, 1994; plankton nets and artificial substrates were used to collect eggs, and plankton nets were used to collect larvae. Fungus-infected eggs collected in plankton nets are shown in parentheses and are included in the numbers reported for the nets. Area refers to the geographic range in River Miles (RM).

sampling period	Eggs			Larvae	
	Area (RM)	Net	Substrate	Area (RM)	Net
19-30 Apr	139-143	41	477		0
1-15 May	140-145	126	699	140-143	8
16-31 May	120-145	179 (3)	412	120-145	30
1-15 Jun	140-143	7 (1)	108	140-145	3
16-30 Jun	139-143	40 (2)	67	139	1
1-15 Jul	140-143	10	9		0
TOTAL		403 (6)	1,772		42

Table 3. White sturgeon egg and larval catches near Ives Island (RM 143) in the Columbia River downstream from Bonneville Dam, 1994. Water temperatures were measured just above the bottom; Bonneville Dam flows were average daily discharges. Generally, two plankton net samples were collected on each sampling day.

Date	Temp.(°C)	velocity (m/s)		Bonneville Dam total discharge (1,000 m^3/s)	Eggs/ 1,000 m^3	Larvae/ 1,000 m^3
		Mean column	Bottom			
19 Apr	11	1.8	1.5	4.45	16.7	0.0
25 Apr	11	1.8	1.2	4.69	14.0	0.0
3 May	12	2.1	1.6	5.91	3.2	0.6
9 May	14	2.1	1.5	5.73	36.8	0.7
16 May	14	1.8	1.4	5.64	12.9	4.6
23 May	14	2.2	1.2	5.94	58.4	0.6
31 May	15	2.2	1.4	5.89	0.0	1.3
6 Jun	15	2.2	1.6	5.78	0.0	0.0
13 Jun	15	2.2	1.2	5.69	0.0	0.0
20 Jun	16	2.2	1.4	4.85	2.0	0.0
27 Jun	17	2.4	1.5	4.90	0.0	0.0
5 Jul	17	1.8	1.2	4.12	3.0	0.0
12 Jul	19	1.9	1.2	4.84	0.0	0.0

Table 4. Numbers of white sturgeon eggs (by developmental stage) collected with plankton nets in three areas downstream from Bonneville Dam, 1994. Upstream and downstream areas were defined in relation to Ives Island.

Date (RM)	Egg developmental stage[a]																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
UPSTREAM																		
9 May (145)	10		0	113		1	0	0	0	0	0	1	0	0	0	0	0	17
16 May (145)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
23 May (145)	0	0	0	0	0	0	0	0	0	2	0	2	2	2	0	0	0	8
Total	10		0	113		1	0	0	0	2	0	3	2	2	0	1	0	26
IVES ISLAND																		
19 Apr	19		2	0	1	0	0	0	0	0	0	0	0	0	0	0		22
25 Apr	14	8	0	1	2	0	0	0	0	0	0	0	0	1	0	0	8	18
3 May	3	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	5
9 May	54	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	55
16 May	14	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	17
23 May	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88
20 Jun	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	3
5 Jul	0	0	0	0	1	0	0	0	0	0	0	2	0	1	0	0	0	4
Total	192	0	2	1	5	0	0	1	2	0	0	3	0	5	0	1	0	212[b]
DOWNSTREAM																		
25 Apr (139)	0	0	0	0	0	0	0	0	0	0	0	1		0		0	0	1
3 May (140)	2	0	0	0	0	0	0	0	0	1	0	0	8	0	8	3	0	10
9 May (140)	9	10		213		0	0	3	4	2	3	0	1	0	0	0	0	38
16 May (140)	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17 May (120)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
23 May (140)	0	0	0	0	6	0	0	0	6	4	3	21	10	6	0	0	0	56
6 Jun (140)	0	0	0	0	0	0	0	0	0	0	0	1	4	1	0	0	0	6
20 Jun (139)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
20 Jun (140)	0	0	0	0	6	0	0	2	1	0	0	1	2	8	14	0		34
5 Jul (140)	0	0	0	0	3	0	2	0	0	0	0	0	0	1	0	0	8	6
Total	15	1	0	2	28	0	2	5	11	7	6	24	21	16	14	4	0	156'

[a] *stage 1 (unfertilized egg) is not included in the* table; *no stage 1 eggs were collected.*

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

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

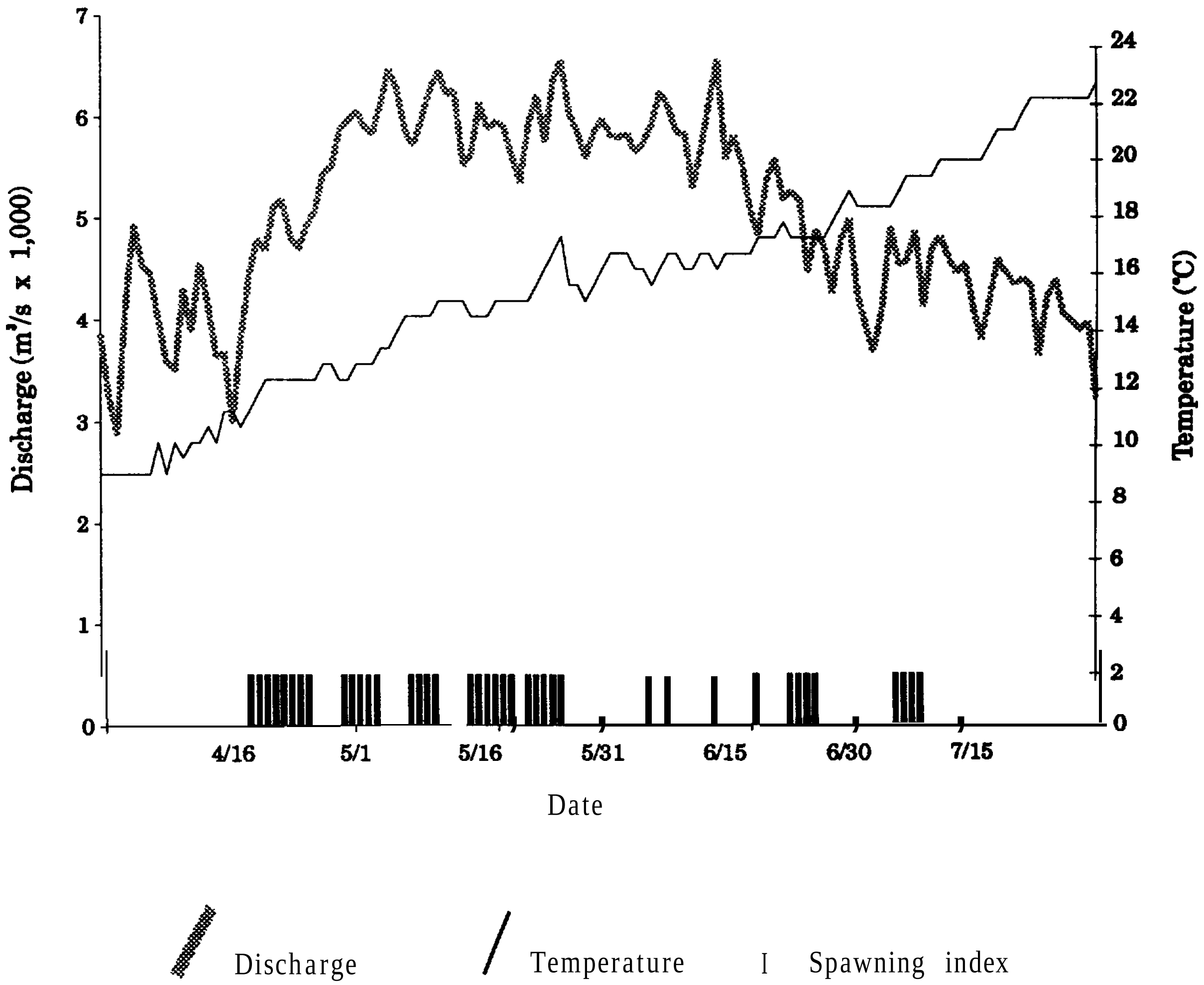

Figure 2. Water temperatures (°C) and Bonneville Dam discharges (mean hourly water discharges by day) from 1 April through 31 July 1994; discharge is shown as m^3/s x 1,000. Water temperatures were measured at Bonneville Dam. The spawning index shows the days on which I estimated that white sturgeon spawned.

In 1994, 42 white sturgeon larvae were collected in plankton nets between RM 120 and 145 (Table 2). Larvae were first collected on 3 May at RM 140 and Ives Island and last collected on 20 June at RM 139. Overall, 83% of the larvae that were staged were classified as posthatch or stage 1 (Table 5). Densities of larvae near Ives Island ranged from 0.0 to 4.6 larvae/l,000 m^3 of water sampled (Table 3).

Physical conditions under which eggs and larvae were collected were generally similar. Bottom-water temperatures at sites where eggs were collected in plankton nets ranged from 11 to 17°C. Bottom-water turbidities at these egg collection sites ranged from 2.0 to 4.3 NTU, and mean water-column velocities ranged from 1.0 to 2.2 m/s. At sites where eggs were collected in plankton nets, water velocities about 0.6 m above the bottom ranged from 0.8 to 1.7 m/s, and depths ranged from 3.7 to 21.6 m. White sturgeon larvae were captured where bottom-water temperatures ranged from 12 to 17°C, bottom-water turbidities ranged from 2.5 to 4.0 NTU, and mean water-column velocities ranged from 1.1 to 2.2 m/s. Water velocities about 0.6 m above the bottom ranged from 0.8 to 1.6 m/s, and depths ranged from 4.0 to 21.9 m.

Juvenile Sampling

In September 1994, 183 juvenile white sturgeon were collected between RM 3 1 and 132. Distribution of juvenile white sturgeon in this section of the river was patchy. There were differences in catches among different areas of the river and between parallel transects at the same river mile.

The YOY group was the only age group that was easily discernible in a length-frequency histogram, as there was considerable overlap in the lengths of the older age groups (Figure 3). The mean fork length (± SD) and weight (± SD) of 19 YOY white sturgeon collected were 196 mm (± 25 mm) and 57 g (± 21 g). Variations in the lengths and weights of YOY were considerable--lengths ranged from 134 to 239 mm and weights ranged from 16 to 102 g.

In 1994, 19 YOY white sturgeon were collected between RM 61 and 132; YOY comprised about 10% of the total catch of juvenile white sturgeon. Densities of YOY white sturgeon at 13 index sampling stations averaged 0.6 fish/hectare during the first survey (l-9 September) and 2.3 fish/hectare during the second survey (19-22 September); the mean for both surveys combined was 1.4 fish/hectare (Table 6).

Twenty-seven (17%) of 157 juvenile white sturgeon were infected with the nematode parasite *Cystoopsis acipenseri*. The mean fork length of infected fish was 372 mm, with a range from 303 to 467 mm.

Table 5. Numbers of white sturgeon larvae (by stage) collected with plankton nets downstream from Bonneville Dam, 1994.

Date (RM)	Larval stage								
	Post hatch	1	2	3	4	5	6	7	Total
IVES ISLAND									
3 May	0	1	0	0	0	0	0	0	1
9 May	0	1	0	0	0	0	0	0	1
16 May	0	5	1	0	0	0	0	0	6
23 May	1	0	0	0	0	0	0	0	1
31 May	1	1	0	0	0	0	0	0	2
Total	2	8	1	0	0	0	0	0	11
OTHER LOCATIONS									
3 May (140)	1	2	0	0	0	0	0	0	3
9 May (140)	2	1	0	0	0	0	0	0	3
16 May (139)	0	3	0	0	0	0	0	0	3
16 May (140)	4	2	0	0	0	0	0	0	6
16 May (145)	1	0	0	0	0	0	0	0	1
17 May (120)	0	1	0	0	0	0	0	0	1
17 May (122)	0	1	0	0	0	0	0	0	1
31 May (140)	1	4	3	0	0	0	0	0	8
31 May (145)	0	0	1	0	0	0	0	0	1
13 Jun (140)	0	1	1	0	0	0	0	0	2
13 Jun (145)	0	0	1	0	0	0	0	0	1
20 Jun (139)	1	0	0	0	0	0	0	0	1
Total	10	15	6	0	0	0	0	0	31

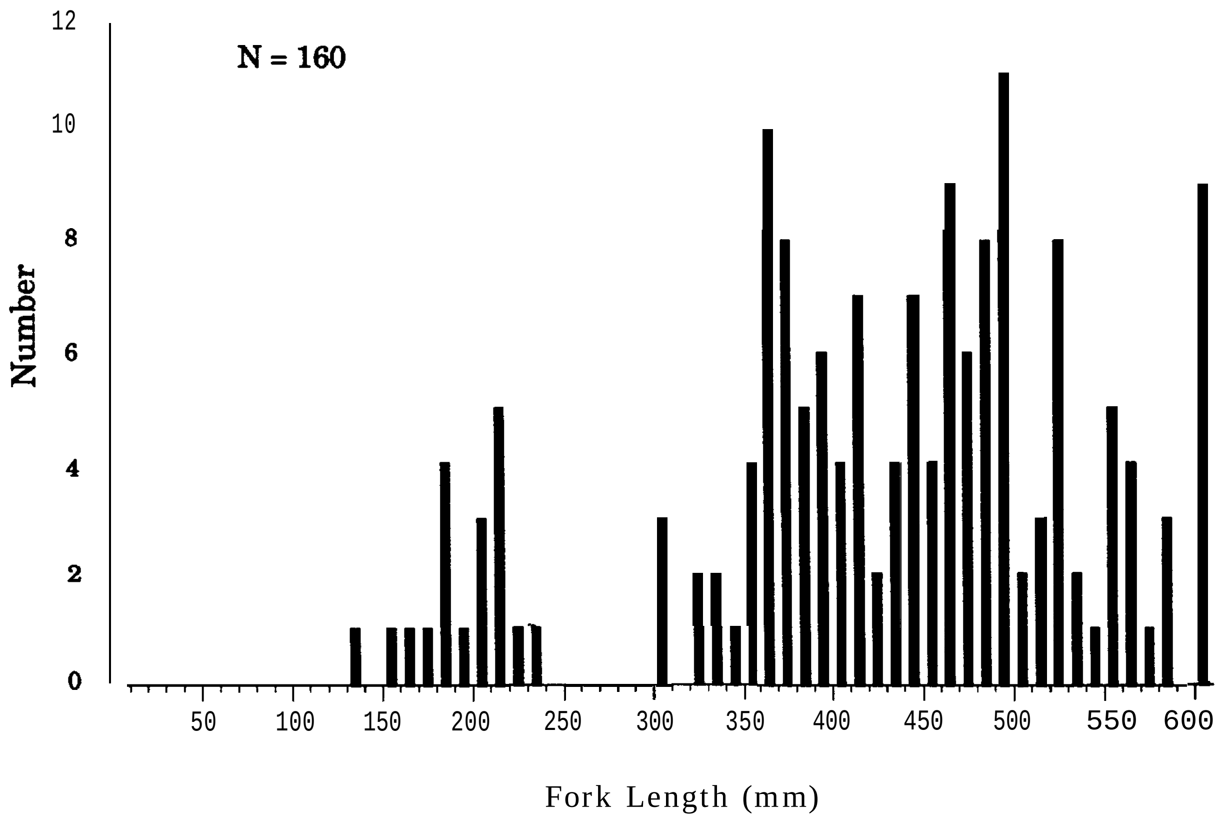

Figure 3. Length-frequency histogram for juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam, 1994. White sturgeon longer than 600 mm are included in the **600-mm** interval.

Table 6. Catches of young-of-the-year white sturgeon in September 1994 at 13 sampling stations in the Columbia River downstream from Bonneville Dam. Location is shown in River Miles (RM) and in some instances a transect number is shown when parallel trawling efforts were done at the same RM.

Location (RM)	1-9 September		19-22 September	
	Number	Number/hectare	Number	Number/hectare
31	0	0.0	0	0.0
42	0	0.0	0	0.0
46	0	0.0	0	0.0
54	0	0.0	0	0.0
61	1	3.4	1	5.7
75	0	0.0	0	0.0
79-1	1	4.1	0	0.0
79-2	0	0.0	0	0.0
95-1	0	0.0	1	4.4
95-2	0	0.0	1	4.4
103	0	0.0	3	12.2
131-1	0	0.0	1	3.8
131-2	0	0.0	0	0.0
Mean	0.2	0.6	0.5	2.3

DISCUSSION

Egg and Larval Sampling

White sturgeon successfully spawned in the Columbia River downstream from Bonneville Dam in 1994, as documented by egg, larval, and YOY collections. Timing of spawning in 1994, which was estimated to have begun on 18 April and ended on 5 July, was similar to that observed in 1988-1993 (McCabe 1995; McCabe and Tracy 1994). In 1988, the spawning period was estimated to have extended from 22 April to 22 June; in 1989, from 22 April to 2 July; in 1990, from 23 April to 14 July; in 1991, from 5 May to 14 July; and in 1993, from 26 April to 13 July. From 1988 through 1991 and in 1993, spawning was estimated to have occurred on 38 to 48 days each year; in 1994, I estimated spawning occurred on at least 40 days.

Spawning in 1994 occurred during water temperature regimes suitable for incubation. Successful white sturgeon egg incubation occurs at temperatures between 10 and 18°C, with highest survival and uniform hatching between 14 and 16°C (Wang et al. 1985). It should be noted that Wang et al. (1985) conducted their research in a laboratory. In 1994, I estimated that spawning occurred at water temperatures of 11 to 17°C. Based on larval collections of white or green sturgeon (*Acipenser medirostris*), or both, Kohlhorst (1976) estimated sturgeon in the Sacramento River spawned at water temperatures ranging from 7.8 to 17.8°C, with peak spawning at 14.4°C.

White sturgeon spawning in 1994 occurred over a wide range of Bonneville Dam discharges (daily). Apparently, water velocities, which are directly related to dam discharge, did not limit white sturgeon spawning downstream from Bonneville Dam in 1994. Based on computer simulations by Parsley and Beckman (1994) and daily Bonneville Dam discharges in 1994, more than 100 hectares of usable spawning habitat should have been present daily during much of the period from 18 April to 5 July.

Young-of-the-Year

Catches (number/hectare) of YOY white sturgeon at 13 index trawling stations in late September 1994 were not significantly different (Kruskal-Wallis, $P = 0.08$) than catches at the same sites in late September of 1991 and 1993. Catches at the 13 sites averaged 6.7, 9.0, and 2.3 YOY/hectare in 1991, 1993, and 1994, respectively. In all years, catches at 3 1% or more of the stations were zero. Young-of-the-year white sturgeon were not collected over as large a geographic area in September 1994 as in September of 1991 and 1993. In 1994, YOY white sturgeon were collected between RM 61 and 132; whereas in 1991 and 1993, YOY white sturgeon were collected between RM 28 and 13 1. In addition, no white sturgeon YOY were captured at RM 75 (side channel near Goble, Oregon) in September 1994; however, in past years this has been a productive sampling site for white sturgeon YOY.

Plans for 1995

Plans for 1995 include sampling for white sturgeon eggs and larvae downstream from The Dalles Dam and juveniles downstream from Bonneville Dam. Specifically, we plan to assist NBS and WDFW in assessing the effects of river flow, water velocity, and water temperature on white sturgeon spawning downstream from The Dalles Dam. In addition, NMFS will estimate the success of YOY white sturgeon recruitment in 1995 by bottom trawling at previously established sampling stations in the Columbia River downstream from Bonneville Dam.

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REPORT E

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

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CONTENTS

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I would like to thank the various members of our field crew including Tim Cummings, Alan Ecklund, Pat Kemper, Mark Dewitt, Brian Ensign, Dan Magneson, Chuck Fuller, and Rex Mertens for the exceptional effort put forth during the long, hot eastern Washington summer days on the river. I would also like to thank the National Biological Service, Mike Parsley specifically, for assistance with equipment and field work and Greg Ruppert with the Pasco Field Office of the U.S. Geological Survey for the frequently complicated coordination on the Acoustic Doppler Current Profiler which was used extensively for data collection. Battelle PNW Labs assisted with GPS data collection.

ABSTRACT

The U.S. Fish and Wildlife Service selected 122 main channel cross sections in the Columbia River between McNary Reservoir and Priest Rapids Dam and 7 cross sections in the Snake River between McNary Reservoir and Ice Harbor Dam for white sturgeon ***(Acipenser transmontanus)*** habitat quantification. Riverbank profiles, velocity distributions, and a total of 13 1 stage-discharge data pairs were collected on 74 cross sections. Hydraulic data were collected at flows ranging from 1,3 17 m^3/s to 5,139 m^3/s in the Columbia River and 3 17 m^3/s to 2,201 m^3/s in the Snake River. GPS coordinates were collected for 153 cross section headpins and 60 reference marks. Hydraulic data files were reduced and integrated with riverbank surveying data for input to hydraulic models.

INTRODUCTION

This report describes work conducted by the U.S. Fish and Wildlife Service (USFWS) from 1 April, 1994 to 31 March, 1995 as part of the white sturgeon ***(Acipenser trunsmontanus)*** studies under the Bonneville Power Administration's Project 86-50 on the mainstem Columbia and Snake rivers. The U.S. Fish and Wildlife Service is cooperating with the National Biological Service (NBS) on studies designated under Goal 3, Objective 3.3 of the program. The purpose of Goal 3 is to evaluate the need and identify potential measures for protecting and enhancing white sturgeon populations and mitigating for effects of the hydropower system on productivity of white sturgeon in the Columbia and Snake rivers upstream from McNary Dam. Under Objective 3.3, USFWS is responsible for quantification of white sturgeon spawning and rearing habitat in the free-flowing portion of the Columbia River between McNary and Priest Rapids dams and the free-flowing portion of the Snake River between the confluence with the Columbia River and Ice Harbor Dam. Studies being conducted by NBS under this Objective consist of determining habitat used by spawning and rearing white sturgeon and quantification of spawning and rearing habitat in the impounded portion of the study area (NBS REPORT C in this volume).

Funding was not available for USFWS studies under this task between 1 October, 1994 and 3 1 March, 1995. As a result, work conducted during the time period cited above, actually occurred between 1 April and 30 September, 1994. Specific work activities conducted during this time period were:

1) Selection and identification of cross sections for hydraulic data collection;

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

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

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

5) Field data reduction and formatting for input to hydraulic models.

METHODS

The sampling program was designed to acquire field data for analysis within the Physical Habitat Simulation System (PHABSIM) developed as part of the Instream Flow Incremental Methodology (IFIM; Bovee 1982). Within the PHABSIM, field measurements of depth, water column velocity, river elevation, and river discharge are used to calibrate hydraulic models for simulation of depths and velocities at unmeasured discharges (Bovee and Milhous 1978, Milhous et al. 1989). Output from the hydraulic models along with substrate or cover data is then compared to habitat suitability criteria for the species of interest to predict habitat quality and quantity over a range of river discharges. The Columbia River between White Bluffs near river mile (RM) 368 and Priest Rapids Dam at RM 397 and the Snake River between McNary Pool (RM 4.5) and Ice Harbor

Dam (RM 10) were selected for hydraulic data collection in 1994 (Figure 1).

The two river segments were first divided into main channel and split channel (islands) sections. Main channel sections in the Columbia River were separated into hydraulically controlled and uncontrolled sections. Within each controlled river section, cross sections were randomly selected based on a sensitivity analysis conducted in early 1994 (Anglin 1995) and within each uncontrolled river section, cross sections were placed at quarter-mile intervals. Channel structure and physical habitat in the main channel section of the Snake River was more consistent than we observed in the main channel sections of'the Columbia River. As a result, cross sections in the Snake River were selected to characterize observed habitat conditions. Cross section placement was not determined for split channel sections during 1994. Cross sections were marked on each river bank above the high water mark with painted lath and rebar capped with labeled plastic surveying markers (headpins). A reference mark was established near each cross section on a stationary object (usually a large boulder) to be used as a relative datum for profile and water surface elevation surveys.

An electronic total station (provided by NBS) was used to measure river bank profiles and water surface elevations and an Acoustic Doppler Current Profiler (ADCP) on loan from the U.S. Geological Survey (USGS) was used to collect depths and water column velocities and to measure discharge on each cross section. An electronic total station utilizes laser technology to measure distance while electronically compensating for atmospheric conditions and curvature of the earth. Horizontal and vertical angles are measured electronically and combined with distance measurements to provide slope distance, horizontal distance, and vertical difference (elevation). The ADCP uses the Doppler effect (the apparent change in the frequency of a wave resulting from relative motion of the source and the receiver) to measure the motion, direction, and depth of water from the echoes of a sonic pulse. Four transducers emit sonic pulses and the ADCP transforms the returning echoes into depths and water velocities. Water velocity profiles were collected for a single discharge on each cross section and relative water surface elevations (stages) were collected for up to four discharges (stage-discharge pairs) on each cross section. Portable electromagnetic flowmeters were used to collect velocity data from inshore areas which were too shallow for ADCP data collection.

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

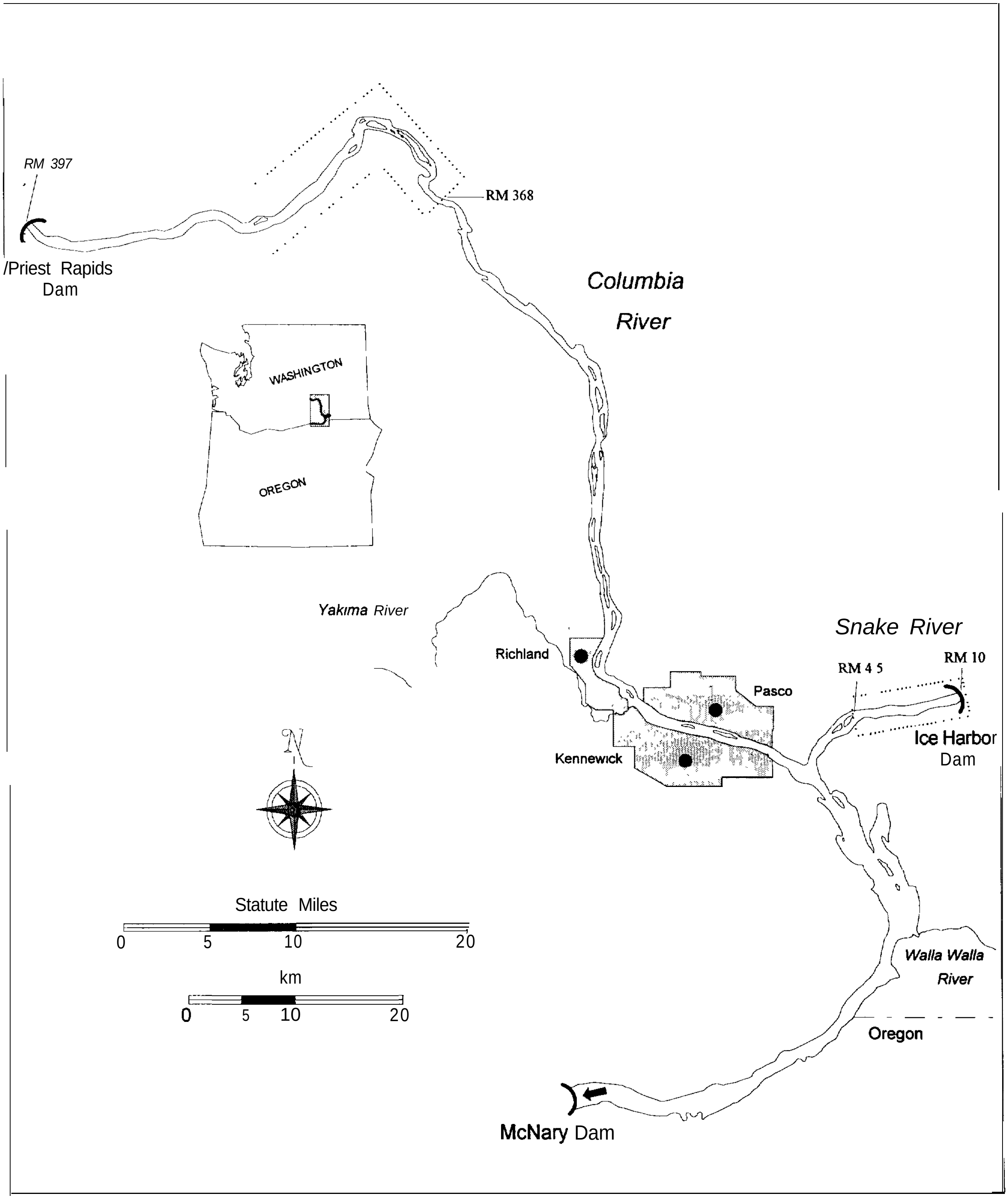

Figure 1. Location of study area between White Bluffs (RM 368) and Priest Rapids Dam on the Columbia River and below Ice Harbor Dam on the Snake River.

RESULTS

Field Sampling

We determined locations for a total of 122 main channel cross sections in the Columbia River and 7 cross sections in the Snake River. Snake River cross sections were selected at various locations to characterize observed habitat conditions. Five controlled (97 cross sections) and four uncontrolled (21 cross sections) sections were identified in the Columbia River between RM 368 and the Priest Rapids Dam tailrace. The last upstream section consisted of the tailrace area below the Dam (4 cross sections). Controlled sections ranged from 3,000-6,500 m in length and uncontrolled sections ranged from 1,500-3,200 m in length. The tailrace section was approximately 1,600 m in length. Four of the controlled sections will be characterized with 20 cross sections each and one controlled section will be characterized with 17 cross sections. Cross sections were selected at quarter-mile (402 m) intervals within each of the uncontrolled sections and at 305 m intervals in the tailrace area. Headpins were installed for 67 and 7 cross sections in the Columbia and Snake rivers, respectively. Cross section widths ranged from 402-9 19 m in the Columbia River and 402-641 m in the Snake River.

River bank profiles and velocity distributions were measured for all of the established cross sections in the Columbia and Snake Rivers. River bank profiles consisted of horizontal distance (from headpin) and elevation (relative to reference mark) for a variable number of points down to the waters edge for description of the bank contour. Velocity distributions were comprised of measurements of water column velocity for 25 cm bins from surface to river bottom. Horizontal distance, relative elevation, depth, and water column velocities were measured at 50- 100 points along each cross section.

An additional 13 1 stage-discharge data pairs were collected on these cross sections at discharges ranging from 1,317-5,139 m^3/s in the Columbia River and 3 17-2,20 1 m^3/s in the Snake River. With the assistance of personnel from the NBS and Battelle PNW Labs, differentially corrected GPS coordinates were collected for a total of 153 cross section headpins and 60 reference marks in the Columbia River portion of the study area.

Analysis

All ADCP data files were converted to ASCII files, then to list files including horizontal distance, depth, mean column velocity, and velocity direction. Survey data were normalized to the respective reference marks and integration of survey data with ADCP list files was initiated.

DISCUSSION

The USGS ADCP enabled us to collect a large amount of physical and hydraulic data in a relatively short time under continuously fluctuating river flow conditions. Flows in the Columbia River portion of the study area fluctuated up to 2,800 m^3/s on a daily basis and were constantly changing throughout the day. Since coordination with the USGS for use of their ADCP will not be possible in the future, acquisition of an ADCP has been planned to expedite collection of the large volume of data over the wide range of conditions required to complete this analysis, particularly when spring high flows- occur (May, June). Data collection during 1994, particularly measurement of stage-discharge pairs, was limited by persistent medium to low flow conditions during spring/summer.

Plans for 1995

The U.S. Fish and Wildlife Service plans to complete cross section placement and continue hydraulic data collection for main channel cross sections in the Columbia and Snake Rivers in 1995. The type of water year (beginning October 1) and hydrograph will determine to what extent we are able to complete data collection. We plan to complete substrate characterization where needed and compile water temperature data for use in the habitat analysis. We will also develop a sampling plan for the island complexes within the Columbia and Snake river study areas.

Conversion and reduction of ADCP data files and integration of hydraulic data with survey data will be the primary analytical task followed by calibration of the hydraulic models. Habitat analysis will begin as hydraulic model calibration is completed.

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