September 1987

STATUS AND HABITAT REQUIREMENTS OF WHITE STURGEON POPULATIONS IN THE COLUMBIA RIVER DOWNSTREAM FROM MCNARY DAM

Annual Report 1987

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STATUS AND HABITAT REQUIREMENTS OF WHITE STURGEON POPULATIONS IN THE COLUMBIA RIVER DOWNSTREAM FROM MCNARY DAM

Annual Progress Report

July 1987 - March 1988

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CONTENTS

EXECUTIVE SUMMARY

We report on **our** progress from July 1987 through March 1988 on determining the status and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. The study is a cooperative effort by the Oregon Department of Fish and Wildlife (ODFW), Washington Departnent of Fisheries (WDF), U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS). Study objectives addressed by each agency are

1.ODFW (Appendix A) : Describe the life history and population dynamics of **subadults** and adults between Bonneville and McNary dams and evaluate the need and identify potential methods for protecting mitigating and enhancing populations downstream from McNary Dar.

2. WDF (Appendix B) : Describe the white sturgeon recreational fishery between Bonneville and McNary dams, describe some reproductive and early life history characteristics downstream from Bonneville Dam and describe life history and population dynamics of subadults and adults downstream from Bonneville Dam.

3. FWS (Appendix C) : Describe reproduction and early life history characteristics, define habitat requirements for spawning and rearing and quantify extent of habitat available between Bonneville and McNary dams.

4. NWFS (Appendix D): Describe reproduction and early life history characteristics, define habitat requirements for spawning and rearing and quantify extent of habitat available downstream from Bonneville Dam.

Our approach is to work concurrently downstream and upstream from Bonneville Dam[1]. Upstream from Bonneville Dam we began work in The Dalles Reservoir in 1987 and plan to expand efforts to Bonneville Reservoir in 1988 and John Day Reservoir in 1989.

Highlights of results of our work in The Dalles Pool are

1. We found that a combination of setline and gillnet catches best represented the population of subadults and adults in The Dalles Reservoir. Crews caught 1041 fish and marked 837 fish. Our catch per unit effort in the upper one-half mile of the John Day Dam tailrace was five times that elsewhere in the reservoir. Sturgeon retained spaghetti tags and did not regenerate barbel and fin ray clips. Sturgeon did not retain tattoos.

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1 ODFW, WDF, FWS and NWFS. 1987. Status and habitat requirements of white sturgeon populations in the Co1umbia River downstream from McNary Dam. Annual Progress Report to the Bonneville Power Administration, Portland.

2. We found we can effectively sample many different habitats for eggs and larva using high rise and beam trawls and 0.5-m diameter and D-ring larval nets. We collected 132 eggs and 11 larvae of sturgeon from The Dalles Reservoir in late Hay and in late June/early July. All eggs and larvae were collected in a 2.5-mi stretch of John Day Dam tailrace beginning about one mile downstream from the dam. About 878 of eggs collected were dead and fungused causing us concern about spawning success. Ye collected most eggs in June and July when water temperatures exceeded the known lethal level (18°C) and did not subsequently capture any young-of-the-year sturgeon.

3. We caught 497 sturgeon ranging from 22 to 70 cm long with trawls. Although less than 25% of our sampling sites had depths greater than 17 m, 508 of **our** catch came from those sites.

4. Ages assigned sturgeon ranged from 1 to 38. We caught fish upto 6 years old with trawls. For fish over 70-cm long assigned ages frequently differed among three readers. Readers worked together to define criteria for identifying annuli and reduce disagreement. Growth cf sturgeon in The Dalles Pool appeared linear and allometric.

5. We were able to identify reproductively active female sturgeon from ovary samples collected from the commercial fishery between Bonneville and McNary dams. Eggs from reproductively active fish fell into two size groups indicating two cohorts that spawn in successive years or one cohort whose eggs develop at different rates. We will work to determine if samples are from one or two cohorts because each scenario produces a different reproductive potential for the population.

6. Our estimate of abundance of sturgeon in The Dalles Reservoir ranged from 8,000 and 31,000. The estimate is crude and we have not yet examined assumptions associated with the estimator. Our estimate of exploitation of sturgeon in The Dalles Reservoir ranged from 0.06 to 0.09 for the sport fishery and was 0.29 for the commercial fishery. **Ye** estimated sport anglers harvested 1,983 sturgeon from June through **October.** Based on angler reports we estimate anglers caught almost 2.5 times as many sublegal (<82 cm) sturgeon. Less than one percent of catch was oversize (>166 cm). We estimated a commercial harvest from The Dalles Reservoir of 2,386 fish. This was 42% of the total harvest between Bonneville and McNary dams. We **are** working with commercial fishermen and buyers to better identify the reservoir from which each catch originated.

7. Simulated yield (as an index of productivity) was most dramatically affected by the type of recruitment function used. If we estimate spawning success and stock densities, especially during the present expansion of the commercial fishery when numbers may be declining, we may be able to define the stock-recruitment function.

Highlights of results of our work downstream from Bonneville Dam are

1, We tagged and released 4,448 sturgeon in 1986 and 3,756 sturgeon in 1987 working with commercial fishermen. We believe that sampling with commercial drift gillnets to mark and recapture sturgeon may bias our estimates of abundance and other population parameters because sampling effort is not distributed over the entire study area and gear may not sample the entire size range present. We can diminish biases caused by sampling a relatively small proportion of the study area by relying on recreational angler surveys to recover marks. The recreational fishery is distributed over the entire study area and we assume takes a random sample of the population. We will complete an evaluation of size selectivity of our gear based on the ratio of recoveries to marks at larger per length interval in 1988. However, by relying on the recreational fishery for mark recoveries, we will only be able to estimate abundance of legal-sized sturgeon.

2. We were most successful sampling sturgeon eggs and larvae using a D-ring plankton net. We collected 18 eggs and 40 larvae between April 21 and June 19. We collected all eggs in a one-mile stretch of river, one to two miles downstream from Bonneville Dam. We collected larvae in a 30-mile stretch of river, two to 32 miles downstream of Bonneville Dam. One egg was fungused, another was abnormal and a third was unfertilized: the rest were viable. Larval ages ranged from one to thirteen days posthatch; 53% were one-day posthatch. We estimated spawning period (from egg and larval stages in samples) to extend from 20 April to 19 June, peaking in May.

3. A 7.9-m semiballoon shrimp trawl was the best method for collecting juvenile white sturgeon. We collected 1,954 juvenile sturgeon in a Ill-mile stretch of the river from the mouth to five miles downstream from Bonneville Dam. Distribution of juveniles was patchy and varied over the length and width of the study area. Minimum and maximum depths sampled and bottom water temperature were poor predictors of juvenile sturgeon densities, explaining less than 20% and 4%, respectively, of the variation.

4. Young-of-the-year white sturgeon comprised less than 3% of juvenile sturgeon catch. Mean fork length of young-of-the-year sturgeon increased from 85 mm to 226 mm from July through November.

5. We tagged 1,689 juvenile sturgeon with monel metal bird-banding tags. We subsequently recaptured twelve fish. Sturgeon apparently tolerated the tag well: tissue immediately around the tag was only slightly inflamed. Mean condition factor of 1,788 juvenile sturgeon was 0.65. Fourteen percent of 1,534 juveniles examined for the nematode parasite *Cystoopsis acipenseri* were infected with the parasite.

6. We have not yet made estimates for 1987 of white sturgeon abundance, age structure, growth or exploitation downstream from Bonneville Dam because we have not completed data analyses. Estimates of exploitation in the combined fisheries in 1986 ranged from 0.16 to 0.35, but may change when we stratify data to account for variation in sampling rates among river sections. We estimated total mortality of 8 to 13 year old sturgeon in 1986 to be between 0.39 and 0.44, but recognize that estimates are based on catch curves and are biased by increases in harvest from 36,400 to 61,200 over the last five years.

We conclude from our 1987 sampling that we can sample a variety of habitats and collect enough sturgeon of various sizes to describe population status, dynamics, reproduction, early life history and habitat requirements of stocks pstream and downstream from Bonneville Dam. We recognize that our sampling programs need to be adjusted to address some limitations in approach and are making necessary adjustments. We have not focused much effort on quantifying available spawning and rearing habitat, but will do so in 1988. Our emphasis will now shift from the question “Can we determine stock status and habitat requirements?" to “What are the stock status and habitat requirements?”

APPENDIX A

1. Description of the life history and population dynamics of subadult and adult white sturgeon in the Columbia River between Bonneville and McNary dams.

2. Evaluation of the need and identification of potential methods for protecting, mitigating and enhancing white sturgeon populations in the Columbia River downstream from McNary Dam.

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CONTENTS

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ABSTRACT

We report on our effort from July 1987 through March 1988 to representatively sample the white sturgeon population in The Dalles Reservoir on the Columbia River and refine methods to describe the life history and dynamics of subadults and adults. Based on length frequencies, we concluded that setline catches best represent 3- to 6-ft long sturgeon and gillnet catches best represent sturgeon less than 3 ft in length. Ye believe that spaghetti tags and the removal of a fin ray section and barbel are viable marks, but must evaluate tag shed and effects of fin ray and barbel removal on behavior and survival. Three other marks; coded-wire tags, subcutaneous dye injections and scute removal are promising and will be evaluated in 1988. The regression of fork length against weight produced a good model, enabling us to use fork length to estimate additional weights. We continue to refine criteria used to age sturgeon to reduce uncertainty caused by disagreement among readers. Our estimates of growth, abundance and mortality are imprecise but precision should improve as we mark more fish and pool samples among years.

We believe that reproductive potential may be the population characteristic most important to stock productivity and most sensitive to environmental change. We can identify reproductively active females from ovary samples collected from the commercial catch, although we need samples of oversized fish and are working on a surgical technique to take them from live fish. Ye must determine whether different sized eggs we observed in reproductively active fish represent two cohorts that will spawn in successive years or one cohort whose eggs are developing at different rates. This question is important because it affects our estimate of spawning periodicity and reproductive potential of the population. Our initial modeling suggests that yield is particularly sensitive to the type of recruitment function used. We continue to work to define the stock-recruitment relationship. Declines in sturgeon populations between Bonneville and McNary dams because of heavy exploitation may enable us to determine how spawning success and recruitment relate to stock size.

INTRODUCTION

We began our study of white sturgeon life history and population dynamics in July 1986. Ve reported our progress in the first eight months of the study in our 1987 report (Rieman et al. 1987). During that time we prepared for the 1987 field season and used population simulation and equilibrium yield models to analyze available data and identify critical information needs. In this report we describe our activities and results from April 1987 through March 1988. Our objective was to use data we collected sampling white sturgeon in The Dalles Reservoir to

1. Develop sampling methods that we could use to accurately represent the population with the least cost.

2. Develop marking methods that will enable long term identification of fish.

3. Define the limits of and biases in our estimates of growth, population size, mortality and reproductive potential.

METHODS

Sampling

We sampled white sturgeon populations from March through September 1987 in The Dalles Reservoir, a mainstem impoundment of the Columbia River located between John Day and The Dalles dams (RM 191.5 - 215.6). We divided the reservoir into seven sections and sampled with approximately equal effort in each (Table 1). Six sections were approximately four river-miles long and one section (the boat-restricted zone adjacent to and downstream from John Day Dam) was approximately one-half river-mile long (Figure 1). We treated the boat restricted zone (BRZ) as a separate section because it was a unique habitat. We caught two to five times as many fish in the BRZ as elsewhere.

We sampled sturgeon with setlines and gillnets (Rieman et al. 1987) and hook and line. Also, on four occasions we accompanied U.S. Army Corps of Engineers staff to check the draft tubes at The Dalles Dam and John Day Dam powerhouses for stranded sturgeon (Rieman et al. 1987) laced setlines in a variety of habitats in depths of three to 70 m. We fished lines for 13 to 28 hours and retrieved lines with an hydraulic pot hauler. We baited setlines with pieces of adult coho salmon or lamprey. We set gillnets in slackwater areas in depths of three to 35 m. We fished gillnets for one to four hours.

We fished with hook and line in areas where velocity or bottom contour or structure prevented us from using setlines or gillnets. We fished from a boat in a fixed location for one-half to three hours . We used a medium heavy action rod, 40-lb test line, and 7/O or 9/O J-type hooks. We baited our hook and line gear with smelt,

Table 1. Sampling effort (in hours with number of sets in parentheses) for white sturgeon in The Dalles Reservoir, March through September 1987.

Gear, Week[b]	Location[a] 1	2	3	4	5	6	7
Setline							
13	--		--	3 (1)	--	4 (1)	4 (1)
15[c]	--	--	--	--	--	127 (10)	24 (7)
16	--	--	--	--	--	119 (6)	120 (6)
17	337 (17)	--	--	--	--	--	--
18	114 (5)	164 (7)	--	--	--	--	--
19	--		--	45 (2)	283 (13)	66 (3)	--
20	--	--	--	--	--	171 (8)	141 (7)
21	--		142 (6)	142 (6)	--		--
24[c]	339 (16)	--	--	--	--	--	--
26[c]	--	518 (24)	--	--	--	--	--
27	--	--	377 (18)	127 (6)	--	--	--
28	--	--	--	--	--	82 (4)	118 (6)
29	--	--	--	140 (3)	120 (3)	98 (3)	--
33[c]	--	335 (14)	--	--	--	--	--
34	310 (14)	--	--	--	--	--	--
36[c]	457 (21)	--	--	--	--	--	--
Gillnet							
13	--		--	--	--	2 (1)	1 (1)
14	--	16 (8)	1 (1)	8 (8)	--	7 (7)	2 (2)
15	--		--	--	--	--	2 (2)
23[c]	18 (9)	--	13 (6)	13 (4)	19 (5)	7 (2)	--
30[c]	--	--	--	--	26 (4)	16 (4)	3 (2)
32[c]	--	--	--	--	--	4 (2)	9 (8)
38[c]	--	12 (6)	--	9 (3)	--	2 (1)	4 (2)
Hook and Line							
16	--		--	--	--	--	13 (4)
17	9 (3)	--	--	--	--	--	--
18	3 (1)	8 (3)	--	--	--	--	--
19	--	--	--	--	--	3 (1)	20 (5)
20	--		--	--	--	--	14 (2)
21	--	--	--	12 (2)	--	--	--
24[c]	6 (3)	9 (1)	--	--	--	--	--

[a] 1 = The Dalles Forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = Upper Tailrace, 7 = John Day BRZ.
[b] Weeks are numbered from the start of the 1987 calender year.
[c] Denotes a gap in weeks.

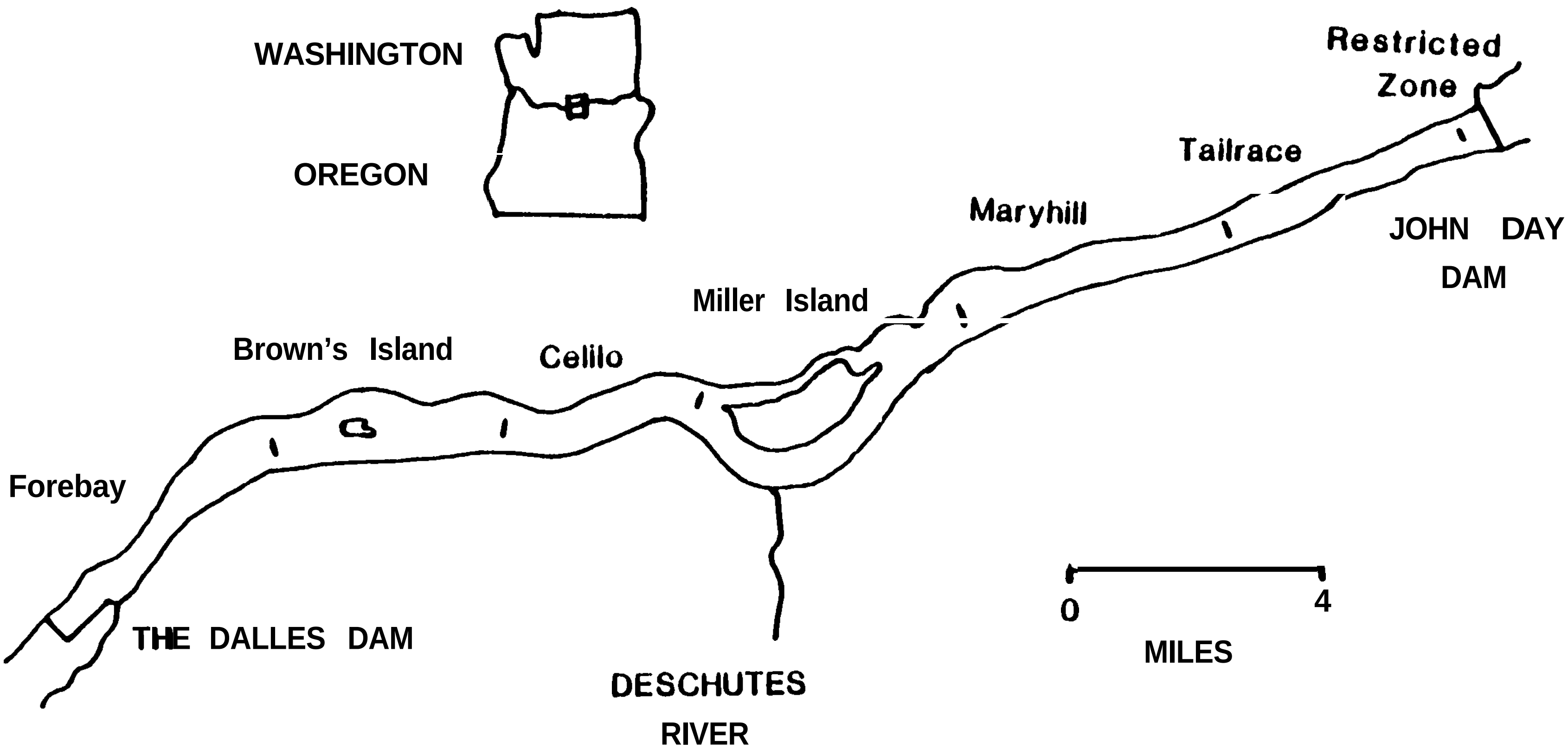

Figure 1. Sampling sections in The Dalles Reservoir on the Columbia River.

chinook or steelhead smolts, pieces of adult coho salmon or lamprey and pickled “roll-mop” herring.

We placed sturgeon with total lengths less than 90 cm in a live well onboard the boat or in a net pen that we hung over the gunnel. We tied sturgeon with total lengths greater than 90 cm alongside the boat. We measured total and fork lengths and pectoral and pelvic girths to the nearest cm. We weighed fish to the nearest 100 g; fish with total lengths greater than 183 cm (6 ft) were taken to shore and weighed in a sling. We marked sturgeon we caught by removing a barbel and section of a fin ray, applying a tattoo, and inserting one or two spaghetti tags (Rieman et al. 1987). We removed the left outside barbel of all fish we caught. We removed a section of the leading ray of the left pectoral fin from every other fish we caught. We tattooed all fish with total lengths at least 90 cm. We marked fish with total lengths at least 70 cm with a single spaghetti tag and marked those at least 90-cm long with two spaghetti tags. Ye released all live fish after measuring and marking.

Gear Evaluation

We evaluated gear based on size-selectivity and efficiency. We evaluated size-selectivity of gear by comparing length frequencies of catch among gear. We also tried to use recoveries of marked fish to estimate size-selectiv ity (Youngs and Robson 1978), but we did not recapture enough fish to make estimates. Ye evaluated sampling efficiency by comparing catch per unit effort (CPUE) by man hour among gear. We calculated catch per crew week based on 13.4 crew weeks of setlining, 3.7 crew weeks of gillnetting, and 0.9 crew weeks of angling. We also weighed the effectiveness of a gear by the physical condition of its catch.

Mark Evaluation

We evaluated marks based on retention and effects on survival. We estimated the retention of the tattoo, of removal of a barbel, of removal of a fin ray section, and of spaghetti tags by noting their presence or absence on fish known to have been marked by those methods. We also noted natural loss of barbels to estimate potential of identifying unmarked fish as marked if the barbel clip was the only mark applied or that persisted. Ye removed a section of fin ray from only one-half of sturgeon caught to evaluate its effect on survival (Youngs and Robson 1978) but did not recover enough marked fish to estimate survival.

Morphometry

We used regression analysis (Ricker 1975) to define relationships between norphometric measurements to determine whether a single measurement can be used as an index of the others. The measurements we considered were total length, fork length, weight, pelvic girth, and pectoral girth.

Age and Growth

We examined fin ray sections (Hess 1984) to age sturgeon and estimate growth. Staff from ODFW, WDF and FWS worked together to develop criteria used to define annuli following Brennan (1987). Three individuals aged each specimen. We estimated bias **caused** by reader disagreement by calculating the mean age, deviation from mean age and range of ages assigned individual fish. We described growth by plotting mean age at length and by fitting age and length data with a Von Bertalanffy equation.

Reproductive Potential

We defined reproductive potential two ways; potential egg deposition by a population and potential egg deposition by an individual female in her lifetime. To estimate reproductive potential we need estimates of mortality, fecundity, and the proportion of the population that are spawning females. WDF and ODFW's Columbia River Management program are estimating fecundity from ovaries removed from all fish sampled from sport and commercial fisheries. During this performance period we have focused on determining the spawning proportion from gonad samples WDF collected for us from sport and commercial catches. To determine spawning periodicity we must be able to recognize fish whose eggs (oocytes) are ripening (are vitellogenic) and that will spawn at some known time in the future. We defined vitellogenesis according to a commonly used generalized classification (Appendix A-1). We examined ovary samples, measured oocyte diameters and classified oocytes as vitellogenic or not vitellogenic based on size and pigmentation.

Abundance and Distribution

We estimated abundance and described distribution of sturgeon during the sampling season. We estimated abundance using a Petersen mark-recapture estimator (Youngs and Robson 1978). We considered fish marked before 31 Ray 1987 (1 July 1987 for estimates made using recoveries from commercial fishery) to be marks at large and used recoveries from this cohort after 31 May to estimate abundance. We described distribution of sturgeon by comparing CPUE among sampling areas.

Mortality

We estimated exploitation using recoveries of marked fish in the sport and commercial fisheries. Ye were unable to estimate total and natural mortality because the recent expansion of fishing effort on legal-sized fish precluded **use** of catch curves to estimate their total mortality (Ricker 1975) and we did not catch enough undersized or oversized fish to construct a catch curve. Men estimating exploitation by the sport fishery we considered fish marked before 31 May 1987 to be marks at large and used recoveries from this cohort to make the estimate. We assumed non-response by sport anglers to be 0.50 when making the estimate based on voluntary returns. When making the estimate based on recoveries from the angler survey, we estimated the number of marks recovered in the sport fishery as the number observed divided by a sampling rate of 0.18 (telephone interview with G. Kreitman, Washington Department of Fisheries, Columbia River Fisheries Laboratory, Battle Ground, Washington). Men estimating exploitation by the commercial fishery we considered fish marked before 1 July 1987 to be marks at large., We made the estimate based on recoveries from buyer sampling: estimating the number of marks recovered in the commercial fishery as the number observed divided by a sampling rate of 0.19 (telephone interview with G. Kreitman, Washington Department of Fisheries, Columbia River Fisheries Laboratory, Battle Ground, Washington).

Population Modeling

We used MOCPOP, a generalized population simulator (Beamesderfer 1988) to estimate yield (as a percent of unexploited biomass) from a theoretical population given various exploitation (u = 0 to 0.5), natural mortality (n = 0.05 to 0.10), growth (L_{00} = 229 to 340) and recruitment (Beverton-Holt **A** = 0.2 to 0.8) scenarios. We used this approach as a general sensitivity analysis to identify critical information needs. We varied parameter estimates over the range reported above. These ranges are consistent with the literature.

RESULTS

Gear Evaluation

We caught 1041 sturgeon (Table 2). We observed no sturgeon in turbine draft tubes. Size at full recruitment and catch per crew hour varied among gear. Fork lengths of catches ranged from 20 cm to 260 cm (Figure 2). Setlines provided the greatest range of lengths and only setlines caught fish longer than 40 cm. We also found that setlines were the most productive gear (Table 2). We estimated that catch per crew week (40 hours) with setlines (61.4 sturgeon per crew week) was 1.24 times catch with gillnets and 1.78 times catch with hook and line.

Mark Evaluation

We marked 837 sturgeon. We subsequently recovered with our gear and from sport and commercial fisheries from 7 to 32 fish, depending on the mark applied (Table 3). Of the sturgeon we examined for tattoos,over half did not retain the mark. For all six sturgeon with missing tags we found fresh tag scars and no evidence of tag

Table 2. Catch of white sturgeon in The Dalles Reservoir, March through September 1987.

Gear, Week[b]	Location[a]						
	1	2	3	4	5	6	7
Setline							
13			--	0	--	1	4
15[c]	--	--	--	--	--	0	7
16	--	--	--	--	--	58	9
17	18	--			--		
18	4	9	--	--	--	--	--
19			--	2	25	5	
20	--	--	--	--	--	20	135
21	--	--	12	16	--	--	--
24[c]	49	--				--	--
26[c]	--	149	--	--	--	--	--
27	--	--	63	23	--	--	--
28					--	11	92
29	--	--	--	14	20	16	--
33[c]	--	4			--		
34	28	--	--	--	--	--	--
36[c]	32	--	--	--	--	--	--
Gillnet							
13	--		--	--	--	0	44
14	--	2	0	1		3	1
15	--	--	--	--	--	--	3
23[c]	0	--	1	15	1	7	--
30[c]	--	--	--	--	16	15	14
32[c]	--		--	--	--	2	50
38[c]	--	0	--	2	--	1	6
Book and Line							
16	--	--	--	--	--	--	8
17	0	--	--	--	--	--	--
18	0	1	--	--	--	--	--
19	--	--	--	--	--	0	10
20	--	--	--	--	--	--	9
21	--	--	--	2	--	--	--
24[c]	0	1	--	--	--	--	--

[a] 1 = The Dalles Forebay, 2 = Browns Island, 3 = Celilo, 4 = Miller Island, 5 = Maryhill, 6 = Upper Tailrace, 7 = John Day BRZ.
[b] Weeks are numbered from the start of the 1987 calender year.
[c] Denotes a gap in weeks.

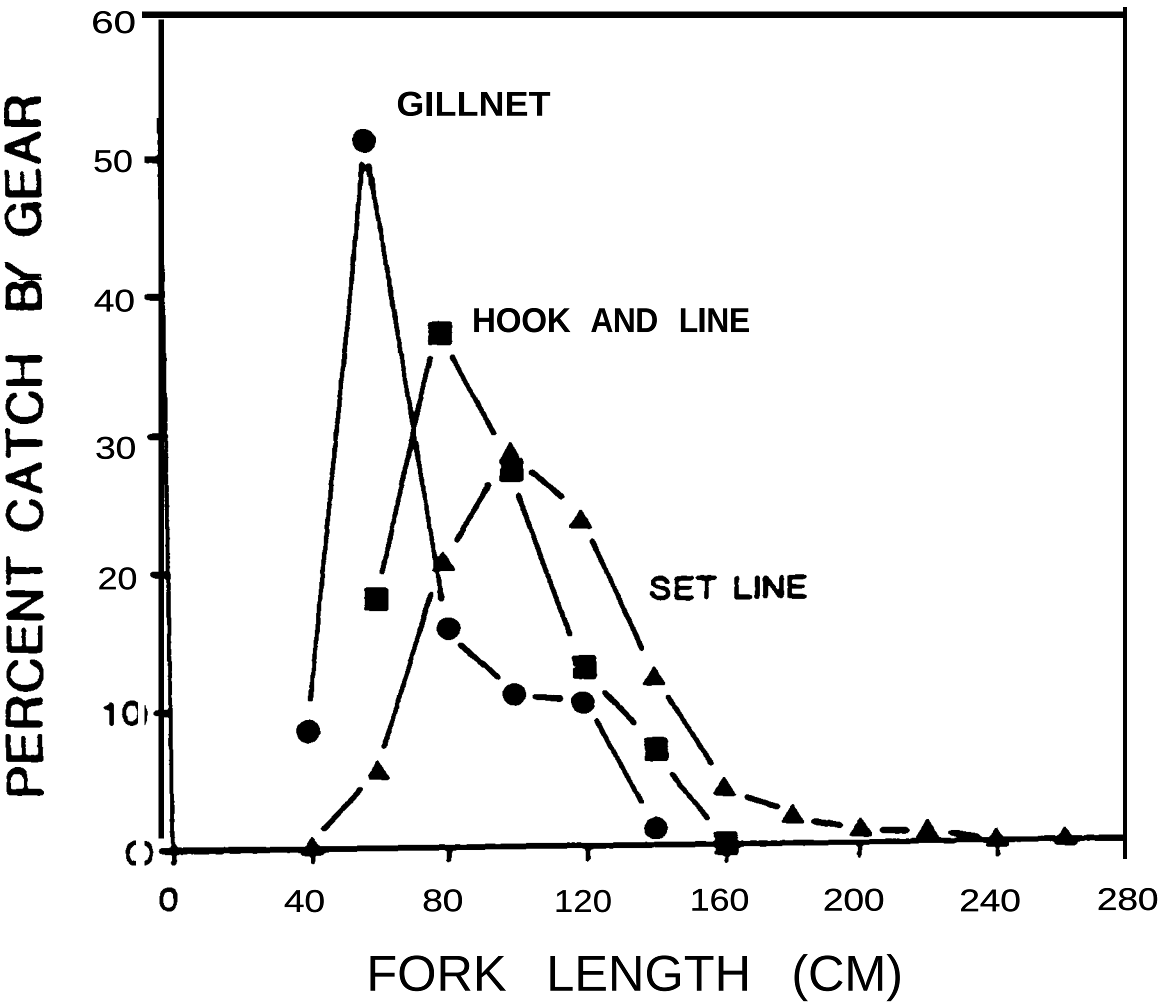

Figure 2. Length-frequency distributions of white sturgeon collected in The Dalles Reservoir by three gears, 1987.

Table 3. Retention of marks by white sturgeon recaptured in The Dalles Reservoir, March through September 1987.

Hark	Number Lost	Number Recaptured[a]
Spaghetti Tag	6[b]	32
Tattoo	4	7
Barbel Clip	0	29
Fin Ray Section	0	9

[a] We only included fish examined for all marks.
[b] Tag scars were fresh and we saw no evidence of tag migration.

migration. We observed 16 missing or partially missing barbels out of 1027 fish examined. Loss was similar among all four barbels, averaging four per individual barbel (2 outer left, 5 inner left, 5 inner right and 4 outer right).

Morphometry

Regression of fork length against total length produced a good model for conversions (Table 4). The relationship between fork length and weight was exponential (Figure 3). Regressions of fork length, pectoral girth, and pelvic girth against weight produced good models for predicting weight.

Age and Growth

We assigned mean ages ranging from 2 to 38 to 116 sturgeon whose fin ray sections we examined (Table 5). Range of ages assigned by our three readers increased with mean age assigned (Figure 4). A regression of mean length against age was nearly linear (Figure 5). Aged samples were incomplete: all ages were not represented in all age groups present in the current sample (Table 5).

Reproductive Potential

We collected samples of ovaries from 231 sturgeon observed in the commercial fishery. We classified nine percent (20) of those as mature and reproductively active. Size of oocytes in reproductively active fish ranged from 0.6 mm to 2.7 mm (Figure 6). The proportion of reproductively active fish in a length group increased with length (Figure 7). The relationship between length and the proportion reproductively active varied depending on whether size differences of oocytes represented two cohorts that will spawn in successive years (assuming constant rate of development) or a single cohort that will spawn in the same year (assuming different rates of development) (Figure 7) .

Abundance and Distribution

Estimates of abundance varied with the method used to recover marks (Table 6). Assuming abundance to be 29,000 we sampled approximately 3 percent of the population of fish larger than 70 cm (837/29,000). Catch per unit effort of sturgeon was similar throughout the reservoir downstream from the John Day BRZ (Figure 8). However CPUE in the BRZ was 5.6 and 7.9 times higher than elsewhere with setlines and gillnets.

Table 4. Linear regression equations and statistics describing relationships between selected morphometric characteristics of white sturgeon, The Dalles Reservoir, 1987.

Characteristics[a]	Regression Equation	Statistics[b]
TL vs. FL	TL = 1.09 FL + 2.37	n=988 r^2=0.99, $p<0.01$
WT vs. FL	lnWT = 3.37 lnFL - 11.23	n=728: r^2=0.98, $p<0.01$
WT vs. PG	lnWT = 3.02 lnPG - 6.74	n=716, r^2=0.98, $p<0.01$
WT vs. VG	lnWT = 2.83 lnVG - 5.15	n=716, r^2=0.98, $p<0.01$

a We measured total length (TL), fork length (FL), weight (WT), pectoral girth (PG) and pel vic girth (VG).

b We present sample size(n), the coefficient of determination (r^2), and level of significance (p).

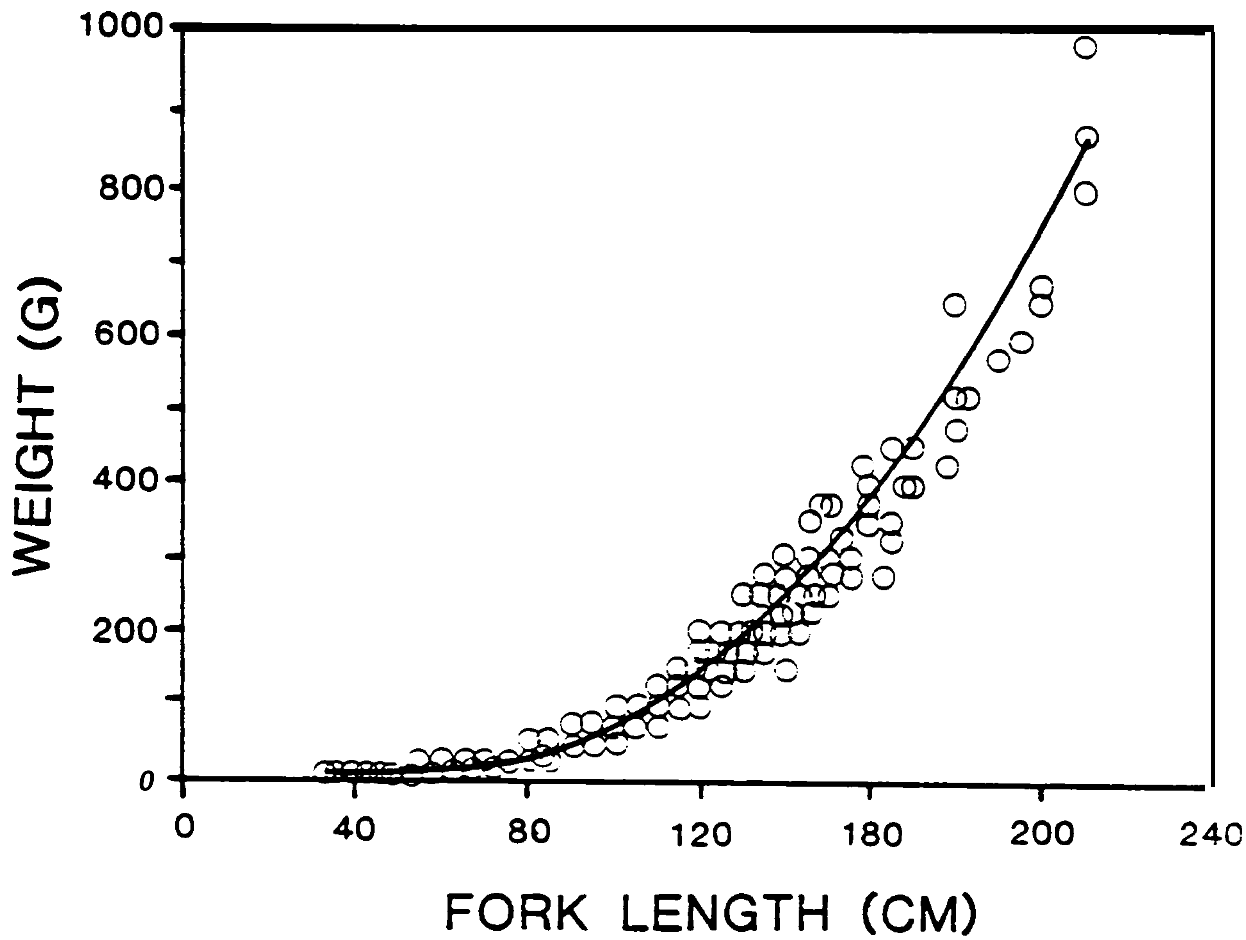

Figure 3. Weight versus length of white sturgeon collected in The Dalles Reservoir, 1987.

Table 5. **Age** distribution of white sturgeon by length group, The Dalles Reservoir, 1987.

Length Group (cm)	No.	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
30 - 39	3		3																																				
40 - 49	12		2	8	1			1																															
50 - 59	8			3	5																																		
60 - 69	6			1	1	2	2																																
70 - 79	4					1	1	2																															
80 - 89	12						1		3	1	1	2	1	2					1																				
90 - 99	9								1	1	2	2	1		1			1																					
100 - 109	7										1	1	1		1		3																						
110 - 119	10											1	1		2		2		1	1	2																		
120 - 129	6															1	1	1	1		2																		
130 - 139	6																1	1		2	1	1																	
140 - 149	8													1					3		2	1											1						
150 - 159	8															2		1			2	2				1													
160 - 169	7																1			1	1		1	1				2											
170 - 179	3																				1					1			1										
180 - 189	1																				1																		
190 - 199	2																						1		1														
200+	4																						1	1			1												1

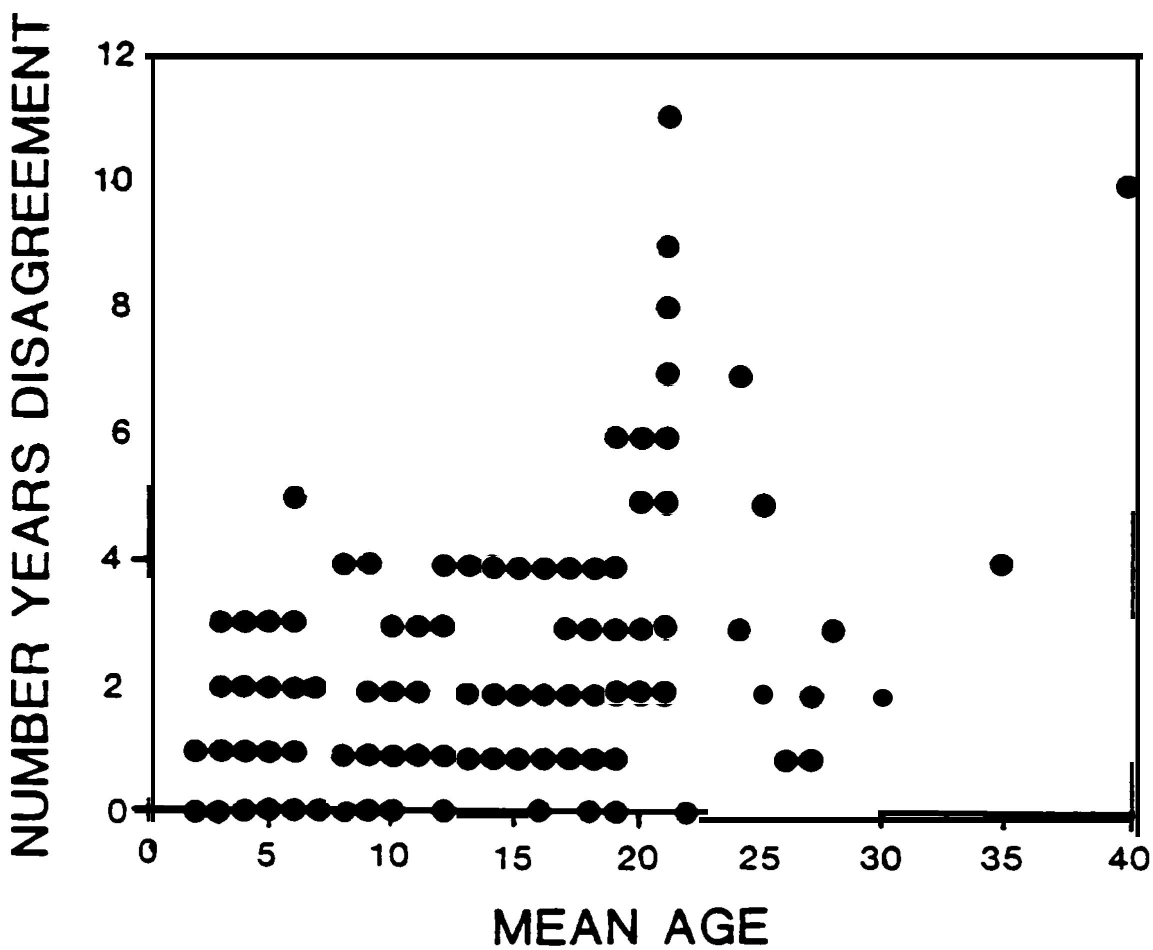

Figure 4. Differences between maximum and minimum ages assigned by three readers to white sturgeon based on fin ray sections.

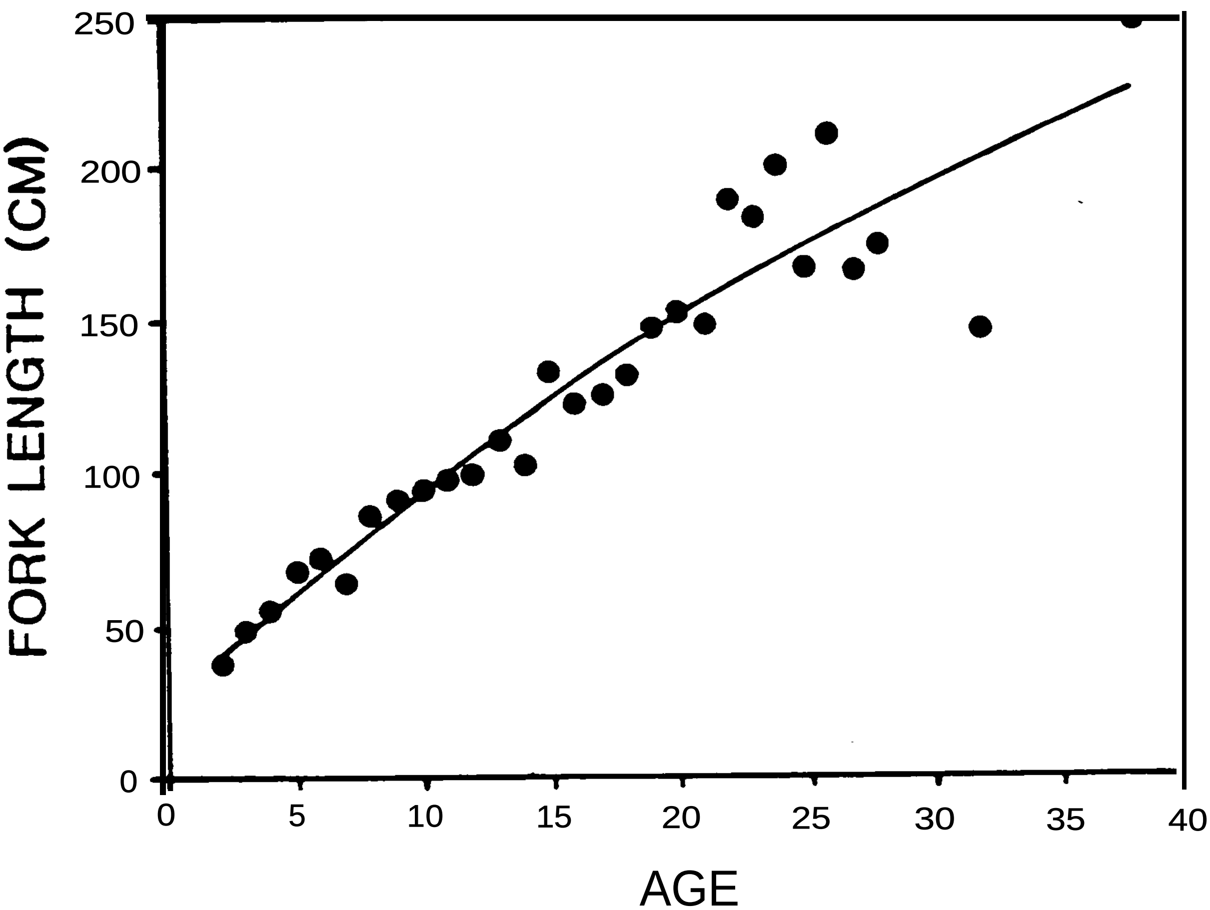

Figure 5. Length versus age of white sturgeon collected in The Dalles Reservoir, 1987.

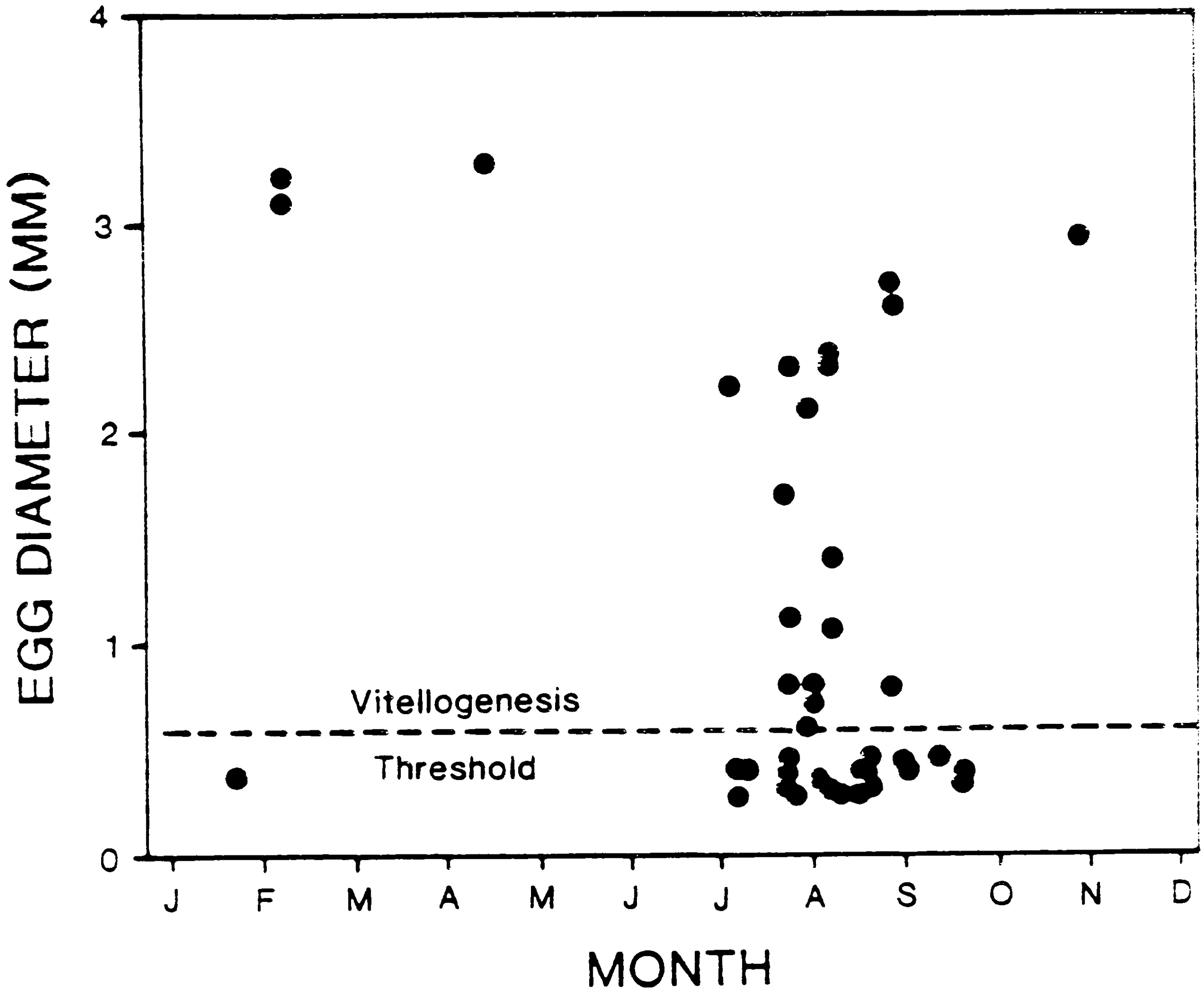

Figure 6. Mean diameter of eggs from gonad samples of white sturgeon collected in The Dalles Reservoir, 1987-88.

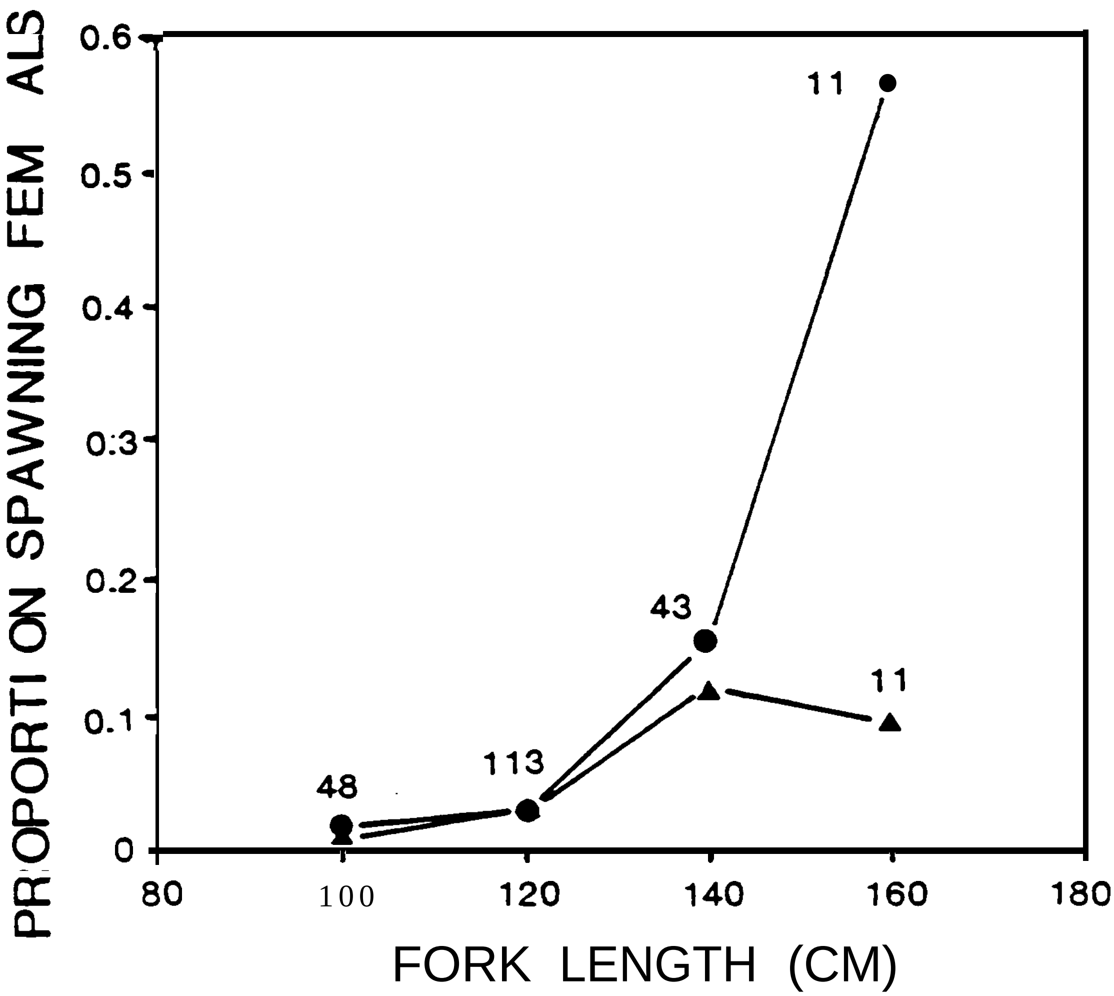

Figure 7. Proportion of white sturgeon from The Dalles Reservoir that are females which will spawn in 1988, in relation to length. Two lines represent 12 to 16 month (upper line) and 20 to 24 month (lower line) developmental scenarios. Sample sizes are indicated for each length group.

Table 6. Estimates of white sturgeon abundance by length group. The Dalles Reservoir., 1987.

Length Group (cm)[a]	Marks At-large[b]	Catch	Marks Recaptured[c]	Abundance[d]
70 - 180	500	408	7	29,143
90 - 180x	429	367	5	31,489
90 - 180y	429	1983[e]	40[f]	21,268
122 - 180	197	445[g]	11[g]	7,970

[a] Length groups correspond to sampling method used to recover fish; setlines, gillnets and angling (70 - 180), sport angler survey (90 - 180x), voluntary angler returns (90 - 180y) and commercial fishery sampling (122 - 180).

[b] Marks at-large include fish marked and released prior to 30 May 1987 for all sampling methods but commercial fishery sampling. Fish marked and released prior to 1 July were considered at-large for commercial fishery sampling because that is when the commercial fishing season began,

[c] Marks recaptured are recoveries of at-large marks after 30 May (1 July for commercial sampling).

[d] Abundance =(Marks At-large x Catch)/Marks Recaptured.

[e] WDF estimated sport harvest to be 1983 (see Appendix B).

[f] Anglers returned 20 tags. We assumed 0.50 non-response rate.

[g] WDF estimates of number of fish in sampled in commercial fishery that came from The Dalles Reservoir (see Appendix B).

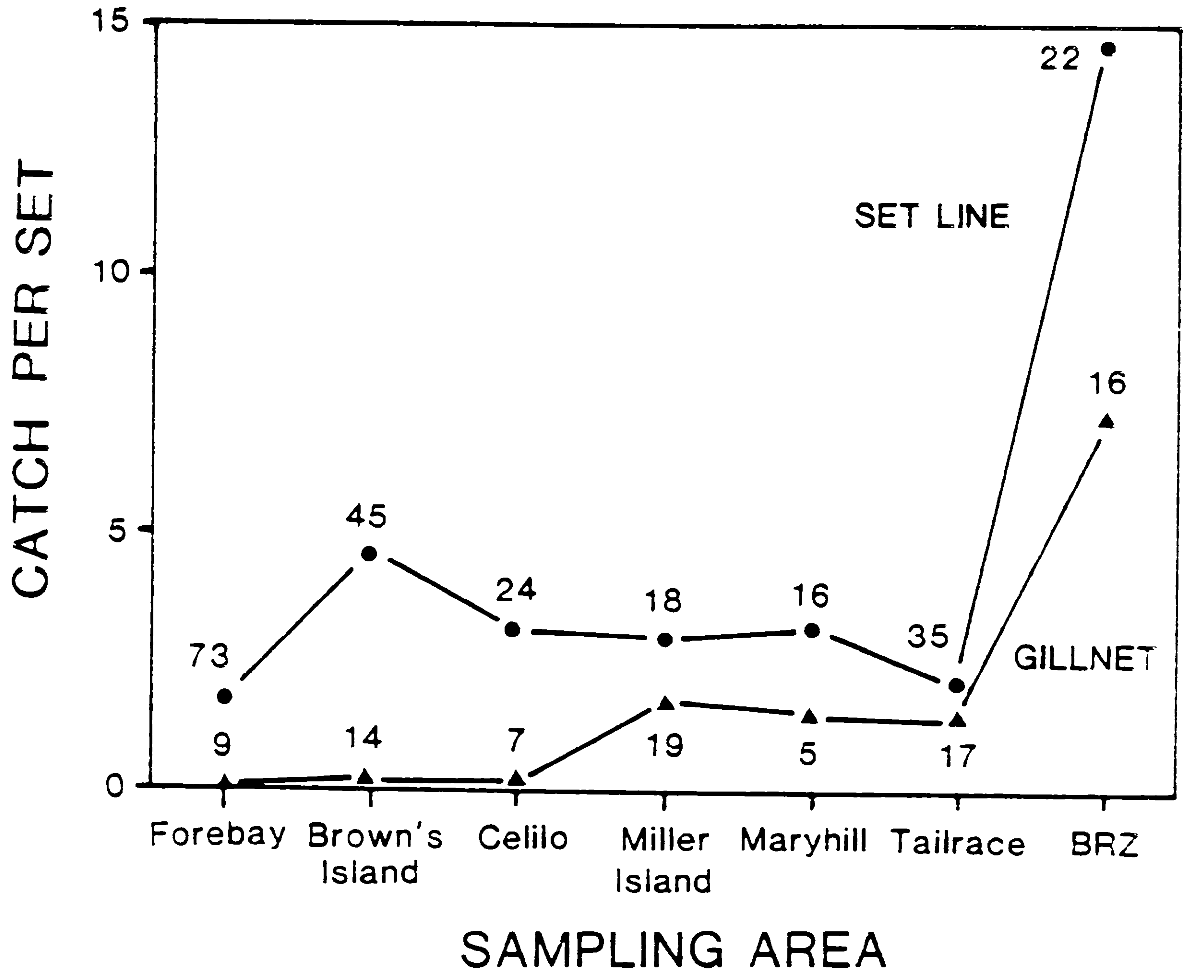

Figure 8. Catch per unit effort of white sturgeon by gear in The Dalles Reservoir, 1987. Number of sets is indicated for each area.

Mortality

We estimated that exploitation by the sport fishery from 31 May through 31 October 1987 varied between 0.06 (based on tag recoveries in the angler survey) and 0.09 (based on voluntary tag returns) (Table 7). We estimated exploitation by the commercial fishery from 1 July through 12 December 1987 as 0.29.

Population Modeling

Simulated yield of 3-ft to 6-ft long sturgeon at different exploitation levels varied depending on values we used for natural mortality, growth, and the recruitment function Figure 9). Maximum yield ranged from 0.2 to 2.9 percent of unexploited biomass. Exploitation producing maximum yield ranged from 2 to 20 percent.

DISCUSSION

Gear Evaluation

Based on length frequencies we believe catch with setlines best represented the population of 3-to 6-ft long sturgeon and gillnets best represented the population of sturgeon less than 3-ft long. Our use of gillnets was more restricted than our use of setlines because gillnets could be fished only in areas of low flow, during periods when few salmon were present. We will sample only with setlines in 1988 because they are easier to use, catch more fish for a given investment in manpower,and seldom catch anything but sturgeon. We will rely on sampling by the FWS for information on sturgeon less than 3 feet long,

We caught few sturgeon outside the John Day Dam BRZ with hook and line and will no longer use this gear. We will not sample fish from turbine draft tubes because we did not observe any fish during our inspections and believe the low potential catch does not justify the effort. We will attempt to estimate size-selectivity of setlines by pooling recoveries of narked fish from all years and we will use these estimates to correct for bias.

Mark Evaluation

Our evaluation of mark retention is preliminary. We need more recaptures to reasonably estimate retention. Our results suggest that tattoos are not useful marks because they quickly became unreadable. We believe that spaghetti tags, removal of a barbel, and a fin ray section are viable marks, however we must evaluate some questions associated with each mark. We need to recapture more spaghetti-tagged fish to estimate tag shed. The only loss of spaghetti tags we observed may have been caused by deliberate removal by fishermen. We also need to evaluate the effects of removal of a barbel and fin ray section on behavior and survival. Changes in

Table 7. Estimates of exploitation of white sturgeon in the sport and commercial fisheries, The Dalles Reservoir, 1987.

Fishery	Marks At-large	Marks Recaptured	Sampling Rate	Exploitation[a]
Couercial	197	11[b]	0.19	0.29
Sport				
Angler **Survey**	**429**	**5**[b]	0.18	0.06
Voluntary Returns	429	20	0.50	0.09

a *Exploitation = (Marks Recaptured/Sampling Rate)/Marks At-large.*
b *Number of marks observed by WDF (see Appendix B).*

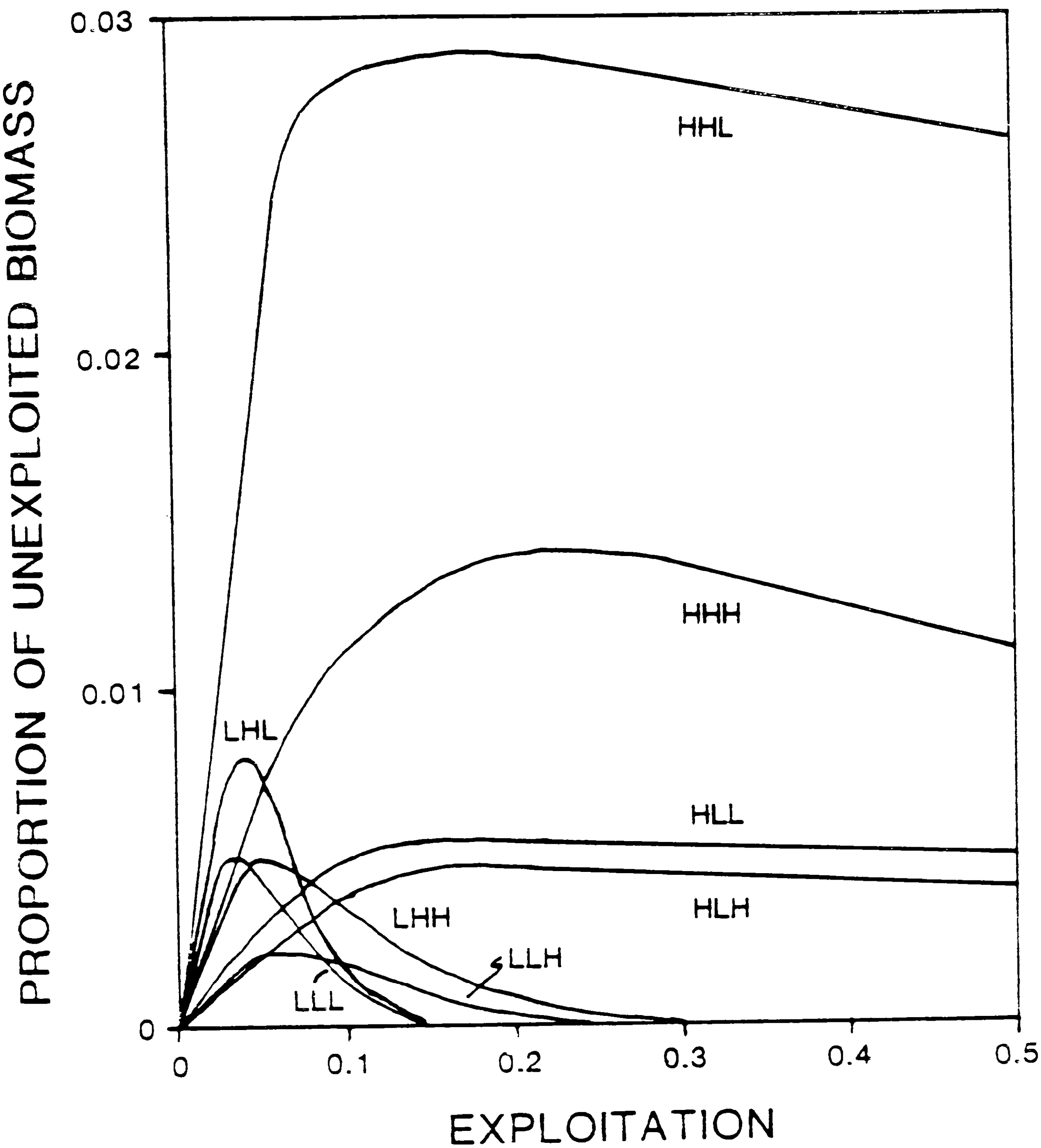

Figure 9. Potential yield in relation to exploitation of theoretical white sturgeon populations with varying levels of resilience in recruitment (A in Beverton-Holt equation), natural mortality, and growth. L and H refer to low and high levels for each based on ranges reported in the literature.

catchability or differential survival of marked and unmarked fish could bias estimates of abundance and aortality. We need to recover more marked fish to complete our evaluation of fin ray section removal and will begin an evaluation of barbel removal in 1988.

We are also considering using three other marks in 1988; a coded-wire tag implanted in a dorsal scute, subcutaneous injections of dye, and removal of a scute or scutes along the lateral line. Others have used the coded-wire tag with sturgeon and have found retention to be excellent (telephone interview with F. Hall, Northwest Marine Technologies, Olympia, Washington). Hall also noted that others have successfully used subcutaneous injections of dyes with salmonids. Scute loss is a persistent natural scar. We are presently noting occurrence of natural scute loss to determine whether removal of scutes is a viable mark.

Morphometry

Because the regression of fork length against weight produced an excellent model, we are planning to estimate weights from fork length alone. Inclusion of a girth measurement did not improve the regression. We will continue to weigh fish over 150 cm in length from The Dalles Pool because we have insufficient numbers of big fish in our samples.

Age and Growth

The regression of mean age against length suggests growth was nearly linear. Growth also appeared allometric ($b = 3.37$ for the length(l)-weight (w) relationship, $w = al^b$). However sample sizes are too small for precise estimates of growth because of inherent variation in growth and uncertainty in ages assigned individual fish. Despite efforts to define clear criteria for aging sturgeon, aging is necessarily subjective and we had a great deal of disagreement among readers. We will inject sturgeon with oxytetracycline in 1988 to establish benchmark circuli in the fin ray and enable future verification of aging criteria.

Reproductive Potential

We can easily recognize vitellogenic oocytes in ovary samples without histological preparation. Our results can be interpreted in two ways depending on whether current theory about oocyte development holds true for sturgeon in the Columbia River basin. If vitellogenesis takes place in less than 20 months, then differences in size of vitellogenic oocytes suggest individuals may develop at different rates. If vitellogenesis takes more than 20 months, then differences in size of oocytes could show two cohorts, one that will spawn next year and one that will spawn the year after that. We observed that frequency of reproductively active fish increased with size. Depending on which development scenario is true, the rate of increase in frequency can be dramatic and greatly influence reproductive potential. We need samples from fall, winter and spring, and from large 0150 cm) fish to better describe oocyte development. We will work with a veterinarian in 1988 to develop a procedure for surgically removing ovary samples from live fish to increase our samples of large fish. We are also examining the feasibility of using blood chemistry to determine reproductive activity.

Abundance and Distribution

Estimates of abundance are imprecise but should improve when 1987 and 1988 recoveries are pooled. Because recovery rates are low ((10%) we will rely on a Petersen estimator using fish marked in the previous year as marks at large. We will correct estimate8 for in-season mortality and tag shed. If the 3% recovery rate of 1987 can be doubled in 1988 by increasing sampling effort, precision of estimates should be ± 30%

Density of sturgeon appears greater in the John Day Dam BRZ than elsewhere in the reservoir. Outside of the BRZ, densities appear similar throughout the reservoir. More recoveries of tagged fish should enable us to better describe movements among areas.

Mortality

Exploitation estimates are imprecise, but suggest that exploitation was high. Commercial harvest of sturgeon between Bonneville and McNary dams has increased 10-fold in the last 10 years (Bohn et. al 1987). Exploitation in The Dalles Pool should have increased at a similar rate. We should be able to increase precision of exploitation estimates by increasing number of marks at large and improving abundance estimates.

We should be able to use catch curves to estimate total mortality of sublegal fish as we increase sample sizes and complete aging. We are presently working on estimating natural mortality of sturgeon using an empirical model based on growth (Pauly 1980).

Population Modeling

Modeling showed that yield predictions were sensitive to natural mortality, growth and recruitment. Potential yield was most dramatically affected by the type of recruitment function used: typical for long-lived species (Francis 1986). To describe the recruitment function we must estimate recruitment over a wide range of stock densities. We may have an opportunity to look at recruitment at different stock densities if sturgeon numbers are declining because of recent heavy exploitation. Using estimates of spawning success by the U.S. Fish and Wildlife Service, we may be able to examine changes in recruitment with stock size. Defining the stock recruitment relationship will enable us to determine and compare productivity of stocks downstream of McNary Dam.

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APPENDIX A-l

Generalized Classification Used to Define Vitellogenesis

We described the developmental stage of sturgeon ovaries according to the following classification:

1. Pre-vitellogenic with attritic oocytes: Gonads do not show visual signs of vitellogenesis, but dark pigment spots are present that may be reabsorbed eggs.

2. Pre-vitellogenic: Gonads do not show visual signs of vitellogenesis. Eggs are present, but have an average diameter less than 0.5 mm.

3. Early vitellogenic: Eggs in gonad are clear, opaque or gray and have an average diameter from 0.6 mm to 2.2 mm.

4. Late vitellogenic: Eggs in gonad are fully pigmented and are securely attached to ovarian tissue. Average egg diameter ranges from 2.2 mm to 2.9 mm.

5. Ripe: Eggs in gonad are fully pigmented and are completely detached from ovarian tissue.

6. Spent: Gonads are flaccid and contain some residual pigmented eggs -

APPENDIX A-2

Sampling Plan of the Oregon Department of Fish and Wildlife

Status and Habitat Requirements of White Sturgeon in the Columbia River Downstream from McNary Dam

April 1988

INTRODUCTION

In 1986 the Bonneville Power Administration (BPA) funded a 6-year multi-agency study of white sturgeon. The study addresses objectives of a research program implementation plan developed in response to the 1987 Fish and Wildlife Program measure 903(e)(1). This sampling plan outlines the approach of the Oregon Department of Fish and Wildlife (ODFW) to collecting information needed to satisfy its responsibilities under its agreement with BPA. This document serves as a guide for ODFW staff, cooperators, and other interested parties.

This plan contains three sections; plan of action, field guide, and tasks of staff. The plan of action lists 1988 objectives and expected products and describes the data we will collect. The field guide describes sampling seasons and sites and procedures for setting gear, using radios, handling fish, and collecting and recording data. The tasks by staff lists tasks necessary to sample or support sampling and identified staff responsible for each task.

PLAN OF ACTION

Objectives and Expected Products

ODFW has responsibilities to (1) describe the life history and population dynamics of subadult and adult white sturgeon in the Columbia River between Bonneville and McNary dams and (2) evaluate the need and identify potential methods for protecting, mitigating, and enhancing white sturgeon populations in the Columbia River downstream from McNary Dam. Actions presently focus on the first responsibility and will produce the following:

1. Abundance. Hydrodevelopment has affected resource users if yield has been reduced. To estimate yield we must first estiamte abundance.

2. Reproductive Potential. Hydrodevelopment could reduce yield by reducing reproductive potential. To estimate reproductive potential we must first estimate fecundity and the proportion of the population that are females spawning.

3. Natural Mortality. Increased natural mortality caused by hydrodevelopment could reduce yield, if it occurs in ages that will enter or are presently in the fishery. We will most likely estimate natural mortality using growth, temperature, and apparent longevity.

4. Growth. Poor growth caused by hydrodevelopment could cause reduced reproductive potential and increased natural mortality; either would reduce yield.

Data

The data we will collect are presented by task contained in our 1987/88 work statement.

Task 2.2

We will follow the scheme below when marking fish and evaluating the effectiveness of the marks we use. See field guide for marking methods.

1. Spaghetti tags. We will tag fish whose total lengths are between 70 and 90 cm with a single tag. We will tag fish whose total lengths equal or exceed 90 cm with two tags.

2. Fin rays. We will remove a section of the right fin ray from all live sexed fish and from live unsexed fish that are in length groups we need to age or have fork lengths that equal or exceed 150 cm. We will remove the right and left fin rays from all dead fish.

3. Barbels. We will remove the right barbel from 1/2 of all fish.

4. Tetracycline. We will inject tetracycline into muscle tissue of all sublegal-sized fish.

5. Scutes. We will remove the third scute from the right lateral line of all fish. We will remove the second and third scute from fish injected with tetracycline.

Task 2.3

We will collect the following information to determine age structure and growth. We will maintain a running total of fin ray samples by length category and stop sampling a given category when we get 15 fish per sex.

1. Fin rays. See Task 2.2.

2. Fork length. We will measure fork lengths of all fish.

3. Weight We will weigh all sexed fish and fish whose fork length equals or exceeds 150 cm.

4. Pectoral girth. We will measure pectoral girth of all sexed fish and fish whose fork length equals or exceeds 150 cm.

Task 2.4

We will collect the following information to estimate reproductive potential. A Clackamas crew will collect blood samples during a feasibility study in July.

1. Gonad "punch." We will surgically remove samples of gonad from live fish whose fork lengths equal or exceed 150 cm.

2. "Whole" gonads. We will encourage Washington Department of Fisheries (WDF) and Columbia River Mangement (CRM) to collect whole gonads from all dead fish they see in sport and commercial fisheries. We will assist with sampling the commercial fishery in August (3 people, 1/2 time).

Task 2.5

To describe distribution we will record locations where we capture and release fish. We will record tag and tattoo numbers; missing fin rays, scutes and barbels; and subcutaneous marks from all fish we sample.

Task 2.6

To estimate abundance we will mark fish as described in Task 2.2. 1988 marks will differ from 1987 marks so that we can calculate annual Petersen estimates. Our goal for 1988 is to double our 1987 effort and examine 2,000 fish for marks.

Task 2.7

To estimate survival of fish of legal size or greater, we will use mark recoveries; catch curves would be biased because of recent increase in fishing mortality. To estimate survival of sublegal-sized fish we will rely on catch curves. We have no catch quotas; we will take what we get when attempting to meet other objectives.

FIELD GUIDE

Field Season

We will begin our 1988 field season on April 25 and continue through September 2. We will spend the first 2 weeks familiarizing the crew with sampling equipment and techniques and field testing the boats and hydraulic gear. We will spend the remainder of the season sampling fish in The Dalles and Bonneville pools. We will sample fish in The Dalles Pool using setlines for 12 weeks; May through July. We will sample fish in Bonneville Pool using setlines for 4 weeks in August.

Crew Size

We will use two three-person crews to sample fish with setlines in The Dalles pool from May through July and in Bonneville Pool in August. We will employ five EBA-1's and an FWT-3, in the field from April 25 through July 30. Six people will sample fish in The Dalles pool each week. The seventh person will work a minimum of 16 hours in the office and may take the rest of the week off (to "burn off" compensatory time).

Sampling Approach

Crews working in The Dalles pool will work four, 10-hour days when setlining.

The Dalles Pool

We will divide The Dalles pool into six, 4-mile long sections (Table 1). We will also divide each section into four, l-mile long subsections. One crew will spend 3 days sampling each section. A crew will set at least 30 setlines per section (10 per day) and 6 per subsection (two per day) discretion. Six sets (two per day) will be made at the crew's discretion.

If we have time to set more than 10 setlines in a day, the crews will choose where to place additional sets as long as the same site is not sampled more than once per week.

We will sample all six sections in a 3-week period. We will randomly choose a pair of adjacent sections (see Table 1 for pairings) every 3 weeks and will begin sampling in those sections. We will sample this next pair of "downstream" sections the following week. Crews will choose the order that they sample subsection based on weather conditions, etc.

Table 1. Sampling areas in The Dalles Reservoir, 1988.

Description	River Mile Lower	River Mile Upper	Length in Miles
Tailrace (John Day Dam)	212.0	215.6	3.6
Maryhill	208.0	212.0	4.0
Upper Miller I.-Biggs	204.0	208.0	4.0
Celilo-Lower Miller I.	200.0	204.0	4.0
Browns Island	196.0	200.0	4.0
Forebay (The Dalles Dam)	191.5	196.0	4.5

Bonneville Pool

We will divide Bonneville Pool into eight, 6-mile long sections (Table 2). One crew will spend 3 days sampling each section. A crew wi 11 set at least 24 setlines per section (8 per day) and 3 per river mile (1 per day). We will sample all eight sections in a 4-week period.

Table 2. Sampling areas in Bonneville Reservoir, 1988.

Description	River Mile Lower	River Mile Upper	Length in Miles
Tailrace (The Dalles Dam)	187	192	5
Mayer Park	181	187	6
Memaloose	175	181	6
Bingen	169	175	6
Hood River	163	169	6
Drano Lake	157	163	6
Wind River	151	157	6
Forebay (Bonneville Dam)	145.5	151	5.5

GEAR DESCRIPTION AND METHODS

Setlines measure 183-m long (600 ft) and consist of l/l-inch twisted soft or medium lay nylon mainline with 40 circle halibut hook lines attached every 4.6 m (15 ft). Hook lines measure 0.7 m (2 ft) and consist of a 1/4-inch mainline snapwith a 4/O swivel attached by a hog ring and a gangion line tied between the swivel and hook. Hooks will be size 7 (12/O)), size 5 (14/O), and size 3 (16/O). Thirteen hooks of two sizes and 14 hooks of the third size will be place on each line. Number per size will be randomly chosen.

Setlines are primarily deployed parallel to flow from a boat. Depth of set is determined and appropriate float lines are selected. An anchor and float line are attached to the end of the mainl ine. The float is tossed overboard and then the anchor is lowered overboard. One person pays out the mainline while the other attaches prebaited hook 1 ines to the mainline every 4.6 m (15 feet) as the mainline is deployed. Once the anchor is on the bottom, the boat operator begins moving the boat in reverse, in the direction of current, matching the pace of the line setters so as not to drag the anchor and keeping the mainl ine straight. When approaching the other end of the mainline and before the last hookline is attached, the second anchor and float line are connected and the last hook line is attached. The mainline is then lowered by the float line to the bottom. The boat operator maintains constant awareness of safety and is ready to maneuver the boat to assist the setters during deployment.

Setlines are retrieved using the following procedures:

The downstream float is retrieved, brought aboard, and the float line is passed through the hydraulic assembly and snatch block. The control operating the hydraulic pot hauler is set to forward and the lines carefully laid into their container. The boat operator begins moving the boat forward as the anchor and mainline are lifted off the bottom, lessening the force needed to pull in the setline and ensuring the lines do not *cross* under the boat. When tne anchor comes up, it is removed and the carabiner attaching the mainl ine to the anchor and float line is lifted over the snatch block and hydraulic assembly, then the mainline is repositioned on the hauler and the mainline is brought in. Each hook line is removed before it reaches the snatch block. If there is a fish on the line, the hydraulic system is stopped while the fish is removed (see fish handling section). The entire mainline is brought aboard, removing hooks as the line is retrieved until the last hook is removed. if the setline is to be pulled, or fish need to be worked up immediately, remove the anchor and bring in the float line. If the setline is to be redeployed, the float line is pulled in, the boat operator repositions the boat at the set location, and the setline is reset.

RADIO USE AND PROTOCOL

If another radio (base of another of our boats) is on the air, check to see if your radio is operating and to let them know where you are. Use Channel 1. Occasionally throughout the sampling day you should call another of our radios (if on the air) to maintain contact. Use Channel 1. Limit use to official business. Always use proper protocol and speak as if the public is listening, often they are. If other ODFW radios are on the air, monitor

Channel 2. If no other ODFW radios are on the air, monitor Channel 1. Channel 1 (ODFW frequency) is used to contact boat to boat or boat to base. Channel 2 (navigation frequency) is used to contact The Dalles Dam and John Day Dam when entering and leaving boat restricted zones when conducting sampling in these areas. Also, channel 1 may be used to contact control rooms or barges during emergency situations. Channel 3 (stacker relay, The Dalles is used for emergency communication. Channel 4 (Spout Springs relay) is used for emergency communication. Use Channel 2 when leaving the water for the night, try to contact the other boat or base station. Use Channel 2 after returning to base try to contact the other boat.

HANDLING AND PROCESSING FISH

The goal of sampling is to live capture, process and release a maximum number of white sturgeon while deploying gears using the prescribed sampling methods.

A. Nontarget Species:

1. Rejuvenation and release of salmonids should be given equal priority with processing and release of white sturgeon. Other nontargets should be released quickly, giving priority to target species. Killing or abuse of nontarget species is unacceptable.

2. Salmonid runs may result in periods when large numbers of these fish are caught in gill nets. While sampling has been scheduled to avoid peak migration timing, crews should evaluate catches and immediately report high numbers of salmonids to project biologists. Areas of high catches should be avoided during the remainder of runs (see passage report summaries for potential timing).

B. White Sturgeon:

1. The boat live well is used to hold white sturgeon until the gill net or setline is pulled or reset. If large numbers of white sturgeon are captured, a portable line bag is hung off the side of the boat to hold fish in excess of the boat live well capacity. Large white sturgeon will need to be tied up or put in a stretcher and held in the water or on the deck until the gear has been brought aboard. Exact length of time that a fish can remain out of the water will depend on air temperature, wind , sunlight or other environmental effects. Common sense and exprience will dictate action depending on the circumstances.

2. One person records while the other two handle and measure the fish. The recorder should observe as much of the processing as possible to check for errors.

3. Fish are processed one at a time, the most stressed fish first. Common sense and experience again dictate action.

4. Approximate order of white sturgeon processing:

a. Examine fish for tag, tag scar, tattoo, fin clip, barbel clip or loss, lateral scute mark or loss, and note general fish condition.

b. Determine species and life stage (maturity).

c. Measure fork length (tip of snout to point where upper and lower caudal lobes meet) to the nearest centimeter (cm). Measure fish as it lays on its side and tail is picked up and dropped into a natural position. Ensure measurement device is straight and not curved along the body.

d. Note total length (tip of snout to end of upper caudal lobe) for tagging group. Measure total length for all fish equal to or exceeding 150 cm fork length.

e. Clip the right barbel as close to its base as possible with toenail clippers from every other white sturgeon to be released. The first fish each day for each crew is clipped, alternating for the rest of the day.

f. Remove the third lateral scute from the right side of all white sturgeon to be released. Cut the scute away from the skin with a sharp knife, taking care not to cut too deep. A pair of pliers may be needed to complete removal. For oxytetracycline injected fish, also remove the second scute on the right side.

g. Apply a single spaghetti tag to the dorsal fin of each white sturgeon over 70 cm total length and two spaghetti tags to the dorsal of each white sturgeon over 90 cm total length to be released. When one spaghetti tag is used, destroy and discard the second tag of the same number in sequence on the roll of spaghetti tags. When two spaghetti tags are used, ensure both tags are legible and have the same number. Clip each tag approximately 1/4 inch from the last character. Insert a sharp tag applicator into the unnumbered end of the tag. Tags are applied by piercing the skin at the base of the dorsal fin ridge with the applicator, shoving the applicator laterally through the musculature and out the skin at the base of the dorsal fin ridge on the other side. Care must be taken not to apply the tag too deep or too shallow. The applicator is removed from the tag and both ends are gathered and tied in a double overhand knot, leaving a loop for fish growth. A properly tied tag will have the knot tight, space for fish to grow inside the loop between the dorsal fin and the knot and the ends of the tag clipped evenly with about 4 inches of the trailing ends of the tag behind the knot. Fish between 70 and 90 cm have the tag applied approximately 1 inch posterior from the anterior insertion of the dorsal fin. Fish larger than 90 cm have a tag applied as in smaller fish and another tag applied approximately 1 inch anterior from the posterior insertion of the dorsal fin.

h. Measure girth immediately behind pectoral fins to nearest cm on fish whose fork length exceeds 150 cm and on all fish of known sex.

i. Place fish in sling, hang from a spring scale and determine wet weight to the nearest 100 grams on known sex fish and those whose fork length exceeds 150 cm. Ensure scale is zeroed.

j. Determine sex, if possible. Sex must be determined either surgically or by presence of sexual products. Surgically examine sex of all mortalities by making a ventral incision. Gonads are paired and located near the dorsal portion of the abdominal cavity. Testes are smooth and ribbon-like when immature, smooth and tubular when mature. Ovaries are folded and convoluted when immature, folded and granular or with visible eggs when developing or ripe.

k. Collect a section of the right pectoral fin spine from every live white sturgeon collected over 150 cm fork length and from all fish of known sex. Spine sections are cut with a hacksaw within 1/4 inch from the articulation (knuckle) of the fin and cut again approximately 1/2 inch distally from the first cut. Spine sections are then separated from the fin with a knife, removing as much flesh and skin as possible, and placed into a scale envelope with a completed identification tag.

From all mortalities, collect the whole pectoral fin spine, including knuckle, from both sides of the fish. Separate the spines from the fins by running a knife between the spine and the rest of the fin. Press the spine anteriorly until the knuckle pops loose from connective tissue and cut it free with the knife. Remove as much flesh and skin as possible and place both spines in a plastic bag along with a completed identification tag.

l. Remove whole gonads from all developing or ripe female white sturgeon mortalities. Weigh the total egg mass to the nearest 10 grams prior to taking the gonad sample described in (1), or when collecting whole gonads. A few whole, developing, ripe female gonads will be needed to assess the optimum locatin for collection of samples. Whole gonad samples are placed in plastic bags along with a completed identification tag and covered with 10% formalin solution.

m. Collect a gonad sample from all unknown sex and all developing or ripe female gonads from each white sturgeon mortality for which the whole gonad is not collected. Samples of developing or ripe females should come from three locations of the egg mass and have a total weight of approximately 100 grams. Place samples in plastic bags, along with a completed identification tag, seal and keep cool. Immediately upon returning to the lab, weigh sample to the nearest 0.1 gram and immerse in Bovins solution. Allow the gonad sample to fix for 24 to 48 hours, then transfer sample to 70% ethenol for storage.

n. Ensure sturgeon is in good condition and actively swimming after processing is completed prior to releasing. Hold the fish overboard or in the live well and observe gilling action, orientation and swimming action. If the fish has obvious problems, retain until it is decided whether the fish will survive. Sacrifice any sturgeon that are doubtful and obtain biological information as if the fish was a mortality. Be sure tc change data codes to reflect the new disposition of the fish.

DATA RECORDING

Complete and accurate data recording is essential to accomplishing project objectives. Perfection in data recording is required, because without a reliable data set we may as well not sample. Double check everything to make sure the data is correct and recording is complete and legible.

A. Physical Sampling Information (top of data sheet)

This data describes the particular sampling situation that makes a set unique and identifies that set from all others. All physical sampling data except stop time is filled in after each set is deployed (most can be filled out prior to the set). The data sheet is retained until the gear is retrieved at which time stop time is recorded. Codes for data are described below and a summary sheet is available for reference while sampling.

1. Page ___ of ___ - initial sheet of each set is page 1. If more than 20 white sturgeon are captured, pages are numbered accordingly and all physical sampling information is copied to the new sheet.

2. Personnel - Initials of the sampling crew.

3. Station, set type - Identify of the general area and whether the set was made in an index area or a discretionary site.

4. Site Description - Detailed written description of the site so that it could be identified by the description above.

5. Weather - A short description of the weather conditions existing at the time of the set..

6. Setline Set On - Date and time setline was initially deployed. If the setline is checked and deployed at the same site, this date and time is again recorded on the new and any subsequent data sheets.

7. Pulled On - Date and time setline was pulled. Pulled time is the same as stop time.

8. **Record Type** - Identifies which data set this data belongs to

1 Physical sampling information

2 Fish biological information
C Angler survey counts
d Angler interviews
e Age data and annuli measurements
f Stomach contents
g Benthic information
h Physical and fish biological information

9. **Agency** Identifies agency collecting data

O - Oregon Department of Fish and Wildlife
N - National Marine Fisheries Service
F - U.S. Fish and Wildlife Service
W - Washington Department of Fisheries

10. **Sample Number** - Unique identification number corresponding to each unit of effort on a given sampling day. Each sampling day begins at midnight and the first set of the day is sample number 1. If more than one data sheet is needed to record catch, the sample number from the first page is repeated on subsequent pages.

11. **Date** - Date on which gear was retrieved.

A six digit code (format [MM,DD,YY]) - Month, Day, Year

12. **Resewoir** -

L - Below Bonneville Dam (lower river)
B - Bonneville Reservoir
D - The Dalles Reservoir
J - John Day Reservoir

13. **Location**

A five digit code - the first four digits are river mile (to nearest 1/10) - the last digit is a cross river code

1 - within 1/4 mile of WA shore
2 - midpoint of river to 1/4 mile from WA shore
3 - midpoint of river to 1/4 mile from OR shore
4 - within 1/4 mile of OR shore

NOTE: If the river is less than 1/2 mile wide adjust the above to 1/8 mile.

14. **Gear** - Two digit code uniquely identifying gear type

01 - Angling from boat
02 - Angling from bank

21 - 10 ft deep by 150 ft long experimental slacker net (4", 6-3/4", 9" stretch meshes)
40 - 600 ft long mainline, 40 hooks, 13-14 hooks each of 12/0, 14/0, and 16/0, size on 24' gangion lines.

15. Start Time - Time at which gear was fully deployed.
Military time (with midnight always 0000).

16. Stop Time - Time at which initial recontact with gear was made. For angling, time stopped fishing.
Military time (with midnight always 0000).

17. Effort - Length of time gear was in the water (float to float).
Recorded in hours (to 1/100 hour).

18. Depth of Set
Minimum depth - Depth at shallowest portion of set (to nearest foot).
Maximum depth - Depth at deepest portion of set (to nearest foot).

19. Water Temperature
Taken at surface (to nearest ^{o}C).
Note: If taken at depth, note temperature and depth in comments.

B. Biological sampling information (bottom and back of data sheet)

The front of the data sheet describes each white sturgeon captured by an individual set including measurements, condition at capture and subsequent disposition, marks and tags at capture and release and any samples taken. The back of the data sheet enumerates incidental catch of other species. Codes for data are described below and a summary sheet is available for reference while sampling.

1. Line Number

a. Line number of data sheet corresponding to an individual fish from a particular sample. Each data sheet will record up to 20 fish. When over 9 fish are captured, be sure to fill in first column.

b. If more than 20 fish are captured, begin page 2 with line number 21, page 3 with line number 41 and so on.

2. Species

For each white sturgeon captured enter "36" in species column. All other species are enumerated on the back of the data sheet.

3. Life Stage (Maturity) - The stage of gonadal development as determined surgically or by presence of extruded sexual products.

00 - Unknown adult maturity stage
05 - Pre-vitellogenic with attritic oocytes
06 - Pre-vitellogenic (nondeveloping and never spawned before)
01 - Maturing (gonads developing but will not spawn within 12 months)
02 - Mature (will spawn within 12 months)
03 - Ripe (will spawn within 2 months)
04 - Spent
70 - Immature (gonads undeveloped)
99 - General unknown (unknown maturity regardless of site)

4a. Fork Length

Length from tip of snout to point where upper and lower caudal lobes meet. Measured as fish lays on its side and tail is picked up and dropped into a natural position. Recorded to nearest whole centimeter.

4b. Total Length

Length from tip of snout to end of upper caudal lobe to nearest whole centimeter. Recorded in "Remarks" for fish whose fork length equals or exceeds 150 cm.

5. Weight - Wet weight of the fish in grams.

Recorded to nearest 100 grams (1 = 100 grams).

6. Pectoral Girth - Measurement around the fish immediately behind pectoral fins.

Recorded to nearest whole centimeter.

8. Sex - Determined surgically or by presence of sexual products.

M - Male
F - Female
U - Unknown

9. Total Gonad Weight (Female Only) - Weight of entire egg mass.

Recorded to nearest 10 grams.

10. Fish Disposition

First digit is sample type

1 - Regular Sampling
2 - Oxytetracycline injection
3 - Blood Chemistry
4 - Surgery Sample

Second digit is fish condition at capture and subsequent disposition.

0 - Unknown, no information
1 - Alive and released undersized
2 - Alive and released legal size
3 - Alive and released oversized
4 - Alive and kept or sacrificed undersized

5 - Alive and kept or sacrificed legal sized
6 - Alive and kept or sacrificed oversized
7 - Dead undersized
8 - Dead legal sized
9 - Dead oversized

11. Tag Status at Capture - *A* two digit code describing the status of tags on a fish at time of capture (spaghetti and tattoo).

First digit is dorsal tag:

0 - Unknown, no information
1 - Never before tagged
2 - Anterior and posterior present
3 - Anterior present, posterior never tagged before
4 - Anterior present, posterior missing
5 - Anterior never tagged before, posterior present
6 - Anterior missing, posterior present
7 - Anterior and posterior missing
8 - Another tag present
9 - Monet tag present

Second digit is tattoo:

0 - Unknown, no information
1 - No tattoo present, no evidence of previous tagging
2 - Tattoo present, legible
3 - Tattoo present, illegible
4 - No tattoo present, evidence of previous tagging

12. Tags Applied During Processing - a two-digit code describing the tags applied to a fish during processing.

First digit is dorsal tag:

0 - Unknown, no information
1 - No tag applied
2 - Anterior and posterior tags applied
3 - Anterior tag only applied
4 - Posterior tag only applied

Second digit is other tags applied:

0 - Unknown, no information
1 - No other tags applied
2 - Other tags applied

13. Marks at Capture - Secondary marks found on fish at time of capture

14. Marks Applied - Secondary marks applied to fish during processing.

Data codes are the same for both 13 and 14 above. Codes are three digits, the first describes fin mark, the second describes the barbel mark, and the third describes the lateral scute mark.

First digit is fin mark:

0 - Unknown, no information
1 - No fin marked
2 - Left pectoral fin ray section removed
3 - Left pectoral fin ray removed totally
4 - Right pectoral fin ray section removed
5 - Right pectoral fin ray removed totally
6 - Both pectoral fin rays removed totally

Second digit is barbel mark:

0 - Unknown, no information
1 - No barbel clip
2 - Left barbel clip
3 - Left center barbel clip
4 - Right center barbel clip
5 - Right barbel clip

Third digit is scute mark:

0 - Unknown, no information
- No lateral scutes removed
2 - Right 3rd lateral scute removed (1988 mark)
3 - Right 2nd and 3rd lateral scute removed (1988 with oxytet)

15. Tag Color - Color of spaghetti tag and or tattoo

0 - Orange
R - Red
W - White
Y - Yellow
G - Green
B - Black
Z - Other
1 - Orange spaghetti and black tattoo
2 - Yellow spaghetti and black tattoo

16. Tag Number - Number of spaghetti tag and/or tattoo

Includes 2-digit alpha and 5-digit numeric characters for spaghetti tags and/or 4-digit numeric character for tattoo.

17. Remarks - Used for recording anything about a fish that seems noteworthy. This space will also be used to record data on tag number and color from tags removed or other agencies tags. Also, data on total length may be recorded in "remarks," as needed. If more space is needed, indicate on the front and continue on the back of the data sheet. Be sure to iaentify line number on the back.

18. Nontarqet Species - Record number of each species, other than white sturgeon captured. by each gear set on the back of the data sheet. Preprinted lines with species names are provided. Hash marks or numbers are acceptable, however, if numbers are-used, circle the number on each line.

DAILY AND SEASONAL SCHEDULES

The crew will spend 2 weeks before scheduled field season constructing setlines, preparing boats (25-ft Munson and 22-ft '82 Boston Whaler) and training to use setlines and identifing suitable sampling sites. The crew will also outfit both boats to sample sturgeon as outlined in the Sampling Plan. The technician will maintain an inventory of gear throughout the sampling season. We will prepare or purchase replacement gear as needed.

Crews will sample two adjacent sections each week so that one crew can assist the other in an emergency, when one crew catches many more sturgeon than the other or when the Munson or '82 Whaler is out of service and a backup boat must be used (Table 3).

The technician will assign the Munson where he anticipates the greatest catch and the Whaler where he anticipates rough water. If we need to perform scheduled maintenance or repair on the Munson or Whaler crews may use a 22-ft '76 Boston Whaler to assist with sampling. Because we have not equipped the 76 Whaler with a line hauler, its crew will process fish captured by the crew of the Munson or '82 Whaler.

The technician will assign crews so that all crew members will (1) work together at sometime during the field season and (2) work on each boat for a similar length of time. The biologist and technician, however, will not work together on the same boat. The biologist or technician aboard the boat will be responsible for accomplishing sampling as planned. If the biologist and technician are not present, the technician will assign the responsibility to a seasonal employee.

We will assign seven people to work in The Dalles during each sampling week. Six crew members will sample sturgeon. The seventh person will:

1. Verify field data sheets
2. Summarize data
3. Perform scheduled maintenance on boats and vehicles (or ensure it is completed)
4. Fuel vehicles and boats
5. Maintain and fabricate field gear
6. Ensure the office is orderly
7. Brief the Clackamas staff on progress and needs
8. Replace a crew member who cannot sample

Table 3. White sturgeon sampling schedule The Dalles and Bonneville reservoirs, Oregon Department of Fish and Wildlife, 1988.

	Upper Tailrace	Lower Tailrace	Biggs-Upper Miller	Lower Miller-Celilo	Browns Island	Forebay	Upper Bonn.	Lower Bonn.
Apr 24-30				Training week				
May 1-7				Training week				
8-14	1	2						
15-21			1	2				
22-28					1	2		
May 29-Jun 4	1	2						
Jun 5-11					1	2		
12-18	1	2						
19-25					1	2		
Jun 26-Jul 2	1	2						
Jul 3-9			1	2				
10-16	1	2						
17-23			1	2				
24-30					1	2		
Jul 31-Aug 6							1&2	
Aug 7-13							1&2	
14-20								1&2
21-27								1&2

1 - Crew one
2 - Crew two

The technician will assign a different crew member to this position each week.

Crews will work four 10-hour days each week. Daily activities are as follows.

1. Day 1

   a. Crews will bait setlines.

   b. Crews will set setlines.

   c. If sets are completed before end of shift, crews will perform scheduled maintenance on boats and repair setlines as needed.

2. Day 2.

   a. Crews will pull a line, remove fish, bait empty hooks, and set line gain.

   b. Crews will process catch. Crews will repeat procedure for every setline.

3. Day 3

   a. Crews will pull a line, remove fish and bait, bait all hooks and set line again.

   b. Crews will process catch.

   c. Crews will repeat procedure for every setline.

4. Day 4

   a. Crews will pull a line, remove fish and bait, and stow setline.

   b. Crews will process catch.

   c. Crews will repeat procedure for every setline.

Crews will start at 0800 on Day 1. Crews will start at 0400 on days 2 through 4, so they can complete sampling by 1400 and avoid rough water caused by afternoon winds.

Crews will remove the following gear from boats daily:

1. Fathometer
2. Ice chest
3. Data sheets
4. Two-way radio
5. Personal gear

Crews will remove gangions and hooks from boats at the end of each sampling week.

TASKS BY STAFF

Project Leader

1. Write progress reports.
2. Prepare work statements.
3. Give presentations.
4. Design, direct, and assist with sampling program.
5. Design, direct, and assist with data analysis.
6. Hire, train, supervise, and evaluate performance of staff.
7. Review, approve, and track expenditures.
8. Coordinate activities with cooperators [work with WDF to schedule commercial sampling with FWS on tetracycline)

Assistant Project Leader

1. Assist project leader with designing sampling program and data analysis
2. Train project technician in scheduling and assigning sampling activities, maintaining vehicles, boats and equipment, and monitoring expenditures, mileage sheets, and seasonal timesheets.
3 Assist with sampling.
4. Review data sheets and arrange data entry on computer.
5. Write and execute computer programs to verify data entries.
6. Assist project leader with preparing reports, work statements, and presentations.

Project Technician

1. Prepare boats and equipment for the field.
2. Procure supplies and bait.
3. Secure
4. Arrange CPR training and orientation sessions.
5. Direct and assist with move to field station.
6. In consultation with the project leader, schedule and assign sampling activities and monitor expenditures, mileage sheets, and seasonal timesheets.
7. Assist with sampling.
8. Direct and assist with maintenance of boats and equipment.
9. Direct and assist with move back to Clackamas.
10. Assist project and assist project leaders with data analysis and report writing.

Seasonals

1. Assist with move to field station.
2. Prepare bait and gear (setlines, floats, and anchors).
3. Conduct sampling.
4. Maintain and repair boats and equipment.
5. Purchase supplies.
6. Maintain inventory list.
7. Maintain and submit mileage reports for vehicles.
8. Maintain office and storage areas (cleaning and upkeep).
9. Distribute and replace tag posters.

10. Review, verify, and summarize data sheets (what's been caught and where).
11. Prepare and section rays.
12. Prepare for sampling Bonneville Pool (maps and gear)

Other Agencies and Programs

What we need from CRM and WDF

1. Fin rays from sublegal fish and corresponding data.
2. Data sheets for tetracycline marked fish.

FIELD CHECK LIST

Boat

Radio
Fathometer
First aid kit
Flashlight (spare batteries)
Flares
Paddles
Fire extinguisher
Scrub brush on a stick
Propellers
Replacement spark plugs
Boat plugs
Batteries (freshly charged)
Fuel
Tool box
Outboard motor oil
Throwable device
Cotter pins

Setlining

Set Day

10 lines (2 trash cans full)
20 floats
20 anchors
Cooler with freshly baited hook
Bucket of 50 ft float lines
Bucket of 75 ft float lines
Bucket of 100 ft float lines
Carabeaners
Wash bucket

Subsequent Day

2 spare lines
2 spare floats
3 spare anchors
Cooler with new bait
Spare 50 ft lines
Spare 75 ft lines
Spare 100 ft lines
Spare carabeaners
40 spare hooks of each size
Lots of spare gangions
Wash bucket
Hook sharpener

Fish Processing

Measuring board
Large spaghetti tag needles
Spaghetti tags (at least 200)
Loose measuring tape
Spine saw (spare blades)
Spine envelopes
Knife
Gloves
Code sheet
Data sheets
Sharpened pencils
Large weighing scale (100 kg)
Small weighing scale (10 kg)
Large & small sling
Diagonal cutters
Finger nail clippers

Surgery

Surgical box
Towels
Scalpels
Scalpel blades
Tissue forceps
Viles
Otoscope
Sutures
Hemostats
Probe
Scissors
Tupperware containers
Nolvosan short term sterilant

Tetracycline Treatment

3 cc disposable syringes filled with oxytetracycline
Replaceable needles
Iodine
Cotton balls

Personal **Gear**

Coveralls
Rain jacket
Rain bibs
Hip boots
Life vest
Sun tan lotion (Sunscreen)
Sun glasses
Water

Tools and Tool Box

Screwdrivers (flat and phillips)
Pliers
Vice grips
Gap tool
Open end wrenches (assorted)
Electrician tool
Assorted nuts and bolts
WD-40
Switches
Crescent wrench
Needle nose pliers
Wire brush
Socket set
Diagonal cutters
Electrical tape
Rag
Wire
Fuses

CRR-1

APPENDIX B

1. Description of the white sturgeon recreational fishery in the Columbia River between Bonneville and McNary dams.

2. Description of some reproduction and early life history characteristics of white sturgeon populations in the Columbia River downstream from Bonneville Dam.

3. Description of the life history and population dynamics of subadult and adult white sturgeon in the Columbia River downstream from Bonneville Dam.

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CONTENTS

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ABSTRACT

A primary WDF study responsibility was sampling the recreational fishery in The Dalles Reservoir for mark recovery, biological, and harvest data required for ODFW's population dynamics modeling. From June-October 7,038 anglers were interviewed for a total estimated harvest of 1,983 legal-size white sturgeon. An estimated 27 sturgeon marked by ODFW were included in that harvest.

WDF was also responsible for developing, then applying a population dynamics model to the white sturgeon population below Bonneville Dam. The model parameters were selected. Data from existing, separately-funded programs was analyzed for adequacy for use in the model. Initial estimates of survival and mortality were determined from the data.

Finally, coordination and cooperation efforts with ODFW, NMFS, and FWS continued through the year. WDF's sampling for white sturgeon eggs and larvae under another existiug program was closely coordinated with NMFS.

INTRODUCTION

Under the study agreement, WDF is responsible for segments of Study Objectives 1, 2, and 4 (ODFW et al. 1987). Primary tasks include sampling the recreational and commercial fisheries above Bonneville Dam for white sturgeon Acipenser transmontanus mark recovery, biological profiling and harvest data; as well as characterizing the iife history, dynamics, and stock status of white sturgeon populations below Bonneville Dam. This report describes sampling activities and results for 1987, and preparations for the 1988 sampling season.

METHODS

Reproduction and Early Life History

Coordination of existing WDF program activities to assess reproduction below Bonneville Dam and NMFS activities under this study to assess early life history continued. As in 1986, WDF provided personnel and D-ring plankton nets with flow meters to the sampling activities which occcurred from March-November. See APPENDIX D National Marine Fisheries Service for specifics regarding gear types, sampling techniques utilized, and other data collected.

Samples were preserved in buffered 10% Formalin. WDF examined the samples for eggs and larvae, of which ail found were enumerated, aged, and placed in 10% methanol. White sturgeon eggs were staged and larvae aged according to Beer (1980). Spawning dates were back calculated for all eggs and posthatch larvae according to Wang et al. (1985). Larvae were measured to the nearest 0.01 ma.

Subadult and Adult White Sturgeon

Commercial Fishery Sampling

Commercial fishery sampling for mark recovery, biological profiling. and harvest data was conducted under state-funded programs during gillnet fisheries below Bonneville Dam, and setnet and setline fisheries above Bonneville Dam (Tracy 1987b, 1987c, 1987d. 1988a; WDF. unpublished data). Biological data collected included pectoral fin rays for aging. total and fork lengths, weight, sex, and gonad maturity samples. All fish were examined for marks from ODFW sampling under this study, and for marks from previous tagging studies in Bonneville (Malm 1981) and John Day (personal interviews with Thomas Macy, U.S. Fish and Wildlife Service. Vancouver, Washington) reservoirs, and below Bonneville Dam (Kreitman 1984; Bluestein 1985. 1986; WDF, unpublished data).

Recreational Fishery SAmpling

Angler sampling in The Dalles Reservoir occurred from June-October 1987 to recover marked white sturgeon, collect biological profiling data, and to estimate harvest. Biological data collected included fork and total lengths, weight, sex, pectoral fin ray and gonad samples.

Angler effort was estimated from aerial counts of all bank and boat anglers along the entire reservoir and ground counts within an index area. The index area extended from John Day Dam downstream 10 miles (Figure 1). On flight days, an index area count was made every three hours throughout the day including a simultaneous count during the time of the flight. Index counts took from 1 to 1 l/2 hours, but were considered instantaneous. From the aerial count data, the proportion of the total effort represented by the index area counts was determined from a comparison of the two simultaneous counts. This proportion was applied to the index counts during the nonflight hours to yield an estimate of the total angling effort that occurred on the flight day. On nonflight days, a single ground index count was made each day that samplers were in the field. These single counts occurred at variable hours. The intent of the effort estimating procedure was to have a count (aerial or single) on at least 75% of the days.

Aerial counts were conducted on one randomly selected weekend day per week and three weekdays per month. No two weekday flights were made in the same week each month.

Index counts began within three hours of sunrise, continued until sunset,and consisted of bank rod counts to determine bank effort, and boat trailer counts to determine boat angler effort.

Samplers interviewed anglers at bank fishing sites and boat ramps to determine angler type and catch per hour of effort for each species in the catch. Interviews took place between effort counts and on nonflight days.

Both effort and catch sampling data was stratified by bank and boat angler types, and river section, as well as weekday and weekend effort to account for differences in catch rates. Boundaries between river sections were the railroad bridge (RM 201.2) and the Highway 97 bridge (RM 209.1). Trailer counts within the index section were correlated to counts of angler boats observed during the flights. Removal of marked white sturgeon per two week period was estimated by multiplying the observed harvest of marked fish per hour of effort for each angler type by the total estimated effort for each angler type for that period.

Population Dynamics Modeling

Mortality, growth,and reproductive potential have been identified as the primary parameters needed to describe the life history and population dynamics of subadult and adult white sturgeon. These parameters will be estimated for populations below Bonneville in this study and for populations above Bonneville Dam by ODFW. For populations downstream of Bonneville Dam.

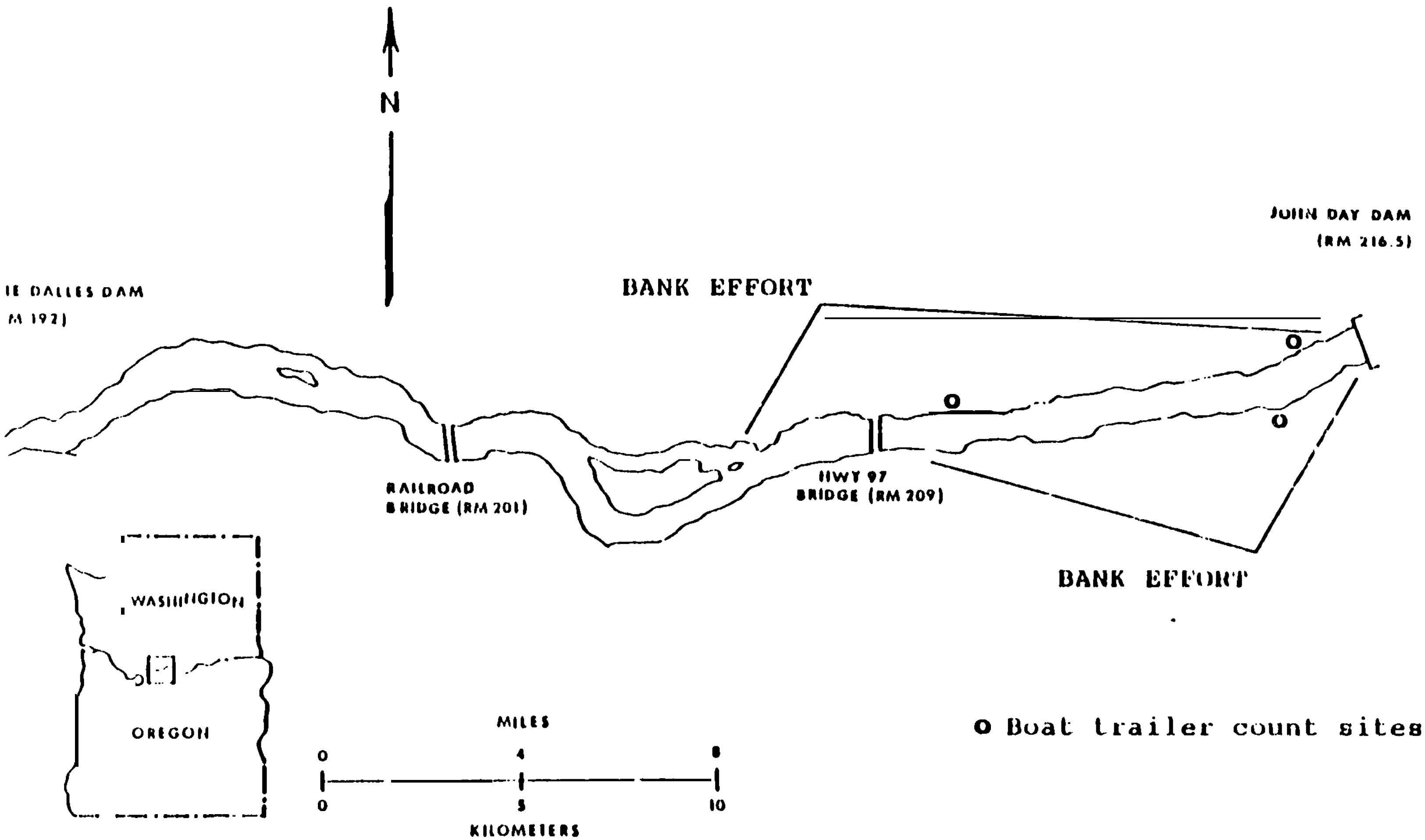

Figure 1. Area where anglers were counted on The Dalles Reservoir, 1987.

data is being collected through separately funded tagging studies and fishery sampling programs. These data will be compared to the associated estimates from white sturgeon populations above Bonneville Dam. This comparison and the integration of the population dynamics data from other sturgeon studies is one primary objective of this study. A population dynamics model for white sturgeon is being refined by ODFW from a population simulation model developed for other species. The simulator incorporates growth, recruitment, mortality, and reproductive potential using an age-structured Leslie type matrix approach. The white sturgeon model will be used to assess differences in the population dynamics of the stocks above vs. below Bonneville Dam. After these differences are identified then further investigation will determine the impacts that hydroelectric projects have on white sturgeon. So far, our work efforts have focused on analyzing the information from the studies of white sturgeon below Bonneville Dam.

The methods used for making initial estimates of population parameters for white sturgeon downstream of Bonneville Dam are described below.

The approach selected to estimate abundance and fishing mortality required the capture, external marking, release, and future recovery of white sturgeon. Sturgeon tagging in 1987 occurred from March-September at five primary locations on the Columbia River below Bonneville Dam (Figure 2) (Tracy 1987a; WDF unpublished data). Commercial fishermen were contracted to catch white sturgeon with drift gillnets ranging in mesh size from 6 l/4 in. to 8 in. stretch mesh. Untagged sturgeon caught greater than 62 cm FL were tagged with either one or two spaghetti tie tags at the base of the dorsal fin, then released. Tag loss was addressed by examining recoveries of double tagged fish (Eberhardt et al. 1979). Each tag was sequentially numbered to identify individual fish.

Size selectivity by capture gear (drift gillnet) was examined by comparing size composition of white sturgeon caught during tagging with the size composition of samples taken from the recreational fishery below Bonneville Dam. Only the 1986 data has been examined so far. but 1987 data will also be analyzed.

Tag recoveries from recreational and commercial fishery sampling were used to calculate exploitation. The number of tagged fish observed during sampling was expanded by the proportion of the total estimated harvest sampled.

Initial estimates of white sturgeon survival and total mortality were made by examining existing length and age structure data. Catch curves were constructed from length data collected from both the 1986 recreational fishery and fish captured for tagging in 1986. Ages were assigned to observed lengths based on the age length relationship reported by Hess (1984). Average annual survival was calculated as described in Ricker (1975). Log transformed sample size (Y) was regressed on age (X). The slope from this regression was multiplied by 2.3 (Ricker 19753 to get the instantaneous rate of mortality (Z). Annual survival (S) was calculated as S=e^-2 and annual total mortality (A) as A=l-S.

The leading rays of pectoral fins collected below Bonneville Dam were dried, sectioned with a jeweler's saw, and mounted in preparation for aging. Pectoral fin ray samples collected in 1987 were aged.

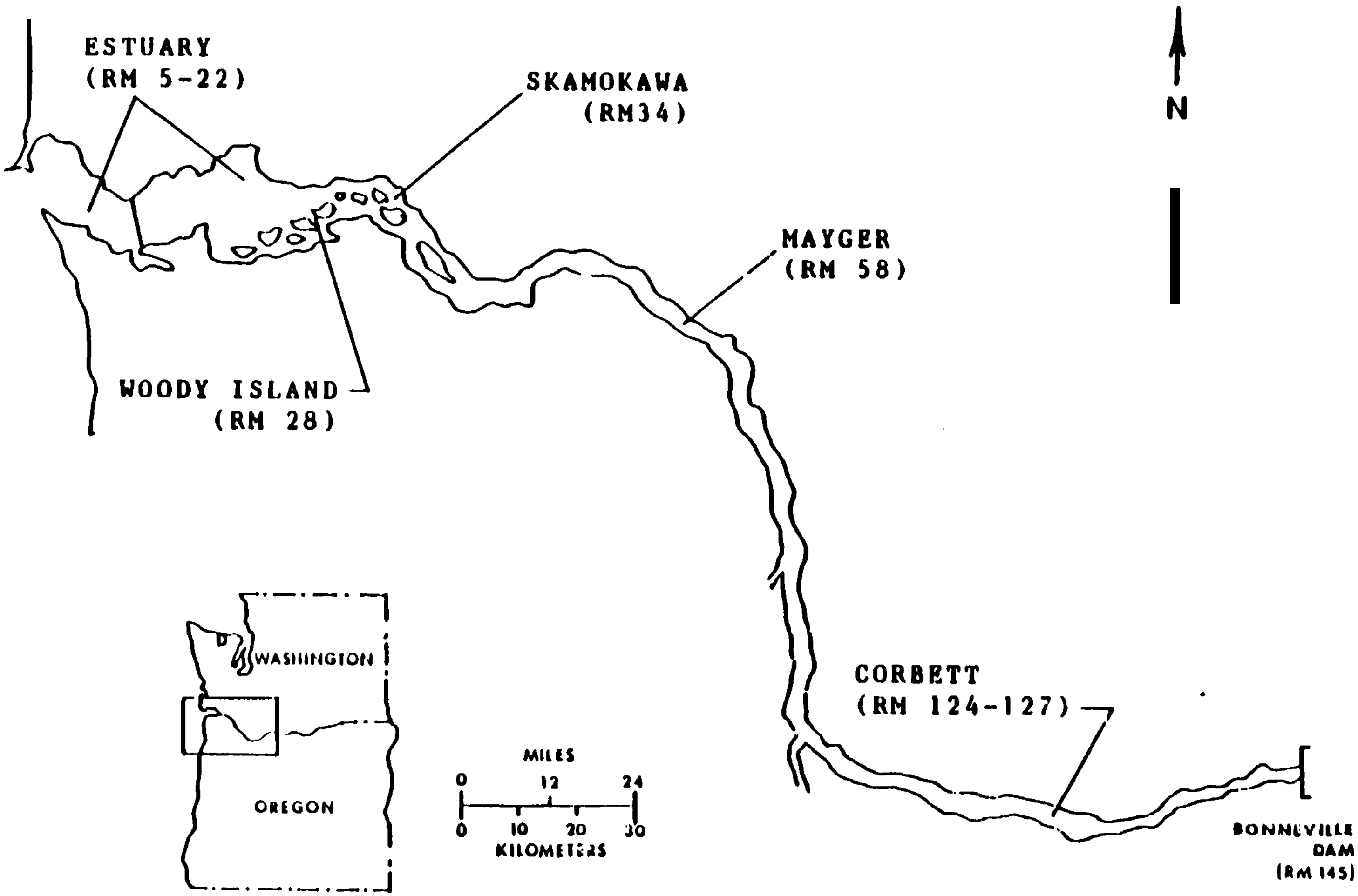

Figure 2. Locations on the Columbia River below Bonneville Dam where white sturgeon were captured and tagged in 1986 and 1987.

RESULTS

Reproduction and Early Life History

Sampling for sturgeon eggs and larvae below Bonneville Dam started on 18 March and concluded on 16 November (Tracy 1988b). A total of 18 white sturgeon eggs and 40 larvae were taken during sampling. For results pertaining to data other than egg and larval age and length, see APPENDIX D National Marine Fisheries Service.

All eggs were taken between 21 April and 19 June, and all but two were sampled from the Ives Island area. The other two eggs were sampled upstream off Hamilton Island. One egg was fungused and another was abnormal. The other 16 eggs ranged from unfertilized to about four days prehatch (Table 1). Stage 2, initial fertilization, eggs represented 38% of the staged eggs sampled in 1987.

Estimated spawning dates back calculated from the egg stages and larval ages ranged from 20 April to 19 June, with peak spawning activity between May 4 and May 24.

Forty larvae were taken between 5 May and 2 June anywhere from Ives Island downstream to the I-205 bridge. Larval ages ranged from posthatch to thirteen days posthatch, with one-day posthatch representing 53% of those aged (Table 2). The average length of all larvae measured was 13.76 mm (Figure 3).

Subadult and Adult White Sturgeon

Commercial Fishery Sampling

A preliminary estimate of 5,671 white sturgeon were landed during the 23 June-10 July and 8 August-15 November commercial setnet fisheries, and the July-November portion of the sturgeon setline fishery between McNary and Bonneville dams (Table 3). Forty two percent of that preliminary catch, or 2,386 fish, reportedly came from The Dalles Reservoir.

About 18% of the commercial harvest was sampled for marked fish (Table 3). Fourteen ODFW marked white sturgeon were observed during sampling, 11 from landings known to have originated from The Dalles Reservoir. Estimated total harvest of ODFW marked white sturgeon was 77 fish for June-November.

Fork length (FL) of white sturgeon averaged 121 cm and ranged from 102 to 167 cm (Figure 4). Totals of at least 207 female gonad and 509 pectoral fin ray samples were collected and delivered to ODFW for processing.

Table 1. Numbers of white sturgeon eggs by developmental stage by date sampled at Ives and Hamilton Islands, 1987.

	Egg development stage									
Date	1	2	4	6	7	8	9	11	16	Total
Apr 21	1	3	0	0	0	1	0	0	0	5
May 5	0	0	0	0	0	0	0	1	0	1
21	0	2	1	1	0	0	2	0	1	7
Jun 2	0	1	0	0	0	0	0	0	0	1
19	0	0	0	1	1	0	0	0	0	2
Season										
No.	1	6	1	2	1	1	2	1	1	16
%	6	38	6	13	6	6	13	6	6	100

Table 2. Numbers of white sturgeon larvae by age by date sampled, 1987.

Date	Post-hatch	1	2	3	4	5	6	10	13	Total
		Number of days posthatch								
May 5	0	1	0	0	0	0	0	0	0	1
21	2	3	2	0	1	1	0	0	0	9
22	0	5	0	0	0	0	0	0	0	5
27	1	4	0	1	1	0	0	0	0	7
28	1	8	3	0	0	0	0	0	1	13
Jun 1	0	0	0	0	0	1	0	0	0	1
2	0	0	1	1	0	0	1	1	0	4
Season										
No.	4	21	6	2	2	2	1	1	1	40
%	10	53	15	5	5	5	2	2	2	99

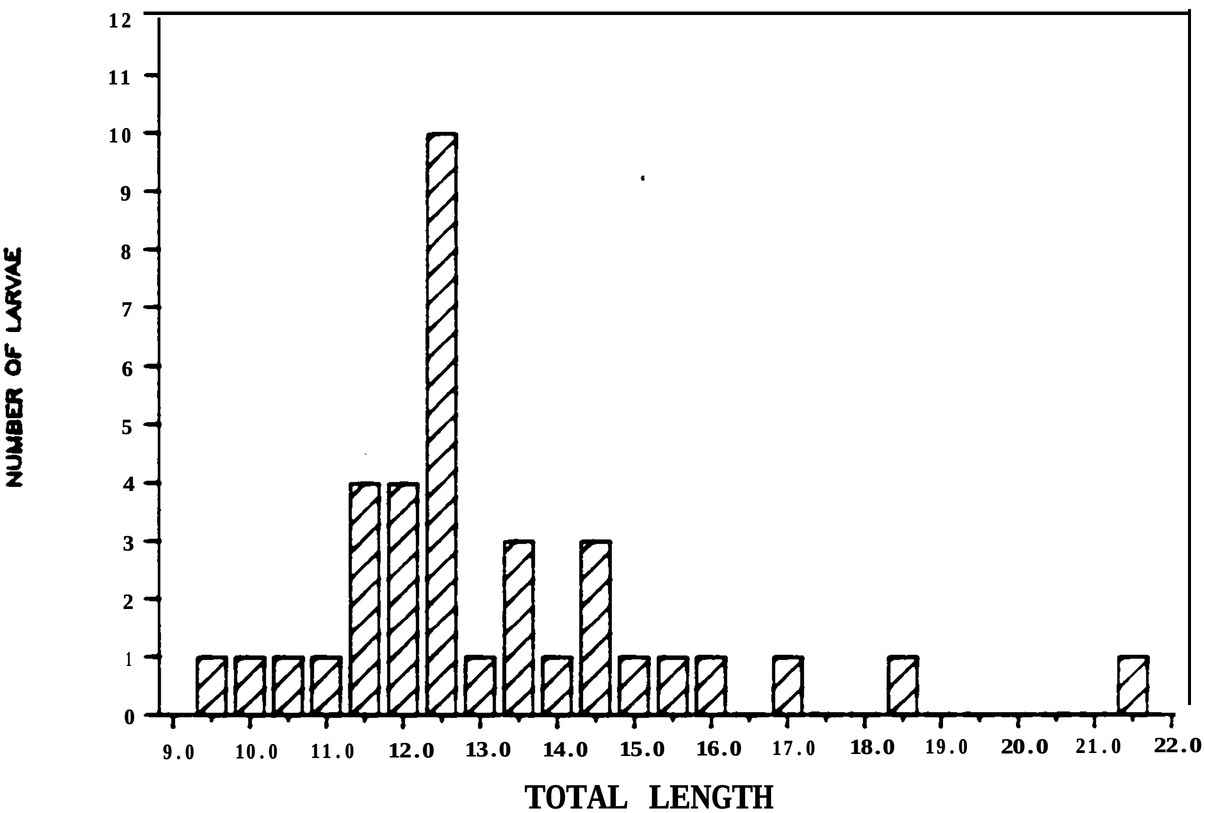

Figure 3. Length frequency distribution of white sturgeon larvae sampled below Bonnevilele Dam in 1987.

Table 3. Preliminary landings, mark sample summary and estimated harvest of ODFW marked white sturgeon by month by reservoir from commercial fisheries between McNary and Bonneville dams, June-November 1987.

Category	Jun	Jul	Aug	Sep	Oct	Nov	Total
Landings:							
The Dalles pool	0	516	1,066	618	185	0	2,285
Other pools[a]	216	713	1,525	434	315	83	3,286
No. mark sampled:							
The Dalles pool	0	76	187	148	34	0	445
Other pools[a]	6	105	257	104	58	3	533
Mark sample rate:							
The Dalles pool	0.00	0.15	0.18	0.24	0.18	0.00	0.19
Other pools[a]	0.03	0.15	0.17	0.24	0.18	0.04	0.16
Observed marks:							
The Dalles pool	0	2	5	2	2	0	11
Other pools[a]	1	1	0	1	0	0	3
Total mark harvest:							
The Dalles pool	—	—	–	–	–	—	59
Other pools[a]	—	—	–	–	–		18
Total	—	—	--	--	--		77

[a] Includes cases where the pool was not identified.

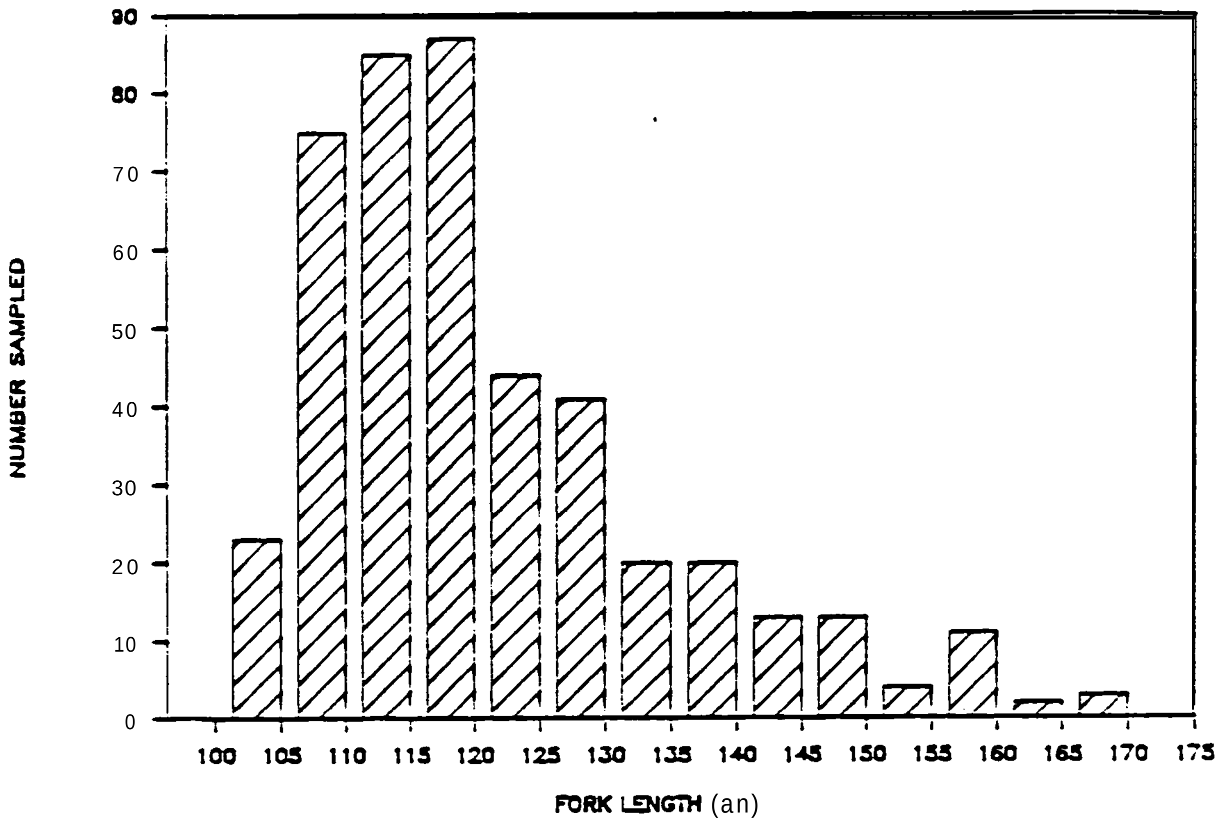

Figure 4. Length frequency distribution of white sturgeon sampled from The Dalles Reservoir commercial fishery landings, June-November, 1987.

Recreational Fishery Sampling

Angler effort was counted on 126 of a possible 153 days available for sampling in June-October (Table 4). Samplers interviewed 7,038 anglers in The Dalles Reservoir from June-October (Table 5). This includes sampling of Columbia River boat anglers at both the Deschutes River mouth and Celilo ramps by ODFW's district office and Columbia River Management (CRM) section from July-October.

Anglers harvested an estimated 2,002 white sturgeon during June-October (Table 6). Interviewed anglers handled 1,949 white sturgeon of which 439 were kept (Table 7). Proportions of sublegal (less than 82 cm FL), legal-site, and oversize (greater than 166 cm FL) handled were 0.70, 0.29, and 0.01 respectively. Fish harvested ranged from 81-170 cm FL with a mean of 110 cm FL (Figure 5).

Five ODFW marked white sturgeon were observed in the sampled harvest. An angler released a sixth ODFW marked sturgeon while being interviewed. Anglers harvested an estimated 27 ODFW marked sturgeon during June-October (Table 8). Additional information on 31 kept or released tagged fish was voluntarily returned to WDF by anglers, 25 from fish reportedly caught during the angler survey, and 6 from fish caught after the survey (1 in November and 5 in December).

Population Dynamics Modeling

Existing white sturgeon tagging programs were evaluated for their usefulness in providing mark-recapture data to estimate abundance and fishing mortality and in providing age structure data to estimate total mortality and growth. Recreational and commercial fishery sampling data was examined for white sturgeon fecundity, spawning frequency, age at first maturation and age structure data.

In tagging programs below Bonneville Dam, a total of 4,448 white sturgeon were tagged in 1986 and 3,756 in 1987. These values represent 87% and 67% of the total number handled during tagging activities in 1986 and 1987 respectively. Most of the tagging effort occurred in the lowermost 35 miles of the Columbia River where sturgeon abundance was high.

An initial investigation into the size selectivity of drift gillnets to capture white sturgeon for tagging revealed that the length frequency of legal-size fish captured during tagging in 1986 was similar to the distribution found in the recreational fishery (Figure 6). This would indicate minimal size bias exists in the 3-6 foot tagged fish population. The white sturgeon captured for tagging in 1986 ranged in size from 24-185 cm FL (Figure 7).

Preliminary analysis of 1986 tagging data provided exploitation estimates ranging 16-35X for fish tagged at the different tagging sites (Table 9). Monthly tag loss rates of 0.016 and 0.001 for fish marked with single and double tags respectively, were applied to the observed removals

Table 4. Numbers of angler effort count days from The Dalles Reservoir recreational fishery, June-October 1987.

Sample period	Effort count type		
	Flight	Sunrise-sunset index	Once through index
6/ 1 - 6/14	3	3	7
6/15 - 6/28	4	4	7
6/29 - 7/12	3	3	8
7/13 - 7/25	3	3	7
7/26 - 8/10	4	4	9
8/11 - 8/23	3	3	6
8/24 - 9/ 7	3	3	12
9/ 8 - 9/20	4	4	8
9/21 - 10/ 4	3	3	9
10/ 5 - 10/18	4	4	10
10/19 - 10/31	2	2	6
Total	36	36	90

Table 5. Numbers of anglers interviewed from The Dalles Reservoir recreational fishery, June-October 1987.

Sample period	Boat		Bank	
	Sturgeon	Other	Sturgeon	Other
6/ 1 - 6/14	64	25	220	144
6/15 - 6/28	84	36	429	90
6/29 - 7/12	110	64	370	76
7/13 - 7/25	86	123	338	104
7/26 - 8/10	46	119	196	161
8/11 - 8/23	28	25	116	152
8/24 - 9/ 7	53	676	152	237
9/ 8 - 9/20	31	969	157	202
9/21 - 10/ 4	38	310	137	277
10/ 5 - 10/18	46	36	101	228
10/19 - 10/31	6	3	61	113
Total	592	2,385	2,277	1,784

Table 6. Estimated angler effort and white sturgeon harvest from The Dalles Reservoir recreational fishery, June-October 1987.

Category	Sample period											
	6/1-6/14	6/15-6/28	6/29-7/12	7/13-7/25	7/26-8/9	8/10-8/23	8/24-9/7	9/8-9/20	9/21-10/4	10/5-10/18	10/19-10/31	Total
Total effort:												
All[a] bank	10,128	11,892	10,709	9,494	7,979	4,948	7,594	5,321	5,090	4,758	3,261	81.174
All[a] boat	4,176	4,092	4,550	5,125	12,685	6,803	17,267	12,223	4,919	3,993	1,482	77,315
Total	14,304	15,984	15,259	14,619	20,664	11,751	24,861	17,544	10,009	8,751	4,743	158,489
Stgn[b] bank	6,783	10,513	8,675	7,272	5,202	2,632	3,152	2,348	1,593	1,706	818	50,694
Stgn[b] boat	2,344	3,079	3,284	2,144	3,942	1,521	1,852	879	402	871	561	20,879
Total	9,127	13,592	11,959	9,416	9,144	4,153	5,004	3,227	1,995	2,577	1,379	71,573
Success rate:												
Stgn[b] bank	0.030	0.036	0.028	0.011	0.012	0.009	0.015	0.026	0.015	0.010	0.011	0.023
Stgn[b] boat	0.058	0.084	0.034	0.043	0.021	0.021	0.029	0.016	0.032	0.039	0.032	0.041
Total harvest:												
Stgn[b] bank	205	376	246	83	64	23	46	60	24	17	9	1,153
Stgn[b] boat	137	259	113	93	83	32	53	14	13	34	18	849
Total	342	635	359	176	147	55	99	74	37	51	27	2,002

[a] All - Total effort in hours for all angler types.
[b] Stgn - Sturgeon. Total effort in hours, harvest rate,and estimated total harvest for sturgeon anglers only.

Table 7. Numbers of white sturgeon reported in the sampled catch from The Dalles Reservoir recreational fishery, June-October 1987.

Sample period	Boat				Bank			
		Legal-size				Legal-size		
	Sub Legal	Rel.[a]	Kept	Over-Site	Sub Legal	Rel.[a]	Kept	Over-Size
6/1 - 6/14	65	6	20	3	34	5	33	7
6/15 - 6/28	186	4	40	1	193	49	92	7
6/29 - 7/12	50	2	24	0	207	25	53	1
7/13 - 7/25	93	6	25	1	150	9	19	1
7/26 - 8/10	45	5	9	0	45	2	13	0
8/11 - 8/23	15	0	5	0	21	0	18	0
8/24 - 9/7	18	0	6	0	33	0	16	1
9/8 - 9/20	9	1	4	0	28	2	19	0
9/21 - 10/4	52	1	11	0	23	0	11	3
10/5 - 10/18	60	0	11	0	32	1	7	0
10/19 - 10/31	0	2	1	0	6	0	2	0
Total	593	27	156	5	772	93	283	20

[a] Legal-size (about 82-166 cm FL) sturgeon which were released.

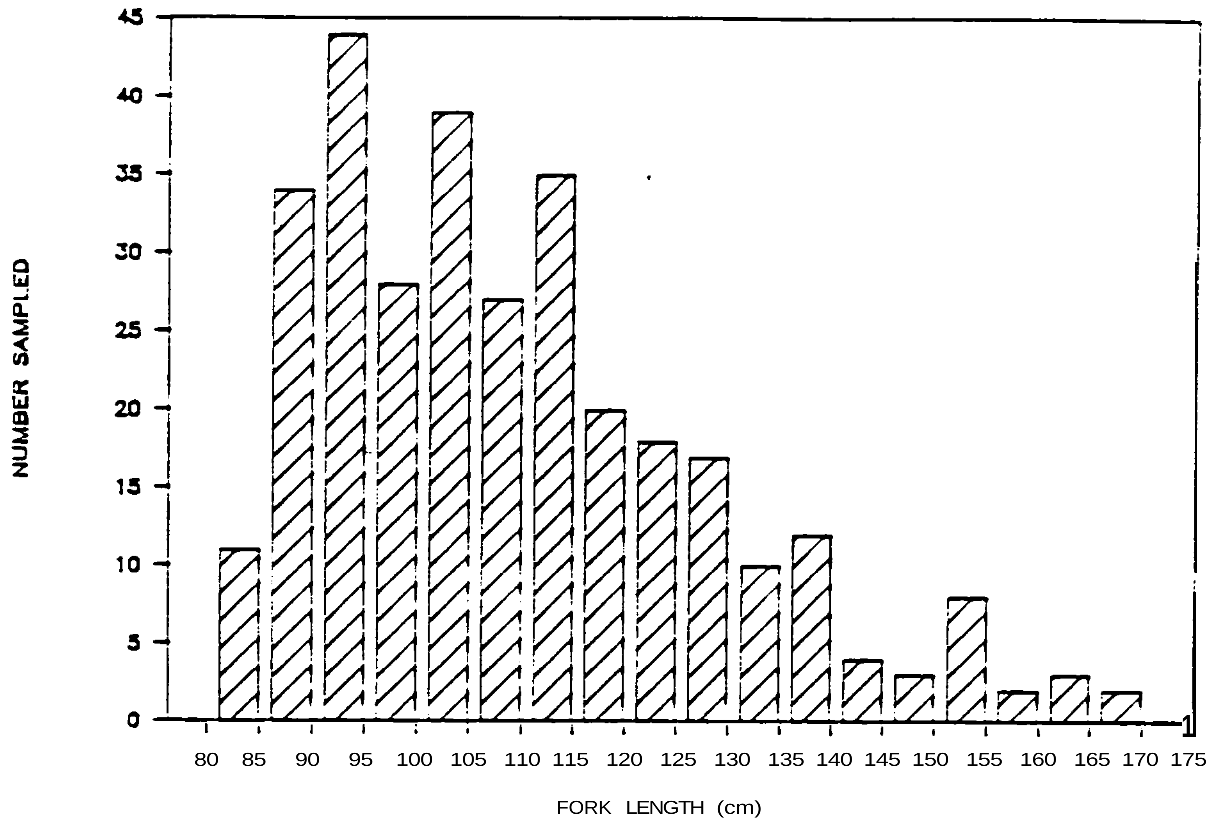

Figure 5. Length frequency distribution of white sturgeon sampled from The Dalles Reservoir sport fishery, June- October, 1987.

Table 8. Mark sample summary and estimated harvest of ODFW marked white sturgeon from The Dalles Reservoir recreational fishery, June-October 1987.

Sample period	Estimated harvest	No. mark sampled	Hark sample rate	Observed marks	Estimated mark harvest
6/ 1 - 6/14	342	41	0.12	0	--
6/15 - 6/28	635	114	0.18	2	--
6/29 - 7/12	359	65	0.18	0	--
7/13 - 7/25	176	38	0.22	2	--
7/26 - 8/10	147	22	0.15	0	--
8/11 - 8/23	55	13	0.24	0	--
8/24 - 9/ 7	99	18	0.18	0	--
9/ 8 - 9/20	74	15	0.20	0	--
9/21 - 10/ 4	37	21	0.57	0	--
10/ 5 - 10/18	51	18	0.35	1	--
10/19 - 10/31	27	2	0.07	0	--
Total	2,002	367	0.18	5	27

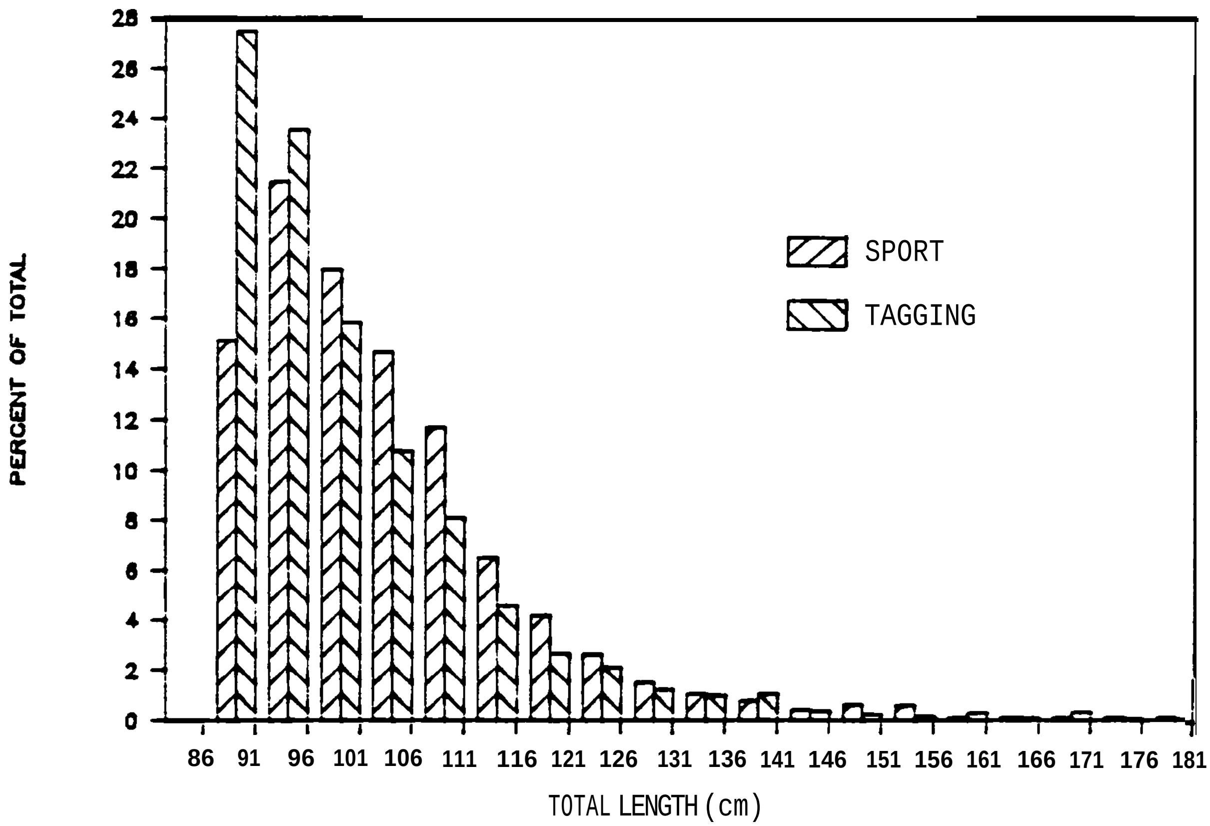

Figure 6. Relative length frequency distributions of legal-size white sturgeon sampled from the recreational fishery and tagging operation below Bonneville Dam in 1986.

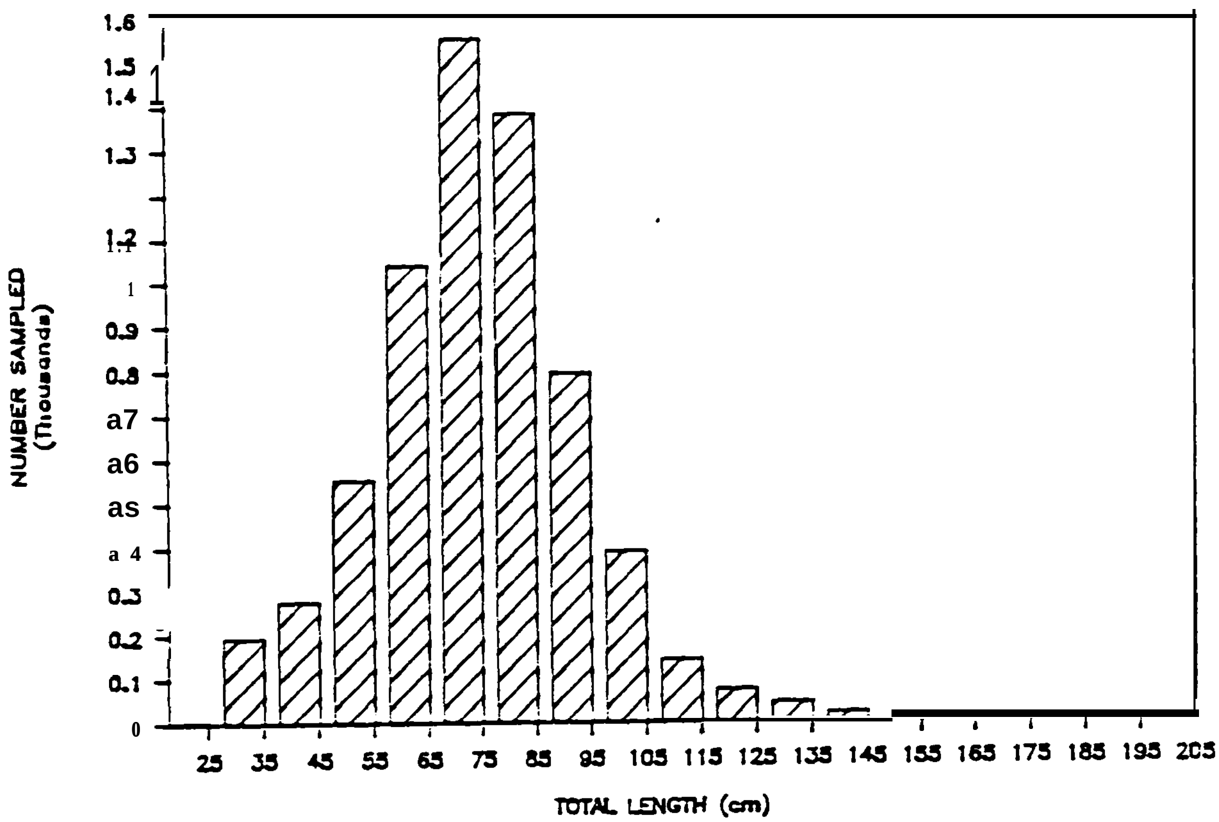

Figure 7. Length frequency distribution of white sturgeon captured during tagging operations below Bonneville Dam, March-September, 1986.

Table 9. Estimated exploitation of legal-size white sturgeon captured, tagged and released below Bonneville Dam, March-June 1986, and removed by recreational and commercial fisheries the following 12 months.

Month	Number tagged & released	Observed removals	Estimated total removals	Exploitation
Mar	345	25	119	0.35
Apr	924	33	151	0.16
May	796	41	201	0.25
Jun	947	67	310	0.33
Total	3,012	166	780	0.26

to account for marked fish overlooked by samplers due to tag loss. The observed removals were expanded by mark sampling rates of 18% for the recreational fishery and 35% for the commercial fishery to estimate total removals. This initial analysis did not include stratifying sampling data by subsection to adjust for varying sample rates between river section. Fishing mortality rates based on 1987 tagging data have not been completed.

Two preliminary estimates were made of recent year average annual survival experienced by 3-4 foot white sturgeon from below Bonneville Dam sampled in 1986. The estimates were based on the frequency of the age 8-13 year-old fish represented by this size class and assumed that recruitment of age 8 year-old fish during the previous 5 years was stable. Annual total survival, averaged for the five years, was estimated to be 0.61 for 3-4 foot white sturgeon represented by recreational fishery samples and 0.56 for 3-4 foot fish sampled during tagging. These values convert to average annual total mortality estimates of 0.39 and 0.44 respectively.

Initial age determination was made for approximately 240 white sturgeon sampled in 1987 from below Bonneville Dam. Fin ray samples from The Dalles Reservoir were also examined. Three different readers aged The Dalles Reservoir samples with inconsistent results. The samples collected from white sturgeon below Bonneville Dam appeared easier to age, however, they were examined by only one reader. Standard aging criteria were developed to improve consistency between readers.

Maturity was estimated for 314 female white sturgeon sampled from 1987 commercial fisheries below Bonneville Dam. These fish ranged in size from approximately 100-175 cm FL. A problem was identified with determining mature female white sturgeon abundance and spawning frequency. The majority of spawning female sturgeon are larger than the legal limit; consequently, the opportunity to collect samples representative of the entire population is limited. Similarly, the reproductive parameters determined for mature legal size sturgeon may not be valid for the larger fish.

DISCUSSIOA

Reproduction and Early Life History

Sampling methodology and environmental conditions in 1987 differed from previous years. Sampling procedures have been expanded from those initiated in 1983 under a Dingell-Johnson funded study by WDF (see Kreitman 19831. Low flow conditions in 1987 precluded using the site at Ives Island which was used as an index in prior years. Sampling and environmental differences may have combined to partially explain the peak spawning period between May 4 and May 24. This timing is earlier than 1985-86 but later than 1984. The relationship between time of spawning and river flows and water temperature remains somewhat unclear. Data in 1987 and from previous years suggest that water temperature of 10-14^{O}C is the key factor. Flow may simply be correlated with temperature or could possibly be a direct stimulus to fish activity and spawning because of the increased water movement.

Subadult and Adult White Sturgeon

The angler survey approach in The Dalles Reservoir was evaluated by examining both the proportion of the estimated harvest that was mark sampled and the proportion of observed effort that was in the index area. About 19% of the estimated June-October recreational harvest was sampled for marked sturgeon. The index area accounted for about 97% of the observed bank effort and 24% of the boat effort. Consequently, several changes have been made to the 1988 sampling approach. First, the index section was modified to include the boat fishery off the Deschutes River mouth. Second, to strengthen effort estimates without significantly impacting time devoted to interviews, an additional weekday flight per month was added. Finally, boat counts rather than trailer counts would be made during the index counts.

Limited information is available to compare with the 1987 recreational sturgeon fishery in The Dalles Reservoir. In June-July 1981 a white sturgeon harvest estimate of 659 fish was made for the area from Miller Island to John Day Dam (King 1981). For the same general area and time period, 1,138 fish were harvested in 1987. Greater effort and a higher catch per unit effort was observed in 1987 than in 1981.

Evaluation of existing programs to provide abundance, mortality, growth and reproductive parameters of white sturgeon populations below Bonneville Dam was a primary objective in 1987. Efforts focused on analyzing data collected in 1986 and 1987.

Under other existing programs, Columbia River white sturgeon below Bonneville Dam have been captured and tagged since 1965. Use of drift gillnets has proven to be an efficient method to capture large numbers of white sturgeon for tagging. Columbia River commercial fishermen are contracted to do the fishing, while on-board biologists conduct the tagging operation. Of the dozen or so tags tried since 1965, the spaghetti tie tag has had the best retention. It has been the tag of use since 1982, and is now readily recognizable by both fishermen and samplers.

A common mark-recapture practice in estimating abundance is to utilize the same sampling effort to capture fish for tagging and to sample for recoveries from previous tagging efforts. This requires a systematic approach which insures that representative samples are collected from the entire river and that the tagged fish have the same chance of being recovered as nontagged fish. In this respect the existing tag program is probably inadequate and a modified approach is needed.

The existing programs below Bonneville Dam have concentrated on capturing sturgeon where they are most abundant. Four of the five sites used to capture sturgeon are located within 35 miles of the Columbia River mouth while the distance between Bonneville Dam and the Columbia River mouth is 145 miles. Therefore, the tagged sturgeon population is probably biased. It is unreasonable to assume the tagged fish have adequately mixed with the entire lower river population prior to subsequent sampling efforts.

Another problem with using the tagging efforts to sample for previously tagged fish has been that relatively few tagged fish are recaptured with this gear. In both 1986 and 1987 fewer than three percent of the tagged fish were recaptured during subsequent tagging operations the same year. Those that were recovered tended to be fish which had just been released a few weeks earlier at the same location.

These two deficiencies and the biases they create can be diminished by relying on in-sample recoveries from the recreational fishery. This fishery is extensively sampled for harvestable-size fish in a relatively unbiased manner . Over five percent of the legal-size white sturgeon tagged in 1986 were recovered during the following twelve months of recreational fishery sampling. Intensive angling effort occurs throughout the length of the lower Columbia River from Bonneville Dam to the estuary. Tag recovery information from this fishery would be expected to more accurately represent actual abundance and distribution compared to the tagging efforts which have area limitations. One obvious limitation to this approach is that any abundance estimate would be limited to harvestable-size fish.

We plan to use a simple Peterson approach to derive an initial abundance estimate of harvestable-size fish. Recreational fishery sampling will provide mark recoveries and total mark sample size. Sampling data will be stratified by ten subsections to adjust for varying sample rates between sections. The Columbia River below Bonneville Dam is an open system which violates a key assumption of the Peterson estimator. To limit the effect of immigration and emigration on the estimator, only tagged fish recovered within the first few months of tagging will be used. As this leaves little time for tagged fish to thoroughly mix with nontagged fish, it will be assumed that the recreational fishery harvests a random sample of the legal-size sturgeon population.

Our attempts to estimate total mortality and natural mortality may be complicated by the rapidly escalating recreational harvest below Bonneville Dam. Total mortality estimates derived from age structure data based on a given year of sampling is only valid when recruitment remains constant (Ricker 1975). While recruitment of white sturgeon to harvestable-size may have been constant, exploitation most likely has not. Harvest has increased three-fold since 1974, from 24,800 to 72,200 in 1987 (ODFW and WDF 1987, ODFW and WDF, unpublished data). Additional annual total mortality estimates will be made based on age specific catch per unit of effort differences from one year to the next.

Use of a tagged cohort model to estimate total mortality was considered; however, a problem was identified with using this method. Emigration of tagged fish to the ocean has not been quantified; therefore, differentiation between tagged fish that have died and those that have migrated out of the Columbia River can not be made. This would result in fewer recoveries in subsequent years, thereby inflating the mortality estimate. Quantifying the amount of emigration and immigration to and from the ocean does not appear feasible at this time.

In addition to the difficulties in estimating abundance and mortality from existing data, age and growth may be more difficult to determine than originally assumed. Age readings from the pectoral fin rays were not consistent and much effort has been expended to develop standardized aging criteria. Age validation was considered a requirement for the future. Use of an oxytetracycline marker was explored for incorporation in the 1988 sampling approach. Preliminary review of the initial age structure data and comparison with that done by Hess (1984) suggests extensive variability exists between length and age.

Lastly, quantifying reproductive potential presents another need where the existing data collection methods may be inadequate. Both the spawning periodicity and fecundity components of reproductive potential appear to be very important to white sturgeon population dynamics. They are also the most difficult parameters to quantify. Female white sturgeon in the Columbia River below Bonneville Dam first mature when about 138-166 cm FL (WDF, unpublished data). A large number of these fish are available for sampling through the commercial fishery, so no sample size problems are anticipated to determine a spawning frequency schedule for legal-size fish. However, the majority of reproducing female sturgeon are believed to be greater than 166 cm FL and the spawning frequency relationship for legal-size fish may not necessarily hold for larger fish. The current capture and tagging operation may offer an opportunity to biopsy live oversize sturgeon. Following evaluation of ODFW's 1988 attempts at biopsy of live fish in the field (ODFW et al. 1987), an adjustment to the below Bonneville Dam tagging approach may occur. Until such time opportunistic sampling of large sturgeon will continue to occur.

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APPENDIX C

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

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

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CONTENTS

ABSTRACT

The Fish and Wildlife Service (FWS) is responsible for parts of study objectives 1 and 3 pertaining to reproduction and early life history characteristics of white sturgeon Acipenser transmontanus and defining habitat requirements for their spawning and rearing. The FWS conducted field operations from April thru November, 1987 in The Dalles Pool using high-rise and beam bottom trawls, and 0.5 m diameter and D-shaped larval nets. About 725 tows were taken with the various gears to collect eggs, larvae, and juveniles of white sturgeon.

During late May the first documented eggs and larvae upstream from Bonneville Dam were collected in a limited area below John Day Dam and again on several occasions thru mid-July in the same area. However, most of the eggs collected were covered with fungus and some larvae appeared to be in poor condition. It appears that survival beyond the yolk-sac stage was very low because no post-larvae were taken in spite of intense trawling effort throughout the reservoir. However, numerous individuals from age-groups I-IV were collected; these age-groups were poorly represented in catches with other gears. Thus, the trawling effort provided preliminary information on the biology and habits of this important segment of the population.

INTRODUCTION

Field activities by the FWS to address parts of study objectives 1 and 3 (See Executive Summary) occurred in The Dalles Pool from April thru November, 1987. Initial efforts focused on describing the reproduction and early life history characteristics of white sturgeon with minimal effort to define their habitat requirements for spawning and rearing. Presently, little is known about reproduction, development, and early life history of white sturgeon in the natural environment. Specific objectives for the first year were:

1. Determine effective sampling gears for collecting eggs, larvae, and juveniles in available habitats.

2. Determine if spawning occurred.

3. Determine where spawning occurred.

4. Develop a standardized sampling system.

This report summarizes the first year study results and provides limited infomation on the life history characteristics of the sub-adult population; these initial findings provide insight toward evaluation of their habitat requirements.

Study Area

The Dalles Pool (Lake Celilo) (Figurx was oas formed by the closure of The Dalles Dam in 1957 for the primary purposes of generating power and improving navigation. The reservoir is the smallest created by the Columbia's lowermost 4 dams with a length of 38.6 km, a shoreline distance of 88.5 km, and a mean width of approximately 1.45 km. Maximum depth is over 40 m and mean depth is about 7.6 m at full pool, 48.8 m above-mean sea level. The pool has a surface area of 4,249 hectares and a volume of 4,108 x $10^9 m^3$. The only major tributary is the Deschutes River, located at about mid-reservoir and John Day Dam forms the upper end of the reservoir.

We divided the pool into three equal sections (lower, middle, upper) for comparative purposes. Boundaries were set at each dam and at RM 200 and 208.

METHODS

Field Sampling

Sampling for early life stages of white sturgeon in The Dalles Pool was conducted from April 6 to November 19 during 1987. Sampling was conducted weekly during May through August, biweekly during April, September, and October and once during November. Sampling gears used to collect white sturgeon eggs, larvae, and juveniles included 0.5-m diameter larval nets, D-shaped larval nets, a 6.2-m wide high-rise bottom trawl, and a 3.0 m wide beam bottom trawl. The bottom trawls were capable of sampling all early life stages, whereas the larval nets were for sampling egg and larval stages. Complete descriptions of each gear can be found in Appendix C-l.

Larval nets were fished on the bottom in pairs (either two 0.5-m nets or one 0.5-m and one D-shaped net) and were either fished stationary or towed against the current. The D-shaped nets were weighted with a pair of 9.1 -kg lead cannonballs and the 0.5-m diameter nets were weighted with a single 13.6-kg torpedo shaped weight. All larval nets were equipped with digital flowmeters to determine the volume of water filtered.

Bottom trawls were towed by a 23-ft boat fitted with dual hydraulic winches and a towing stanchion. Both trawls were towed against the current, and the beam trawl was occasionally fished stationary in areas with high water velocities. Bottom trawls were deployed and a timer started when the net contacted the bottom. The trawls were retrieved after a given amount of time had elapsed (usually 15 minutes) or when hung up on bottom obstructions. Because of the variability in duration of tows, all trawl efforts and catches

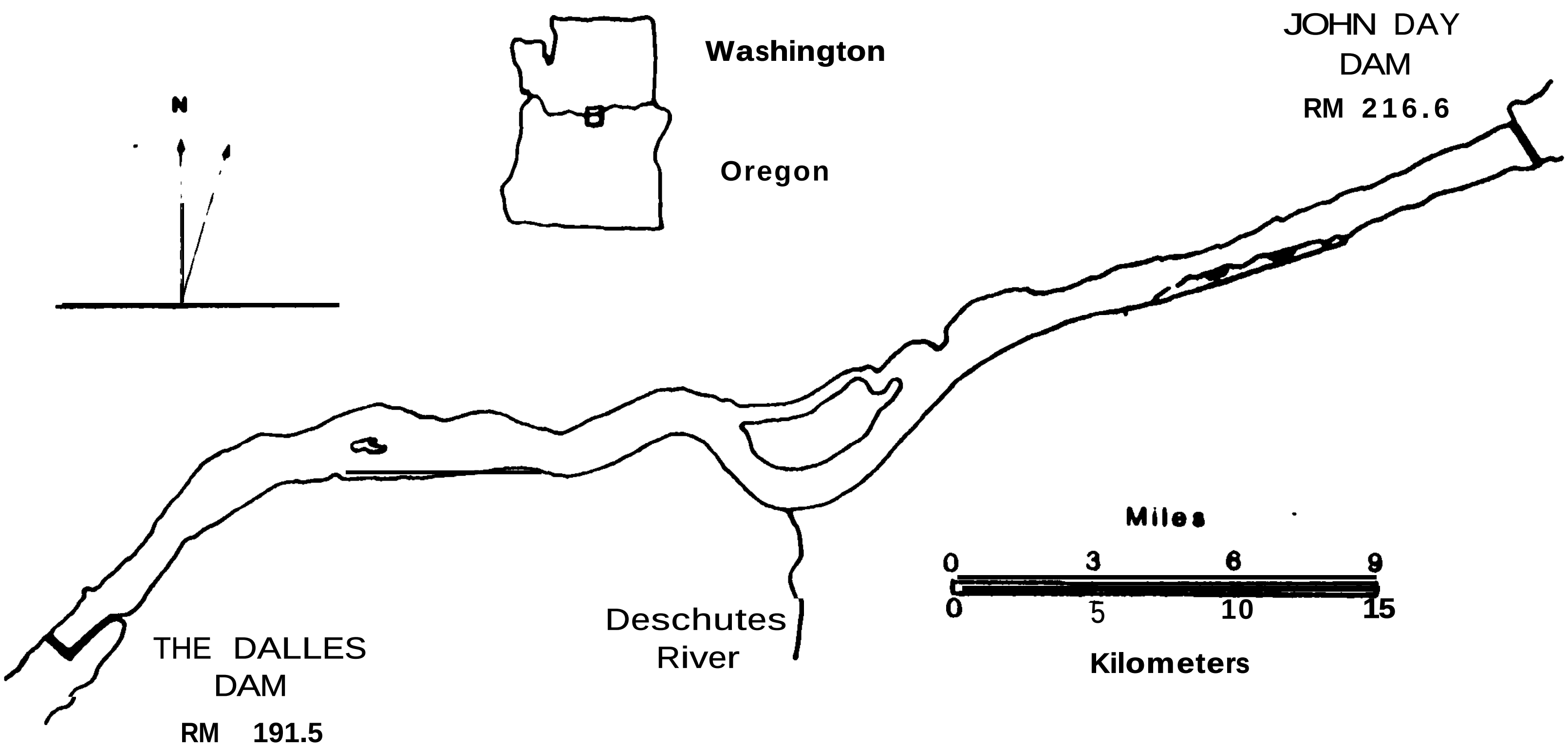

Figure 1. Location of The Dalles Pool on the Columbia River.

were equated to 15 minute tows to permit comparisons of catch per unit of effort (CPUE).

Egg and larval samples were preserved in the field with 10% unbuffered formalin tinted with Phloxine B and sorted later in the laboratory. Juvenile white sturgeon were measured to fork and total length (mm) and weighed(g). The left barbel was clipped to recognize recaptured fish and pectoral fin rays were taken from some fish for age determination. All other fish were identified, counted, and released.

Physical parameters measured in the field included maximum and minimum depth (m) encountered during a tow and water temperature (C). Hourly discharge information at John Day Dam was obtained from the Fish Passage Center. Water temperature records from John Day Dam forebay from 8 May to 31 July were obtained from the U.S. Army Corps of Engineers (USACE). Temperature probe malfunctions caused erroneous readings prior to May 8, 1987.

Artificial spawning substrates were deployed in The Dalles Pool in an attempt to collect newly spawned white sturgeon eggs. They consisted of three matting materials (excelsior, fibrous fiberglass, and sprayed rubber) cut in squares fastened to 0.5-m square steel frames with poultry netting. Three substrates, one of each matting material, were anchored as a gang at ten locations throughout The Dalles Pool during May and June and checked weekly for evidence of sturgeon spawning.

Laboratory

Eggs and Larvae

Samples preserved in the field were sorted in the laboratory; eggs and larval fish were identified to the lowest taxonomic level possible and enumerated. Eggs and larvae of white sturgeon were assigned developmental stages based on criteria established by Beer (1981) and the age from the time of fertilization was determined using the relationship developed by Wang et al. (1985). Wang's relationship uses the timing of embryonic stages and incubation temperature to backcalculate time of fertilization. Temperature was assumed to be constant during incubation and water temperatures we measured at the time of collection were used in the relationship.

Age Determination of Juvenile Sturgeon

Pectoral fin rays from juvenile white sturgeon were sectioned using a custom made spine saw powered by a dremel tool. The saw was equipped with a sliding vise which held the fin ray and permitted the operator to cut sections of uniform thickness. Sections were mounted on microscope slides using clear fingernail polish and viewed under a disecting microscope at low magnification. Sections were independently aged by three people using standard techniques (Jearld 1983).

Food Habits of Juvenile Sturgeon

Food items were recovered from juvenile sturgeon on two occasions. We tested the feasibility of using a stomach pump to flush gut contents from the digestive tracts of 12 sturgeon in early October and we used hydrogen peroxide as an emetic on six sturgeon in mid-November; hydrogen peroxide has been used successfully as an emetic on fish (Miranda 1986).

RESULTS

Spawning Characteristics

Successful spawning and incubation of white sturgeon eggs occurred in The Dalles Pool during 1987. A total of 132 eggs and 11 larvae were collected immediately downstream of John Day Dam between RM 212.3 and 214.7 (Table 1). Eqgs and larvae were collected at several sites across the breadth of the river within the spawning area. No eggs or larvae were collected below RM 212.3 or between RM 214.7 and John Day Dam at Rm 215.6. White sturgeon eggs were collected from May 21 through July 17 and larvae were collected from May 28 through July 2 in water depths ranging from 4 to 17 m.

Environmental Conditions During Spawning

Discharge of water through John Day Dam during the sampling period ranged from 1.42 to 9.19 kcms (Figure 2). John Day Dam is operated as a peaking facility as evidenced by the extreme die1 fluctuations in discharge. Flows were lowest during late evening-early morning and highest during mid morning. The change in discharge during this 12-hour period often approached 5 kcms.

Water temperatures during the estimated spawning period ranged from 13 to 20°C. The temperatures at John Day Dam during this time were characterized by spikes of short duration. These spikes encompassed changes of up to 3.5°C and generally lasted for only a few hours (Figure 3).

Table 1. Number and CPUE of white sturgeon eggs and larvae collected with 0.5-m diameter and D-shaped larval nets (catch/1000m^3) and beam and high-rise trawls (catch/l5 minute tow) between RM 212.3 and 214.7 from May 21 through July 17, 1987.

Gear/Catch	Viable eggs	Fungused eggs	All egg stages	Larvae
0.5-m diameter net				
Number	3	0	3	4
Catch/1000m^3	0.20		0.20	0.71
D-shaped net				
Number	0	1	1	1
Catch/1000m3		0.14	0.14	0.20
Beam trawl				
Number	5	24	29	1
Catch/l5 min.	0.10	0.48	0.58	0.04
High-rise trawl				
Number	9	90	99	5
Catch/l5 min.	0.25	2.49	2.74	0.15
All gears				
Number	17	115	132	11

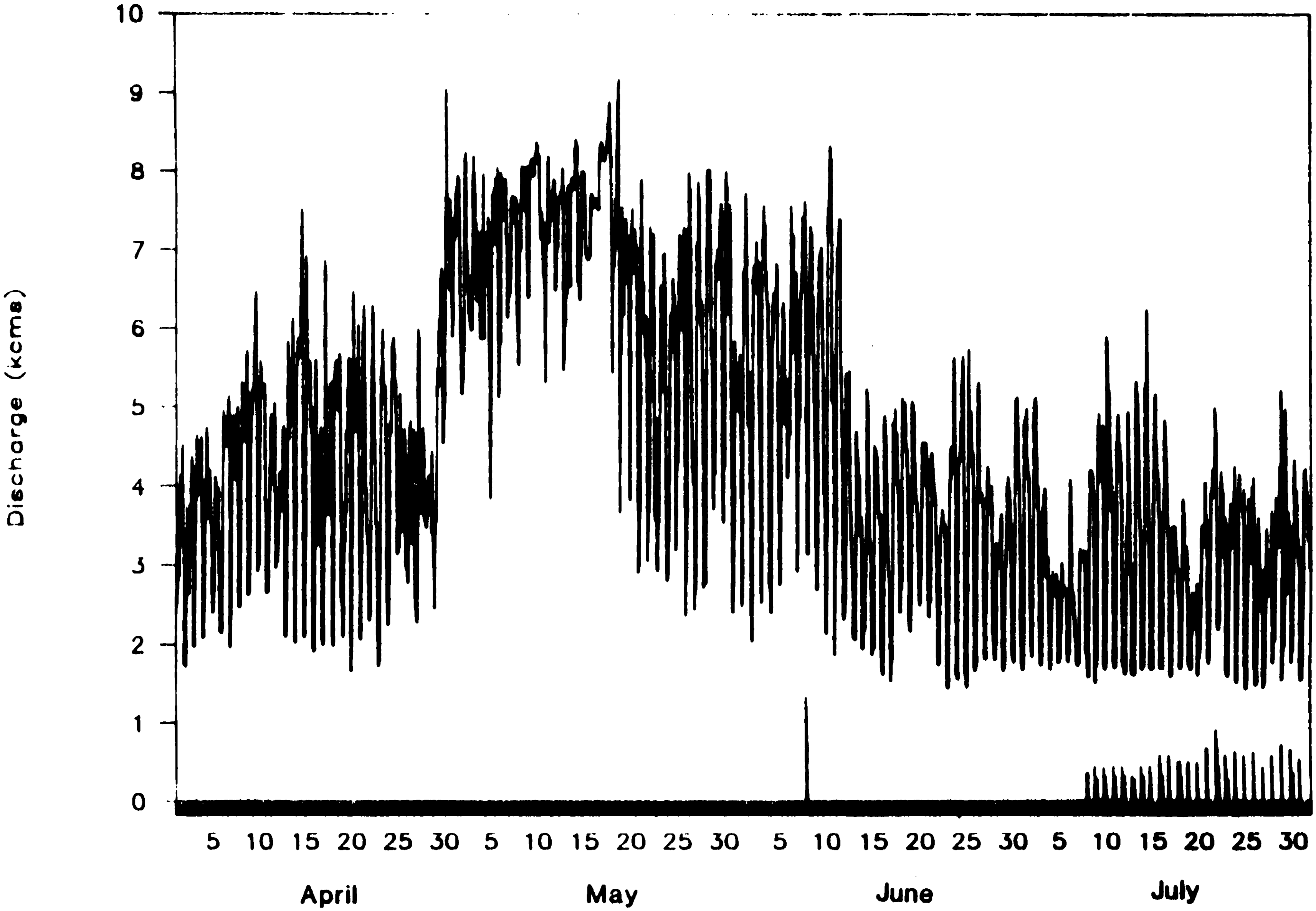

Figure 2. Hourly discharges through John Day Dam during April-July, 1987. The upper line indicates total discharge, the lower line indicates spill discharge.

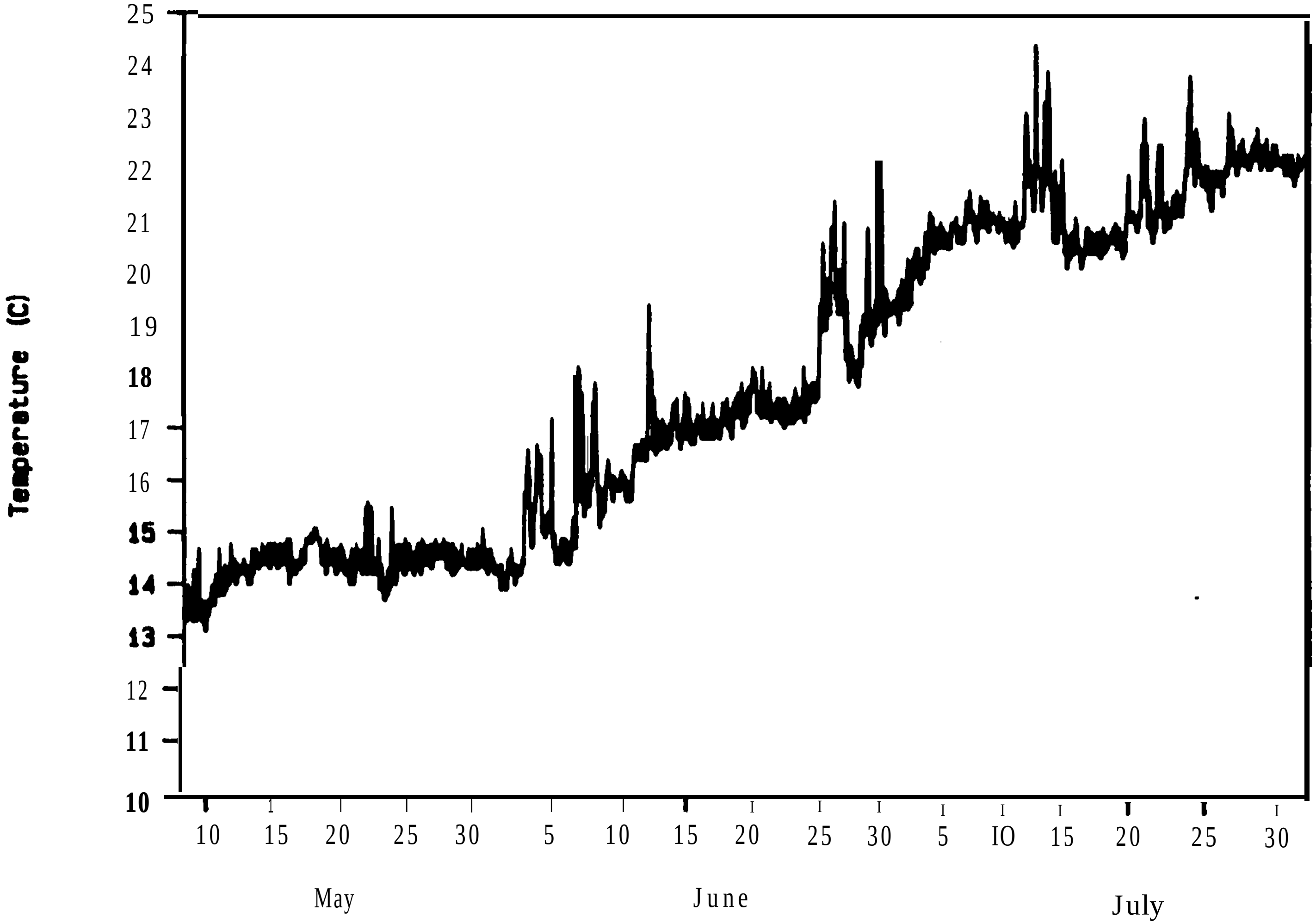

Figure 3. Water temperatures at John Day Dam recorded by the USACE, May 8-July 31, 1987.

Egg Deposition

Spawning did not occur continuously throughout the season. Instead, egg deposition was estimated to have occurred on three occasions, May 20-21, June 26-30, and July 11-12. Eggs at various stages of development were collected during each of the three spawning episodes. Developmental stages ranged from newly spawned and adhesive (aproximately 1 hour old, water temperature 14°C) to prehatch (approximately 70-80 hours old, water temperature 18°C). However, the majority of eggs collected (87%) were dead and covered with fungus. It is not known if dead eggs are as prevalent in the environment as in our collections or if the gears used were more selective towards dead eggs.

Artificial Spawning Substrates

No eggs were observed on the artificial spawning substrates. Initially, artificial substrates were anchored at 10 locations throughout the reservoir. After sturgeon eggs were collected at RM 214.3 on May 21, most of the substrates were moved to this location for the remainder of the spawning period.

Larvae

All larvae collected were post-hatch or l-day post-hatch and ranged from 8 to 13 mm TL; no post-larvae young-of-the-year white sturgeon were collected during 1987.

Juveniles

Catch of Juveniles

We captured 497 juvenile white sturgeon in The Dalles Pool with trawls. Fork lengths ranged from 224 to 706 mm (Table 21. We marked 372 of these sturgeon with a left barbel clip and recaptured 17 (4.4%) during the 1987 field season.

Trawl catches of juvenile sturgeon varied spatially and temporally (Table 3). CPUE of juvenile sturgeon with the high-rise trawl ranged from 2.23 in April to 0.38 in November with an overall mean CPUE of 1.2. Spatially, CPUE with the high-rise trawl ranged from 0.54 in the middle reservoir to 1.51 in the upper reservoir. Mean CPUE for the beam trawl was similar among reservoir areas, ranging from 0.36 to 0.48. The high-rise trawl captured 89% (442) of the juvenile sturgeon while comprising 72% of the total trawling

Table 2. Length frequencies of white sturgeon captured in The Dalles Pool with trawls during 1987.

Fork length (mm)	MONTH						
	Apr	May	Jun	Jul	Aug	Sep	Oct-Nov
201 - 210							
211 - 220							
221 - 230	1						
231 - 240							
241 - 250	1	1	1				
251 - 260	2		2			1	
261 - 270		1	1	1			
271 - 280	4	1	1		1		
281 - 290		1	1				1
291 - 300		1	1		2		1
301 - 310	1	2	2	3	1		2
311 - 320	1	1	3	3	2	1	
321 - 330	2	1	2	7	2		1
331 - 340	1	4	5	6	2	4	
341 - 350	2	7	8	7	1	2	4
351 - 360	3	8	4	10	3	6	2
361 - 370	3	5	6	4	5	5	8
371 - 380	6	7	8	1	5	2	3
381 - 390	1	6	1		1	4	1
391 - 400	4	5	4	9	6	3	1
401 - 410	3	3	4	6	2	2	2
411 - 420	4	1	3	6	3	3	2
421 - 430	1	2	4	6	3	1	4
431 - 440	1	4	1	6	1		1
441 - 450	3	4		6			3
451 - 460	1			1	3	2	2
461 - 470	2	1	3	5	2		1
471 - 480		2	2	5	1	5	
481 - 490		2	2	1		1	
491 - 500			1	3		1	1
501 - 510		1	2	6	1	2	1
511 - 520	1	1	2				
521 - 530	1	1	1	2	2		
531 - 540		1	1	1		1	2
541 - 550		1	1		2	2	2
551 - 560	1	1		1		1	1
561 - 570	1			2			
571 - 580			1	3	2	2	2
581 - 590			1	2	2		1
591 - 600		1	2	1			
>601	2	1	1	2			5
TOTAL	53	78	80	118	55	51	54

Table 3. Number and catch per 15 minute tow (CPUE) of juvenile white sturgeon with high-rise and beam trawls at lower (RM 191.5-200), middle (RM 200-208), and upper (RM 208-215.6) reservoir locations in The Dalles Pool during 1987.

Gear/location	April	May	June	July	Aug	Sept	Oct	Nov	Total number	Mean CPUE
High-rise trawl										
Lower reservoir										
Number	3	5	19	26	20	15	14	3	105	
CPUE	1.10	0.69	1.80	2.83	0.79	2.48	0.99	1.00		1.34
Middle reservoir										
Number	0	1	11	22	10	3	8	0	55	
CPUE	0.00	0.25	0.62	1.42	0.50	0.18	0.40	0.00		0.54
Upper reservoir										
Number	41	42	49	66	22	33	26	3	282	
CPUE	3.01	1.86	1.53	1.34	0.76	2.41	1.32	0.39		1.51
Total number	44	48	79	114	52	51	48	6	442	
Mean CPUE	2.23	1.41	1.31	1.54	0.70	1.41	0.89	0.38		1.20
Beam trawl										
Lower reservoir										
Number	4	0	-	-	-	-	-	-	4	
CPUE	0.84	0.00								0.36
Middle reservoir										
Number	1	11	0	-	1	-	-	-	13	
CPUE	0.49	1.24	0.00		0.33					0.48
Upper reservoir										
Number	4	24	2	5	3	-	-	-	38	
CPUE	0.65	2.36	0.04	0.17	0.24					0.36
Total number	9	35	2	5	4				55	
Mean CPUE	0.70	1.38	0.03	0.17	0.26					0.39

effort. Catch rates between the two trawls could not be compared temporally because of reduced effort with the beam trawl after May.

Weight-Length Relationship and Condition

The weight-length relationship was calculated from a sample of 462 sturgeon captured from April through November, 1987. They ranged from 224 to 706 mm FL. The weight-length relationship is described by the equation log W = log FL (2.950) - 5.058; where W is the weight in grams and FL is the fork length in mm. The correlation coefficient (R^2) for this sample was 0.96. Average condition factor of juvenile white sturgeon was determined to be 0.655 (Sd-0.081, N=462). Condition factors were determined using the formula $C=(W/L^3)\ 10^5$.

Age Determination

Fin ray sections were aged from 80 juvenile sturgeon collected in The Dalles Pool from May through October, 1987 (Table 4). Fork lengths ranged from 263 to 659 mm for aged sturgeon. Mean fork lengths were 343, 383, 447, and 487 mm for ages I-IV, respectively.

Food Habits

A stomach pump and emetics were successful in removing some food items from the digestive tracts of 18 juvenile sturgeon (Table 5); however, neither technique was appropriate for a quantitative analysis of food habits. The stomach pumping technique was harmful to the fish with several mortalities occurring within one week after pumping. It appeared that water pressure associated with the flushing technique caused internal injuries. An examination of fish showing harmful effects indicated that two fish had ruptured swim bladders and others were observed bleeding from the anal vent. No harmful side effects were observed using hydrogen peroxide as an emetic.

Depth Preference

Preference of sturgeon for deeper areas was determined by comparing maximum depths of trawl tows with catch of sturgeon (Figure 4). The resulting figure shows that although 75% of all trawl tows had maximum depths less than 17 m, 50% of the sturgeon were captured during tows when maximum depths were greater than 17 m. Field observations also indicate that juvenile sturgeon tend to be captured in the deepest portion of the channel at any location.

Table 4. Mean range in fork length for various ages of juvenile white sturgeon collected in The Dalles Pool, May through October, 1987.

Length/Sample Size	Age					
	I	II	III	IV	V	VI
Mean FL	343	383	447	487	659	614
Range	263-424	297-458	330-580	425-649		
Sample Size	21	25	21	11	1	1

Table 5. Items recovered from stomachs of 18 juvenile white sturgeon collected in October and November, 1987.

Phyllum: Mollusca

class: Gastropoda

Class: Pelecypoda

Order: Heterodonta

Family: Corbiculidae

Corbicula manilensis

Phylum: Arthropoda

Class: Crustacea

Order: Mysidacea

Neomysis mercedis

Order: Amphipoda

Family: Gammaridae

Anisoqammarus spp.

Family: Corophidae

Corophium spp.

Order: Decapoda

Class: Insecta

Order: Ephemeroptera

Order: Trichoptera

Phylum: Chordata

Class: Osteichthyes

non-salmonid vertebrae

Other material found: Woody debris, aquatic plant leaves, bryozoan statoblasts.

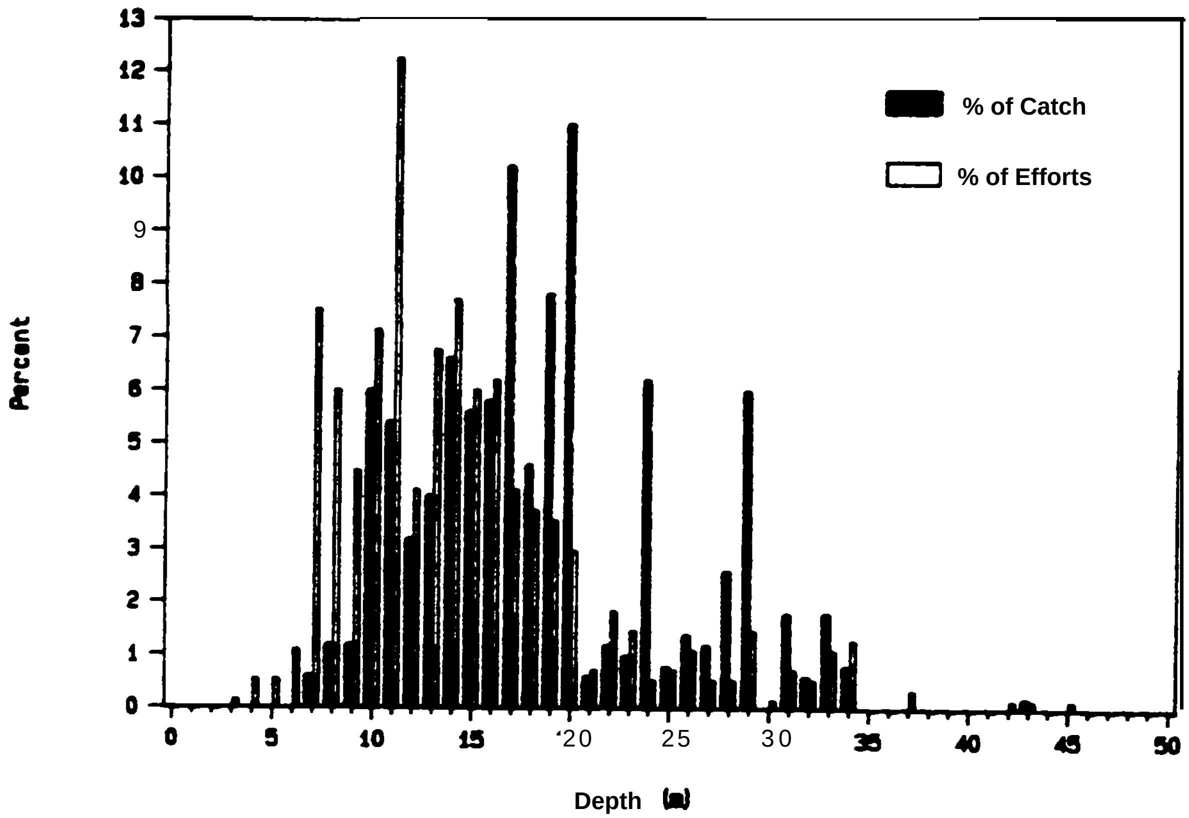

Figure 4. Percent of the catch of juvenile sturgeon and the percent of the number of trawl tows at maximum depths we encountered.

Catch of Non-Sturgeon Fishes

Several species of fish other than white sturgeon were identified in our catch during 1987 (Table 6). Trawl and net catches were dominated by young-of-the-year and older prickly sculpin, Cottus asper. Other species commonly found included American shad, Alosa sapidissima, common carp, Cyprinus carpio, peamouth, Mylocheilus caurinus, northern squawfish, Ptychocheilus oregonensis, largescale sucker, Catostomus macrocheilus, channel catfish, Ictalurus punctatus, sand roller, Percopsis transmontanus, and walleye, Stizostedion vitreum vitreum.

DISCUSSION

During 1987, high-rise and beam trawls and 0.5-m diameter and D-shaped larval nets were evaluated for their effectiveness in sampling early life history stages of white sturgeon in The Dalles Pool. The high-rise bottom trawl was the most versatile gear and actively sampled all habitats except for areas with abrupt changes in bottom contours and accounted for the largest catches of eggs, larvae and juveniles. The beam trawl, 0.5-m diameter and D-shaped larval nets all collected eggs and larvae but were not as versatile or effective as the high-rise trawl. However, the beam trawl and larval nets could be used to passively sample the drift and could therefore be used where bottom contours were too rough for towing the high-rise trawl.

The sampling gears we used in The Dalles Pool also were evaluated periodically in conjunction with efforts by NMFS below Bonneville Dam where all life stages are known to occur. Sampling effort with our gears below Bonneville Dam produced catches of all early life history stages including post-larval young-of-the-year which were not collected in The Dalles Pool.

Eggs of white sturgeon were initially taken in late May and the first larvae was taken a few days later. Then after a hiatus of a month numerous eggs and larvae were taken from late June thru mid-July. All eggs and larvae were collected from a two mile river reach approximately one mile below John Day Dam. The habitat found in this section of river appears similar to the area below Bonneville Dam where NMFS collects eggs and larvae.

Although spawning occurred below John Day Dam, we believe that survival was poor. A large percentage (87%) of the eggs collected were dead and fungused and some larvae appeared to be in poor condition. Also, in spite of intense sampling effort throughout the reservoir for several months after spawning had occurred no young-of-the-year were captured. The reason for poor survival may have

Table 6. Number and catch per unit of effort (CPUE) of non-sturgeon fishes collected with beam and high-rise trawls (catch/l5 minute tow) and 0.5-m diameter and D-shaped larval nets (catch/1000 cubic m) in The Dalles Pool from April through November, 1987.

	Beam trawl		High-rise trawl		0.5-m net		D-shaped net		Total
	Number	CPUE	Number	CPUE	Number	CPUE	Number	CPUE	Number
Pacific lamprey	5	0.04	12	0.03					17
American shad	14	0.10	256	0.70					270
sockeye salmon	1	<0.0l							1
chinook salmon	27	0.19	61	0.17	1	0.03			89
steelhead trout			2	<0.01					2
mountain whitefish	2	0.01	14	0.04					16
chiselmouth	3	0.02	41	0.11					44
common carp	10	0.07	162	0.44	1	0.03			173
peamouth	3	0.02	216	0.59					219
northern sguawfish	23	0.16	263	0.71					286
longnose dace	1	to.01							1
redside shiner			1	<0.0l					1
unidentified cyprinid			4	0.01	30	0.85	1	0.08	35
largescale sucker	8	0.06	280	0.76					288
bridgelip sucker	6	0.04	105	0.29					111
unidentified sucker	10	0.07	288	0.78	24	0.68	7	0.53	329
channel catfish	20	0.14	168	0.46					188
brown bullhead			2	<0.0l					2
sand roller	86	0.61	248	0.67					334
smallmouth bass	5	0.04	120	0.34					125
black crappie	1	to.01	4	0.01					5
white crappie	16	0.11	35	0.10					51
unidentified crappie	3	0.02	285	0.77					288
pumpkinseed	1	<0.0l	3	to.01					4
unidentified sunfish	1	<0.0l							1
unidentified centrarchid			10	0.03					10
walleye	9	0.06	267	0.72	6	0.17			282
yellow perch	6	0.04	72	0.20					78
prickly sculpin	6686	47.08	13977	37.95	2184	61.95	61	4.64	22908
Total Number	6947		16896		2246		69		26158

been that water temperatures during the last two or three weeks of the spawning period were within lethal limits for developing sturgeon embryos. Wang et al. (1985) found that water temperatures of 18 to 20°C may cause substantial mortalities during the sensitive embryonic stages, and temperatures above 20°C are clearly lethal. The majority of eggs and larvae taken in The Dalles Pool (96%) were collected when water temperatures ranged between 18 and 20°C. Conversely, all eggs and larvae collected by NMFS below Bonneville Dam were taken when water temperatures were less than 18°C (See Appendix D).

Catches of juvenile sturgeon < 700 mm FL were higher than expected. This size group is not represented in the sport fishery or in the set-line and gill-net fishery and was poorly represented in the efforts by ODFW to collect adults and therefore has provided valuable life history information on this segment of the white sturgeon population.

Study plans for the 1988 field season include the continuation of the standardized sampling system established for The Dalles Pool in 1987 to collect eggs, larvae, and juvenile white sturgeon, expansion of exploratory sampling into the Bonneville Pool, and initiate field efforts to define habitat use by spawning and rearing white sturgeon in The Dalles and Bonneville pools.

Based on exploratory sampling activities in The Dalles Pool in 1987, the most suitable sites, sampling techniques, and gears will constitute the standardized sampling scheme in 1988. The expanded effort into Bonneville Pool in 1988 to describe reproduction and early life history characteristics will follow the same design developed and applied in the 1987 exploratory activities in The Dalles Pool.

We will also initiate field efforts to define habitat requirements for spawning and rearing of white sturgeon in The Dalles and Bonneville pools. We will begin exploring approaches to modeling effects of hydropower development and operation on the capacity to support white sturgeon populations. Work to develop methods to quantify available habitat and to delineate food availability as a biological indicator of habitat utilization by white sturgeon in the two pools will also be initiated.

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APPENDIX C-l

SPECIFICATIONS OF FWS SAMPLING GEAR

Table C-l. Specifications of high-rise and beam bottom trawls and 0.5-m diameter and D-shaped larval nets.

High-rise Trawl

Trawl	Four panel rectangular design of 5l-mm stretched mesh, #18 twine.
Cod ends	0.78-m diameter cylinder, 2.44-m in length of 3.18-mm knot less nylon.
	0.78-m diameter cylinder 2.44-m in length of 1.59-mm knotless nylon.
Cover	Cylindrical tube of 38-mm stretched mesh, #15 twine, 96 meshes around
Headrope	6.2-m of 15-mm wire & polypropylene rope.
Footrope (sweep)	6.2-m of wire rope strung with 15.2-cm "cookies" spaced 350-mm apart by S-cm "cookies* over its entire length.
Floats	3 extruded plastic floats (203-cm dia), 1 placed on headrope, others equidistant from center & ends.
Doors	High efficiency 71-cm (3lkg) steel V-doors with mud holes.
Miscellaneous	Tickler chain fished in front of footrope.

Beam Trawl	
Beam (Frame)	Three-sided rectangular aluminum alloy frame (2 sides, 1 top), 3.0-m wide by 1.0-m in height with 0.9-m weighted skids on'each side.
Trawl	Four panel design of 51-mm stretched mesh, 418 twine, attached at footrope and headrope to corners of frame. Total length with cadliners and cover was 7.0-m.
Cod ends	Same as those used in the high-rise trawl.
Cover	Cylindrical tube of 38-mm stretched mesh, #21 twine, 78 meshes around.
Foot rope (sweep)	7.5~mm wire rope with 7.6~cm rubber rollers along its entire length.
Miscellaneous	Tickler chain fished in front of sweep.

0.5-m Diameter Larval Net	
Opening	0.5-m diameter tapering to 0.08m over a length of 2.44-m.
Mesh size	0.7-mm bar
Plankton cup	0.08-m diameter with #00 screen.

D-shaped Larvae Net	
Opening	0.76-m across bottom, 0.54-m at the highest point, with a total area of 0.34-m^2, tapering to 0.08-m over a length of 3.4-m.,
Mesh Size	1.59-mm knotless nylon mesh.
Plankton Cup	0.08-m diameter with #OO screen.

APPENDIX D

1. Description of reproduction and early life history characteristics of white sturgeon populations in the Columbia River downstream from Bonneville Dam.

2. Definition of habitat requirements for spawning and rearing of white sturgeon and quantification of extent of habitat available in the Columbia **River** downstream from Bonneville Dam.

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CONTENTS

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ABSTRACT

During 1987, the National Marine Fisheries Service (NMFW) used various types of gear to sample white sturgeon *Acipenser transmontanus* eggs, larvae, and juveniles in the Columbia River downstream from Bonneville Dam. *A* D-ring type plankton net with a mouth opening of 0.8 m at the bottom was the most suitable method for sampling white sturgeon eggs and larvae. In conjunction with the Washington Department of Fisheries (WDF), 18 white sturgeon eggs and 40 larvae were collected in 1987. All eggs **were** collected in the vicinity of River Miles (RMs) 143 to 144; larvae were collected from RMs 113 to 143. White sturgeon eggs were first collected on 21 April and last collected on 19 June, and larvae were collected from 5 May to 2 June. Mite sturgeon eggs were collected at bottom water temperatures ranging from 10 to 16°C, bottom water turbidities ranging from 3.1 to 5.3 NTU, and water depths ranging from 4.3 to 9.8 m.

A 7.9-m (headrope length) semiballoon shrimp trawl was the most successful gear for collecting juvenile white sturgeon. From March to November 1987, 1,954 juvenile white sturgeon were collected from RMs 29 to 140. Juvenile white sturgeon distributions in the lower Columbia River were patchy, with relatively high catches near RMs 79, 95, 101, and 131. In 1987, catches of young-of-the-year white sturgeon were low--49 young-of-the-year were captured from RMs 30 to 131. Both water depth and bottom water temperature were poor predictors of juvenile white sturgeon densities: however, the mean density of juvenile white sturgeon was lower in areas < 9.1 m deep than in deeper areas. Although 298 of the bottom trawling was done in water < 9.1 m deep, only 7.78 of the total catch was made in this depth range. As a result of 1987 research, NMFS tentatively established five index sampling areas to be used in 1988 and subsequent years to define habitat preferences or requirements of juvenile white sturgeon.

During 1987, 1,689 juvenile white sturgeon were tagged with bird-banding tags; however, only 12 recaptures were made. All recaptures, except one, were made in the areas where the fish were tagged.

INTRODUCTION

Under the agreement with the Oregon Department of Fish and Wildlife (ODFW), the National Marine Fisheries Service (NMFW) is responsible for segments of Objectives 1 and 3 of the study. Objective 1 is to describe reproduction and early life history of white sturgeon populations, and Objective 3 is to define habitat requirements for all life stages of white sturgeon and to quantify available habitat. The NMFS's research is being done in the Columbia River downstream from Bonneville Dam--the Columbia River's only reach known to support all white sturgeon developmental stages in sufficient numbers to provide a control against which habitat availability and use between Bonneville and McNary dams can be compared. Also, under Objective 1, NMFW and the Washington Department of Fisheries (WDF) will attempt to determine the effect of variable flows at Bonneville Dam on the downstream displacement of white sturgeon eggs and larvae. Specific research goals for 1987 were 1) to determine the most suitable method(s) for collecting white sturgeon eggs and larvae: 2) to determine the most suitable method for collecting juvenile white sturgeon, including young-of-the-year (Y-O-Y); 3) to make a preliminary determination of the downstream distribution of white sturgeon larvae: 4) to determine index sampling sites that can be used to define the habitat preferences or requirements of juvenile white sturgeon: and 5) to continue to enter data collected during past NMFW research studies into computer files.

This report describes progress on NMFS's studies from July 1987 to April 1988.

METHODS

Egg and Larval Sampling

In March 1987, NMFW and WDF began a cooperative sampling effort for white sturgeon eggs and larvae in the Columbia River downstream from Bonneville Dam. Generally, sampling was done biweekly from late March through mid-October. The last egg and larval sampling was in mid-November. Various gear types were used to collect white sturgeon eggs and larvae. A D-ring type plankton net, employed routinely by WDF, was used for sampling white sturgeon eggs and larvae (Figure 1), The plankton 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). A digital flow meter (General Oceanics Model 2030) was suspended in the mouth of the net to estimate the water volume sampled. The plankton net was normally fished for 30 minutes from an anchored boat (12.2-m research vessel). Also, we used an epibenthic sled, which had a mouth opening of 50 cm and was constructed of l-mm mesh (lumen) plastic screen attached to a metal frame:a 3.1-m (beam length) plumb-staff beam trawl (Gunderson et al. 1985); a standard 4.9-m (headrope length) semiballoon shrimp trawl: and a modified 4.9-m semiballoon shrimp trawl. Mesh size (stretched) in the plumb-staff beam trawl was 19 mm in the body

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

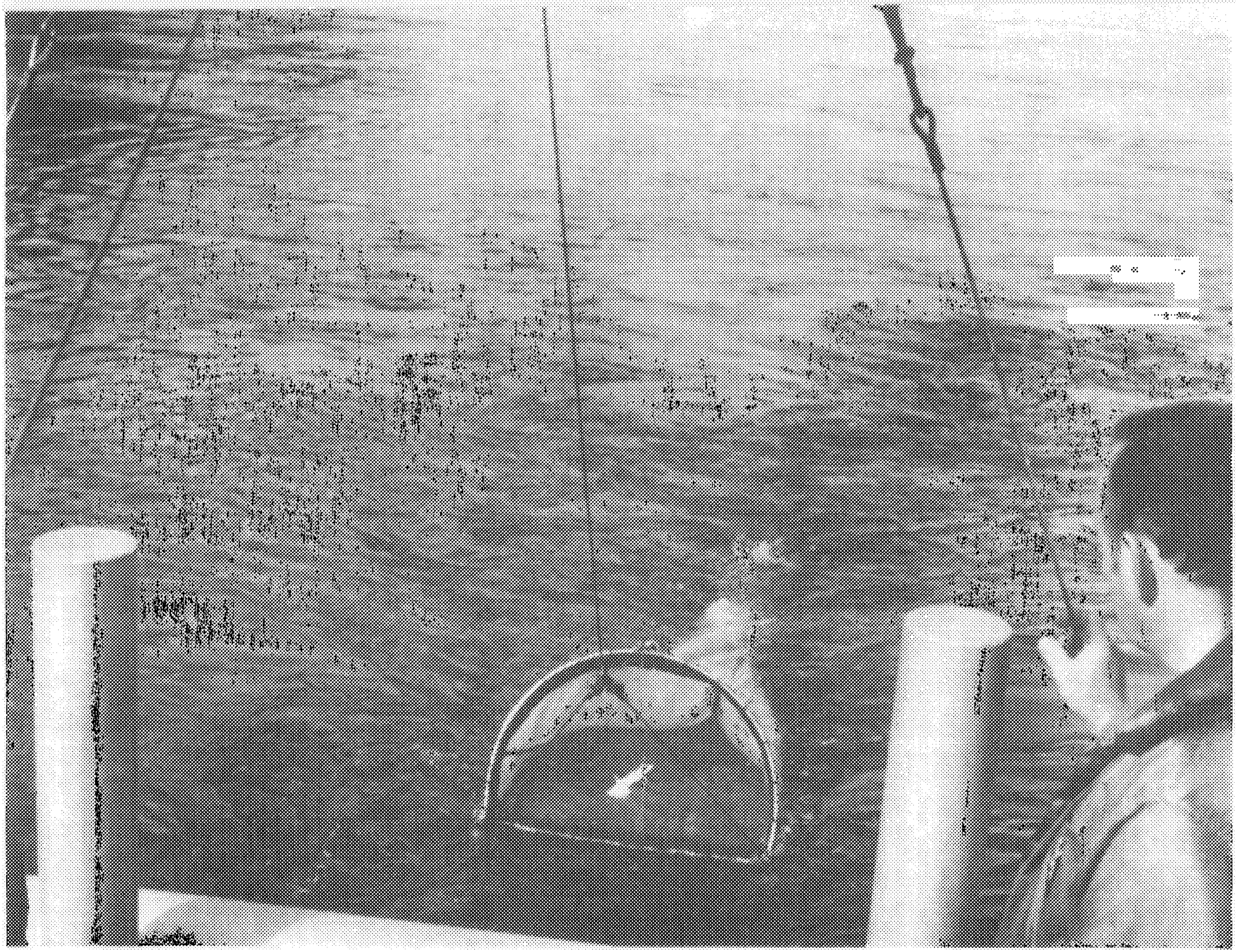


Figure 1 The D-ring type plankton net used to sample white sturgeon eggs and larvae in the Columbia River downstream from Bonneville Dam note the flow meter inserted in the mouth of the net.

and 11 mm in the cod end. The standard mesh size in the bodies of the shrimp trawls was 32 mm; lo-mm mesh liners were inserted in the cod ends. The difference between the standard and the modified shrimp trawl was that 10-mm knotless mesh was inserted in the wings and throat of the modified net. The epibenthic sled and trawls were either towed along the bottom or held in a somewhat stationary position along the bottom.

White sturgeon egg and larval sampling was done at various sites in the lower Columbia River from River Miles (RMs) 29 to 145 (Figure 2). Only sites near Ives Island (RM 143) and Hamilton Island (RM 144) were routinely sampled throughout the field season. White sturgeon eggs and larvae collected during the season were fixed in a buffered 22 formaldehyde solution and transferred to WDF. Timing of egg deposition and hatching **was** estimated by WDF by examining developmental stages of eggs and larvae. Some of the results from the egg and larval sampling are summarized by WDF in their annual report.

Juvenile Sampling

Various bottom trawls were used to collect juvenile white sturgeon--a 3.1-m plumb-staff beam trawl, a standard 4.9-m semiballoon shrimp trawl, a modified 4.9-m semiballoon shrimp trawl, and **a** 7.9-m semiballoon shrimp trawl (Figure 3). Mesh size in the 7.9-m shrimp trawl was 38 mm in the body; a 10-mm mesh liner was inserted in the cod end of the net. Trawl efforts were normally 5 minutes in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable was let out, and the effort was considered ended when 5 minutes elapsed. Using a radar range-finder, we estimated the distance the net fished during **a** sampling effort. Bottom trawling was done from late March to mid-November.

On 25-26 August, night sampling was done with a 7.9-m semiballoon shrimp trawl at RM 95 to determine if Y-O-Y white sturgeon catches increased during darkness. White sturgeon Y-O-Y were collected previously at this site during daylight. Bottom trawls were done every 3 hours from 1800 through 0600 hours along three transects paralleling the shore.

Fishes captured in the bottom trawls were identified and counted. Generally, all white sturgeon were measured (natural total and fork lengths (mm)) and weighed (g) . Soon after the field season started, we began to tag juvenile white sturgeon to provide data on movement and growth. A bird-banding tag, constructed of monel metal, was placed around the anterior ray of the right pectoral fin (Figure 4) small Y-O-Y white sturgeon were not tagged. Also, beginning in late spring, we routinely examined juvenile white sturgeon for the nematode parasite Cystoopsis acipenseri (Chitwood and McIntosh 1950). When present, the parasite is contained in blister-like cysts under the skin.

Physical Conditions

Various physical conditions were measured in conjunction with the biological sampling--depth (m) (maximum and minimum), bottom water temperature (°C), bottom water turbidity (NTU), and water velocity about 0.6 m above the bottom. Water velocities were not measured for all sampling

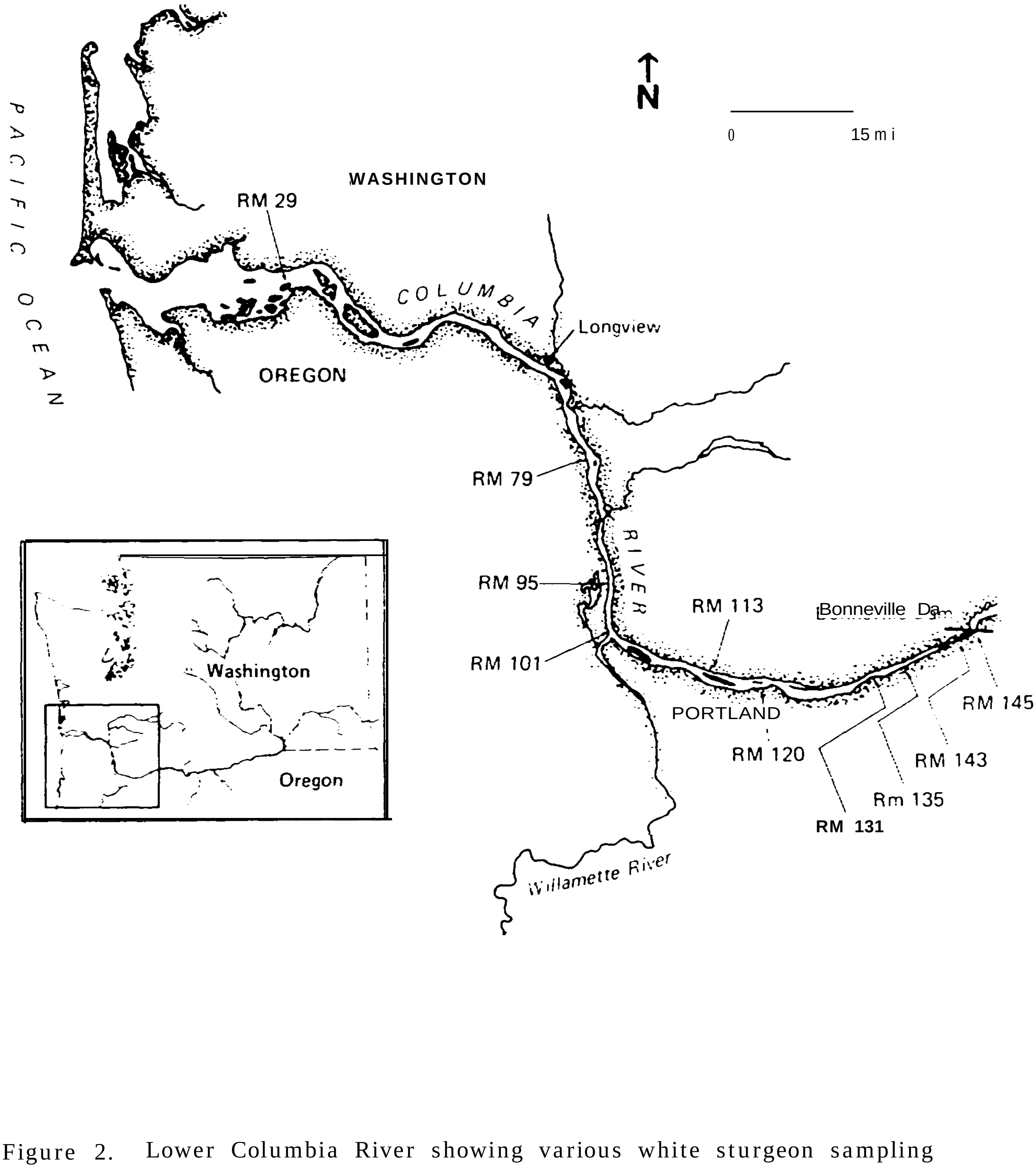
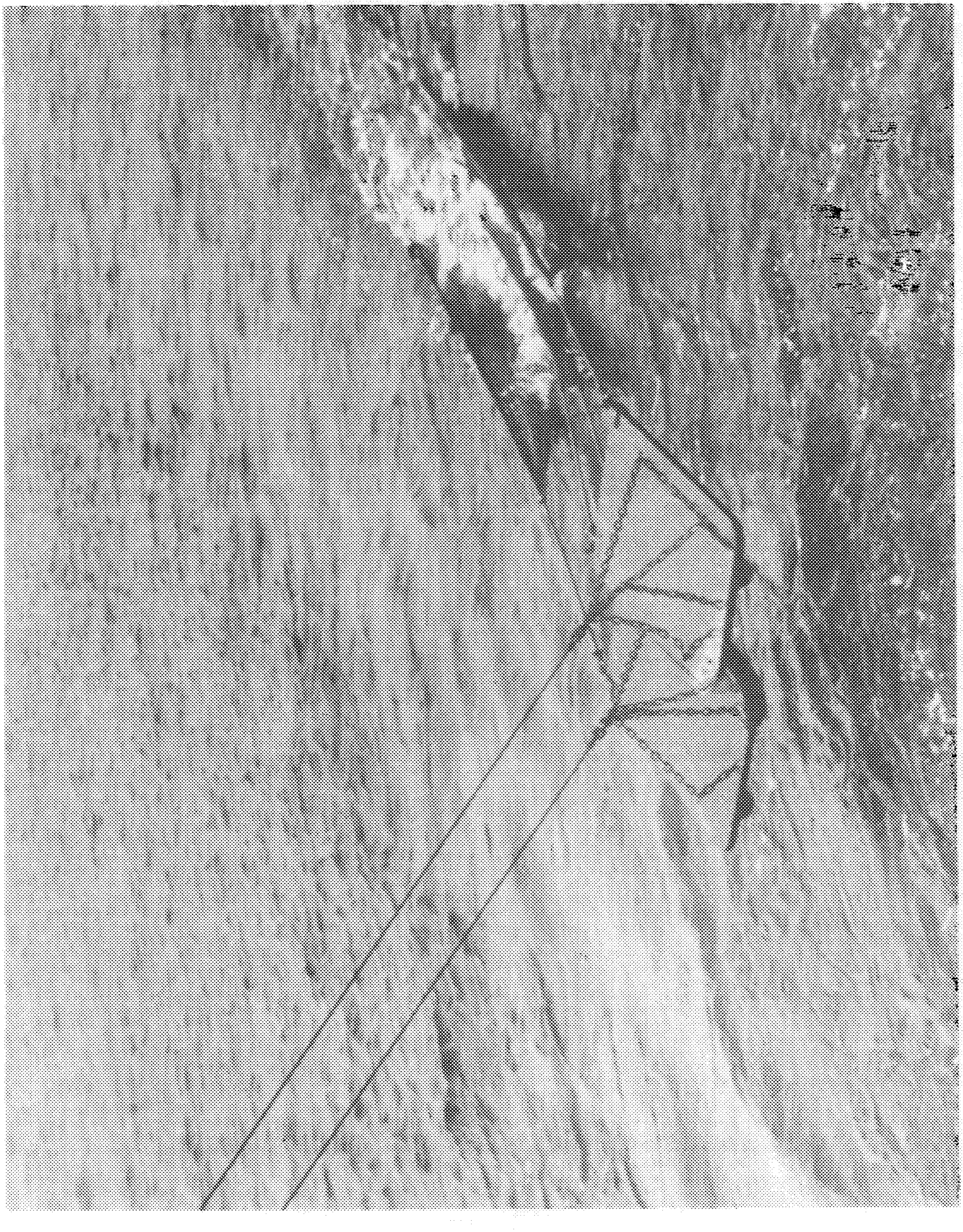


Figure 2. Lower Columbia River showing various white sturgeon sampling areas.



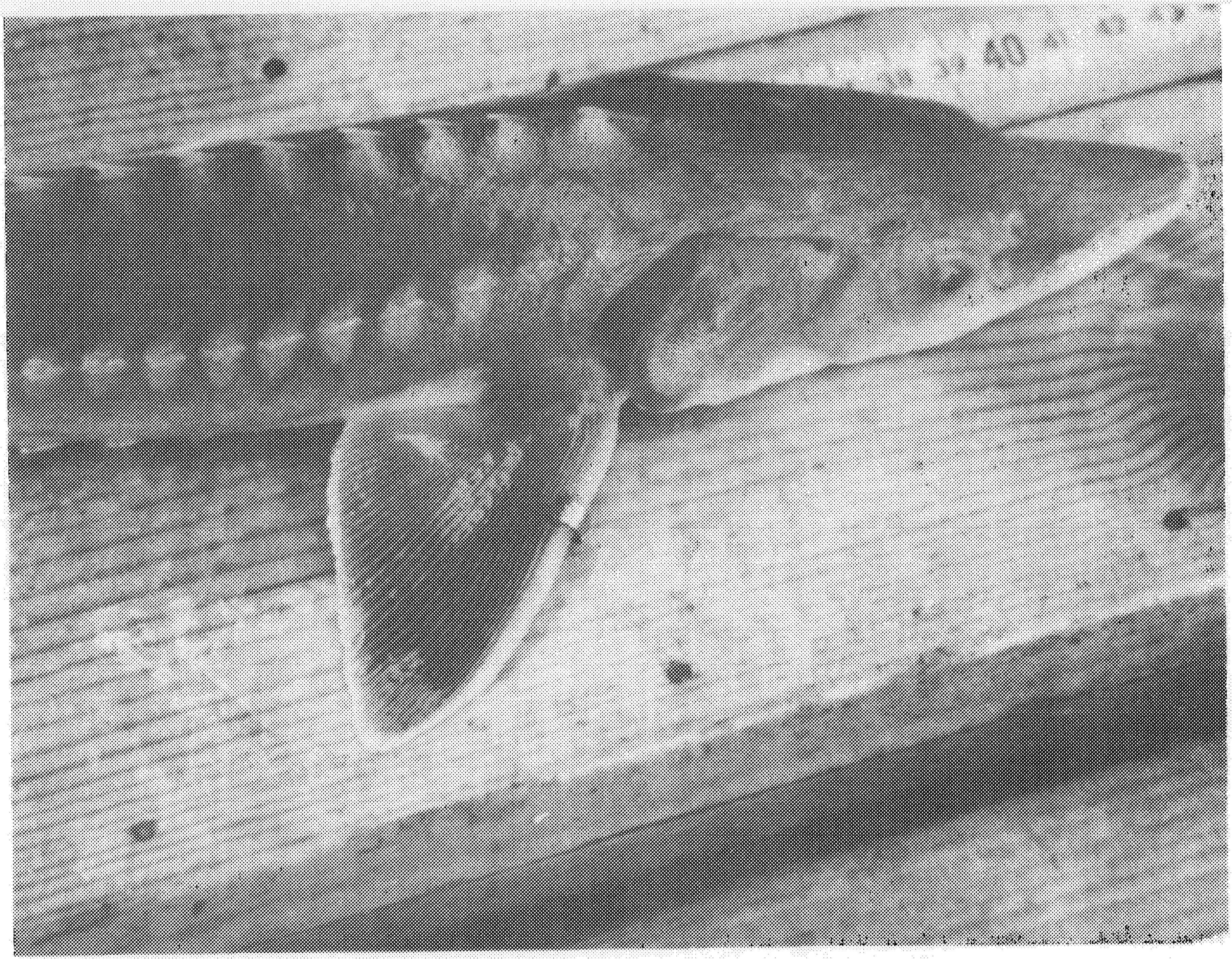


Figure 4. A juvenile white sturgeon tagged with a bird-banding tag placed around the anterior ray of the right pectoral fin.

efforts because the boat had to be anchored to obtain accurate velocity measurements. Depth was measured with electronic depth sounders, and velocity was measured with a Gurley current meter that was attached to a 45.4-kg lead fish. Turbidity was determined in the laboratory using a Hach Model 2100A Turbidimeter.

Sediment (substrate) samples were collected in five juvenile sturgeon sampling areas (RMs 79, 95, 101, 131, and 135; Figure 2) using a 0.1-m Van Veen grab sampler (Word 1976). In four areas, three samples were collected along each of three transects that paralleled the shore. Each transect represented the path of a trawling effort; sediment samples were collected near the beginning, middle, and end of each transect. At RM 135, samples were collected along two transects, and only one sample from each transect was analyzed. The sediment samples were analyzed by Northwest Testing Laboratories, Inc. (Portland, Oregon) for grain size (mm) and percent organic matter (total volatile solids).

Data Analyses

Physical and biological data collected during the season were entered into computer files following formats agreed to by the four agencies involved in the sturgeon study--U.S. Fish and Wildlife Service (FWS), ODFW, NMFS, and WDF. Various computer programs were used to analyze the data.

Using the distance fished during a trawl effort and the estimated fishing width of the net (s) , we calculated the area fished for each effort. Then fish densities (by species) for each effort were calculated and expressed as number/hectare (10,000 m^2). The estimated fishing width of the 3.1-m plumb-staff beam trawl was 2.3 m (Gunderson et al. 1985); estimated fishing widths of the 4.9-m semiballoon shrimp trawls (standard and modified) and the 7.9-m semiballoon shrimp trawl were 3.3 and 5.3 m, respectively.

For data analysis, Y-O-Y white sturgeon were separated from older juvenile sturgeon using length frequencies. For this report, a white sturgeon's birth date is assumed to be 1 January, although in reality the birth date is generally sometime later in the year. Throughout the field season, pectoral rays (left) were removed from Y-O-Y white sturgeon and given to WDF for age confirmations. The anterior ray of the left pectoral fin was cut just distal to the fin articulation and removed from the fish.

Linear regression was used to compute the fork length-weight relationship for white sturgeon: the data were transformed ($\log_{10}$) prior to computing the relationship. The relationship between natural total length and fork length was determined by using linear regression on untransformed data.

A condition factor (Everhart and Youngs 1981) was computed for each white sturgeon using the formula:

$$C = (W/L^3) \times 10^5;$$

C = condition factor, W = weight, and L = length. Weight was in grams and fork length was in millimeters. A mean condition factor and accompanying standard deviation were calculated for all white sturgeon combined.