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

Annual Progress Report

April 1990 - March 1991

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Project No. 86-50
Contract Number DE-A179-86BP63584

September, 1991

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EXECUTIVE SUMMARY

We report on our progress from April 1990 through March 1991 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 Department 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 (Report 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 Dam.

2. WDF (Report B): Describe the white sturgeon recreational fishery between Bonneville and McNary dams, describe 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 (Report 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. NMFS (Report 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 expanded efforts to Bonneville Reservoir in 1988 and John Day Reservoir in 1989.

Highlights of results of our work in The Dalles, Bonneville and John Day reservoirs are

Report A

1. We caught 623 white sturgeon in John Day Reservoir in 1,188 longline sets. We caught an additional 236 white sturgeon in 26 gill net sets. White sturgeon caught with longlines ranged from 26 cm to 230 cm FL, whereas those caught with gill nets ranged from 29 to 100 cm FL. Vulnerability to capture by longlines was greatest for white sturgeon in the 101 to 125 cm FL length class. of the white sturgeon caught we marked 512, all with fork lengths greater than 64 cm. We subsequently

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

recaptured 28 fish we marked in 1990 and 3 we marked in 1989. One marked fish was recovered while sampling the recreational and commercial fisheries and six marked fish were recaptured by recreational and commercial fishermen. Catch rates of white sturgeon with longlines in John day Reservoir were less than 16 percent of catch rates in Bonneville and The Dalles reservoirs.

2. Sturgeon moved throughout John Day Reservoir; some recaptured fish moved up to 119 km and over half the marked fish we recaptured had moved at least 10 km from where tagged. Five sturgeon marked in Bonneville Reservoir in 1988 and 1989 were recaptured by recreational anglers downstream from Bonneville Dam in 1990. Another three white sturgeon marked in The Dalles Reservoir in 1987, 1988 and 1989 were recaptured by anglers in Bonneville Reservoir in 1990. Although we have observed downriver movement of white sturgeon, only one white sturgeon marked since 1987 has been recaptured in a reservoir upriver from the one in which it was marked. Catch rates of white sturgeon with longlines in the McNary Dam tailrace boat-restricted-zone were 17 times greater than in the rest of the reservoir.

3. Ages of sturgeon sampled from 1987 through 1990 ranged from 0 to 38 years in Bonneville Reservoir, 0 to 46 years in The Dalles Reservoir, and 2 to 38 years in John Day Reservoir. We recaptured 78 white sturgeon we had previously marked with oxytetracycline (OTC); 74 had an OTC mark on their fin ray section. For most of the fish marked in May and June the OTC mark was within or immediately adjacent to the annulus. For most of the fish marked in July and August, the annulus was separate from the OTC mark. These results suggest annulus formation is complete by the end of June when growth resumes.

4. We increased the number of white sturgeon gonads examined from 3,198 to 3,906. Of the white sturgeon we examined, 2 percent had developing or ripe eggs and were expected to spawn the year following capture. Our attempts to use blood samples to determine stage of maturity have been hampered by low sample sizes. However, we are continuing work to define the relationship between blood levels of alkaline-labile phosphoproteins and stage of maturity. We are also continuing work to define'the relationship between length and fecundity.

Report B

1. We interviewed 4,854 recreational anglers in Bonneville Reservoir and 4,952 recreational anglers in John Day Reservoir in 1990. Our estimates of angling effort for sturgeon were 83,927 hours in Bonneville Reservoir and 43,650 hours in John Day Reservoir. We estimated harvest by the recreational fishery to be 2,114 sturgeon from Bonnevilie Reservoir and 316 sturgeon from John Day Reservoir. Catch per hour by sturgeon anglers averaged about 0.03 for boat anglers and 0.02 for bank anglers in Bonneville Reservoir and 0.01 for boat anglers and <0.01 for bank anglers in John Day R'eservoir.

2. Recreational anglers handled almost 8 sublegal-sized sturgeon for every legal-sized sturgeon handled in Bonneville Reservoir. In John Day

Reservoir, recreational anglers handled almost 9 sublegal-sized sturgeon for every legal-sized sturgeon handled. In Bonneville Reservoir, anglers handled 83 legal-sized sturgeon for each overlegal-sized sturgeon handled, whereas in John Day Reservoir, 3 legal-sized sturgeon were handled for each overlegal-sized sturgeon. The average fork length of white sturgeon harvested by recreational anglers in 1990 was 104 cm in Bonneville Reservoir and 111 cm in John Day Reservoir.

3. The tribal commercial fishery harvested an estimated 1,206 sturgeon from The Dalles Reservoir, 1,890 from Bonneville Reservoir and 405 from John Day Reservoir in 1990. Average fork lengths of commercially harvested sturgeon were 128 cm in The Dalles Reservoir, 117 cm in Bonneville Reservoir, 125 cm in John Day Reservoir.

4. Samples of sturgeon from recreational and commercial fisheries were 53 percent female in Bonneville Reservoir and 51 percent female in John Day Reservoir; 46 percent of fish sampled from The Dalles Reservoir tribal commercial fisheries were female.

Report C

1. Water temperatures of 14-17C considered optimal for white sturgeon spawning occurred between June 8 and July 9, 1990 in all three reservoirs between Bonneville and McNary dams. Also, river discharges during this period were higher than in previous years in all three 'reservoirs. We caught 768 sturgeon eggs in The Dalles Dam tailrace, 337 in John Day Dam tailrace, and 71 in McNary Dam tailrace from May 23 through July 12, 1990. These catches were much higher than in'previous years. Eggs were collected in water from 4 to 25 m deep. Mean water column velocities where eggs were collected ranged from 0.67 to 1.92 m/sec. Backcalculated ages of eggs indicated spawning occurred on at least.31 days in Bonneville Reservoir, 19 days in The Dalles Reservoir, and 10 days in John Day Reservoir between May 23 and July 7. About 21 percent of the eggs collected in Bonneville, 57 percent of eggs collected in The Dalles, and 14 percent of eggs collected in John Day were dead or covered with fungus. Developmental stages of eggs ranged from unfertilized to prehatch.

2. We collected 221 sturgeon larvae in Bonneville, 66 in The Dalles, and 80 in John Day between May 30 and July 16, 1990. Developmental stages ranged from one-day post-hatch to 10 days post-hatch. Total lengths of larvae ranged from 9 to 24 mm. Larvae were collected at depths of 6 to 38 m; mean water column velocities ranged from 0.70 to 1.92 m/s.

3. Young-of-the-year (YOY) sturgeon were captured for the second consecutive year in Bonneville and for the first time in The Dalles in 1990. No sturgeon YOY were collected in John Day. Numbers collected were 85 YOY in Bonneville and 5 in The Dalles. YOY ranged in total length from 25 mm in July to 262 mm in October. YOY were collected at depths ranging from 18.35 to 47.2 m.

4. We caught 259 juvenile sturgeon (age II or older) in Bonneville, 13 in The Dalles, and 3 in John Day in 1990. Fork lengths ranged from 28

to 92 cm. We marked 242 juvenile sturgeon in Bonneville, 12 in The Dalles, and 3 in John Day. Four marked fish at large in Bonneville and one in John Day were recaptured in 1990; none were recaptured in The Dalles. Over half of juvenile sturgeon were caught in the upper one-third of each reservoir. All juvenile sturgeon collected in Bonneville, The Dalles, and John Day were caught at sites with minimum depths of 9 m.

5. The length-weight relationship of juvenile sturgeon was described as log W = 2.925(log FL) - 4.96 in Bonneville and log W = 3.13 log FL) - 5.51 in The Dalles; where W is weight in g and FL is fork length in mm. Not enough fish were collected in John Day to describe the length-weight relationship. Ages of juvenile sturgeon in Bonneville ranged from 1 to 12 years. The single juvenile sturgeon aged from The Dalles was 4 years old. The single juvenile sturgeon aged from John Day was 6 years old.

6. Food habit analyses of 67 YOY sturgeon collected in Bonneville and 5 YOY collected in The Dalles indicated amphipods of the genus *Corophium* was the most important food item, comprising over 84 percent by weight of food ingested. Other prey items found in stomach samples were *Neomysis mercedis*, *Corbicula manilensis*, Gammarids, Chironomid larvae, Cladocera, and Ephemeroptera.

7. We estimated that approximately 27 percent of the Columbia River downstream from Bonneville Dam is occupied by depths greater than 9 m versus 44 percent in Bonneville Reservoir, 57 percent in The Dalles Reservoir, and 54 percent in John Day Reservoir. Conversely about 40 percent of the Columbia River downstream from Bonneville Dam is occupied by depths less than 4 m versus 20 percent in Bonneville Reservoir, 9 percent in The Dalles Reservoir, and 25 percent in John Day Reservoir. We are using this information along with continuing work to estimate quantities of various substrates and simulate varying hydraulic conditions to evaluate amounts of spawning habitat available to white sturgeon in impounded and free-flowing reaches.

Highlights of results of our work downstream from Bonneville Dam are

Report B

1. We caught 6,555 sturgeon in 1990 using gill nets. Of the fish we caught, we tagged 3,364 sturgeon; 2,756 of which were tagged in the Columbia River estuary. We tagged an additional 139 sturgeon during other tagging studies. We marked significantly higher numbers of sturgeon in 1990 than in previous years; including large numbers of OTC marked fish. These efforts should help refine estimates of abundance, growth, mortality, and distribution.

2. In addition to the 6,555 fish we caught, 1,948 sturgeon caught by the recreational fishery and 1,551 sturgeon caught by the commercial fishery were examined for marks in 1990. Of fish marked in 1990, we recovered 25 marks in our recreational fishery samples, 12 marks in our commercial fishery samples, and 174 marks in our research samples. Of fish marked

in 1983 through 1988, we recovered 125 marks in our recreational and commercial fisheries samples and 370 in our research samples.

3. Fork lengths of sturgeon caught in the recreational and commercial fisheries averaged 103 cm and 119 cm. Fork lengths ranged from 82 to 165 cm in the recreational fishery and 98 to 190 cm in the commercial fishery. Examination of OTC marked fish recovered in 1990 indicate annulus formation downstream from Bonneville Dam may occur by April.

Report D

1. We collected 2,785 sturgeon eggs and 190 sturgeon larvae between April 23 and July 20, 1990. We collected 1,804 eggs with nets and 981 eggs with artificial substrates. Most eggs were collected at the Ives Island sampling station. Over 60 percent of the eggs collected with artificial substrates were collected at Ives Island; 327 eggs were collected just downstream from the spillways at Bonneville Dam. Freshly fertilized eggs made up about 66 percent of the eggs collected at Ives Island, but less than 16 percent of the eggs collected downstream or upstream from Ives Island, suggesting that spawning intensity was greatest near Ives Island. We estimated spawning period, back-calculated from egg stages in samples, to extend from April 23 to July 9. During this period spawning was estimated to have occurred on at least 47 days; 6 days in late April, 22 days in May, 16 days in June, and 3 days in early July.

2. The physical characteristics of sites where eggs and larvae were collected were similar. Bottom temperatures ranged from 11 to 21C, turbidities from 1.9 to 8.5 NTU, mean water column velocities from 0.8 to 2.7 m/s, and depths from 3.7 to 29.0 m.

3. We collected 1,409 juvenile sturgeon with trawls in 1990; 273 that were post-larval young-of-the-year (YOY). We tagged 829 juvenile sturgeon. We recaptured 5 sturgeon; 3 tagged in 1989 and 2 tagged in 1990. Distribution of juveniles was patchy and numbers caught varied greatly among sampling areas and transects within sampling areas. Number of juvenile sturgeon captured per hectare sampled tended to be higher in areas upstream from RM 75, than in areas downstream from RM 75. Juvenile sturgeon were captured at depths ranging from about 6 to 38 m and in areas with sandy substrate; mean densities were highest at depths greater than 18.2 m.

4. Size distributions of juvenile fish sampled were similar among months through June; 1990 was the only discernable year class and was recruited to our gear in June. Mean fork length of YOY sturgeon increased from 31 mm in June to 194 mm in September. The length-weight relationship of juvenile sturgeon was described as $\log W = 2.96(\log FL) - 5.07$; where W is weight in g and FL is fork length in mm.

REPORT 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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ACKNOWLEDGMENTS

Steve Banghart, Roger Barreth, Ken Keller, Corey Miner, and Andy Murrett, assisted with field sampling. Craig Foster helped with sampling site selection, provided guidance in boat maintenance, and tutored us in methods for aging sturgeon from spines. Laurie Allen and Kevin Leader assisted with assembiing the finai draft of this report.

ABSTRACT

We report on our effort from April 1990 to March 1991 to describe the life history and population dynamics of white sturgeon *Acipenser transmontanus* in John Day Reservoir. We set 1,188 set lines and 26 gill nets. We caught 623 white sturgeon with set lines and 236 with gill nets. Catch per unit effort was much higher in areas near the tailrace than in downstream sites. Our setlines were size selective. We recaptured 3 fish released in John Day Reservoir in 1989 and 28 fish released in 1990. Sport and commercial fishermen recovered 62 tags from fish we tagged in Bonneville, The Dalles and John Day reservoirs, 1987-1990. We observed extensive movements of marked sturgeon within the reservoirs. We completed aging of available samples from all three reservoirs from 1987-1990. We aged fish as old as 46 years. Bone marks were observed on 74 of 78 fish previously injected with oxytetracycline and annulus formation was generally complete after June. We estimated parameters in a length-weight equation. About 1.5% of the female white sturgeon we examined to date had early or late vitellogenic eggs and would be expected to spawn the following year.

INTRODUCTION

We began our study of white sturgeon *Acipenser transmontanus* life history and population dynamics in July 1986. We reported our progress through March 1990 in four reports: Rieman et al. (1987), Nigro et al. (1988) Beamesderfer et al. (1989) and Beamesderfer et al. (1990). In this report we describe our activities and results from April 1990 through March 1991, summarizing progress toward study objectives and intermediate results upon which we will base analyses satisfying study objectives.

METHODS

We sampled white sturgeon from April through September 1990 in John Day Reservoir to estimate population statistics. We divided John Day into ten, 7.5 river-mile sections (Figure 1). Results for the boat-restricted tone (BRZ) adjacent to and downstream from McNary Dam are reported separately from other sections of the pool because the BRZ is a unique habitat. The BRZ is less than one-half mile long.

We initially distributed sampling effort equally within sections to obtain a representative sample of the population. We sampled all sections of John Day Reservoir once every five weeks. After three passes though the entire reservoir, we limited sampling to the four sections nearest McNary Dam to increase our catch.

We used set lines as our primary sampling gear because they provide the greatest catch rate and are less site selective than other gears (Elliott and Beamesderfer 1990). We fished set lines overnight for 13 hr to 73 hr (average 23.4 hr). Lines had 40 hooks (sizes: 12/O, 14/O, and 16/O). We baited hooks with pieces of Pacific lamprey *Lampetra tridentata,* and occasionally American shad *Alosa sapidissima* and northern squawfish *Ptychocheilus oregonensis.*

In the BRZ, we used bottom gill nets in addition to regular sampling with set lines. Catch rates from early in the field season indicated our total catch of sturgeon would be lower than it had been in Bonneville and The Dalles reservoirs. Gill nets allowed us to increase the number of small (less than 100 cm fork length) sturgeon we sampled. Our gill nets were 45.6 m long x 2.4 m deep. Each half had three panels: 3.2 cm, 4.4 cm, and 5.1 cm bar mesh nylon. We fished nets during daylight for 0.2 to 2.6 hr (average 1.4 hr). Nets were set parallel to river flow in 4 m to 27 m of water.

We measured fork length (FL) and examined each white sturgeon caught for tags, tag scars, fin marks, barbel clips, and scute marks. All untagged white sturgeon *over* 64 cm FL were tagged with one spaghetti tag placed at the base of the anterior end of the dorsal fin. All white sturgeon longer than 84 cm FL were also tagged with a Petersen disc dangler tag placed at the base of the posterior end of the dorsal fin.

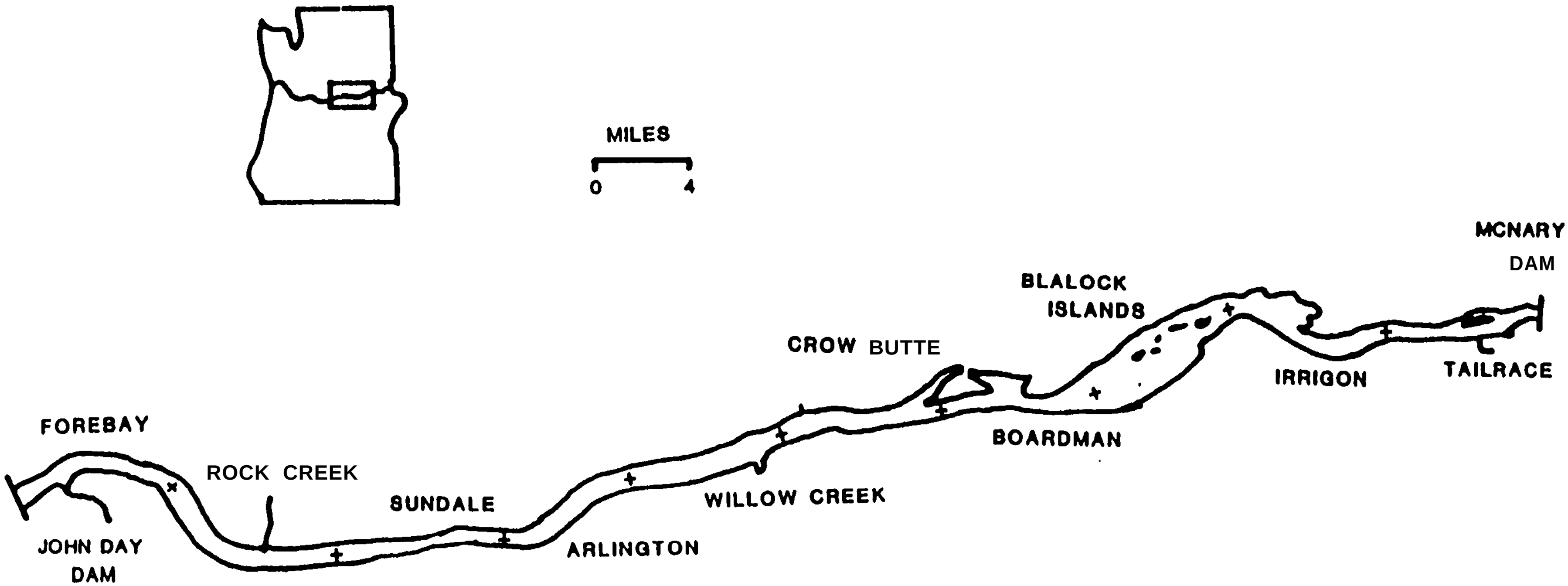

Figure 1. Sampling areas in John Day Reservoir on the Columbia River.

We removed the fourth right lateral scute from tagged white sturgeon to identify tag loss. We weighed all white sturgeon captured until we had at least 30 samples for each 20 cm FL interval. We weighed all recaptured and surgically-examined fish.

Right pectoral fin ray sections were collected to determine age. We collected fin ray samples from every white sturgeon captured until we had at least 30 samples for each 20 cm FL interval.

We injected 646 white sturgeon with oxytetracycline (OTC) to mark fin rays and test the validity of our age interpretations using fish we recapture in future years. We injected 100 mg/ml OTC into the red muscle under the dorsal scutes just behind the head. Doses were adjusted such that each fish received about 25 mg of OTC/kg of body weight. Only white sturgeon with fork lengths less than 85 cm and longer than 170 cm were injected. In this way, anglers would not risk eating flesh from an injected fish within the 15-day period directed by the Food and Drug Administration. (In 1990, anglers could legally keep fish with total lengths from 91 through 183 cm, or 40 through 72 inches). We removed the second right lateral scute from OTC injected fish to permit identification at recapture. We collected fin ray samples from 30 fish previously injected with OTC.

We examined the gonads of every white sturgeon longer than 169 cm FL to determine sex and stage of maturity following procedures outlined in Beamesderfer et al. (1989). We made a small (l-2 cm) incision in the ventral surface anterior to the vent, inspected the gonad with an otoscope, and visually classified gonad condition using criteria outlined in Nigro et al. (1988). A sample (3-f g) of the gonad was removed from females with visible eggs using biopsy forceps. We preserved the samples in formalin. Incisions were closed with sutures and sealed with a surgical adhesive. We released all live fish after handling. Washington Department of Fisheries (WDF) supplied samples of gonads from the catch in recreational and commercial fisheries in Bonneville, The Dalles, and John Day reservoirs. In the lab, we examined the gonad samples to determine the maturity of female sturgeon from mean egg diameter.

We took blood samples from white sturgeon longer than 169 cm FL and analyzed the level of alkaline-labile phosphoproteins (ALPP). We used a vacutainer tube and needle to draw blood from a vein along the ventral side of the caudal peduncle. We froze and stored the samples for later analysis of blood chemistry.

We determined the relative efficiency of our sampling gear by examining length-frequency distributions of fish captured and recapture-to-at-large ratios of different sized fish so we can correct analyses for gear biases. In preparation for estimating abundance and mortality rates of white sturgeon, we summarized number of white sturgeon marked and number recaptured in our sampling and by anglers who voluntarily returned tags.

We examined the distribution of white sturgeon by comparing catch rate among areas. We compared the sites and dates of release with those for recapture of marked fish to determine the extent and timing of movement within each reservoir and to determine whether populations in each reservoir mixed.

The age of white sturgeon was estimated from thin cross sections of pectoral fin rays following procedures outlined in Beamesderfer et al. (1989). We summarized this information in preparation for estimating growth and age composition of white sturgeon populations. Each fin ray section was aged by at least two people. We examined fin ray sections of OTC injected fish to validate our aging technique. We examined the proximity of OTC marks to the annuli formed before injection to determine-time of annulus formation.

We quantified the relationship between length and weight. We measured the diameter of eggs from ovarian samples to help determine the period of development. This will allow us to estimate the proportion of the population that is females that will spawn each year. We included females with early and late vitellogenic eggs in our estimate of the number of females spawning next year. We examined mean egg diameter of individual sturgeon over time to describe the duration of egg development in female sturgeon.

RESULTS

Catch

We set 1,188 setlines (Table 1) and caught 623 white sturgeon (0.52 per set line-set; Table 2). We set 26 gill nets in the McNary Dam BRZ and caught 236 white sturgeon (9.08 per set line set). Set lines captured sturgeon from 26 through 230 cm FL. Gill nets captured sturgeon from 29 through 100 cm FL. Vulnerability to capture with set lines was greatest for fish in the 101-125 cm FL size range (Table 3). We did not recapture any tagged fish with gill nets.

Marking and Mark Recovery

We tagged 512 white sturgeon larger than 64 cm FL in John Day Reservoir in 1990 (Table 4). This includes 3 fish recaptured from 1989 marking in John Day Reservoir (Table 5). We subsequently recaptured 28 fish tagged in John Day in 1990, including 6 that we recaptured in the same period that we tagged them (Table 5). Washington Department of Fisheries personnel recovered 1 tagged fish while sampling recreational and commercial fisheries. Sport and commercial anglers voluntarily reported 6 tagged fish they harvested (Table 6).

Table 1. Sampling effort (number of sets) for white sturgeon in John Day Reservoir, April through September, 1990

Gear, Week of the year	Location[a]											
	1	2	3	4	5	6	7	8	9	10	11	*N*
Set line:												
16	0	0	0	0	0	0	0	0	0	2	2	4
17	0	0	0	0	0	0	24	21	0	0	0	45
18	24	24	0	0	0	0	0	0	0	0	0	48
19	0	0	0	0	21	25	0	0	0	0	0	46
20	0	0	0	0	0	0	0	0	30	14	5	49
21	0	0	30	30	0	0	0	0	0	0	0	60
22	0	0	0	0	0	0	16	10	0	0	0	26
23	30	30	0	0	0	0	0	0	0	0	0	60
24	0	0	0	0	24	30	0	0	0	0	0	54
25	0	0	30	30	0	0	0	0	0	0	0	60
26	0	0	0	0	0	0	25	36	0	0	0	61
27	0	0	0	0	0	0	0	0	36	36	0	72
28	36	28	6	0	0	0	0	0	0	0	0	70
29	0	0	0	0	36	36	0	0	0	0	4	76
30	0	0	0	0	0	0	0	0	36	25	9	70
31	0	0	30	33	0	0	0	0	0	0	0	63
32	0	0	0	0	0	0	36	36	0	0	0	72
33	0	0	0	0	0	0	0	0	36	27	9	72
34	0	0	0	0	0	0	36	36	0	0	0	72
35	0	0	0	0	0	0	0	0	39	24	9	72
36	0	0	0	0	0	0	0	0	20	14	2	36
N	90	82	96	93	81	91	137	139	197	142	40	1188
Gill net:												
29	0	0	0	0	0	0	0	0	0	0	6	6
30	0	0	0	0	0	0	0	0	0	0	4	4
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	6	6
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	6	6
36	0	0	0	0	0	0	0	0	0	0	4	4
N	0	0	0	0	0	0	0	0	0	0	26	26

[a] *1 = John Day Dam Forebay, 2 = Rock Creek, 3 = Sundale, 4 = Arlington, 5 = Willow Creek, 6 = Crow Butte, 7 = Boardman, 8 = Blalock Islands 9 = Irrigon, 10 = Tailrace, 11 = McNary Dam BRZ.*

Table 2. Catches of white sturgeon (all lengths) in John Day Reservoir, April through September 1990.

Gear, Week of the year	Location[a]											
	1	2	3	4	5	6	7	8	9	10	11	*N*
Set line:												
16	--	--		--	--	--	--	--	--	0	0	0
17	--	--	--	--	--	--	4	10	--	--	--	14
18	0	3	--	--	--	--	--	--	--	--	--	3
19	--	--	--	--	2	5	--	--	--	--	--	7
20	--	--	--	--	--	--	--	--	24	4	36	64
21	--	--	1	3	--	--	--	--	--	--	--	4
22	--	--	--	--	--	--	5	6	--	--	--	11
23	5	3	--	--	--	--	--	--	--	--	--	8
24	--	--	--	--	11	7	--	--		--	--	18
25	--	--	0	2	--	--	--	--		--	--	2
26	--	--	--	--	--		17	18		--	--	35
27	--	--	--	--	--	--	--	--	29	50	--	79
28	5	2	0	--	--	--	--	--	--	--	--	7
29	--	--	--	--	8	3		--		--	34	45
30	--	--	--	--	--	--	--	--	26	42	30	98
31	--	--	1	4	--	--	--	--	--	--	--	5
32	--	--	--	--	--	--	4	22		--	--	26
33	--	--	--	--	--	--	--	--	9	19	58	86
34	--	--		--	--	--	0	13	--	--	--	13
35	--			--	--	--	--	--	6	5	55	66
36.	--	--	--	--	--	--	--	--	8	6	18	3 2
N	10	8	2	9	21	15	30	69	102	126	231	623
Gill net:												
29	--	--	--	--	--	--	--	--	--	--	84	84
30	--	--	--	--	--	--		--	--	--	50	50
31	--	--	--	--	--	--	--	--	--	--		--
32	--	--	--	--	--	--	--	--	--	--	--	--
33	--	--	--	--	--	--	--	--	--	--	40	40
34	--	--	--		--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	--	--	45	45
36	--	--	--	--	--	--	--	--	--	--	17	17
N	--	--	--	--	--	--	--	--	--	--	236	236

[a] *1 = John Day Dam Forebay, 2 = Rock Creek, 3 = Sundale, 4 = Arlington, 5 = Willow Creek, 6 = Crow Butte, 7 = Boardman, 8 = Blalock Islands 9 = Irrigon, 10 = Tailrace, 11 = McNary Dam BRZ.*

Table 3. Set line recapture rate of white sturgeon in John Day Reservoir by length interval, 1990.

Fork length interval (cm)	Number of fish at large	Recapture rate
51-75	174	0.0345
76-100	236	0.0551
101-125	51	0.0784
126-150	18	0
151-175	2	0
>175	32	0.0313

Table 4. Mark and recapture data for white sturgeon (>64 cm FL) captured with set lines and by surveyed anglers in John Day Reservoir, 1990.

Period	Number caught	Number marked[a]	Number recaptured	Number removed[b] Unmarked	Number removed[b] Marked	Number of marks at large
4/23 - 5/26	75	75	0	1	0	
5/27 - 7/07	91	88	3	5	0	0
6/24 - 8/04	194	187	3	19	1	75
8/05 - 9/08	186	162	16	28	3	163
						349
Totai	546	512	22	53	4	

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

[b] *Includes* observed *catch by recreational and commercial fishermen from sampling by Washington Department of Fisheries.*

Table 5. Mark and recapture data from Bonneville, The Dalles and John Day pools for white sturgeon (≥ 65 cm) tagged and recaptured in years subsequent to the year of tagging.

Reservoir, year	Number caught	Number marked	Number recaptured 1988	1989	1990	Number removed[a] Unmarked	Marked	Number of marks at large
Bonneville:								
1988	393	392	--	42	5	520	2	--
1989	2,617	2,544	--	--	41	350	13	390
1990	0	0	--	--	--	531	0	2,921
Total	3,010	2,936	--	42	46	1,401	15	
The Dalles:								
1987	837	815	82	17	8	877	59	--
1988	1,416	1,305	--	63	12	377	34	756
1989	174	171	--	--	1	922	2	2,027
1990	0	0	--	--	--	241	0	2,196
Total	2,274	2,161	82	70	21	2,175.	95	
John Day:								
1989	21	21	--	--	3	31	0	--
1990	546	512	--	--	--	85	6	21
Total	567	533	--	--	3	116	6	

[a] *Includes voluntary tag returns, and observed catch by recreational and commercial fishermen from sampling by Washington Department of Fisheries.*

Table 6. Recovery of sturgeon tags by recreational and commercial fishermen in Bonneville and The Dalles reservoirs, 1990. Sources not listed did not recover any tags from the release year.

Release year, source	Jan	Feb	Mar	Apt	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							Month of the year					
Below Bonneville Reservoir												
1988:												
Angler voluntary	10	0		0	0	0	0	0	0	0	0	0
1989:												
Angler voluntary	10		0	0		0	11	0	0	1	0	0
Bonneville Reservoir												
1987:												
Commercial sample'	0	0	0	0	0	0	0	0	1	0	0	0
Angler voluntary	0	0		0		0	010	0	0	0	0	0
1988:												
Angler sample[a]	0	0	0	0	0	0	1	0	0	0	0	0
Angler voluntary	0	0		0	2	0	12	0	0	0	0	0
1989:												
Commercial sample"	0	0	0	0	0	0	0	1	0	0	0	0
Angler sample[a]	0	0	0	3	-0	4	1	0	0	0	0	0
Angler voluntary	2	0	2	6	1	8	5	2	3	0	2	1
The Dalles Reservoir												
1987:												
Commercial sample[a]	0	0	0	1	0	0	0	3	0	0	0	0
Commercial voluntary	0	0	0	0	0	0	0	0	0	1	0	0
Angler voluntary	0	0	0	0	0	0	0	1	1	0	0	0
1988:												
Commercial sample[a]	0	010		0		0	0	0	1	0	0	0
Angler voluntary	0	0		0		0	112	0	3	0	1	1
1989:												
Commercial sample[a]	0	0	0	0	0	0	0	1	0	0	0	0
Angler voluntary	0	0	0	0	0	0	0	0	0	0	0	2
John Day Reservoir												
1990:												
Angler sample[a]	0	0	0	0	0	0	0	0	0	0	1	0
Angler voluntary	0	0	0	0	0	0	1	3	1	0	1	0

[a] *Refers to recoveries during sub-sampling of the catch of recreational* or *commercial fishermen* for *biological information.*

Distribution and Movement

White sturgeon were not evenly distributed and moved widely within the reservoir. Densities in the BRZ (inferred from-catch per unit effort) were seventeen times greater than in the rest of the reservoir (Table 7). We often recaptured white sturgeon in areas other than where released (Tables 8 and 9). Of 35 white sturgeon tagged and recaptured in John Day Reservoir in 1990, 7 traveled less than 1 Km, 9 traveled at least 1 Km but less than 10 Km, and 19 traveled 10 Km or more. We observed movement of up to 119 km.

We observed some movement of white sturgeon between reservoirs in 1990. Anglers recaptured five sturgeon below Bonneville Dam that we originally tagged in Bonneville reservoir in 1988-1989. They recaptured three sturgeon in Bonneville Reservoir that we tagged in The Dalles Reservoir in 1987-1988.

Age, Growth, and Morphometry

We assigned ages to 520, 1,144, and 474 white sturgeon collected from Bonneville, The Dalles, and John Day reservoirs, 1987-1990 (Tables 10-12, and Appendix Tables A-1.1 - A-1.12). The ranges of assigned age were 0-38 years, 0-46 years, and 2-38 years for each of the reservoirs.

Paired samples of fork length and weight from white sturgeon in John Day Reservoir were sufficient to calculate regression equations with high degrees of confidence (Figure 2).

We saw bone marks in 74 of 78 pectoral fin ray sections from white sturgeon previously injected with OTC. Generally, the bone marks were within or abutting the previous year's annulus when injected in May and June (11 of 14 samples), and separate from the annulus when injected in July and August (28 of 34 samples). However, 20% of the fish injected in August still had bone marks bordering the annulus.

Reproduction

We have examined gonads of 3,906 sturgeon (FL > 79 cm) collected from 1987 through 1990. We found 1.51 of these contained developing eggs (stages 2 and 3) which we would expect to be spawned the year following capture (Table 13). Only 0.5% of the samples were from ripe or spent fish. We saw three apparent egg diameter groups from fish collected from February through April (Figure 3). After May, no discrete groupings of egg diameters could be discerned.

We analyzed 19 blood samples that were collected 1988-1990. The level of ALPP increased with egg development stage, but we have too few samples from maturing fish to establish a relationship between ALPP levels and stage of maturity (Figure 4).

Table 7. Catch per set[a] by gear and month for white sturgeon, John Day Reservoir, 1990.

Gear, month[c]	Location[b] 1	2	3	4	5	6	7	8	9	10	11
Set line:											
Apr	--	--	--	--	--	--	0.17	0.48	--	0.00	0.00
May	0.00	0.13	0.03	0.10	0.10	0.20	0.31	0.60	0.80	0.29	7.20
Jun	0.17	0.10	0.00	0.07	0.46	0.23	0.68	0.50	--	--	--
Jul	0.14	0.07	0.00	--	0.22	0.08	--	--	0.76	1.51	4.92
Aug	--	--	0.03	0.12	--	--	0.06	0.49	0.20	0.47	6.28
Sep	--	--	--	--	--	--	--	--	0.40	0.43	9.00
All	0.11	0.10	0.02	0.10	0.26	0.16	0.22	0.50	0.52	0.89	5.78
Gill net:											
Jul	--	--	--	--	--	--	--	--	--	--	13.40
Aug	--	--	--	--	--	--	--	--	--	--	7.08
Sep	--	--	--	--	--	--	--	--	--	--	4.25
All	--	--	--	--	--	--	--	--	--	--	9.0a

[a] *Set lines (40 hooks) were set for about 24 hours. Gill nets were set for about 1 hour.*

[b] *1 = John Day Dam Forebay, 2 = Rock Creek, 3 = Sundale, 4 = Arlington, 5 = Willow Creek, 6 = Crow Butte, 7 = Boardman, 8 = Blalock Islands, 9 = Irrigon, 10 = Tailrace, 11 = McNary Dam BRZ.*

[c] *Months: April = weeks 13 through 17, May = weeks 18 through 22, June = weeks 23 through 26, July = weeks 27 through 30, August = weeks 31 through 35, September = weeks 36 through 39.*

Table 8. Number of white sturgeon tagged and recovered during the year of marking by location in John Day Reservoir, 1990.

Tagging location	Number tagged	Recapture Location											
		0[a]	1	2	3	4	5	6	7	8	9	10	11
1. Forebay	9	2	0	0	0	0	0	0	0	0	0	0	0
2. Rock Creek	8	010		0	0	0	0	0	0		0	0	0
3. Sundale	2	0	0	0	0	0	0	0	0	0		o-o	0
4. Arlington	7	0	0	0	0	0	0	0	0		0	0	01
5. Willow Creek	19	0	0	0	0	0	0	0	0		0	0	01
6. Crow Butte	14	0	0	0	0	0	0	0	0		0	0	01
7. Boardman	29	0	0	0	0	0	0	0	0	l	O	0	1
8. Blalock	59	0	0	0	0	0	0	0	0	0	0	0	3
9. Irrigon	73	0	0	0	0	0	0	0	0		0	12	2
10. Tailrace	89	0	0	0	0		0	0	0	0	12		15
11. McNary BRZ	228	10		0	010		0	0	0	0		3	5
Total	537	3		10	010		0	0		2	3	6	19

[a] White sturgeon recovered from unknown locations in John Day Reservoir.

Table 9. Number of white sturgeon tagged and recovered at least one year after marking by location in Bonneville, The Dalles, and John Day reservoirs, fish marked from 1987-1989 and recovered 1988-1990 are included.

Reservoir, tagging location,	Number tagged	Recapture Location											
		0[a]	1	2	3	4	5	6	7	a	9	10	11
Bonneville:													
1. Bonneville Forebay	258	1	0	0	0	0	0	0	0	0	1	--	--
2. Wind River	419	7	1	9	1	2	0	0	0	0	0	--	--
3. Drano Lake	295	3	1	0	2	1	1	0	0	0	0	--	--
4. Hood River	579	3	2	2	0	3	0	0	0	0	0	--	--
5. Bingen	362	2	0	3	1	3	4	0	1	0	0	--	--
6. Memaloose	334	1	0	0	0	0	1	6	1	0	0	--	--
7. Mayer Park	284	1	0	0	0	0	0	0	5	2	0	--	--
8. The Dalles Tailrace	260	3	0	0	0	1	0	0	1	6	1	--	--
9. The Dalles BRZ	145	3	0	0	0	0	0	0	0	1	0	--	--
Total	2936	24	4	14	4	10	6	6	8	9	2	--	--
The Dalles:													
1. The Dalles Forebay	341	9	9	3	0	1	1	4	1	--	--	--	--
2. Browns Island	290	7	1	6	0	0	0	3	1	--	--	--	--
3. Celilo	219	11	0	2	5	0	1	1	0	--	--	--	--
4. Miller Island	270	9	0	2	2	3	1	0	0	--	--	--	--
5. Maryhill	293	14	0	0	0	0	4	3	2	--	--	--	--
6. John Day Tailrace	328	6	0	0	0	4	4	3	4	--	--	--	--
7. John Day BRZ	524	23	1	2	4	0	7	13	15	--	--	--	--
Total	2265	79	11	15	11	8	18	27	23	--	--	--	--
John Day:													
10. McNary Tailrace	3	0	0	0	0	0	0	0	0	0	0	0	0
11. McNary BRZ	18	0	0	0	0	0	0	1	0	0	0	0	2
Total	21	0	0	0	0	0	0	1	0	0	0	0	2

[a] *White sturgeon recovered from unknown locations within the reservoir they were originally marked in.*

Table 10. Age-length-frequency distributions for white sturgeon in Bonneville Reservoir, 1987-1990. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59.	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2		6										35.9	1.1	6
3		11	3									37.8	4.5	14
4		4	7	1								46.0	9.6	12
5		3	19									49.1	6.8	22
6		1	10	5								56.1	10.0	16
7			3	8	1							65.6	7.5	12
8			4	7	1							65.2	9.5	12
9			5	5	4							67.9	14.3	14
10			2	5	4	1						80.7	17.5	12
11			3	3	5	5	1					85.9	20.8	17
12			2	3	8	4	1					91.2	21.0	18
13			1	1	6	6	2					98.7	19.9	16
14			1	2	7	12	3					101.0	17.6	25
15				5	6	15	9	1				106.6	18.0	36
16				3	8	18	9	1				107.2	19.2	39
17			1	5	10	19	17	3				108.3	20.8	55
18				1	6	15	13					113.6	15.0	35
19				1	3	11	14	2				115.1	16.0	31
20				1	5	8	7	7				118.0	22.6	28
21				1	2	4	7	5	1		1	129.0	29.4	21
22				1		5	11	2				122.6	16.4	19
23						2	1	3	1			136.4	19.7	7
24					1	2	5		1			125.0	22.1	9
25						2	1	1		1	1	147.8	42.1	6
26						1	2			2	1	155.5	43.6	6
27							2	1		1		153.8	29.6	4
28							2	2	1	1	1	161.4	28.3	7
29							2	1	1		2	175.0	48.7	6
≥30							3		1	5	6	193.8	38.3	15
N		25	61	58	77	130	112	29	6	10	12	102.9	38.3	520

Table 11. Age-length-frequency distributions *for* white sturgeon in The Dalles Reservoir, 1987-1990. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1		2										26.9	0.8	2
2		67	15									35.6	4.5	82
3		39	62	1								41.8	5.8	102
4		41	110	8								45.4	7.3	159
5		8	56	19								51.8	10.6	83
6		1	11	14	1							60.6	11.6	27
7		19		8	1							62.0	12.9	19
8				5	5							78.7	10.0	10
9			1	2	6	1						82.8	14.2	10
10				7	12	5						87.8	13.6	24
11				2	8	6	1					96.6	13.7	17
12				1	9	12	1					100.4	13.0	23
13				2	5	20	3	2				108.2	15.2	32
14					6	19	10		1			113.1	14.5	36
15					2	19	7	2	1			117.9	15.3	31
16				1	5	23	14	5	2			120.3	17.4	50
17						13	22	8				125.9	12.9	43
18					1	13	28	11	2	1		130.7	17.3	56
19					1	11	24	16	8			135.9	20.3	60
20						9	25	32	5	3		140.2	18.4	74
21						7	20	14	4	1		137.4	16.5	46
22						2	6	24	4	5	3	154.3	23.3	44
23						1	3	14	5	1	1	152.4	19.6	25
24						3	3	5	10	1	1	155.0	25.0	23
25								1	5			159.8	9.3	6
26							1	1	4		3	175.1	33.6	9
27								1	6	1	4	180.3	22.8	12
28							1		3	2		169.3	18.7	6
29								1	2	1	3	189.7	30.7	7
≥30								4	6	2	14	202.3	37.4	26
N	0	159	264	70	62	164	169	141	68	18	29	96.6	50.0	1144

Table 12. Age-length-frequency distributions for white sturgeon in John Day Reservoir, 1987–1990. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2		5										33.6	2.9	5
3		7	3									38.9	7.0	10
4		8	9	1								44.8	11.1	18
5		6	11	2								47.5	9.4	19
6		3	6	8	1							60.0	15.6	18
7			4	10	6							73.6	14.4	20
8			3	15	4	4						78.1	14.0	26
9			3	3	9	2	1					82.2	18.2	18
10				3	5	3	1					93.4	17.1	12
ii					1	7						107.1	8.8	8
12					a	11	1					103.3	9.6	20
13				1	4	20	8					109.7	11.9	33
14					2	16	10	3				118.3	14.7	31
15					3	14	17	3				120.0	13.9	37
16					2	12	10	4				121.1	15.2	28
17					2	10	13	1	1		1	123.5	22.5	28
18					1	8	21	5	2			129.1	13.6	37
19						4	8	8				135.2	14.9	20
20						3	7	5		2		138.0	23.1	17
21						1	3	10	5			147.9	15.1	19
22							2	4	2	2	1	162.5	27.9	11
23							1	3		2		161.3	24.0	6
24							1	3	2	1		158.7	18.7	7
25								2	2	2		168.5	19.2	6
26								1	1	3	2	183.6	23.0	7
27												--	--	0
28											1	220.0	--	1
29								1		2	2	190.0	30.7	5
≥30											7	211.9	9.2	7
N		29	39	43	48	115	104	53	15	14	14	110.5	40.5	474

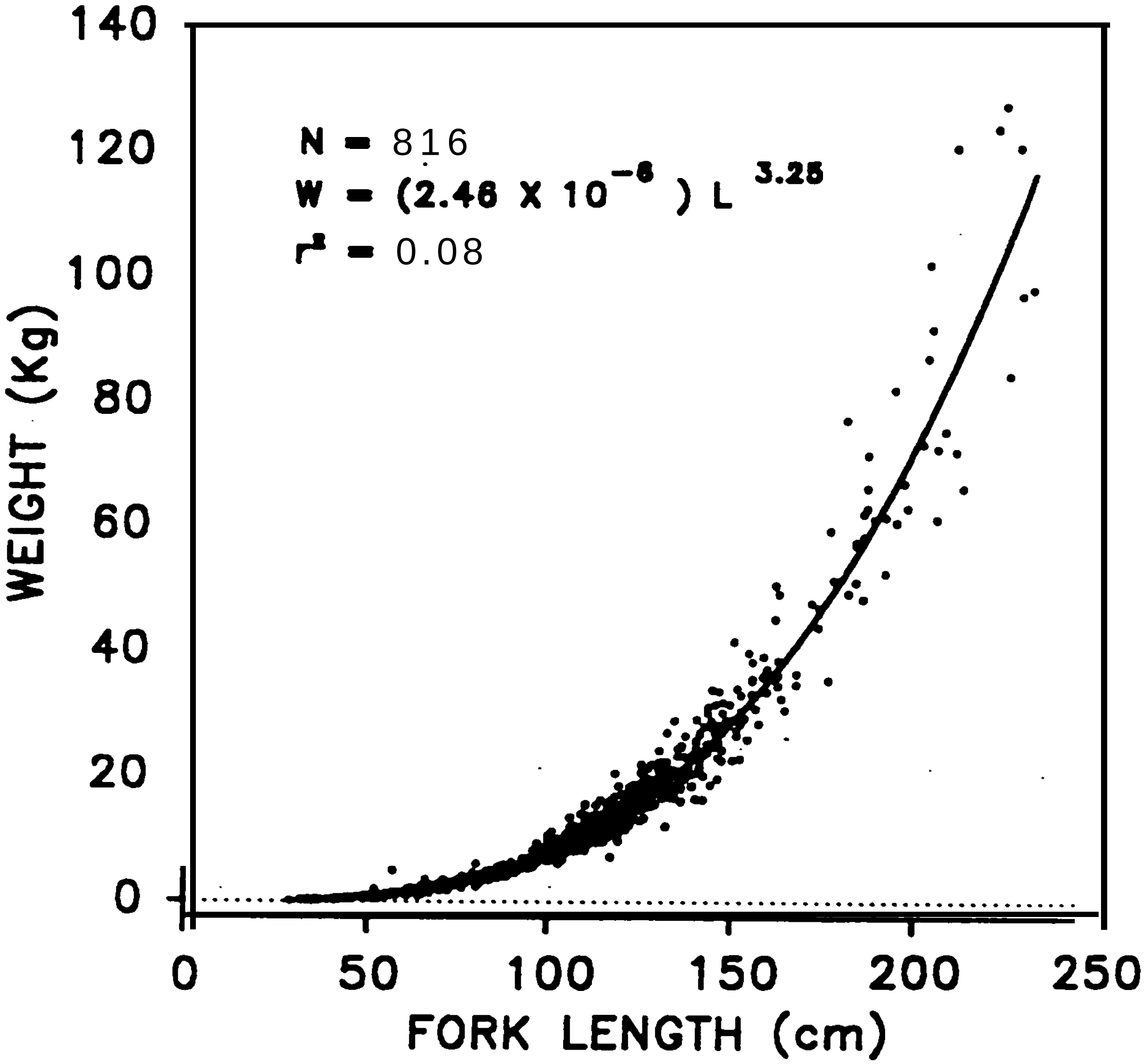

Figure 2. Weight-length relationship for white sturgeon collected in John Day Reservoir, 1987-1990.

Table 13. Developmental stage of gonads of female white sturgeon between Bonneville and McNary dams, 1987-90.

Reservoir, length group (cm)	N[a]	Developmental stage[b]						Expected spawning year	
		1	2	3	4	5	6	Year captured	Year after capture
Bonneville:									
80- 99	330	3	1	1	0	2	153	1	4
100-119	864	33	7	4	0	11	394	4	40
120-139	163	2	1	3	0	1	65	3	3
140-159	22	1	0	1	0	0	8	1	1
160-179	7	0	1	0	0	0	1	0	1
180-199	13	1	0	0	0	0	2	0	1
200-219	17	1	6	0	0	1	2	0	7
>219	12	1	7	0	0	0	1	0	8
The Dalles:									
80- 99	55	0	0	0	0	0	14	0	0
100-119	643	4	1	0	0	0	225	0	5
120-139	511	6	2	0	0	3	183	0	8
140-159	239	13	5	4	0	2	82	4	15
160-179	58	6	5	0	0	1	15	0	11
180-199	12	2	2	0	0	1	2	0	4
200-219	13	3	0	1	0	0	1	1	3
>219	9	2	1	0	0	0	3	0	3
John Day:									
80- 99	15	0	0	0	0	0	6	0	0
100-119	247	0	0	0	0	0	70	0	0
120-139	138	2	1	0	0	0	36	0	3
140-159	69	2	0	1	0	0	20	1	2
160-179	15	1	1	0	0	0	0	0	2
180-199	16	1	0	0	0	0	0	0	1
200-219	10	2	0	0	0	0	1	0	2
>219	6	3	0	1	0	0	0	1	3
Unknown:									
100-119	249	2	1	0	0	0	32	0	3
120-139	114	1	0	0	0	0	17	0	1
140-159	47	0	0	2	0	0	6	2	0
160-179	12	1	0	0	0	0	1	0	1

a *Includes all fish (both sexes) whose gonads were randomly examined.*
b *Stages* are: *1 = Early vitellogenic, 2 = Late vitellogenic, 3 = Ripe,* 4 *= Spent, 5 = Pre-vitellogenic with attritic oocytes, and* 6 *= Pre-vitellogenic.*

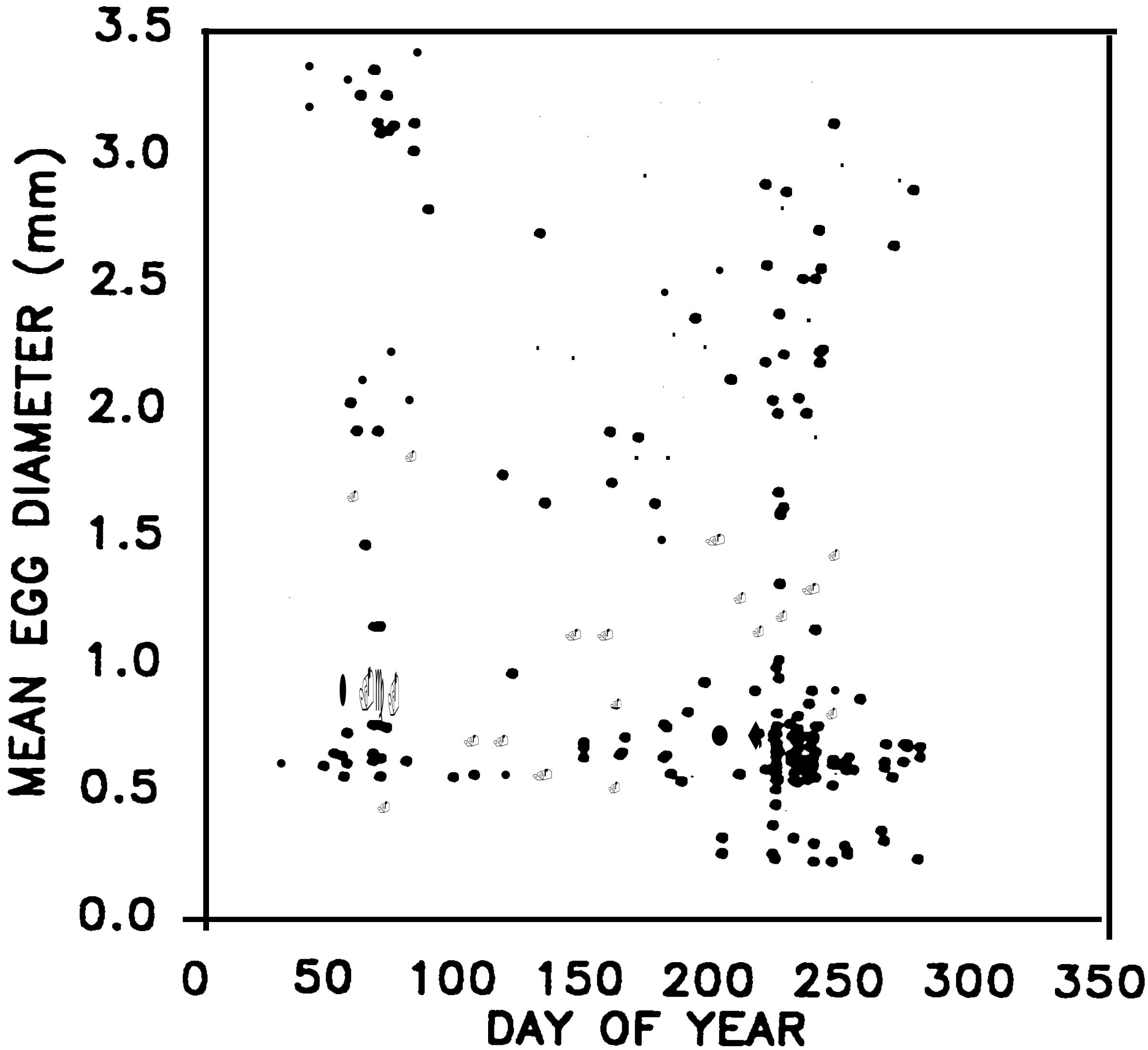

Figure 3. Mean diameter of developing eggs from ovaries of white sturgeon collected in Bonneville and The Dalles reservoirs, 1987-1990.

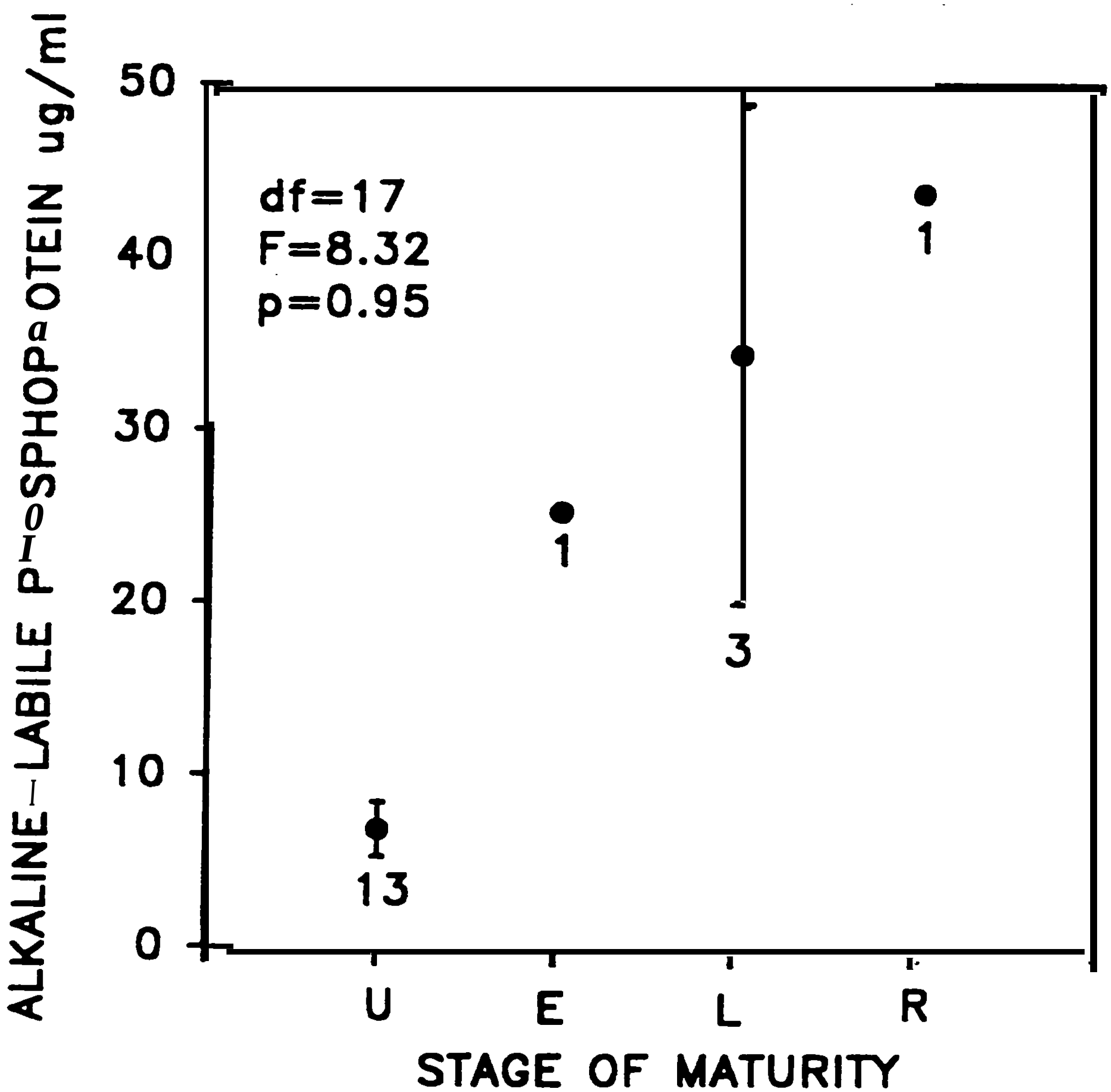

Figure 4. Alkaline-labile phosphoprotein levels in blood samples (μg/ml) compared with the stage of maturity of white sturgeon in the Columbia River between Bonneville and McNary dams, 1988-1990. Maturity stages are: U = undeveloped, E = early vitellogenic, L = late vitellogenic, and R = ripe.

DISCUSSION

We completed collection of most of the data we need to estimate population statistics and potential production of white sturgeon in John Day Reservoir. Sample sizes appear adequate to estimate growth rate and abundance within acceptable degrees of confidence. Our set line catch rate in John Day pool was substantially lower than rates for Bonneville and The Dalles pools from previous years, 0.52 sturgeon per set versus 4.36 and 3.31 respectively (Beamesderfer et al. 1990).

Preliminary estimates of total mortality using catch curves indicated fishing mortality had changed substantially over time in all three reservoirs. Our intent is to develop estimates of mortality based on cohort analysis to eliminate the resulting bias. We completed aging of available samples collected in the three reservoirs from 1987-1990. We need additional age structure and gonad samples to accurately describe the age-length, length-maturity, and length-fecundity relationships for large fish (>169 cm FL).

We will sample in Bonneville, The Dalles, and John Day reservoirs in 1991 to collect additional fin ray samples for aging and to supplement samples of large (> 169 cm) white sturgeon where information on growth and reproduction is incomplete. This sampling will also allow us to recapture additional fish which we injected with OTC to validate our aging technique.

Recaptures of tagged fish show sturgeon move widely within pools and that there is some downstream movement between pools. However, since 1987, we have had only one recapture of a sturgeon that moved to an upstream reservoir. Sampling to date has provided little opportunity to recapture fish that had moved into an upstream reservoir; sampling in 1991 will afford us the opportunity to do so.

Additional recaptures of OTC-marked fish in 1990 reinforce our analysis of time of annulus formation. Most fish resume growth by July, however some fish have little or no annular growth even in August. Sampling in 1991 will provide us an opportunity to recapture OTC injected fish at large in The Dalles and Bonneville pools since 1988. Recaptures of these fish will help us refine our aging technique by allowing us to examine marked fish at large more than one winter.

We collected nineteen additional egg diameter samples in 1990, but the egg diameter groups we see from February through April remain indistinct. It appears unlikely we will determine the period of maturation. In simulations we will assume a duration of egg development in wild sturgeon similar to that for fish held in captivity.

We did not acquire any additional samples of whole gonads in 1990. We need these to refine the relationship between length and fecundity. We will continue working with Washington Department of Fisheries and Oregon State Police to obtain samples of whole gonads from fish caught and killed in recreational and commercial fisheries as well as illegally harvested fish.

We have only four samples of blood from maturing fish. We had hoped to gather enough samples to establish a relationship between ALPP levels and stage of maturity. This would allow us to avoid performing surgery on wild sturgeon. In 1991 we will continue taking blood samples to establish a relationship. While this information will not benefit the current project, it will be invaluable for future studies of white sturgeon.

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Appendix A-l

Age-length Frequency Distributions for White Sturgeon by Reservoir and Year of Capture.

Appendix Table A-1.1. Age-length-frequency distributions for white sturgeon in Bonneville Reservoir, 1907. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2												--	--	0
3												--	--	0
4												--	--	0
5												--	--	0
6												--	--	0
7												--	--	0
8												--	--	0
9												--	--	0
10						1						112.0	--	1
11						1	1					115.0	9.9	2
12						1	1					123.5	14.8	2
13						1						110.0	--	1
14						6	1					114.6	9.6	7
15						4	1	1				119.2	12.1	6
16						5	6	1				123.1	14.0	12
17						5	2					117.0	11.7	7
18						4	3					119.3	9.7	7
19						2	1					113.3	6.7	3
20						2						110.5	3.5	2
21												--	--	0
22							1	1				138.0	4.2	2
23							1					122.0	--	1
24												--	--	0
25												--	--	0
26												--	--	0
27							1	1				140.0	4.2	2
28							1					133.0	--	1
29												--	--	0
≥30												--	--	0
N						32	20	4				120.0	11.9	56

Appendix Table A-1.2. Age-length-frequency distributions for white sturgeon in Bonneville Reservoir, 1988. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2												--	--	0
3			1									43.0	--	1
4			2	1								57.3	12.3	3
5			9									51.6	4.6	9
6			3	4								62.9	8.2	7
7			1	1	1							69.0	12.5	3
8			1	3								67.7	10.0	4
9			3	4	1							65.5	11.9	8
10			1	2	3							83.2	15.9	6
11			1	1	1	1						79.5	26.2	4
12			1	1	4	1						86.6	21.2	7
13			1		1	2	1					102.8	28.9	5
14				1	2	2						96.2	14.7	5
15				3	4	2	3					98.2	19.2	12
16				1	4	5						96.3	13.5	10
17			1	1	6	4	6	2				107.8	23.4	20
18					5	5	5					110.6	14.4	15
19				1	2	6	5					109.4	17.1	14
20				1	1		3	5				125.7	27.4	10
21				1		1	2	2	1			127.9	27.6	7
22				1			3					112.7	27.9	4
23						1			1			138.5	30.4	2
24						1	2					124.0	16.5	3
25								1				150.0	--	1
26							1			1	1	172.3	44.6	3
27										1		198.0	--	1
28										1	1	198.5	4.9	2
29							1	1			1	175.3	58.7	3
≥30									13		1	191.8	18.4	5
N			25	27	35	31	32	11	3	6	4	103.6	38.0	174

Appendix Table A-1.3. Age-length-frequency distributions for white sturgeon in Bonneville Reservoir, 1989. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm) 0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Fork length Mean	Std	N
1												--	--	0
2		6										35.9	1.1	6
3		11	2									37.4	4.4	13
4		4	5									42.3	5.0	9
5		3	10									47.4	7.8	13
6		1	7	1								50.9	8.3	9
7			2	7								64.4	5.6	9
8			3	4	1							64.0	9.7	8
9			2	1	2							67.0	16.2	5
10			1	3	1							71.4	12.7	5
11			2	2	3	2						78.4	14.9	9
12			1	2	2	2						85.0	18.1	7
13				1	5							83.8	4.6	6
14			1	1	3	1						81.3	15.6	6
15				2	1	5	3					104.2	19.5	11
16				2	3	2	1					89.9	18.7	8
17				4	3	7	2	1				99.4	22.2	17
18				1	1	2	4					112.1	22.7	8
19						2	3					114.4	10.7	5
20					4	2	2	1				107.7	22.6	9
21						3	3				1	131.1	39.4	7
22							5	1				129.8	9.8	6
23														
24					1	1	2		1			124.2	28.8	5
25						1	1			1	1	157.8	47.3	4
26						1	1			1		138.7	43.9	3
27							1					137.0		1
28							1	2	1			150.0	15.2	4
29							1		1		1	174.7	49.9	3
≥30							3			2	5	194.8	46.2	10
N		25	36	31	30	31	33	5	3	4	8	91.3	45.4	206

Appendix Table A-1.4. Age-length-frequency distributions for white sturgeon in Bonneville Reservoir, 1990. USFWS samples collected after June 30 *were* excluded.

Age	Fork length interval (cm) 0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Fork length Mean	Std	N
1												a-	--	0
2												--	--	0
3												--	--	0
4												--	--	0
5												--	--	0
6												--	--	0
7												--	--	0
8												--	--	0
9					1							*92.0*	--	1
10												--	--	0
11					1	1						103.0	5.7	2
12					2							97.0	1.4	2
13						3	1					113.2	6.0	4
14					2	3	2					107.7	11.1	7
15					1	4	2					114.0	9.2	7
16					16		2					113.6	10.2	9
17					1	3	7.					117.5	11.3	11
18						4	1					117.0	5.4	5
19					1	1	5	2				125.0	15.6	9
20						4	2	1				122.4	13.9	7
21					2		2	3				127.9	23.5	7
22						5	2					117.7	10.6	7
23						1		3				139.0	19.6	4
24							1					132.0	--	1
25						1						106.0	--	1
26												--	--	0
27												--	--	0
28												--	--	0
29													--	0
≥30													--	0
N					12	36	27	9				117.8	14.9	84

Appendix Table A-1.5. Age-length-frequency distributions for white sturgeon in The Dalles Reservoir, 1987. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1		2										26.9	0.8	2
2		14	6									35.9	5.5	20
3		3	20									45.5	6.2	23
4			22	7								54.8	5.9	29
5			2	13								67.1	7.2	15
6				12	1							69.7	7.0	13
7			1	7	1							71.8	7.1	9
8				4	5							80.1	9.5	9
9					6	1						90.3	7.4	7
10				7	12	2						84.5	11.0	21
11				2	8	1						88.7	9.6	11
12				1	8	9	1					98.9	13.7	19
13				2	5	7	1	1				101.4	17.1	16
14					5	7	4					107.4	13.6	16
15					2	7	2	2				114.1	17.5	13
16				1	5	8	9	2	1			119.4	20.1	26
17						6	7	5				128.6	15.1	18
18					1	4	13	5				129.2	13.1	23
19					1	3	10	6	1			132.2	19.8	21
20						1	5	11	3			145.7	15.9	20
21						2	6	6		1		140.3	18.1	15
22								3	1	1	2	172.7	26.3	7
23								2	3			160.4	7.5	5
24							1	3	4			154.5	15.7	8
25								1	1			155.5	19.1	2
26							1		1		1	164.7	44.5	3
27									3	1		172.3	17.9	4
28							1		1			155.0	25.5	2
29								1				142.0	--	1
≥30								3	1		1	175.4	40.8	5
N		19	51	56	60	58	61	51	20	3	4	101.9	40.7	383

Appendix Table A-1.6. Age-length-frequency distributions for white sturgeon in The Dalles Reservoir, 1988. USFWS samples collected after June 30 were excluded.

	Fork length interval (cm)											Fork length		
Age	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2		48	7									35.2	4.2	55
3		29	25									39.4	4.1	54
4		35	67									42.6	5.3	102
5		3	26	5								50.3	7.7	34
6		1	5	1								51.0	9.8	7
7		1	4	1								53.8	13.4	6
8												--	--	0
9			1	1								67.5	12.1	2
10												--	--	0
11												--	--	0
12					1							98.0	--	1
13						5	1	1				117.1	13.2	7
14					1	6	1		1			117.6	18.5	9
15						3	2					120.4	11.7	5
16						5		2	1			127.2	21.7	8
17						1	8	2				129.4	11.5	11
18						3	4	3	2	1		140.5	26.3	13
19						3	8	5	6			142.9	22.0	22
20						1	5	5		3		148.4	25.5	14
21							2	2	3			148.4	15.4	7
22							4	2	1	4	1	163.0	29.3	12
23							1	2	1	1	1	166.2	29.3	6
24									2	1	1	189.3	18.9	4
25									1			163.0	--	1
26									1		2	201.3	30.7	3
27									1		4	198.8	19.7	5
28									1	2		181.3	10.1	3
29										1	2	212.3	13.2	3
≥30									1	2	10	218.6	26.5	13
N		117	135	8	2	27	36	24	22	15	21	82.4	58.5	407

Appendix Table A-1.7. Age-length-frequency distributions for white sturgeon in The Dalles Reservoir, 1989. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm) 0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Fork length Mean	Std	N
1												--	--	0
2		5	2									38.1	3.1	7
3		7	17	1								43.6	6.3	25
4		6	21	1								45.9	6.6	28
5		5	28	1								46.4	7.6	34
6			6	1								53.2	6.1	7
7			4									52.4	5.0	4
8				1								66.5	--	1
9				1								60.7	--	1
10						2						111.0	2.8	2
11						4	1					111.6	5.4	5
12						2						111.5	0.7	2
13						3	1					114.5	6.1	4
14							2					131.0	5.7	2
15						5	1					123.4	18.3	7
16						4	2					118.0	7.8	6
17						4	2					115.7	4.1	6
18						3	7	3				127.4	13.6	13
19						3	1	2	1			132.0	17.4	7
20						4	6	7	2			136.8	16.3	19
21							6	2				134.0	10.5	8
22						1		11	1			147.4	12.5	13
23						1	1	3				138.0	19.1	5
24						2		1	1			137.0	26.1	4
25									2			160.5	0.7	2
26									1			163.0	--	1
27									1			165.0	--	1
28									1			162.0	--	1
29									1		1	190.0	32.5	2
≥30								1	2		2	191.0	43.2	5
N		23	78	6		38	30	30	14		3	92.2	48.1	222

Appendix Table A-1.8. Age-length-frequency distributions for white sturgeon in The Dalles Reservoir, 1990. USFWS samples collected after June 30 were excluded.

	Fork length interval (cm)											Fork length		
Age	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2												--	--	0
3												--	--	0
4												--	--	0
5												--	--	0
6												--	--	0
7												--	--	0
8												--	--	0
9												--	--	0
10						1						111.0	--	1
11						1						109.0	--	1
12						1						109.0	--	1
13						5						112.8	1.3	5
14						6	3					114.7	7.3	9
15						4	2					117.8	8.9	6
16						6	3	1				118.5	8.7	10
17						2	5	1				122.9	10.2	8
18						2	4					124.3	7.9	6
19						2	5	3				131.2	17.5	10
20						3	9	9				132.6	13.6	21
21						5	6	4	1			131.5	16.0	16
22						1	2	8	1			142.3	14.3	12
23							1	7	1			146.8	7.9	9
24						1	2	1	3			146.1	19.7	7
25									1			164.0	--	1
26								1	1			157.5	3.5	2
27								1	1			158.0	5.7	2
28												--	--	0
29									1			169.0	--	1
≥30									2			167.5	9.2	2
N						40	42	36	12			131.5	17.7	130

Appendix Table A-1.9. Age-length-frequency distributions for white sturgeon in John Day Reservoir, 1987. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2												--	--	0
3												--	--	0
4												--	--	0
5												--	--	0
6												--	--	0
7												--	--	0
8												--	--	0
9						1						107.0	--	1
10												--	--	0
11						2						111.5	7.8	2
12						3	1					111.7	10.9	4
13						8	2					110.6	7.6	10
14						7	3					112.8	8.9	10
15						4	4					119.5	11.0	8
16						3	3	2				124.4	13.7	8
17						3	4	1				120.6	11.7	8
18						2	10	3	2			134.9	13.5	17
19						2	4	3				133.3	15.1	9
20						1	4	3				132.5	13.8	8
21							2	5	3			148.6	11.7	10
22							2		2			152.8	20.1	4
23								2				155.5	4.9	2
24												--	--	0
25								1				155.0	--	1
26								1				140.0	--	1
27												--	--	0
28												--	--	0
29								1				141.0	--	1
≥30												--	--	0
N						36	39	22	7			128.1	17.7	104

Appendix Table A-1.10. Age-length-frequency distributions for white sturgeon in John Day Reservoir, 1988. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2												--	--	0
3												--	--	0
4												--	--	0
5												--	--	0
6												--	--	0
7												--	--	0
8						1						109.0	--	1
9												--	--	0
10						1						104.0	--	1
11						2						107.0	5.7	2
12						4						110.2	1.0	4
13						6	1					113.9	7.5	7
14						4	2					117.5	10.1	6
15						5	5	2				124.9	10.3	12
16						6	5	1				121.2	12.4	12
17						4	8		1			125.8	13.5	13
18						3	8	1				125.1	8.2	12
19						2	4	2				132.1	15.0	8
20							1	2				140.7	11.5	3
21						1		4				142.6	18.8	5
22								2				146.5	0.7	2
23							1					128.0	--	1
24							1	3				148.5	15.8	4
25								1	2			158.7	14.3	3
26												--	--	0
27												--	--	0
28												--	--	0
29												--	--	0
≥30												--	--	0
N						39	36	18	3			126.5	15.8	96

Appendix Table A-1.11. Age-length-frequency distributions for white sturgeon in John Day Reservoir, 1989. USFWS samples collected after June 30 were excluded.

Age	Fork length interval (cm)											Fork length		
	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2												--	--	0
3												--	--	0
4												--	--	0
5												--	--	0
6												--	--	0
7					3							96.0	1.0	3
8												--	--	0
9					1							94.5	7.8	2
10												--	--	0
11													--	0
12					2							96.5	0.7	2
13					1	1	1					108.0	18.0	3
14					1							96.0	--	1
15					1	1	2					108.2	14.6	4
16						1						115.0		1
17						1						117.0	--	1
18												--	--	0
19												--	--	0
20						1				1		157.0	56.6	2
21												--	--	0
22												--	--	0
23										1		185.0	--	1
24									1			167.0	--	1
25												--	--	0
26												--	--	0
27												--	--	0
28												--	--	0
29											1	224.0	--	1
≥30												--	--	0
N					9	6	3		12		1	120.2	38.0	22

Appendix Table A-1.12. Age-length-frequency distributions for white sturgeon in John Day Reservoir, 1990. USFWS samples collected after June 30 were excluded.

	Fork length interval (cm)											Fork length		
Age	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>199	Mean	Std	N
1												--	--	0
2		5										33.6	2.9	5
3		7	3									38.9	7.0	10
4		8	9	1								44.8	11.1	18
5		6	11	2								47.5	9.4	19
6		3	6	8	1							60.0	15.6	18
7			4	10	3							69.6	11.7	17
8			3	15	4	3						76.9	12.7	25
9			3	3	8		1					78.9	17.9	15
10				3	5	2	1					92.5	17.6	11
11					1	3						105.0	11.5	4
12					6	4						98.5	8.0	10
13				1	3	5	4					107.1	15.4	13
14					1	5	5	3				124.2	17.5	14
15					2	4	6	1				119.3	16.9	13
16					2	2	2	1				118.0	22.6	7
17					2	2	1				1	123.5	45.6	6
18					1	3	3	1				122.7	16.2	8
19								3				148.7	9.6	3
20						1	2			1		137.5	30.3	4
21							1	1	2			153.0	20.1	4
22								2		2	1	176.8	34.1	5
23								1		1		172.0	29.7	2
24									1	1		175.0	18.4	2
25										2		190.0	5.7	2
26									1	3	2	190.8	13.9	6
27														
28											1	220.0	--	1
29										2	1	195.0	8.5	3
≥30											7	211.9	9.2	7
N		29	39	43	39	34	26	13	4	12	13	96.4	48.2	25

REPORT B

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

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

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

ACKNOWLEDGMENTS

We would like to thank the following persons and agencies for their support in this project. Kathleen Moyer, Steve Campbell, John Brady, DeeAnn Akita, Dave Samalik, Rick Watson and Robert Morgan of the Washington Department of Fisheries (WDF) conducted angler surveys in Bonneville and John Day reservoirs. -Columbia River research and harvest management staff from WDF and Oregon Department of Fish and Wildlife provided assistance in collection of data from the recreational and commercial fisheries downstream of McNary Dam. The U.S. Army Corps of Engineers authorized access to restricted areas near the dams.

ABSTRACT

The Washington Department of Fisheries **(WDF) censused** the recreational fisheries in Bonneville and John Day reservoirs for mark recovery , biological samples and harvest data on white sturgeon ***(Acipenser transmontanus).*** Samplers interviewed 4,854 anglers in Bonneville Reservoir from March through October 1990 and 4,952 anglers in John Day Reservoir from March through December 1990. Harvest estimates of legal size white sturgeon for these time periods were **2,1**14 in Bonneville Reservoir and 316 in John Day Reservoir. Biological sampling was conducted on 12% of the Bonneville Reservoir sturgeon harvest and 16% of the sturgeon harvest in John Day Reservoir during respective census periods. Of the 265 white sturgeon harvested and examined for marks/tags that were put out by the Oregon Department of Fish and Wildlife in Bonneville Reservoir, 7 marked sturgeon were observed. Technicians mark sampled 52 white sturgeon in the John Day Reservoir and observed **1** mark recovery.

Treaty commercial fishery landings were sampled for harvest, mark and biological information on white sturgeon. The estimated treaty commercial harvest of white sturgeon from Bonneville Reservoir in 1990 was **1,890,** of which 7% were biologically sampled. The Bonneville mark sample from this fishery was 204 sturgeon, of which three were marked. The **Dalles** Reservoir treaty commercial harvest was **1,206** white sturgeon in 1990 with 19% of the harvest biologically sampled. There were 7 marks recovered from 237 sturgeon mark sampled from this fishery. In John Day Reservoir, treaty commercial fishermen harvested 405 sturgeon in 1990. There were no marked sturgeon observed in this fishery.

WDF assisted the National Marine Fisheries Service in assessing reproduction and early life history of white sturgeon downstream from Bonneville Dam. **WDF** processed and staged samples of eggs and larvae collected in 1990.

Population dynamics modeling of white sturgeon downstream **from** Bonneville Dam in 1990 included refinement of abundance and exploitation estimates and reproductive parameters. A total of 3,364 white sturgeon were tagged. Age validation techniques were furthered by injecting OTC and secondarily marking 962 white sturgeon. There were 14 recoveries of OTC-injected sturgeon from 1989 tagging efforts.

Fecundity, age and other biological **parameters** were gathered on oversized sturgeon **(>183** cm **TL)** by monitoring wild broodstock capture activities by Oregon private aquaculturists in 1990. Data were collected on 36 sturgeon including 24 that were oversized.

INTRODUCTION

As part of the study funded by Bonneville Power Administration on Columbia River white sturgeon, the primary responsibility of the Washington Department of Fisheries (WDF) is to describe the population dynamics of white sturgeon downstream of Bonneville Dam. Additional responsibilities include providing the Oregon Department of Fish and Wildlife (ODFW) with mark recovery data, biological samples and harvest estimates from fisheries between Bonneville and McNary dams.

WDF also contributes to this study through sturgeon research programs in the Columbia River which are partially or entirely state funded. Examples of this participation include assisting the National Marine Fisheries Service (NMFS) in the collection and analysis of white sturgeon eggs and larvae collected downstream of Bonneville Dam and the collection of data on subadult and adult white sturgeon downstream of McNary Dam.

This annual report focuses on activities and information from the 1990 field season. The report contains the following sections:

1) egg and larval analysis of samples collected downstream from Bonneville Dam by NMFS;

2) catch and effort information from censusing the recreational sturgeon fisheries between Bonneville and McNary dams;

3) landings in the tribal commercial fisheries between Bonneville and McNary dams;

4) summaries of mark recovery and biological data collected from recreational and commercial fisheries between Bonneville and McNary dams; and

5) progress in describing the yield or production of white sturgeon downstream of Bonneville Dam.

METHODS

Eggs and Larvae Analysis

Sturgeon eggs and larvae downstream from Bonneville Dam were collected by NMFS. A thorough discussion of sampling gear and techniques is presented by NMFS in REPORT D of this document. Refer to Grimes (1991) for additional information.

Initial processing of egg and larval samples was conducted by WDF. Eggs and larvae in the samples were enumerated, aged and preserved in 20% methanol. Eggs were staged and larvae aged according to Beer (1980). Spawning dates were back-calculated using the method of Wang et al. (1985).

Recreational Fishery Census

The 1990 recreational fishery census was conducted in Bonneville Reservoir from March through October and in John Day Reservoir from

March through December (hereafter referred to as the census periods) (Figures 1 and 2). The census occurred in order to estimate the harvest of ODFW marked white sturgeon and collect biological samples from the examined creel.

The method used to estimate total angling effort and white sturgeon harvest was similar to procedures used in the 1988 and 1989 censuses in these reservoirs (LaVoy et al., 1989; DeVore et al., 1990). Our efforts at counting anglers were focussed on representative subareas (indices) within each reservoir. We used periodic aerial counts to expand our estimates of angling effort within these indices to account for angling effort throughout the entire reservoir. Catch per effort data was collected by interviewing anglers and examining the creel.

Index areas for angler counts were established at popular fishing. locations and vantage points in Bonneville and John Day reservoirs (DeVore et al., 1990). The John Day Reservoir index was modified slightly from that used in 1989 (APPENDIX B-1).

Counts of angling effort within each index area were conducted every three hours throughout the day on a twice weekly basis, beginning within three hours of sunrise and continuing until sunset. Bank rods were counted to determine bank effort and boats were counted to determine boat angler effort. The average number of anglers per boat was determined through interviewing boat anglers at the end of their trip. Rounds of index counts were considered instantaneous in the catch and effort modeling. Curves describing average weekday and weekend boat and bank effort were constructed from these counts. These effort curves were derived from an average of six weeks of counts.

A single index count usually took place at variable hours during the remaining five days of each week. Index area angling effort on these days was estimated by comparing that day's count to the average count represented by the appropriate six week effort curve. Daily index area effort estimates were summed by two week periods.

The flights used to make counts of angling effort for the entire reservoir were made on four of every six intensive index area count days. The proportion of total effort represented by the index areas was determined by comparing counts from within and outside the index areas using the aerial count data. Six weeks of flight count data were averaged to derive this relationship, which was then applied to the two week index area effort estimates to determine total reservoir angling effort for two week periods.

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 creel. Interviews took place between index effort counts and on non-flight days.

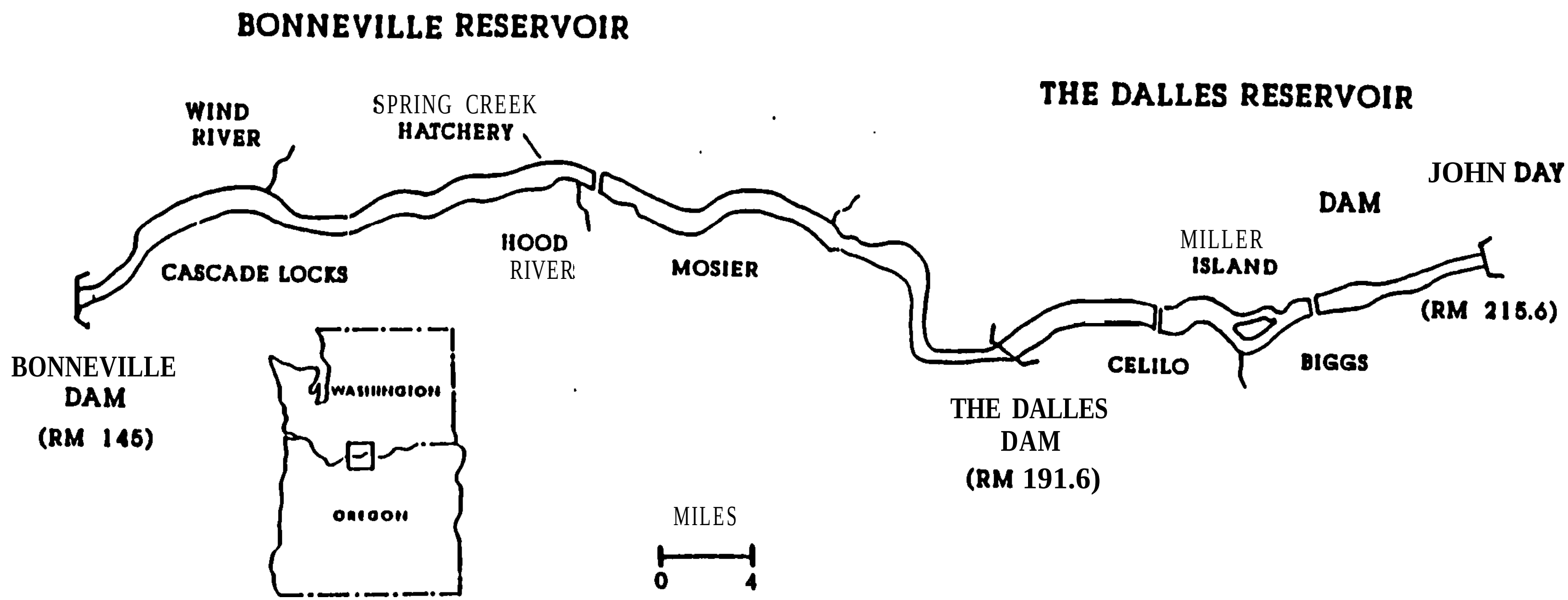

Figure I. Location of Bonneville and The Dalles reservoirs on the Columbia River.

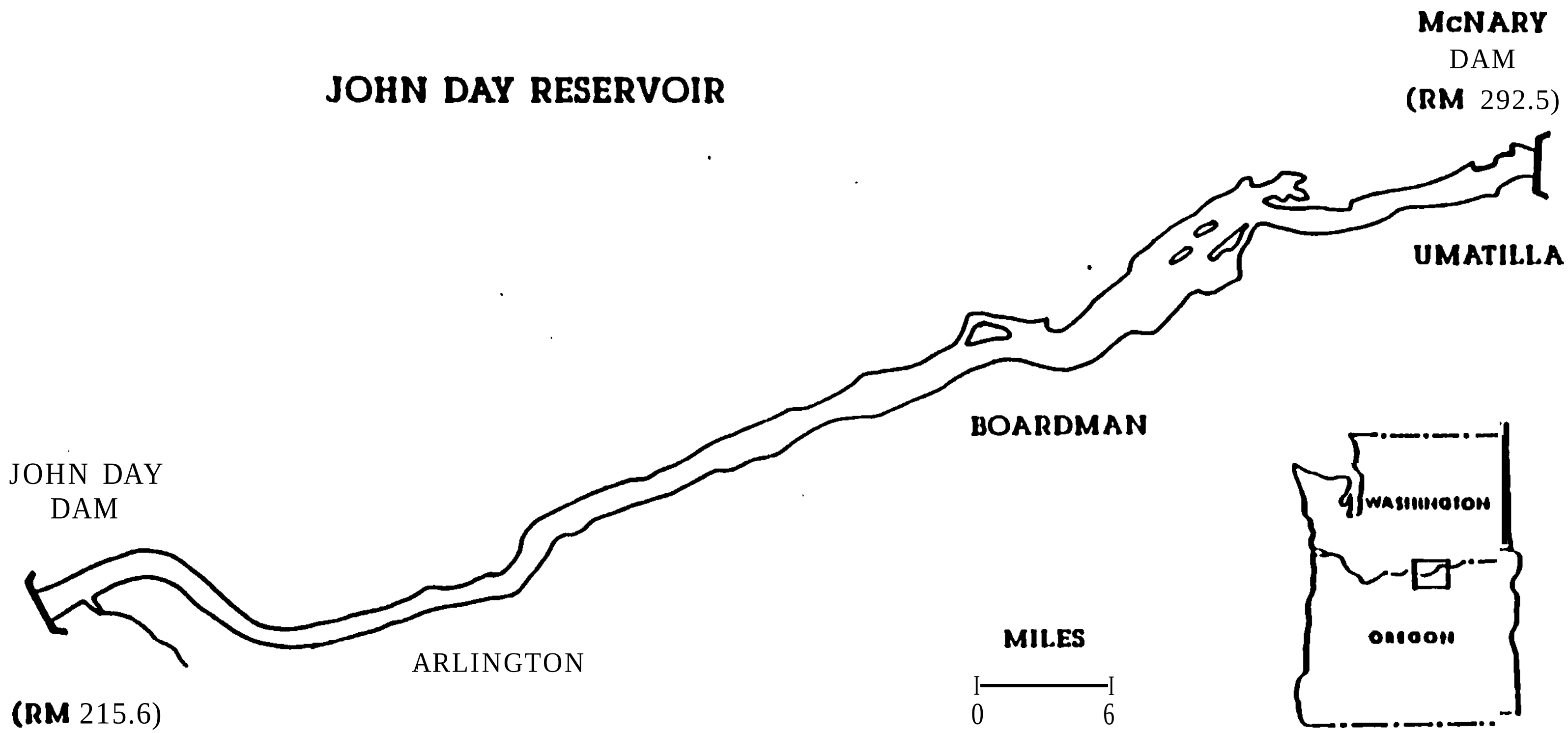

Figure 2. Location of John Day Reservoir on the Columbia River.

Effort and catch sampling data were stratified by bank and boat angler types, river subsections, as well as week day and weekend day effort to account for differential catch rates (DeVore et al., 1990). White sturgeon harvest estimates were made for two statistical week intervals (statistical weeks are Monday through Sunday numbered sequentially from the start of the year). If no 'anglers were interviewed in a subsection for a period when effort was observed, then data from successive periods were combined to derive a representative catch rate and applied to the effort estimate for that time period. Harvest estimates were calculated by multiplying the observed catch per hour of effort for each angler type within a river subsection by the total estimated effort for each angler type for that period and subsection.

Total harvest of marked white sturgeon was estimated by dividing the number of marked fish observed in the creel by the mark sampling rate. The mark sampling rate is defined as the number of fish examined for marks divided by the estimated total harvest.

Tribal Commercial Fishery Landings

Numbers of white sturgeon harvested in Columbia River commercial fisheries were estimated from poundage reported on fish receiving tickets for each gear type. Poundage of white sturgeon were converted to numbers of fish by applying an average weight per fish obtained during random biological sampling by field crews. Average weights and the conversion of numbers from pounds of fish were calculated by statistical week.

Landings by commercial fishing zone were estimated from the catch area reported on fish receiving tickets. There are five commercial fishing zones in the mainstem Columbia River downstream from Bonneville Dam and one commercial fishing zone for tribal fisheries between Bonneville and McNary dams (Zone 6). Zone 6 is further stratified by reservoir on the fish receiving tickets, enabling a reservoir-specific harvest estimate. The legal commercial size slot for sturgeon was 48 to 72 inches in 1990.

Tribal ceremonial and subsistence fisheries for white sturgeon also occurred in 1990 and were sporadically sampled. Harvest estimates and catch accountability for these fisheries are unavailable.

Mark Recovery and Biological Sampling

Mark recovery and biological sampling data were obtained for white sturgeon from the recreational and commercial fisheries from all areas downstream from McNary Dam. Sampling of the recreational catch was obtained as part of the angler interview. Commercial fishery catches were sampled at the fish buying facilities. Samples from the tribal commercial fishery were segregated by reservoir whenever possible. Collection methods and handling of samples were consistent for all fisheries sampled.

Samples were classified as random or "in-sample" if they were obtained during the normal interview/sampling routine. Marked spaghetti-tagged sturgeon, voluntarily turned in by fishermen outside the normal sampling routine, were classified as nonrandom.

Voluntary returns of tagged white sturgeon were solicited with signs posted at access points and at popular fishing locations. Drop boxes for voluntary returns of spaghetti tags were also' established at locations convenient to the anglers. Field samplers often received voluntary information -on tagged fish caught. Occasionally, nonrandom "select" samples were collected from examining recreational catches made on previous days which were being held (eg. tethered) for later processing.

All available sturgeon catches were sampled and examined for identifying marks (spaghetti tags, clipped barbels, scutes and fin rays or Monel bands). Biological data collection included fork length (FL), total length (TL), weight, sex, pectoral fin ray and ovary samples. Pectoral fin rays were packaged unpreserved with identification labels. Ovary samples were preserved in 10% formalin. Both were transferred to ODFW for fur.ther processing.

Population Dynamics Downstream of Bonneville Dam

Data used in modeling the white sturgeon population downstream of Bonneville Dam include estimates of abundance, total and fishing mortality, age, growth and reproduction. Data were collected during mark and recapture projects separately funded by state and federal agencies (Grimes 1990 and King 1990). Data collected in previous years were processed and analyzed.

White sturgeon were collected for marking by contracting with commercial fishermen. Commercial capture gear consisted of conventional diver and floater gillnets 200 to 275 fathoms in length with a single mesh size of 6 1/4 to 8 inch stretch measure. Sequentially numbered spaghetti tie tags were inserted through the base of the dorsal fin to identify marked fish. White sturgeon larger than 70 cm TL were tagged with one or two tags. Double tagging was used to obtain an estimate of tag loss based on recovery data. Most of the white sturgeon marking activities occurred in the Columbia River estuary (RM 5-22) although some marking occurred in three other areas distributed throughout the lower Columbia River (RM 28-127) (Figure 3). The intent of the marking program was to capture and tag as many white sturgeon over 90 cm TL as possible throughout the year while minimizing the incidental handling of salmonids. The primary method of recovering marked white sturgeon was by sampling recreational and commercial fisheries downstream of Bonneville Dam.

Efforts to validate age determination techniques (Brennan 13873 were supplemented by oxy-tetracycline (100 mg/l OTC) injections in sublegal size sturgeon (70-95 cm TL) caught during research fisheries in 1990. OTC injections were accompanied by spaghetti tag marking and a year specific scute removal pattern (2nd right, 4th right lateral in 1990). Subsequent OTC recoveries were analyzed by cross sectioning pectoral fin ray samples. Periodic growth rings were examined under ultraviolet light with a dissection scope. The number and distribution of rings and checks were measured with respect to the fluorescent OTC ring. The identification of annuli in these sections were used to validate ageing techniques and estimate time of annulus formation.

Developmental stages of ovaries collected from sturgeon downstream from Bonneville Dam were classified according to the method used by ODFW for samples collected between Bonneville and McNary dams.

RESULTS

Eggs and Larvae Analysis

The results of the egg and larvae analysis for specimens collected downstream of Bonneville Dam are presented by NMFS in REPORT D of this document. Additional information can be obtained in Grimes (1991).

Recreational Fishery Census

Angling effort on Bonneville Reservoir was counted on 232 days during the 245 day census period (March through October) in 1990 (Table 1). Angling effort on John Day Reservoir was counted on 259 days during the 306 day census period (March through December) (Table 2). Creel samplers interviewed 4,854 anglers fishing Bonneville Reservoir and

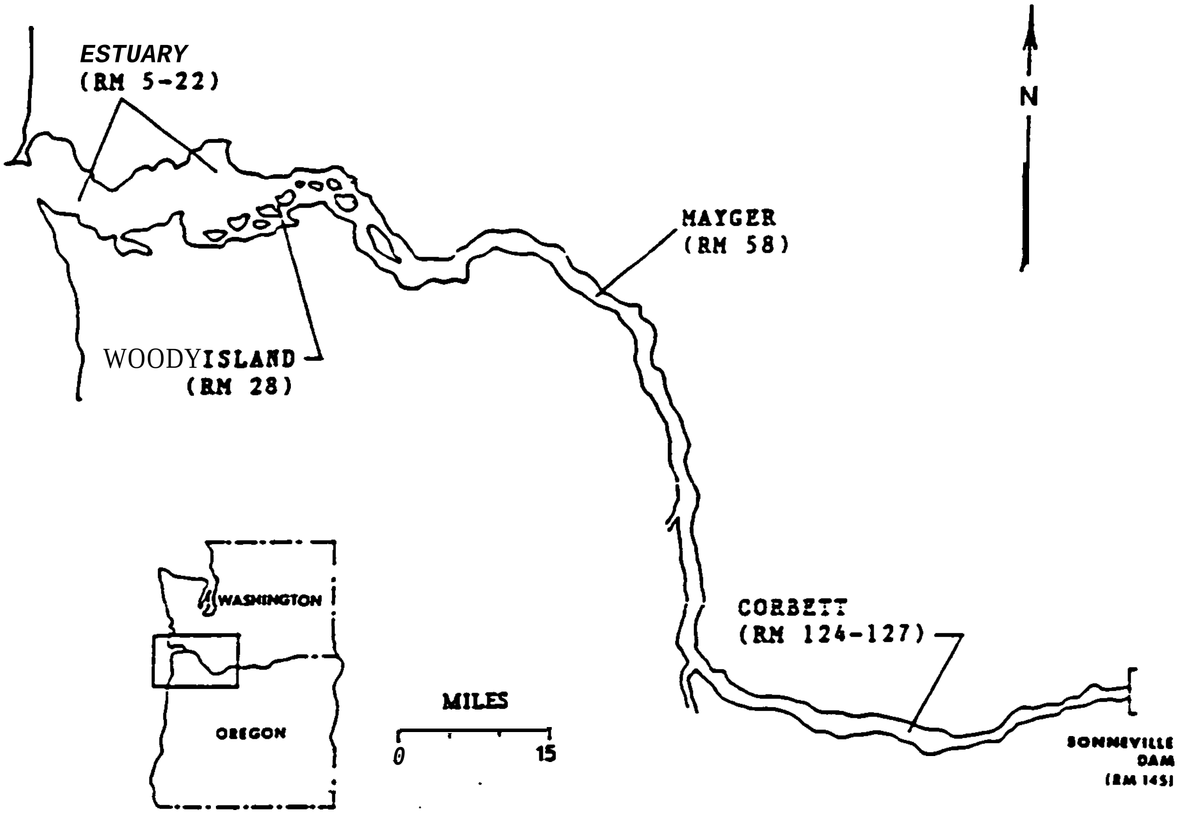

Figure 3. Locations on the Columbia River below Bonneville Dam where white sturgeon were captured and marked in 1990.

Table 1. Numbers of days angler effort was counted on Bonneville Reservoir, March-October 1990.

Reservoir, statistical week	Effort count type		
	Plight	Sunrise-sunset index	Once through index
Bonneville			
9-10	2	3	6
11-12	3	4	10
13-14	2	4	10
15-16	2	4	10
17-18	2	4	10
19-20	3	4	9
21-22	3	4	8
23-24	3	4	10
25-26	2	4	10
27-28	2	4	8
29-30	3	4	10
31-32	3	4	10
33-34	2	4	9
35-36	3	4	10
37-38	2	4	9
39-40	2	4	8
41-42	3	4	8
43-44	2	2	8
Total	44	69	163

Table 2. Numbers of days angler effort was counted on John Day Reservoir. March-December. 1990.

Reservoir, statistical week	Effort count type		
	Flight	Sunrise-sunset index	Once through index
John Day			
9-10	2	1	3
11-12	3	4	8
13-14	2	4	10
15-16	2	4	10
17-18	2	4	9
19-20	3	4	10
21-22	3	4	7
23-24	2	4	10
25-26	3	4	10
27-28	2	4	8
29-30	2	4	10
31-32	4	4	9
33-34	2	4	9
35-36	2	4	6
37-38	3	4	8
39-40	3	4	10
41-42	2	4	10
43-44	2	3	8
45-46	3	4	5
47-48	2	3	5
49-50	2	4	6’
51-52	1	2	7
Total	52	81	178

4,952 anglers fishing John Day Reservoir during the respective 1990 census periods (Tables 3 and 4).

Overall angling pressure on Bonneville Reservoir remained similar to that measured in 1989 (DeVore et al., 1990). Total bank angling effort during 1990 was estimated to be 86,793 hours for the March through October census period, a small decline from 1989, while total boat angling effort increased slightly to 79,873 hours. Boat and bank anglers spent a combined total of 83,927 hours targeting on white sturgeon (Figure 4).

John Day Reservoir anglers fished an estimated total of 55,503 hours from the bank and 146,816 hours from boats during the 1990 census period. Of this, bank and boat anglers spent a combined total of 43,650 hours targeting on white sturgeon (Figure 4).

Ratios of sublegal:legal:oversize white sturgeon handled by anglers during the 1990 census were 623:83:1 in Bonneville Reservoir and 26:3:1 in John Day Reservoir (Tables 5 and 6).

The recreational harvest of white sturgeon in Bonneville Reservoir during the 1990 census period was estimated to be 2,114 fish, while the John Day reservoir harvest was estimated to be 316 fish (Tables 7 and 8). This included a minor number of sublegal and slightly oversize sturgeon.

Catch rates (harvested catch per angler hour) for recreationally caught sturgeon in Bonneville Reservoir peaked in June (weeks 25-26) at 0.043 fish/hour (Figure 5). The catch rate on John Day Reservoir peaked at 0.038 fish/hour in November (weeks 45-46). However, the average catch rate was three times higher in Bonneville Reservoir than in John Day Reservoir.

Tribal Commercial Fishery Landings

The preliminary 1990 tribal commercial harvest estimate for Zone 6 (Bonneville to McNary dams) was 3,501 white sturgeon. Most of this harvest (1,704) occurred in the fall set-net fishery which took place from August 8 through September 29, 1990. The winter set-net fishery ran from February 1 to March 21, 1990 and had a harvest of 1,497 sturgeon. The setline fishery, which ran from January 1 through April 30 in 1990, had a harvest of 300 sturgeon. Bonneville Reservoir was the primary tribal commercial catch area with 1,890 sturgeon harvested. There were 1,206 sturgeon harvested in The Dalles Reservoir by treaty commercial fishermen in 1990. There were 405 sturgeon harvested in John Day Reservoir commercial fisheries. There was no allowable sale of

Table 3. Numbers of anglers interviewed on Bonneville Reservoir. March-October, 1990.

Reservoir, statistical week	Boat		Bank	
	Sturgeon	Other	Sturgeon	Other
Bonneville				
9-10	29	71	66	11
11-12	22	126	162	22
13-14	63	167	96	21
15-16	46	58	104	13
17-18	24	48	57	6
19-20	13	15	107	16
21-22	38	17	163	27
23-24	34	8	217	18
25-26	44	15	294	47
27-28	82	18	145	38
29-30	169	23	165	134
31-32	101	57	112	182
33-34	17	41	62	143
35-36	20	120	50	155
37-38	24	111	43	134
39-40	15	92	19	93
41-42	9	42	20	47
43-44	15	43	13	15
Total	765	1,072	1,895	1,122

Table 4. Numbers Of anglers interviewed on John Day **Reservoir, March-December,** 1990.

Reservoir, statistical week	Boat		Bank	
	Sturgeon	Other	Sturgeon	Other
John Day				
9-10	1	40	12	2
11-12	1	125	32	26
13-14	27	212	48	37
15-16	10	151	41	33
17-18	14	73	33	18
19-20	3	41	50	26
21-22	42	119	57	65
23-24	6	148	39	70
25-26	52	161	53	163
27-28	68	183	80	83
29-30	41	194	65	31
31-32	35	257	49	35
33-34	34	141	39	29
35-36	13	112	28	57
37-38	26	181	17	76
39-40	31	113	29	117
41-42	18	119	15	89
43-44	20	92	28	56
45-46	5	33	38	42
47-48	10	15	21	45
49-50	9	23	19	35
51-52	2	5	1	17
Total	468	2,538	794	1.152

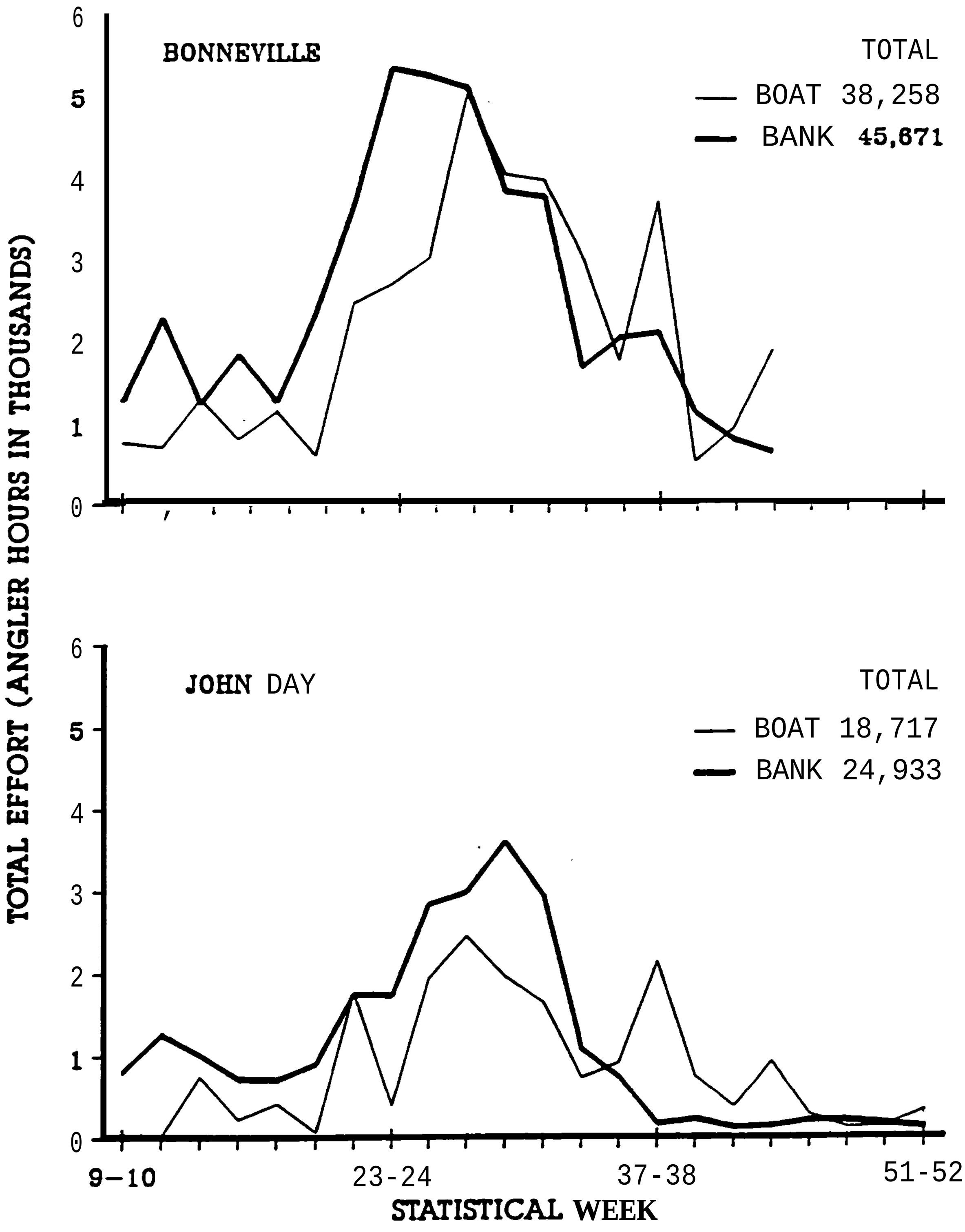

Figure 4. Estimated hours of angling effort by anglers targeting on white sturgeon, summed by two week period. from March through October and March through December. 1990, for Bonneville and John Day reservoirs, respectively.

Table 5. Numbers of white sturgeon. by size group, reported in the sampled recreational fishery catch in Bonneville Reservoir, March-October, 1990.

Reservoir, statistical week	Boat				Bank			
	Sub legal	Legal rel.	Legal kept	Over-size	Sub legal	Legal rel.	Legal kept	Over-size
Bonneville								
9-10	20	0	11	0	2	0	1	0
11-12	2	1	1	0	27	0	1	0
13-14	42	1	3	0	23	0	1	0
15-16	40	5	10	1	64	1	2	0
17-18	19	0	3	0	13	0	6	0
19-20	2	0	1	0	89	0	5	0
21-22	55	0	5	0	107	0	14	0
23-24	84	3	9	0	215	1	22	0
25-26	45	0	15	1	277	0	34	0
2 7-28	201	0	27	0	189	1	15	1
29-30	365	1	58	1	185	0	27	0
31-32	148	0	10	0	85	1	9	0
33-34	24	0	1	0	22	1	2	0
35-36	36	0	5	0	10	0	4	0
37-38	37	0	2	0	20	0	7	0
39-40	10	0	1	0	5	0	0	0
41-42	11	0	1	0	4	0	0	0
43-44	10	0	1	0	4	1	0	0
Total	1,151	11	164	3	1.341	6	150	1

Table 6. Numbers of white sturgeon. by size group, reported in the sampled recreational fishery catch in John Day Reservoir, March-December; 1990.

Reservoir, statistical week	Boat				Bank			
	Sub legal	Legal rel.	Legal kept	Over-size	Sub legal	Legal rel.	Legal kept	Over-size
John Day								
9-10	0	0	0	0	0	0	0	0
11-12	0	0	0	0	1	0	0	0
13-14	7	2	0	1	3	0	1	0
15-16	13	0	0	0	0	0	0	0
17-18	2	0	0	0	0	0	0	0
19-20	0	0	0	0	3	0	0	0
21-22	6	0	2	0	0	1	1	0
23-24	5	0	0	0	3	0	0	0
25-26	77	0	1	0	1	0	1	1
27-28	86	3	8	0	15	2	0	1
29-30	95	0	10	2	11	0	3	2
31-32	62	0	2	0	4	0	2	0
33-34	34	0	1	0	3	0	0	0
35-36	19	0	1	0	0	0	1	0
37-38	15	0	2	0	0	0	0	0
39-40	38	0	2	1	1	1	3	1
41-42	6	0	3	3	0	0	0	2
43-44	30	0	2	1	2	0	1	0
45-46	0	0	1	0	1	0	3	1
47-48	1	0	0	0	1	0	0	0
49-50	3	0	4	5	1	0	0	0
51-52	0	0	0	0	0	0	0	0
Total	499	5	39	13	50	4	16	8

Table 7. Estimated recreational fishery harvest of white sturgeon in Bonneville Reservoir, March-October, 1990.

Reservoir, statistical week	Sturgeon anglers		Other anglers		Combined
	Boat	Bank	Boat	Bank	
Bonneville					
9-10	55	4	0	0	59
11-12	4	5	0	0	9
13-14	24	2	0	0	26
15-16	27	31	0	0	58
17-18	12	35	0	0	47
19-20	20	30	0	0	50
21-22	90	66	0	0	156
23-24	146	94	0	0	240
25-26	206	148	0	0	354
27-28	175	153	0	0	328
29-30	215	105	0	0	320
31-32	102	107	0	0	209
33-34	7	15	0	0	22
35-36	103	18	0	0	121
37-38	25	44	0	0	69
39-40	14	0	0	0	14
41-42	23	0	0	0	23
43-44	9	0	0	0	9
Total	1,257	857	0	0	2,114

Table 8. Estimated recreational fishery harvest of white sturgeon in John Day Reservoir, March-December, 1990.

Reservoir, statistical week	Sturgeon anglers		Other anglers		Combined
	Boat	Bank	Boat	Bank	
John Day					
9-10	0	0	0	0	0
11-12	0	0	0	0	0
13-14	0	3	0	0	3
15-16	0	0	0	0	0
17-18	0	0	0	0	0
19-20	0	0	0	0	0
21-22	9	5	0	0	14
23-24	0	0	0	0	0
25-26	9	8	0	0	17
27-28	42	0	0	0	42
29-30	80	26	0	0	106
31-32	14	27	0	0	41
33-34	3	0	0	0	3
35-36	11	11	0	0	22
37-38	11	0	0	0	11
39-40	6	5	0	0	11
41-42	11	0	0	0	11
43-44	8	0	0	0	8
45-46	15	5	0.	0	20
47-48	0	0	0	0	0
49-50	7	0	0	0	7
51-52	0	0	0	0	0
Total	226	90	0	0	316

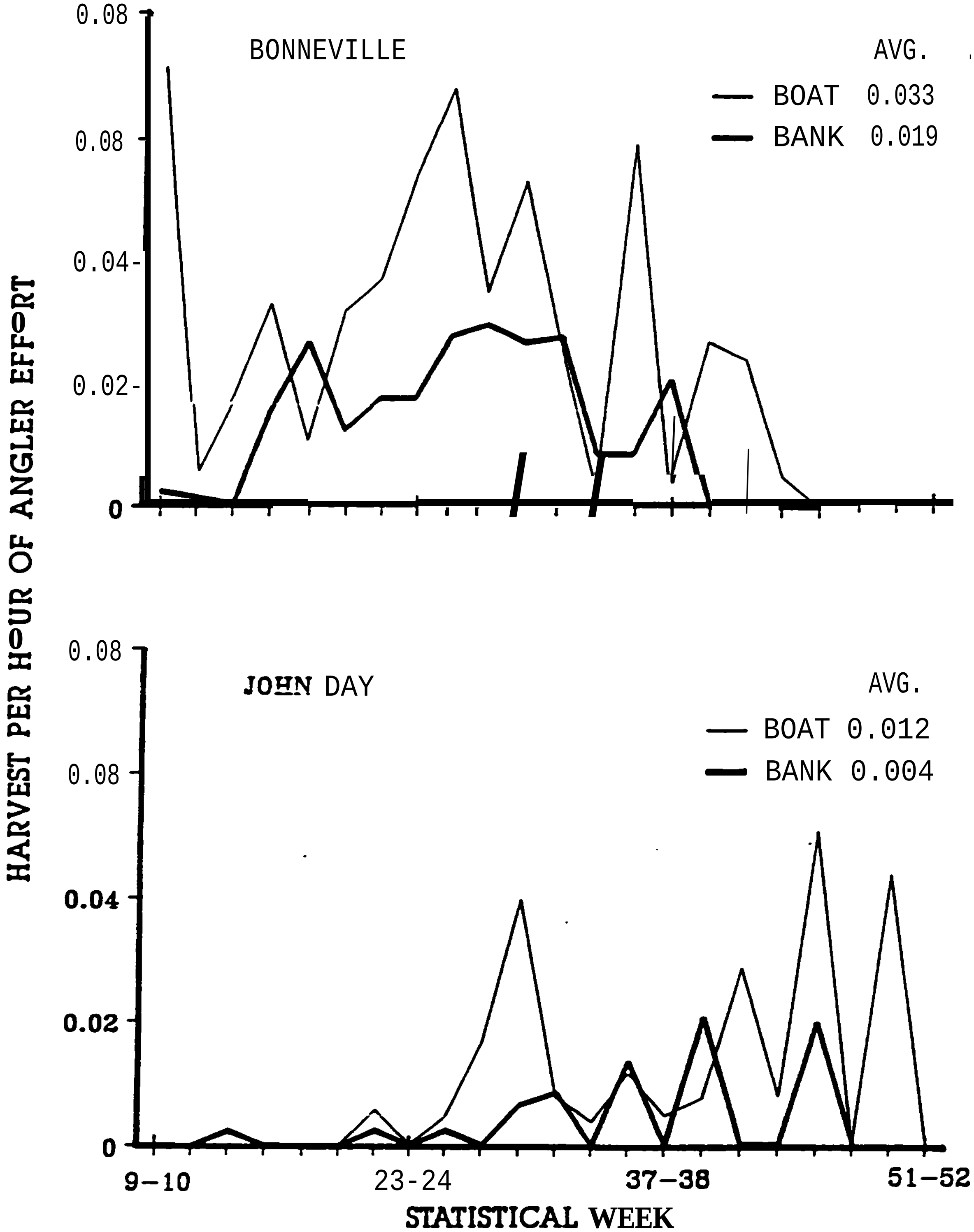

Figure 5. White sturgeon harvest per hour of angling effort by anglers targeting on white sturgeon. averaged by two week period. from March through October and March through December. 1990, for Bonneville and John Day reservoirs, respectively.

sturgeon in any of the other tribal fisheries in 1990. Incidentally caught sturgeon taken after April 30, 1990 during tribal fisheries were not allowed for sale, but were allowed to be taken for ceremonial and subsistence purposes. Ceremonial and subsistence harvest estimates are not available.

Mark Recovery and Biological Sampling

Samplers examined 265 of the estimated 2,114 white sturgeon harvested by anglers fishing Bonneville Reservoir in 1990 for an overall mark sample rate of 0.13 (Table 9). Seven ODFW marked sturgeon were observed resulting in an estimated 56 ODFW marked-sturgeon being harvested from March through October. Another 52 white sturgeon harvested by anglers fishing John Day Reservoir were examined for marks with one ODFW marked fish being observed (Table 10). This equates to a 0.16 mark sample rate and an estimated six ODFW marked white sturgeon being harvested from March through December, 1990.

Information on 13 of the ODFW marked sturgeon harvested from Bonneville Reservoir was voluntarily reported to WDF by anglers during 1990. Information on an additional 10 sublegal marked fish released by anglers was also obtained from the Bonneville Reservoir fishery. Anglers volunteered information on two ODFW marked sturgeon harvested from John Day Reservoir.

Fork lengths were measured on 255 and 52 white sturgeon harvested in the Bonneville and John Day reservoir recreational fisheries, respectively (Figure 6). The average FL of sport harvested white sturgeon in Bonneville Reservoir in 1990 was 104 cm and ranged from 89 to 153 cm FL. White sturgeon recreationally harvested in John Day Reservoir averaged 111 cm FL with a range of 88 to 162 cm FL.

Tribal commercial fishermen sold 1,890 white sturgeon harvested from Bonneville Reservoir in 1990. Of this, 204 were examined for marks (0.11 mark sample rate). three of which were ODFW marked fish, resulting in an estimated 28 ODFW marked fish being harvested during 1990 (Table 11). The tribal commercial white sturgeon harvest from The Dalles Reservoir was estimated to be 1,206 fish. Twenty percent, 237 fish, were examined for marks and seven ODFW marked fish were observed. The estimated total harvest of ODFW marked sturgeon in The Dalles commercial fisheries was 36. Thirty-two (32) sturgeon were randomly sampled from John Day Reservoir tribal commercial fisheries (Table 12). NO marked fish were observed.

Fork lengths were measured on 137, 234 and 29 white sturgeon harvested during 1990 tribal commercial fisheries in Bonneville, The

Table 9. Estimated recreational fishery harvest of ODFW marked white sturgeon from Bonneville Reservoir, March-October, 1990.

Reservoir, statistical week	Estimated harvest	Number examined for marks	Mark sample rate	Observed marks	Estimated mark harvest
Bonneville					
9-10	59	12	0.20	0	--
11-12	9	2	0.22	0	--
13-14	26	3	0.12	0	--
15-16	58	12	0.21	1	
17-18	47	9	0.19	0	--
19-20	50	6	0.12	0	--
21-22	156	18	0.12	2	--
23-24	240	30	0.13	1	--
25-26	354	43	0.12	0	--
27-28	328	41	0.13	2	--
29-30	320	56	0.18	1	--
31-32	209	14	0.07	0	--
33-34	22	3	0.14	0	
35-36	121	5	0.04	0	
37-38	69	9	0.13	0	--
39-40	14	1	0.07	0	--
41-42	23	1	0.04	0	--
43-44	9	0	0.00	0	--
Total	2,114	265	0.13	7	56

Table 10. Estimated recreational fishery harvest of ODFW marked white sturgeon from John Day Reservoir, March-December, 1990.

Reservoir, statistical week	Estimated harvest	Number examined for marks	Mark sample rate	Observed marks	Estimated mark harvest
John Day					
9-10	0	0	0.00	0	--
11-12	0	0	0.00	0	--
13-14	3	1	0.33	0	--
15-16	0	0	0.00	0	
17-18	0	0	0.00	0	--
19-20	0	0	0.00	0	--
21-22	14	1	0.07	0	--
23-24	0	0	0.00	0	. .
25-26	17	2	0.12	0	--
27-28	42	8	0.19	0	. .
29-30	106	12	0.11	0	--
31-32	41	4	0.10	0	--
33-34	3	1	0.33	0	--
35-36	22	2	0.09	0	. .
37-38	11	2	0.18	0	--
39-40	11	5	0.45	0	--
41-42	11	3	0.27	0	--
43-44	8	3	0.38	0	
45-46	20	4	0.20	1	--
47-48	0	0	0.00	0	--
49-50	7	4	0.57	0	
51-52	0	0	0.00	0	
Total	316	52	0.16	1	6

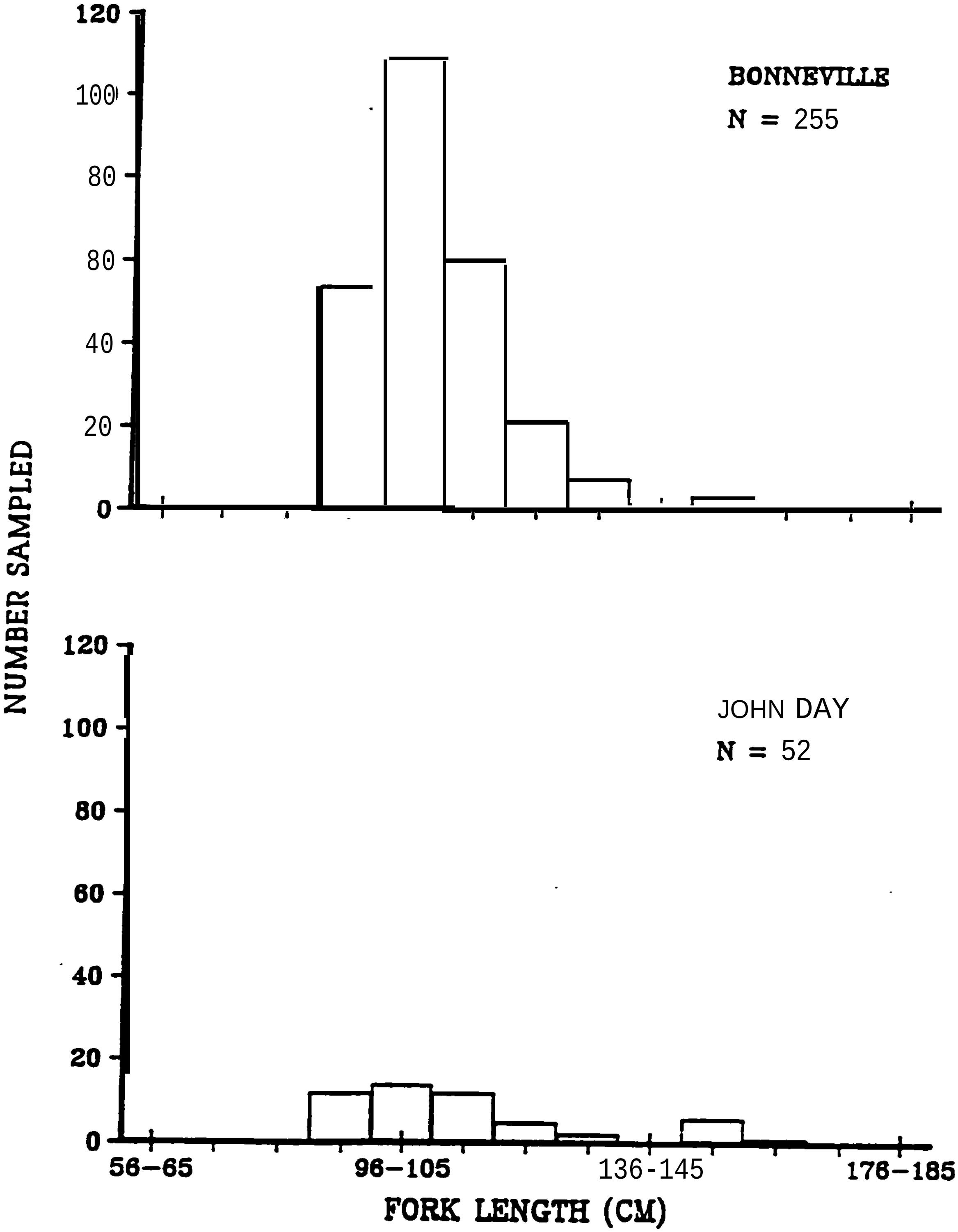

Figure 6. **Length-frequency** distributions of **harvested** white sturgeon sampled from the **March** through October **and** March through **December, 1990,** recreational fisheries for **Bonneville** and John **Day reservoirs,** respectively.

Table 11. Estimated harvest of ODFW marked white sturgeon landed by commercial fisheries in Bonneville and The Dalles reservoirs during 1990.

Reservoir, statistical week	Number landed	Number examined for marks[a]	Mark sample rate	Observed marks	Estimated mark harvest
Bonneville					
1- 2	11	0	0.000	0	--
3- 4	30	0	0.000	0	--
5- 6	333	4	0.012	0	--
7- 8	102	0	0.000	0	--
9-10	254	9	0.035	0	--
11-12	378	24	0.063	0	--
13-14	38	2	0.053	0	--
15-16	57	2	0.035	0	--
17-18	102	0	0.000	0	--
19-30	10	0	0.000	0	--
31-32	115	36	0.313	0	--
33-34	173	51	0.295	1	--
35-36	134	49	0.366	0	--
37-38	100	22	0.220	2	--
39-40	53	5	0.094	0	--
41-52	0	0	0.000	0	--
Total	1,890	204	0.108	3	28
The Dalles					
1- 2	3	0	0.000	0	--
3- 4	13	0	0.000	0	--
5- 6	201	48	0.239	0	--
7- 8	76	4	0.053	0	--
9-10	79	33	0.418	2	--
11-12	55	27	0.491	1	--
13-14	4	0	0.000	0	--
15-16	8	4	0.500	1	--
17-18	6	0	0.000	0	--
19-30	0	0	0.000	0	--
31-32	81	26	0.321	0	--
33-34	486	51	0.105	2	--
35-36	102	21	0.206	0	--
37-38	73	21	0.288	1	--
39-40	19	2	0.105	0	--
41-52	0	0	0.000	0	--
Total	1,206	237	0.197	7	36

[a] *The reservoir was unidentified for eleven mark sampled fish.*

Table 12. Estimated harvest of ODFW marked white sturgeon landed by commercial fisheries in John Day Reservoir during 1990.

Reservoir, statistical week	Number lauded	Number examined for marks[a]	Mark sample rate	Observed marks	Estimated mark harvest
John Day					
1- 2	3	0	0.000	0	--
3- 4	0	0	0.000	0	--
5- 6	0	0	0.000	0	
7- 8	13	0	0.000	0	--
9-10	3	0	0.000	0	--
11-12	14	1	0.071	0	--
13-14	1	0	0.000	0	--
15-16	2	0	0.000	0	--
17-18	0	0	0.000	0	--
19-30	0	0	0.000	0	--
31-32	140	6	0.043	0	--
33-34	101	10	0.099	0	--
35-36	31	6	0.194	0	--
37-38	76	8	0.105	0	--
39-40	21	1	0.048	0	--
41-52	0	0	0.000	0	--
Total	405.	32	0.079	0	0

[a] *The reservoir was unidentified for eleven mark sampled fish.*

Dalles, and John Day reservoirs, respectively (Figures 7 and 8). The average FL from commercially harvested sturgeon from Bonneville Reservoir was 117 cm and ranged from 96 to 153 cm FL. Sturgeon commercially harvested in The Dalles Reservoir averaged 128 cm FL and ranged from 105 to 169 cm FL. White sturgeon sampled from the John Day Reservoir tribal commercial fishery harvest averaged 125 cm FL and ranged from 100 to 159 cm FL.

Females comprised 53% of the 351 white sturgeon harvested from Bonneville Reservoir in 1990 where gonadal tissue was examined (Table 13). Ovary samples were collected from 174 of these fish. The sampled sex ratio for 1990 tribal commercial fisheries in The Dalles Reservoir was 46% female. There were 88 ovary samples obtained from these fish. The sampled sex ratio from 1990 John Day Reservoir fisheries was 51% female and 39 ovary samples were collected. Three ovary samples were collected from sturgeon harvested in unknown reservoirs.

Fin ray samples were obtained from 162, 223 and 82 white sturgeon harvested in Bonneville, The Dalles and John Day reservoir fisheries, respectively in 1990 (Table 13). There were 11 pectoral fin ray samples taken from sturgeon harvested in unknown reservoirs.

Population Dynamics Downstream of Bonneville Dam

Field activities downstream of Bonneville Dam in 1990 focused on continued marking of white sturgeon and sampling recreational and commercial fisheries for mark recoveries and biological samples. A total of 6,555 white sturgeon were captured and 3,364 were marked with spaghetti tie tags during WDF and ODFW research fisheries in. The mark and release effort was distributed as follows: 2,756 in the Columbia River estuary (RM 5-22), 369 at Woody Island (RM 28), 25 at Mayger (RM 58) and 214 at Corbett (RM 128). An additional 139 sturgeon were tagged and released during other tagging activities. There were 962 white sturgeon injected with OTC during 1990 research fisheries. These fish were also tagged and secondarily marked with a specific scute removal pattern. There were 14 recoveries of OTC-injected sturgeon from 1989 tagging efforts in 1990. Pectoral fin rays were collected from eight of those fish.

WDF and ODFW mark sampled 1,948 and 1,551 white sturgeon harvested in the lower Columbia River recreational and commercial fisheries, respectively in 1990. There were 25 recoveries of sturgeon marked in 1990 in recreational fisheries and 12 marks recovered from this same tag group in commercial fisheries in 1990. Additionally, there were 125 recoveries from tag groups marked prior to 1990 in lower Columbia River harvests . There were also 174 and 370 in-sample mark recoveries of 1990

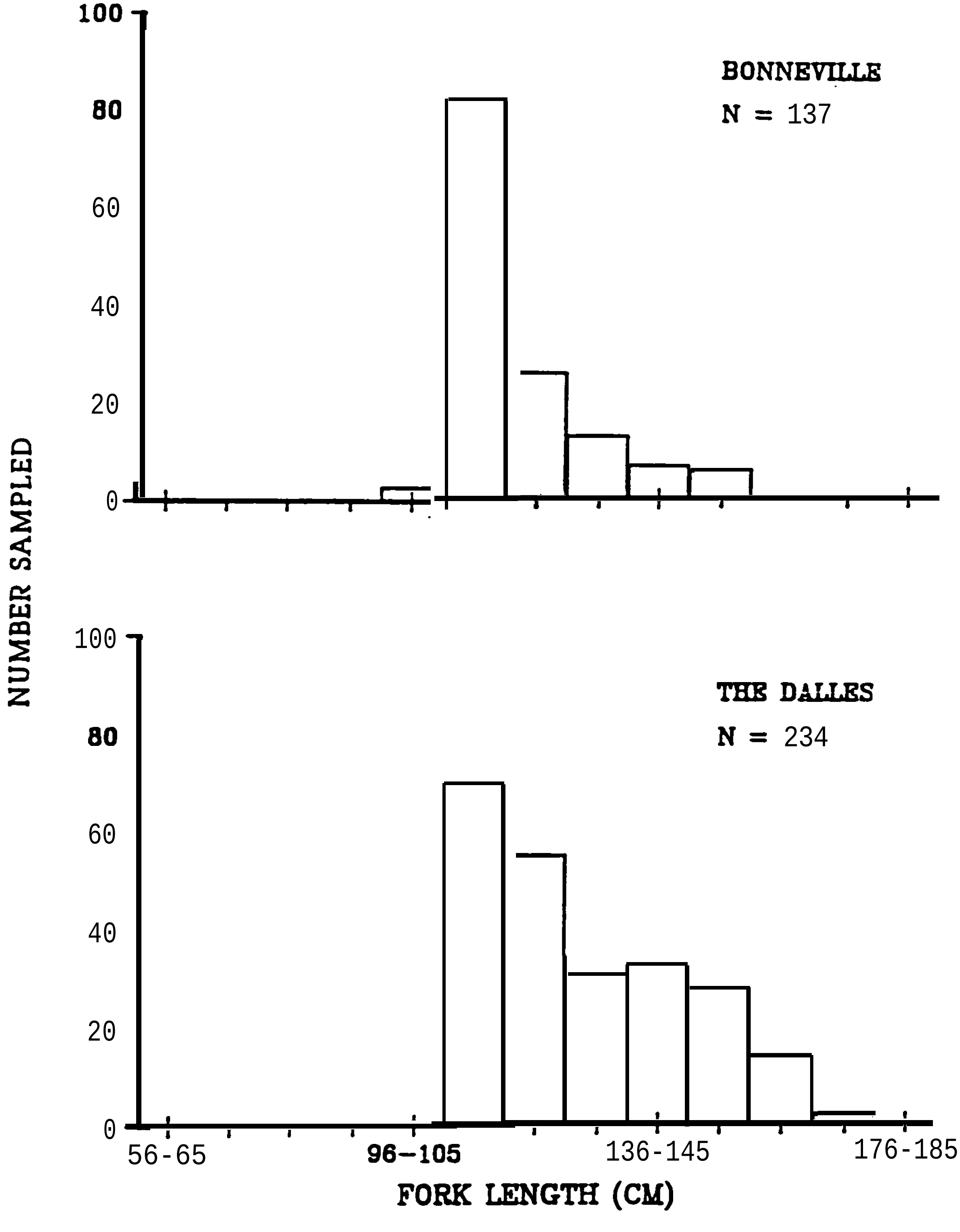

Figure 7. **Length-frequency** distributions of harvested white sturgeon sampled from 1990 commercial fisheries for Bonneville and The **Dalles** reservoirs.

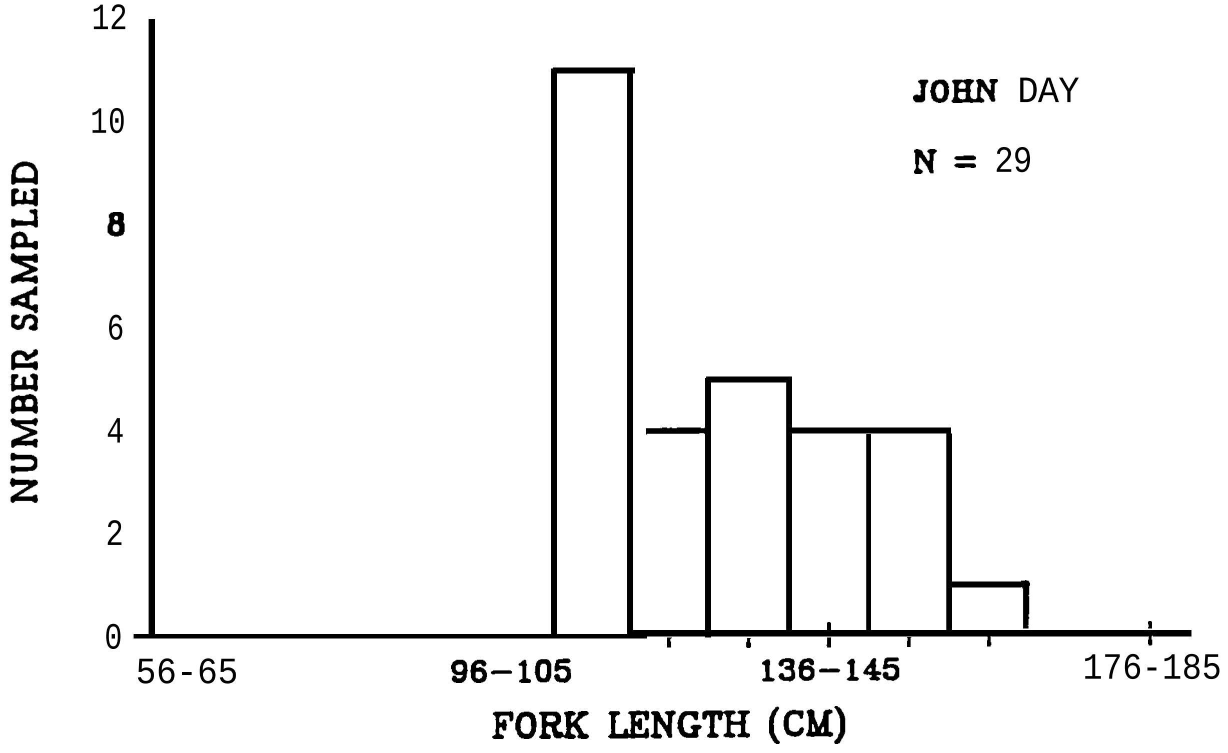

Figure 8. Length-frequency distribution of harvested white sturgeon sampled from the 1990 commercial fishery for John Day Reservorr.

Table 13. Numbers of white sturgeon measured, numbers examined to determine sex, and numbers of ovary and fin ray samples collected during sampling of 1990 recreational and commercial fisheries on Bonneville, The Dalles and John Day reservoirs.

Reservoir, fishery	Length measurement collected	Gonad examined			Ovary sample collected	Fin ray sample collected
		Unknown	Male	Female		
Bonneville						
Sport	255	0	102	111	104	24
Commercial	137	0	64	74	70	138
Total	392	0	166	185	174	162
The Dalles						
Sport	0	0	0	0	0	0
Commercial	234	0	121	102	88	223
Total	234	0	121	102	88	223
John Day						
Sport	52	1	16	31	31	51
Commercial	29	0	23	9	8	31
Total	81	1	39	40	39	82
Unidentified pool						
Sport	0	0	0	0	0	0
Commercial	11	0	8	3	3	11
Total	11	0	8	3	3	11

tag groups and pre-1990 tag groups, respectively in 1990 research fisheries.

Biological data on white sturgeon were collected by WDF and ODFW during routine sampling of 1990 fisheries downstream of Bonneville Dam. The recreational harvest sample of 2,642 white sturgeon averaged 103 cm FL with a range of 82 to 165 cm FL. Random samples of white sturgeon from the commercial harvest ranged from 98 to 190 cm FL with an average FL of 119 cm (n-763). Pectoral fin ray samples were collected from 100 white sturgeon in the recreational fishery and 812 white sturgeon in the commercial fishery . Ovary samples were obtained from 378 commercially harvested white sturgeon. Fin ray aging and ovary maturity analysis of 1990 samples have not been completed.

Forty three white sturgeon were handled during broodstock monitoring in 1990. Sex and maturity data was collected on 36 of those fish including 24 that were over 183 cm TL (maximum legal size for harvest). All but two were tagged before being released.

DISCUSSION

Significant progress was made in the 1990 white sturgeon marking program downstream of Bonneville Dam. A record number of sturgeon over 90 cm TL were marked and released. These efforts should help-refine abundance estimates and associated bias, growth rates, gear selectivity, tag retention rates, migration and mortality parameters. Likewise, a record number of sublegal sturgeon were marked, OTC-injected and released. Efforts to validate our ageing techniques were also advanced by increased recoveries of previously injected sturgeon. Preliminary results indicate that circuli are formed on an annular basis for sturgeon below Bonneville Dam and this annulus development occurred prior to April for the fish recovered to date. Age validation work will be continued next year with an emphasis towards marking and OTC-injecting sturgeon during all months of the year to refine estimates of the timing of seasonal annulus formation.

Efforts towards defining parameters affecting white sturgeon population dynamics downstream of Bonneville Dam were advanced but not completed. Data collected in 1990 are being processed, analyzed and incorporated into databases. Problems associated with adequate mixing of marked and unmarked individuals within an open system and the exchange of white sturgeon between the Columbia River and the ocean during the marking and recapture period have not been resolved. Efforts will be made to identify subgroups within the population that are segregated temporally and spatially.

Endeavors to obtain sex, maturity and age data on oversized brood stock sturgeon have been fruitful. Accompanying broodstock collection efforts by private hatchery interests during the spring spawning time period have provided valuable information that will help us define the reproductive potential of the white sturgeon population downstream from Bonneville Dam. Coupled with sampling the reported mortalities of oversized sturgeon on the Lower Columbia River, we are generating a significant database on the adult portion of the population that is not susceptible to legal harvest.

Major investigative efforts on white sturgeon downstream of Bonneville Dam in 1991 will be directed towards continued sampling of eggs and larvae, continued tagging and age validation work, addressing the problems associated with open system population assessment and obtaining reproductive data on oversize fish through continued broodstock monitoring. WDF will continue to collect and analyze sturgeon eggs and larvae. Indices of spawning obtained during hydrological periods that are markedly different than past years will help determine the importance of flow and current velocity in Columbia River white sturgeon spawning success. Progress will also be made in population dynamics modeling and age validation with our sturgeon tagging efforts . Temporal and spatial distribution of our tagging efforts will be increased to optimize mixing of tagged and untagged sturgeon in the population. We are hopeful that important strides will be made in refining population abundance and exploitation estimates as well as seasonal growth and migration patterns of individuals with this increased distribution of effort.

General field activities in 1991 will include sampling of all recreational and commercial fisheries below McNary Dam that harvest white sturgeon. Research fisheries downstream of Bonneville Dam will be intensively sampled in 1991 to achieve marking and recovery objectives.

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APPENDIX B-1

Angler Effort Count Index Areas

John Day Reservoir

Boat

West of Boardman, OR (RM 272.0) upstream past Glade Creek on the Washington shore (RM 274.0).

Irrigon. OR (RM 278.0) upstream to McNary Dam (RM 292.5).

Bank

The Oregon shore just west of Irrigon, OR (RM 279.1 to RM 279.3).

The Oregon shore just upstream of Hwy. 82 bridge at Umatilla, OR (RM 291.0).

The Oregon shore just downstream of McNary Dam (RM 292.1).

Report 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 quantify the extent of habitat available in the Columbia River between Bonneville and McNary dams.

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CONTENTS

ACKNOWLEDGMENTS

Bill Nelson and Dena Gadomski provided helpful critiques of this manuscript. Janice Brown and Milton Hunter assisted with laboratory analysis and Alice Murphy assisted with GIS procedures. Carol Rike and Sue Neece provided administrative support. Mike Poe provided surveying expertise for the layout of habitat transects. The National Marine Fisheries Service provided pectoral spine samples from white sturgeon captured downstream from Bonneville Dam for age determination.

ABSTRACT

The U.S. Fish and Wildlife Service (FWS) sampled white sturgeon (Acipenser transmontanus) eggs, larvae, and juveniles in the three Columbia River pools between Bonneville (RM 146.5) and McNary (RM 292.0) dams from April through October, 1990. White sturgeon spawned in the tailrace areas in each pool at water temperatures of 12.9 to 17.9°C, and mean water column velocities of 0.4 to 2.3 m per second. Based on back-calculated egg age, white sturgeon spawning occurred from 23 May to 7 July in Bonneville Pool, from 4 June to 2 July in The Dalles Pool, and from 27 May to 12 June in John Day Pool. Seven-hundred and sixty-eight white sturgeon eggs were collected in Bonneville Pool, compared with 337 in the Dalles Pool, and 71 in John Day Pool. Twenty-one percent of the eggs collected in Bonneville Pool were non-viable (dead or fungused) compared with 57% in The Dalles Pool, and 7% in John Day Pool.

Three to four times as many larval white sturgeon were collected in Bonneville Pool (221) than in The Dalles Pool (66) or John Day Pool (80). Young-of-the-year (YOY) white sturgeon collected in Bonneville Pool accounted for nearly 95% of the 1990 total annual catch of YOY from all three pools combined. Young-of-the-year white sturgeon were collected in all pools at 19.5 to 48.8 m depths, over sand, mud, gravel, and cobble substrates. For the first time in this study, which began in 1987, YOY white sturgeon were collected in the Dalles Pool. Five YOY were collected in The Dalles Pool, while no YOY were collected in John Day Pool.

Nearly 92% of all juvenile white sturgeon collected were caught in Bonneville Pool; juvenile catch per hectare was substantially higher in Bonneville Pool (3.84) than in the Dalles (0.92) and John Day pools (0.16). Juvenile white sturgeon were collected from water depths ranging from 9.1 to 36.0 m over substrates ranging from silt to cobble.

Invertebrates of the genus Corophium accounted for 84% of the food items recovered from the stomachs of 67 YOY white sturgeon from Bonneville Pool; Neomvsis, gammarids, chironomids, and cladocerans were also frequently consumed prey items.

INTRODUCTION

The U. S. Fish and Wildlife Service (FWS) is responsible for tasks related to Objectives 1 and 3 of the white sturgeon (Acipenser transmontanus) study. Objective 1 is to describe reproduction and early life history characteristics of white sturgeon populations: Objective 3 is to define habitat requirements for white sturgeon spawning and rearing, and to quantify available habitat between Bonneville and McNary dams.

Specific tasks for 1990, were to: 1) continue sampling Bonneville, The Dalles, and John Day pools for white sturgeon eggs, larvae, young-of-the-year (YOY) and older juveniles; 2) continue to define white sturgeon spawning and rearing habitat; and 3) complete computerized maps which quantify available spawning and rearing habitat for each pool. This report presents progress towards study objectives 1 and 3 and supporting tasks from April 1990 through March 1991.

METHODS

Field Sampling

Collections

White sturgeon eggs through juveniles were sampled at locations used in previous years in Bonneville, The Dalles, and John Day pools (Figure 1.; Duke et al. 1990, Parsley et al. 1989, Palmer et al. 1988). White sturgeon egg and larval sampling was conducted in the uppermost seven miles of each pool (Figures 2-4): YOY and juvenile white sturgeon were sampled throughout each pool. In this study larvae refers to white sturgeon < 25 mm FL and YOY refers to white sturgeon ≥ 25 mm FL, which are less than age I. Juvenile refers to white sturgeon ≥ age I which are < 800 mm FL (about age VIII).

D-shaped larval nets were fished between the second week of April and the fourth week of July to sample white sturgeon eggs and larvae: the beam trawl was fished between the second week of April and the first week of August to collect white sturgeon eggs, larvae, and YOY (Appendix C-l). Young-of-the-year and juvenile white sturgeon were sampled with the high-rise trawl between the second week of April and the fourth week of October. Collection techniques remained the same as those used in 1989 (Duke et al. 1990) except the high-rise trawl sampling was reduced from 15 to 10 minutes per tow.

Catch per unit effort (CPUE) of white sturgeon was expressed as number caught/l5 minutes (CPT) for each gear type, number caught/hectare (CPHA) with the high-rise trawl, and number caught/1000 m^3 with the D-shaped larval net. Only effort from the first to the last day eggs or larvae were collected was used in calculations of egg and larval CPUE. Egg and larval collections were preserved in 5% unbuffered formalin tinted with phloxine B. Larval white sturgeon were measured to total length (TL mm) and weighed (nearest 0.001g) in the lab; YOY and juvenile

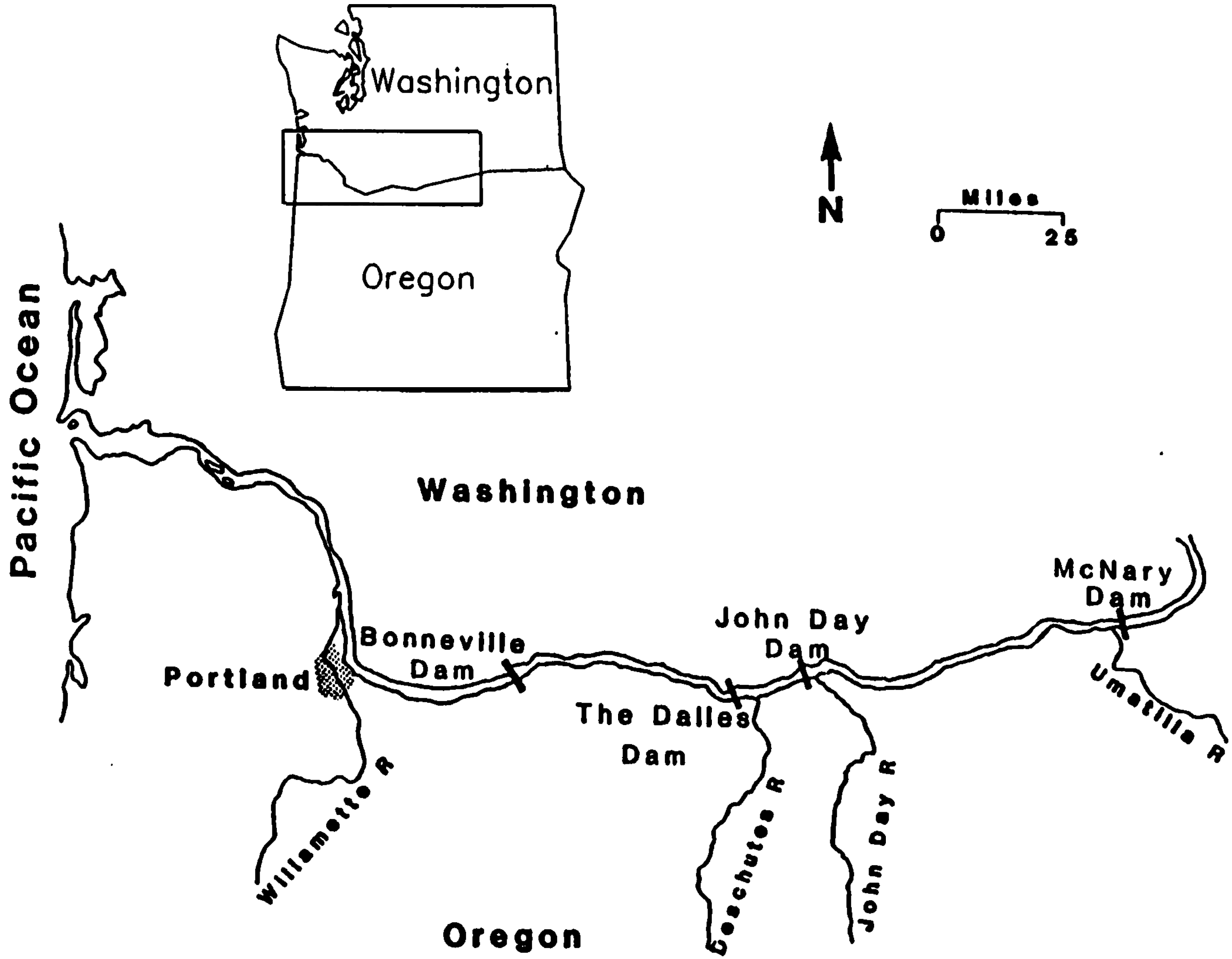

Figure 1. Location of study area between Bonneville and McNary dams along the Columbia River.

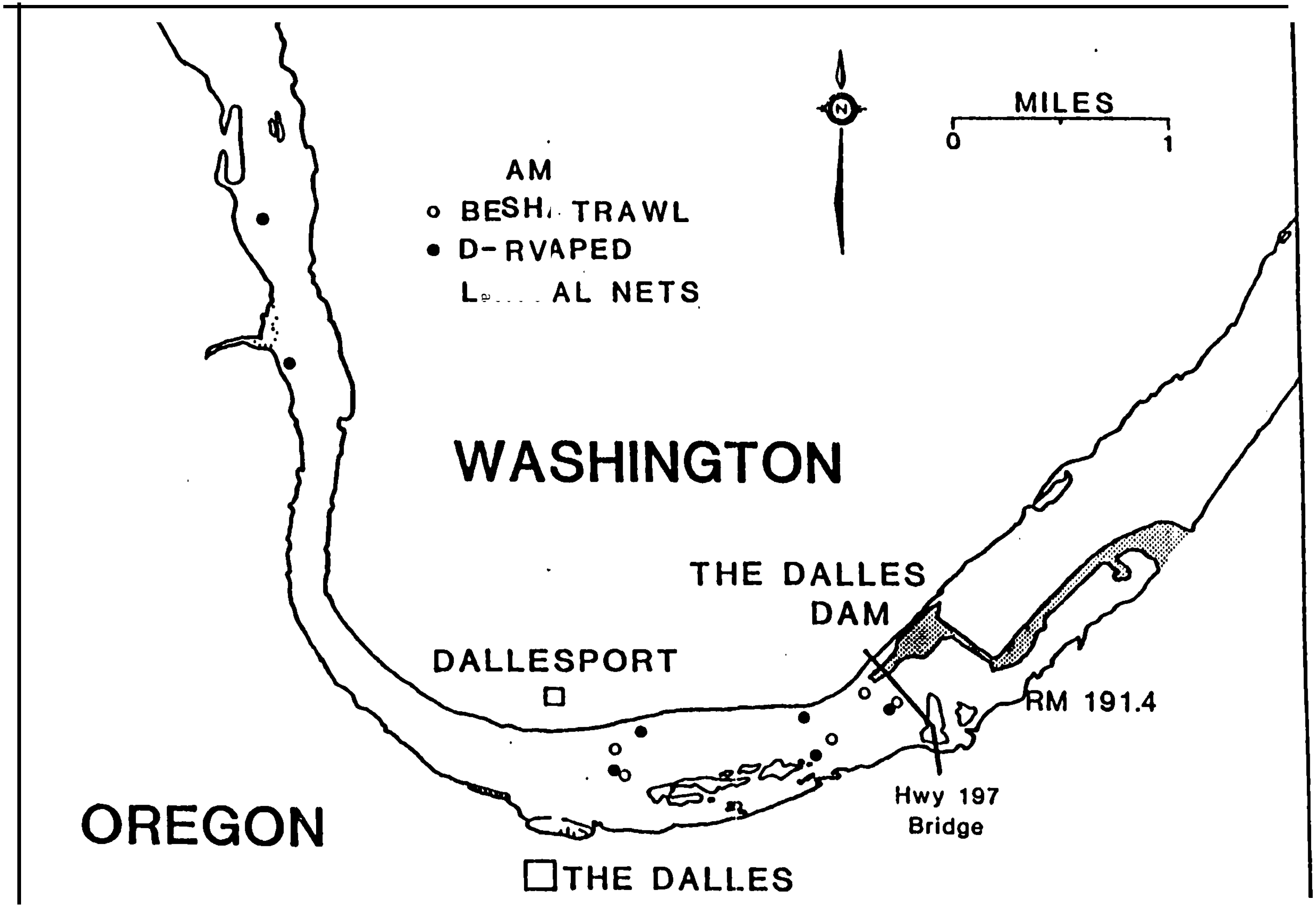

Figure 2. White sturgeon egg and larval sampling areas in Bonneville Pool, 199.

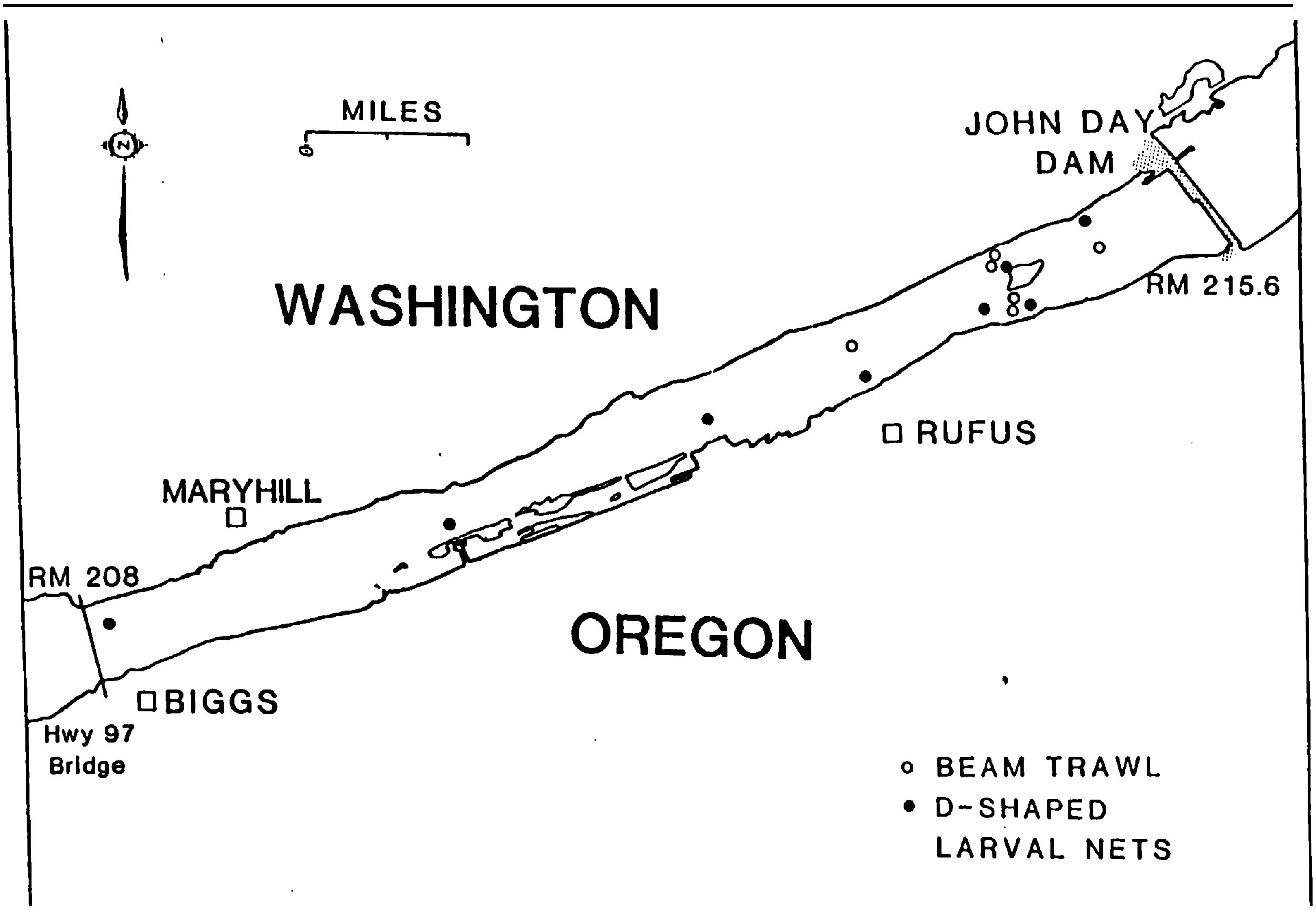

Figure 3. White sturgeon egg and larval sampling areas in The Dalles Pool, 1990.

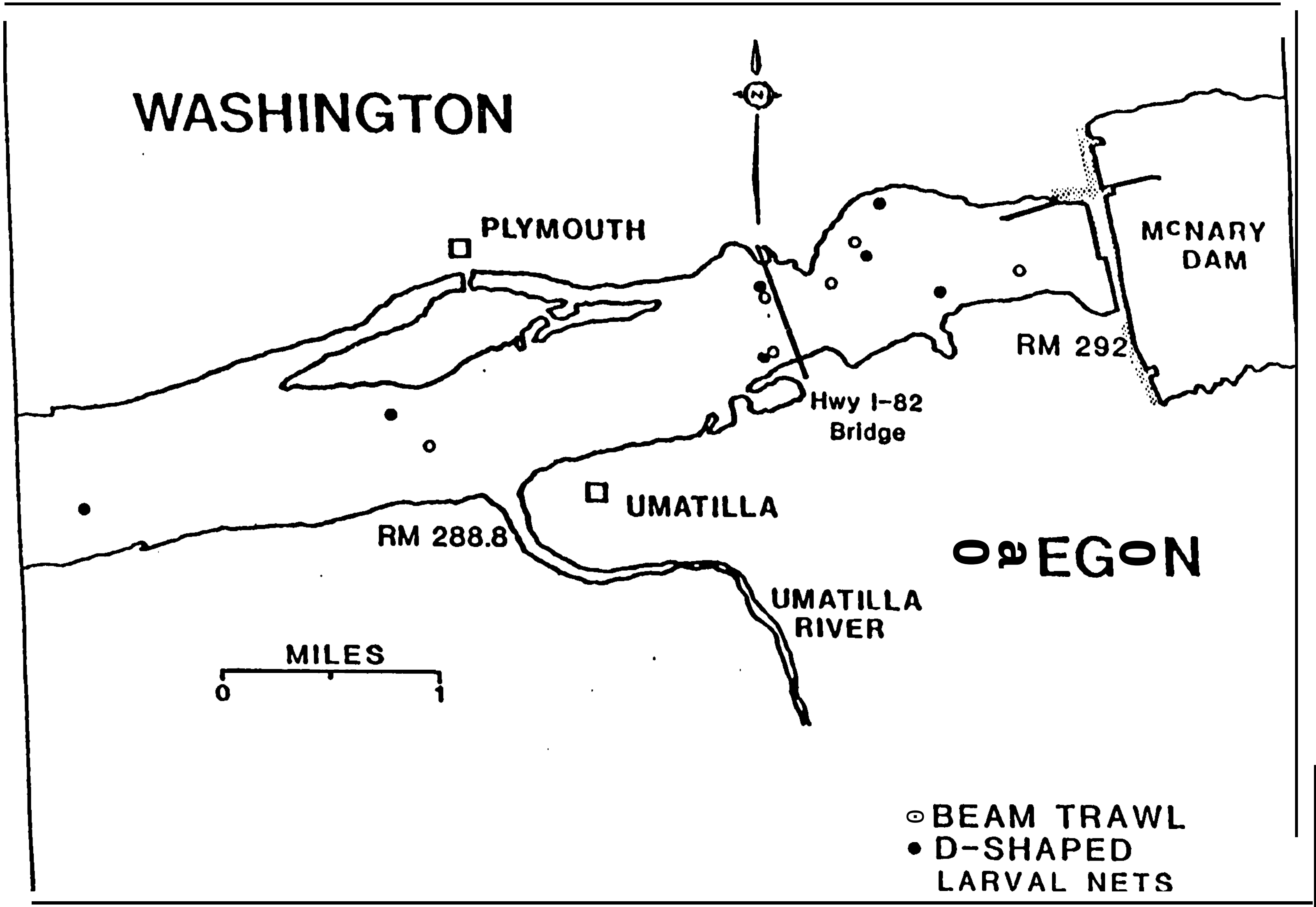

Figure 4. White sturgeon egg and larval sampling areas in John Day Pool, 1990.

white sturgeon less than 800 mm fork length (FL) were measured (nearest mm) and weighed (nearest 10 grams) in the field.

Left pectoral fin ray sections were removed from up to 100 juvenile white sturgeon per pool for age determination. Juveniles less than 800 mm (FL) were tagged with a monel bird band (right pectoral fin ray) to provide movement and growth information. Captured white sturgeon were examined for previous marks and for the external parasite Cystoopsis acipenser. All other fish captured were identified, enumerated and released.

Stomach Contents

The digestive tracts of YOY white sturgeon collected in Bonneville and The Dalles pools -were examined. The fish were preserved in 10% formalin containing phyloxin B, and the abdomens of the larger fish were slit to allow formalin to enter the body cavity.

Habitat Use

Environmental and physical parameters addressed were water temperature, turbidity, discharge at each dam, water velocity and water depth. Water temperatures, velocities and turbidity were measured prior to setting the D-shaped larval nets. Hourly discharge records of the four lower Columbia River dams for April through July were obtained from the Fish Passage Center. Water temperatures in known or suspected white sturgeon spaying areas were recorded hourly with Ryan Tempmentor thermographs . Thermographs were placed on the substrate downstream from each dam at River Miles 190.8, 214.3, and 290.6 from late April through August or September. Water temperature was measured with a Yellow Springs Instrument Co. Model 58 dissolved oxygen and temperature meter. Turbidity was measured with a Hach model 16800 Turbidimeter on samples collected approximately 0.2 m above the substrate with a vertical van Dorn sampler.

Mean water column velocity (an average of the velocity measured at 0.2 and 0.8 of the total depth) and bottom velocity (measured 0.6 m from the substrate) at sample sites was measured with a cable suspended Price type "AA" sensor connected to a Swoffer Instruments Model 2200 direct reading current velocity meter. Measurements were taken prior to most efforts with the D-shaped larval nets.

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1 Use of trade names does not imply endorsement by FWS.

Laboratory

Egg and Larval Samples

As during 1989, samples preserved in the field were sorted in the laboratory. Non-sturgeoneggs were counted, and non-sturgeon larvae were identified to family and enumerated. White sturgeon eggs and larvae were assigned developmental stages based on criteria described by Beer (1981). To back-calculate time of egg fertilization for eggs and larvae, we used the relationship developed by Wang et al. (1985). Water temperatures at the time of collection were used in the relationship and assumed to have been constant during incubation.

Age and Growth

Pectoral fin rays of white sturgeon *were* cross-sectioned and age was estimated by counting annuli. Fin ray sections were independently-aged by four persons following criteria summarized by Beamsderfer et al. (1989).

Weight-length relationships and condition factors were determined for YOY white sturgeon in Bonneville Pool and for juvenile white sturgeon in Bonneville and The Dalles pools. Least squares regression was used to compute the weight-length relationship using transformed ($\log_{10}$) data. Condition factors were determined using the formula $C = (W/L^3)*10^5$.

Annual relative (h) and average instantaneous (G) growth rates (Ricker 1975) were determined for ages I to VIII white sturgeon captured *in* Bonneville Pool and downstream from Bonneville Dam. Data collected downstream from Bonneville Dam were provided by the National Marine Fisheries Service. Growth among pools was compared by plotting mean fork length at age.

Stomach Contents

Digestive tracts of YOY white sturgeon were examined for type and quantity of food items. The foregut and pyloric region anterior to the pyloric sphincter were dissected and contents removed. Food items *were* identified, enumerated, weighed, and placed in 40% ethanol. A fullness index was used to describe percent stomach fullness (1 = empty, 7 = distended). Stomach contents were also assigned an index value between 1 and 6 to indicate the degree of digestion (1 = all stomach contents unidentifiable, 6 = no digestion). Percent occurrence of specific food items was calculated using the following formula:

$$\frac{\text{\# of stomachs w/ food item}}{\text{\# of stomachs sampled}} \times 100$$

Relative abundance of prey items was also determined:

$$\frac{\text{\# organisms of each species}}{\text{\# specimens in all samples}}$$

Habitat Quantification

Surface areas of each pool that are comprised of specific depths and substrates, or a combination thereof, are being determined through cartographic modeling with a geographic information system. Data were digitized from nautical charts (scale = 1:20,000 and 1:40,000) published by the National Oceanic and Atmospheric Administration. Pre and post-impoundment aerial photographs and field measurements were used to adjust or add information to the nautical charts.

The amount of habitat available for white sturgeon spawning in each tailrace will be estimated using the Physical Habitat Simulation System (PHABSIM), a component-of the Instream Flow Incremental Methodology described by Bovee (1982). Habitat changes in response to river discharges are modeled at points along transects across the river channel. Nine transects were established in The Dalles Dam tailrace, five in the John Day Dam tailrace, and seven in the McNary Dam tailrace. Transects were marked with headpins on each river bank. Headpin elevations (ft above mean sea level) were determined by surveying from nearby known benchmarks placed by the U.S. Geological Survey or the U.S. Army Corps of Engineers. Distances between headpins and transects were measured with an electronic distance meter (EDM). Water depths, water velocities, and substrates were measured at points along each transect by aligning a boat along the transect and measuring the distance between the boat and a headpin with the EDM. Bed elevations were determined at these points by subtracting the water depth (determined with a recording fathometer to the nearest 0.5 ft) from the water surface elevation.

Water surface elevations at each transect, for use in the hydraulic simulations, were predicted by least squares regression of the water surface elevation at each transect and the corresponding tailwater elevation of the upstream dam. Discharges used in the simulations ranged from 50,000 to 500,000 cfs.

RESULTS

Bonneville Pool

Environmental Conditions

Hourly discharge of water through The Dalles Dam ranged from 2.15 to 11.52 kcms (76 to 407 kcfs) during April through July (Figure 5), and was characterized by wide daily fluctuations. Peak discharge occurred during June.

Water temperatures gradually increased from 7.7°C on 1 April to 20.8°C on 30 July (Figure 6). Water temperatures considered optimal for white sturgeon spawning (14-17°C; Wang et al. 1985) occurred between 8 June and 28 June. Mean daily turbidities ranged from 3.3 to 15.8 NTU (Figure 6).

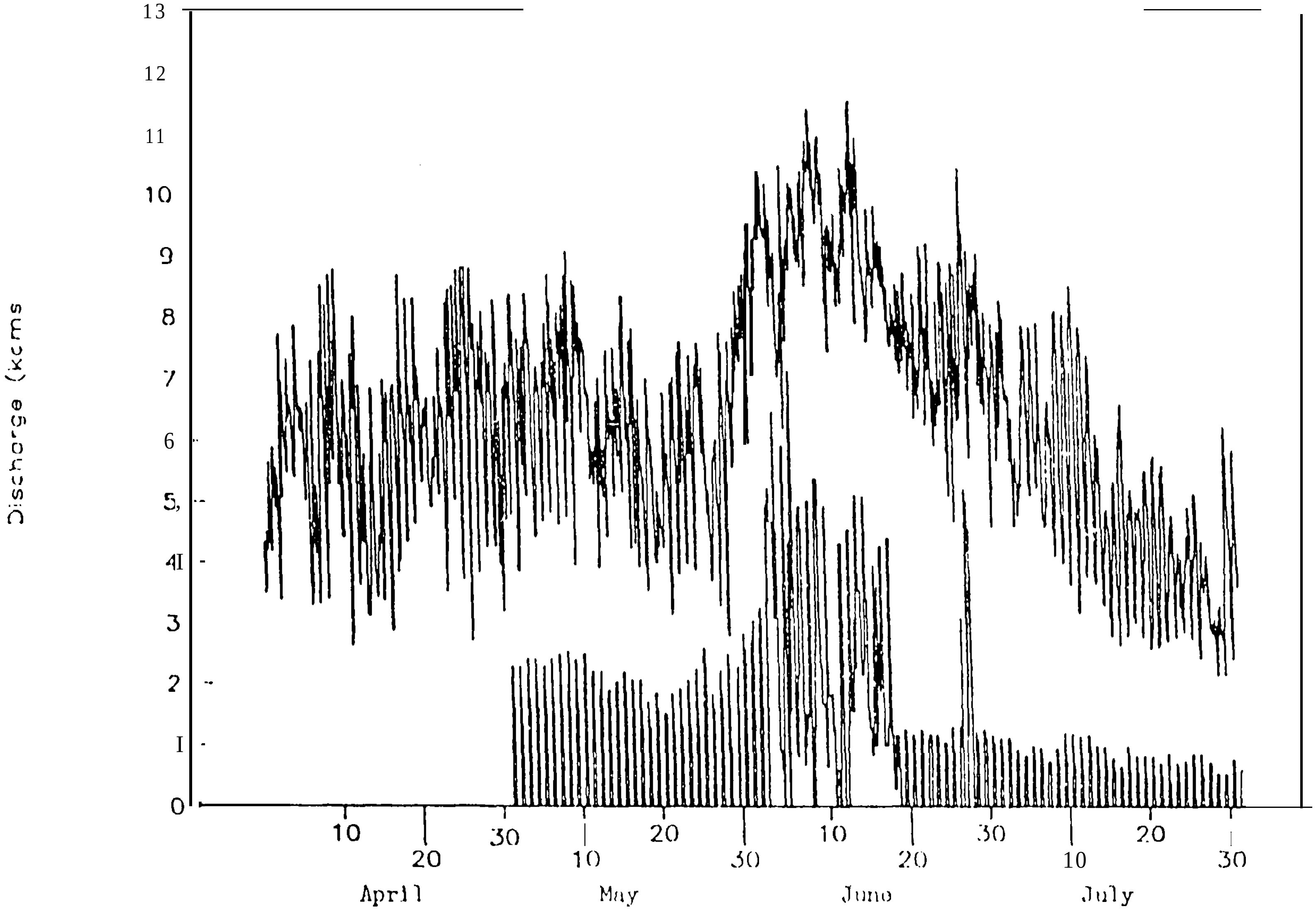

Figure 5. Hourly discharge through The Dalles Dam, April 1 through July, 1990. The upper line indicates total discharge, the lower line indicates spill discharge.

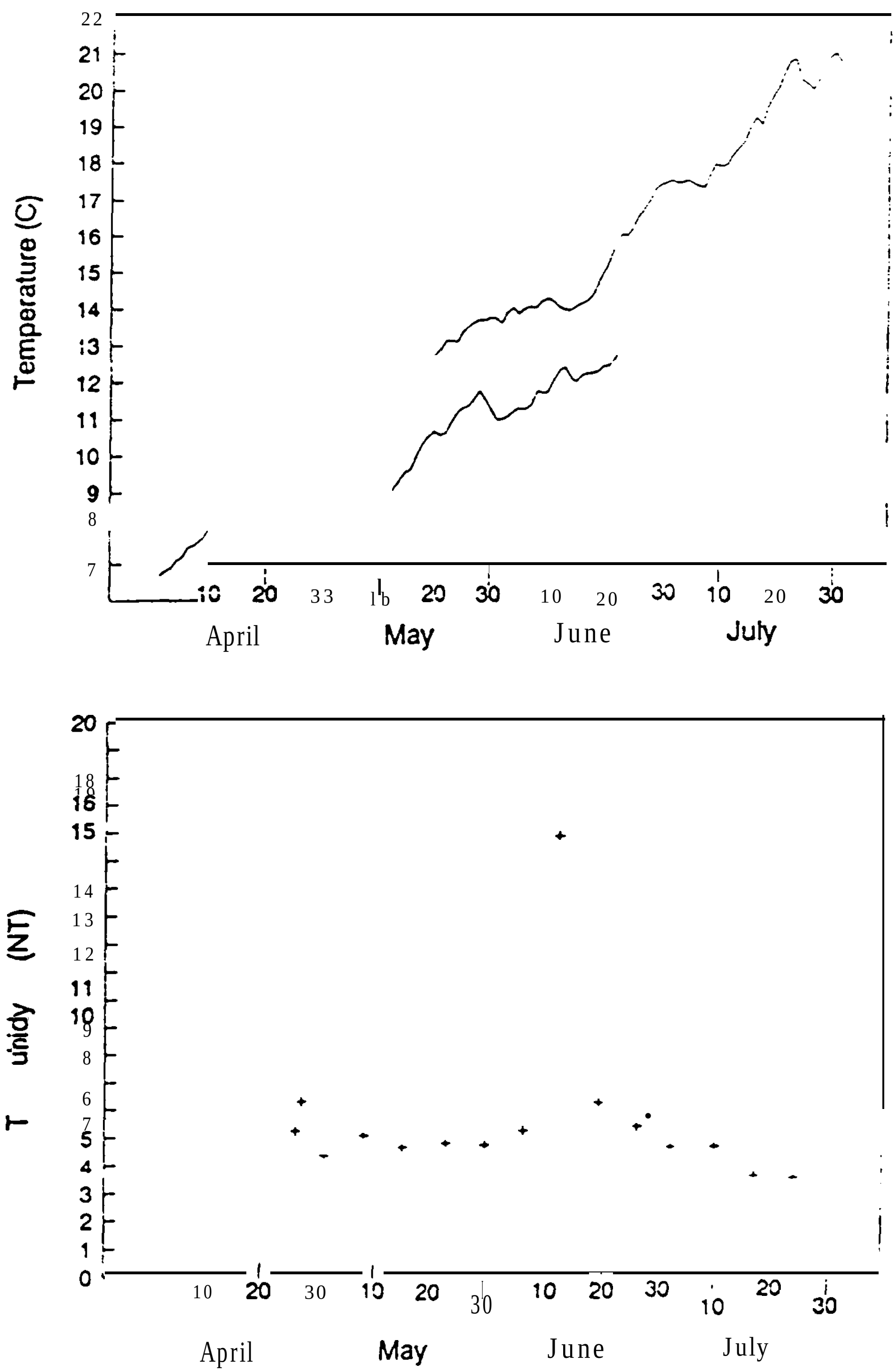

Figure 6. Mean daily water temperature and turbidities from The Dalles Dam tailrace, 1990.

Egg Collections

During 1990, 772 white sturgeon eggs were collected in Bonneville Pool between RM 185.0 and RM 191.5 (The Dalles Dam tailrace) from 23 May through 12 July (Table 1). Eggs ranging in development from unfertilized to pre-hatch were collected on 16 sampling days at depths ranging from 4.0 to 24.4 m. Mean water column velocities ranged from 0.67 to 1.58 m/s during collection with D-shaped larval nets from tows which collected eggs. Back-calculated ages of eggs indicated that spawning occurred on at least 31 days from 23 May through 7 July. Adhesive eggs were found on 8 sampling dates between 31 May and 27 June indicating that spawning occurred within three hours prior to collection. Mean daily water temperatures during this period ranged from 13 to 17°C. Non-viable (dead or fungused) eggs comprised 21% (163 of 768) of all eggs collected in Bonneville Pool in 1990.

Larval Collections

Two hundred twenty-one white sturgeon larvae were collected between RM 180.5 and RM 191.4 from 30 May through 12 July (Table 1). Developmental stages ranged from post-hatch (<1 day post-hatch, as defined by Beer 1981) to approximately 10 days post-hatch (48% were 1 day post-hatch). Total lengths ranged from 9 to 24 mm (mean 14 mm). Larvae were collected on the bottom at depths from 6 to 38 m with 99% collected at depths of 6 to 24 m. Mean water column velocities ranged from 0.70 to 1.51 m/s and bottom velocities ranged from 0.37 to 1.10 m/s during collections with D-shaped larval nets from tows which collected larvae.

Young-of-the-Year Collections

This -was the second consecutive year YOY white sturgeon were captured *in* Bonneville Pool. Eighty-five YOY white sturgeon ranging from 25 mm TL on 11 July to 233 mm TL on 25 September (Table 2) were collected from RM 150 to RM 183; catches were dispersed throughout the pool. All fish appeared healthy and active after capture. Beam trawl tows were effective for collecting YOY white sturgeon ranging from 25 to 96 mm TL and high-rise trawl tows were effective for collecting fish from 69 to 233 mm TL.

Young-of-the-year white sturgeon were collected only from the deeper areas of Bonneville Pool. All YOY white sturgeon were collected at depths ranging from 19.5 to 47.2 m. Efforts with the high-rise and beam trawls occurred at depths of 1.2 to 48.8 m. ***Most*** YOY white sturgeon were captured over smooth substrates (sand, mud, and gravel), however, efforts to collect these fish were concentrated over these substrates. No trawl efforts were conducted over boulder or bedrock substrates.

The weight-length relation for 83 YOY white sturgeon was described by the equation $\log W = -4.805 + \log TL(2.759)$ ($r^2 = 0.995$). Mean condition factor was 0.53 (Sd = 0.09; n = 83).

Table 1. Number and catch per unit effort of white sturgeon eggs and larvae collected with the D-shaped larval net and beam trawl in Bonneville Pool between RM 180.5 and 191.5 from 23 May through 12 July, 1990.

	Eggs			Larvae
Gear	Viable	Dead	Total	Total
D-shaped larval net				
Number	67	19	86	40
Catch/1000 m^3	1.97	0.56	2.53	0.27
Catch/15 min	0.40	0.11	0.51	1.68
Beam trawl				
Number	538	148	686	181
Catch/l5 min	5.14	1.41	6.55	2.35
Combined gears				
Total number	605	167	772	221

Table 2. Length frequency of YOY white sturgeon collected in Bonneville Pool during 1990 (N = 83)[1].

Total Length (mm)	Month			
	Jul	Aug	Sep	Total
25-30	2			2
31-40	4			4
41-50	3	1		4
51-60	3	1		4
61-70	5	3		8
. 71-80	5	4		9
81-90	3	2		5
91-100		4		4
101-110		8		8
111-120		4		4
121-130		5		5
131-140		2	1	3
141-150		2	3	5
151-160		1	4	5
161-170		1	1	2
171-180		1		1
181-190			1	1
191-200			2	2
201-210			3	3
211-220			2	2
221-230			1	1
231-240			1	1
Totals	25	39	19	83

[1] Excludes two YOY white sturgeon captured in Bonneville Pool that were measured only by fork length.

Ages were estimated from pectoral fin rays from ten of the largest of the 83 YOY white sturgeon sampled. All were estimated to be age 0 so it was assumed that all smaller fish in the sample were also YOY.

Juvenile Collections

Two hundred fifty-nine juvenile white sturgeon (age I and older) were captured in Bonneville Pool during 1990; 255 with the high-rise trawl and four with the beam trawl. Fork lengths ranged from 278 to 920 mm (Table 3). Monel bands were applied to 242 white sturgeon. Four (1.7%) were recaptured, three had been tagged in 1989 and one in 1988 (Table 4). The nematode parasite Cvstoossis acipenser was observed on one (0.3%) white sturgeon captured: the infected fish was 372 mm FL.

Catches of juvenile white sturgeon in the high-rise trawl at each of the 22 routinely sampled locations in Bonneville Pool varied markedly, indicating patchy distribution both spatially and temporally (Appendix C-2). Catches at two locations (RM 179.1 and RM 183.5) accounted for 42% of the total catch: two or less (< 1%) white sturgeon were collected at eight trawl locations. Catches were highest during June and lowest during July. Catches were highest in the upper one-third of the pool (Table 5); 72% of the juvenile white sturgeon were caught in the upper one-third of the pool, 16% from the middle one-third, and 11% from the lower one-third.

Juvenile white sturgeon were collected only from the deeper areas of Bonneville Pool. Collection depths ranged from 9.1 to 48.8 m. Efforts with the high-rise and beam trawls occurred at depths of 1.2 to 48.8 m. Most juvenile white sturgeon were captured over smooth substrates (sand, mud, and gravel). However, efforts to collect these fish were concentrated over these substrates and no trawling was conducted over boulder or bedrock substrates. Six juveniles were captured over a cobble and gravel substrate.

A weight-length relation was calculated from a sample of 247 juvenile white sturgeon (278-770 mm FL) collected in Bonneville Pool from April through September, 1990. The weight-length relation was described by the equation log W = - 4.964 log FL (2.925) (r^2 = .926). The mean condition factor of those juvenile white sturgeon was 0.69 (Sd = .09).

Ages were estimated for 110 juvenile white sturgeon collected from April through July, 1990. Ages ranged from I to XII years (Table 6). Annual relative (h) and instantaneous (G) growth rates are presented in Table 7.

Other Species

Sixteen fish species other than white sturgeon were identified from catches in Bonneville Pool in 1990. Numbers of American shad caught were greater than for any other species, followed by prickly sculpin (Table 8).

Table 3. Length frequencies of juvenile white sturgeon collected in Bonneville Pool during 1990 (N = 257)[1].

Fork length (mm)	Month: Apr	May	Jun	Jul	Aug	Sep	Total
271-280	1						1
281-290		1					1
291-300							0
301-310	1						1
311-320	1						1
321-330	1				1		2
331-340			1		1		2
341-350					1		1
351-360		2					2
361-370							0
371-380		2				1	3
381-390	1	1	1	1	1		5
391-400	1	1	2				4
401-410	1	1	3	2	1		8
411-420	2	2	1		4	2	11
421-430	2	2	6			3	13
431-440	1	1	1		2	4	9
441-450	2	3	2	1	2	2	12
451-460	3		1	1	2	3	10
461-470		2	3		6	2	13
471-480	3	4	7	3	3	2	22
481-490	1	1	2		3	2	9
491-500	7	1	2		2	1	13
501-510	2	3	3	1	3	1	13
511-520	2	2	2	2	3	1	12
521-530	2		1				3
531-540	2				2		4
541-550	1	3	2	1			7
551-560		1	2		2	2	7
561-570		2	2	1	1		6
571-580		1	2		2	1	6
581-590		1		1	1		3
591-600		1				1	2
> 601	7	7	10	4	12	11	51
Totals	44	45	56	18	55	39	257

[1] Two juvenile white sturgeon captured in Bonneville Pool were not measured.

Table 4. White sturgeon recaptured from Bonneville Pool in 1990[1].

Location (RM) Tagged	Recaptured	Days at Large	Change in Fork Length (mm)	Change in Weight (g)
190.0	190.0	299	5	-170
183.5	183.5	444	13	-40
183.5	183.5	206	-1	-10

[1] Excludes one recaptured white sturgeon that had shed its tag.

Table 5. Number, catch per 15 minutes (CPT), catch per hectare (CPHA) and overall catch per unit of effort (CPUE) by month of juvenile white sturgeon captured with the high-rise trawl in the lower (RM 149-163), middle (RM 163-178), and upper (RM 178-191.5) reaches of Bonneville Pool.

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE All Months
Lower								
Number	5	4	2	5	12	1	29	
CPT	0.54	0.46	0.21	0.55	1.29	0.11		0.53
CPHA	1.46	1.17	0.56	1.31	3.00	0.26		1.32
Middle								
Number	8	9	6	4	6	9	42	
CPT	0.71	0.67	0.56	0.50	0.60	0.82		0.65
CPHA	1.94	1.71	i.57	i.32	i.57	2.08		1.72
Upper								
Number	31	32	48	9	35	29	184	
CPT	3.32	2.29	5.54	2.08	3.75	3.25		3.37
CPHA	8.31	6.81	14.99	5.48	10.20	9.03		9.24
All Locations								
Number	44	45	56	18	53	39	255	
CPT	1.47	1.25	1.95	0.84	1.85	1.33		1.46
CPHA	3.90	3.37	5.29	2.12	4.71	3.44		3.84

Table 6. Mean and range in fork length for white sturgeon ages I-XII captured with trawls from Bonneville Pool (N = 110) in 1990.

Age	Mean fork length	Range	N
I	313	278-355	7
II	394	360-426	6
III	431	385-468	13
IV	477	378-616	26
V	499	401-661	28
VI	548	444-710	13
VII	594	534-707	4
VIII	670	667-672	2
IX	664		
X	615	548-689	3
XI	623	506-698	3
XII	693	693-693	1

Table 7. Relative (h) and instantaneous (G) growth rates (Ricker 1975) for white sturgeon ages I - VIII captured with trawls from Bonneville Pool in 1990.

Age	Mean FL	Predicted Weight	h	G
I	313	217		
II	394	424	79	.582
III	431	552	31	.264
IV	477	742	34	.296
V	499	847	14	.132
VI	548	1114	32	.274
VII	594	1410	27	.236
VIII	670	2006	42	.353

Table 8. Number and catch per unit effort (CPT = catch/15 min; CPHA = catch/hectare) of fishes other than white sturgeon, collected with the high-rise trawl, beam trawl and D-shaped larval nets in Bonneville Pool from April through September 1990.

	High-rise trawl			Beam trawl		D-shaped larval net			
Species	No.	CPT	CPHA	No.	CPT	No.	CPT	C/1000m^3	Total
Pacific lamprey	1	<0.01	0.02	1	<0.01	1	<0.01	0.02	3
American shad	1237	0.50	18.7	22	<0.01	1	<0.01	0.02	1260
Chinook salmon	a57	0.10	3.90	4	<0.01	0			261
Sockeye salmon	1	<0.01	0.02	0		0			1
Common carp	1	<0.01	0.02	0		0			1
Peamouth	478	0.20	7.21	0		0			478
Northern squawfish	71	0.03,	1.07	0		0			71
Redside shiner	32	0.01	0.48	0		0			32
Mountain whitefish	1	<0.01	0.02	0		0			1
Largescale sucker	33	0.01	0.50	0		0			33
Bridgelip sucker	4	<0.01	0.06	0		0			4
Sand roller	65	0.02	1.00	0		0			65
Smallmouth bass	9	<0.01	0.12	0		0			9
Walleye	19	<0.01	0.30	0		0			19
Threespine stickleback	1	<0.01	0.02	0		0			1
Prickly sculpin	556	0.21	8.40	96	0.04	36	<0.01	0.64	688
UID[a] cyprinid	1	<0.01	0.02	84	0.03	0			85
UID sucker	4	<0.01	0.06	129	0.05	18	<0.01	0.32	151
UID fish	0			4	<0.01	0			4
Total	2,771			340		56			3,167

[a] UID = unidentified spp.

The Dalles Pool

Environmental Conditions

Hourly discharge of water through John Day Dam ranged from 2.04 to 10.84 kcms (72 to 382.9 kcfs) during April through July (Figure 7). Wide daily fluctuations occurred during April and May. On 29 May, a fire in the control room at John Day Dam required a shutdown of the turbines, and all discharge was then routed through the spill gates through 31 May. Wide fluctuations in hourly discharge were not common from 29 May through 20 June.

Water temperatures in the John Day Dam tailrace during April through July ranged from 7.0°C on April 1 to 20.8°C on 22 July (Figure 8). Water temperatures considered optimal for white sturgeon spawning occurred from 10 to 27 June. Mean daily turbidities ranged from 3.4 to 13.2 NTU (Figure 8).

Egg Collections

During 1990, 310 white sturgeon eggs were collected from the John Day Dam tailrace between RM 213 and RM 215 from 4 June through 10 July (Table 9); eggs from 17 of the 19 developmental stages (Beer 1981) were collected on 12 sampling days at depths of 5.8 to 16.8 m. Samples from four sites accounted for 79% (265 of 337) of all eggs collected. Mean water column velocities. ranged from 1.34 to 1.92 m/s during collections with D-shaped larval nets from tows which collected eggs. Back-calculated ages of eggs indicated that spawning occurred on at least 19 days from 4 June through 2 July. Adhesive eggs, evidence of spawning within three hours of collection, were found on four sampling dates between 5 June and 3 July when water temperatures ranged from 13 to 14°C. Water temperatures ranged from'13 to 16°C when viable eggs were collected, and from 13 to 17°C during non-viable egg collections. Non-viable (dead or fungused) eggs comprised 57% (192 of 337) of all eggs collected in The Dalles Pool in 1990.

Larval Collections

Sixty-six white sturgeon larvae were collected between RM 210 and 215 from 12 June through 3 July (Table 9). Developmental stages of collected larvae ranged from post-hatch to approximately 8 days post-hatch (67% were 1 day post-hatch): total length ranged from 11 to 17 mm (mean 13 mm). Larvae were collected at depths of 5.8 to 16.4 m, with 55% collected at depths from 5.8 to 6.4 m. During 1990, larval collection from channels on the Washington and Oregon sides of the unnamed island at RM 214.5 produced similar results (27 and 20 larvae) while during 1989 only three of 18 larvae were collected in the channel on the Oregon side, though effort was nearly identical (Duke et al. 1990). Mean water column velocity ranged from 1.12 to 1.92

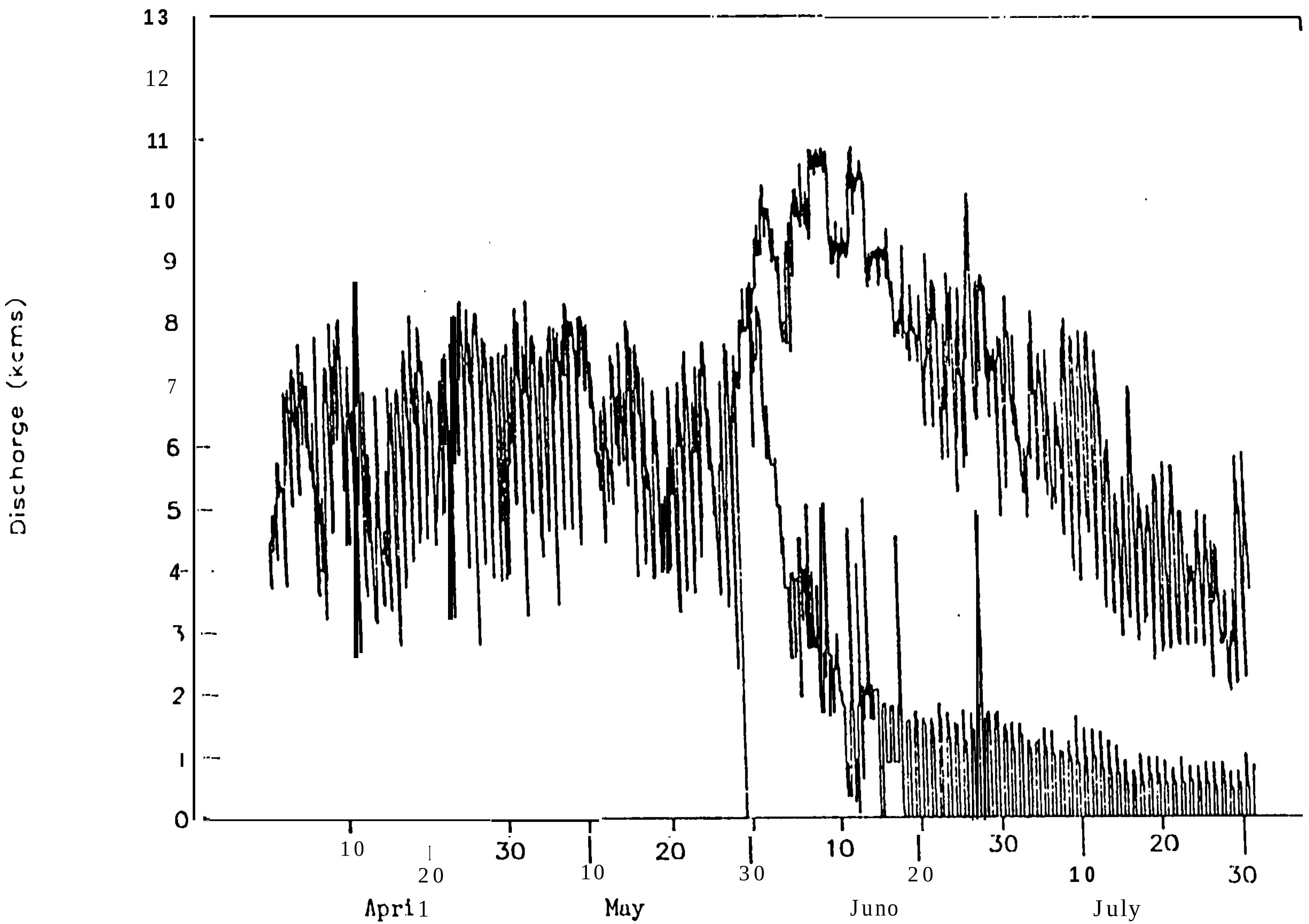

Figure 7. Hourly discharge through John Day Dam, April through July, 1990. The upper line indicates total discharge, the lower line indicates spill discharge.

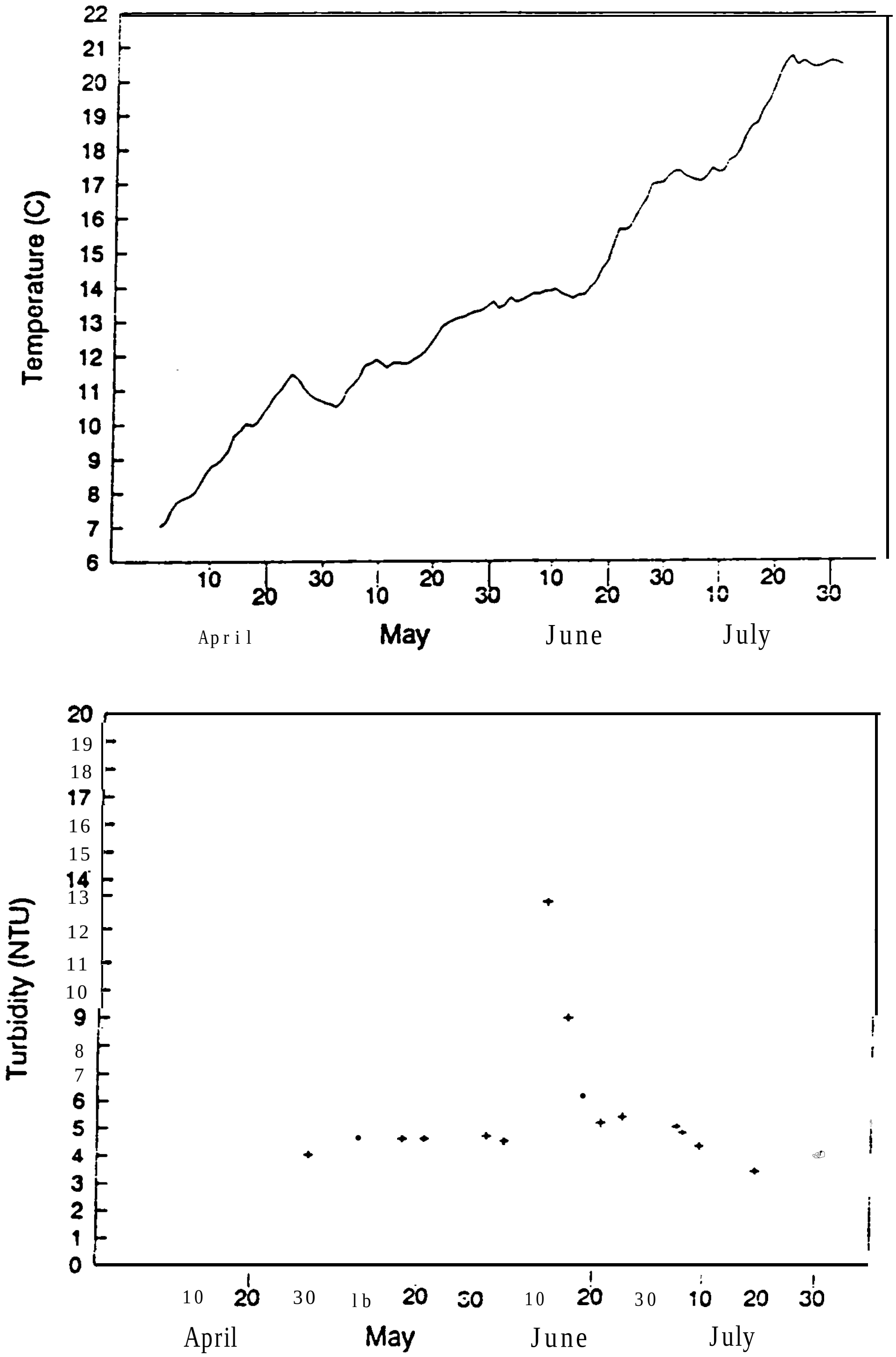

Figure 8. Mean daily water temperatures and turbidities from the John Day Dam tailrace, 1990.

Table 9. Number and catch per unit effort of white sturgeon eggs and larvae collected with the D-shaped larval net and beam trawl in The Dalles Pool from RM 210 to RM 215 from 4 June through 10 July, 1990.

Gear	Eggs			Larvae
	Viable	Dead	Total	Total
<u>D-shaped larval nets</u>				
Number	24	18	42	26
Catch/1000 m^3	0.85	0.64	1.49	0.74
Catch/15 min	0.29	0.21	0.5	0.22
<u>Beam trawl</u>				
Number	121	147	268	40
Catch/15 min	2.63	3.20	5.83	1.11
<u>Combined sear</u>				
Total	145	165	310	66

m/s and bottom velocity ranged from 0.67 to 1.28 m/s during collection with D-shaped nets from tows which collected larvae.

Young-of-the-Year Collections

In 1990 YOY white sturgeon were captured in The Dalles Pool for the first time during the study. Five YOY white sturgeon ranging in TL from 87 mm on 3 August to 262 mm on 31 October were collected (mean 180 mm), from RM 199 to 213. All fish appeared healthy and active after capture.

Young-of-the-year white sturgeon were collected from the deeper areas of The Dalles Pool; the five YOY were collected at depths of 18.3 to 46.9 m. Efforts with the high-rise and beam trawls ranged from 2.7 to 46.9 m. Four of the five YOY white sturgeon collected in The Dalles Pool were captured over a mud/soft clay substrate; the other fish was captured over a rubble substrate. No trawl effort occurred over boulder or bedrock substrates.

Juvenile Collections

Thirteen juvenile white sturgeon were captured in The Dalles Pool during 1990; twelve with the high-rise trawl and one with the beam trawl. One white sturgeon from The Dalles Pool was aged (IV) and fork lengths of the other juveniies ranged from 445 to 703 mm (Table 10), indicating that age I and II fish (1989 and 1988 year classes) probably were not captured. Monel bands were applied to all 12 white sturgeon captured. The nematode parasite *Cystoopsis acipenser* was not observed on any white sturgeon captured in The Dalles Pool.

Distribution information is limited in The Dalles Pool due to small sample size. Six white sturgeon were captured in the upper one-third of the pool, none in the middle one-third, and six in the lower one-third (Table 11). Catches at RM 199 accounted for 42% of the total catch. In 1989 this location accounted for 16% of the total catch. Catch per time and area was highest during August and lowest in April (Appendix C-3).

Juvenile white sturgeon were collected from the deeper areas of The Dalles Pool. The thirteen juveniles were captured at depths of 9.4 to 33.5 m. Effort with the high-rise and beam trawls ranged from 2.7 to 46.9 m. Juvenile white sturgeon were collected over mud, gravel/mud, gravel/sand, cobble, cobble/silt, and cobble/gravel substrates. No trawl efforts occurred over boulder or bedrock substrates.

A weight-length relation was calculated from all 13 juvenile white sturgeon collected in The Dalles Pool; the fish ranged from 445 to 703 mm FL. The relation was described by the equation log W = - 5.512 log FL(3.131) (r^2 = .983). Mean condition factor was 0.70 (Sd 0.04).

Age was estimated for only one juvenile white sturgeon collected in The Dalles Pool in April, 1990. The fish was 555 mm FL and age was estimated at IV years. Estimates of annual

Table 10. Length frequencies of juvenile white sturgeon collected in The Dalles Pool during 1990 (N = 13).

Fork length (mm)	Apr	May	Jun	Jul	Aug	Sep	Total
	Month						
441-450					1		1
451-460							
461-470					2	1	3
471-480							
481-490							
491-500							
501-510							
511-520							
521-530							
531-540						1	1
541-550			1				1
551-560	1					1	2
561-570							
571-580					1		1
581-590							
591-600					2		2
> 601					1	1	2
Total	1		1		7	4	13

Table 11. Number, catch per 15 minutes (CPT), catch per hectare (CPHA) and overall catch per unit effort (CPUE) by month of white sturgeon captured with the high-rise trawl the lower (RM 191.5-200), middle (RM 200-208), and upper (RM 208-215.6) reaches of The Dalles Pool. No sampling occurred during May, June, or July.

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE All Months
Lower								
Number	1				4	1	6	
CPT	0.75	-	-	-	1.50	0.38		0.59
CPA	1.71	-	-	-	3.41	0.78		1.35
Middle								
Number	0				0	0	0	
CPT	0.0				0.0	0.0		0.0
CPHA	0.0				0.0	0.0		0.0
Upper								
Number	0				4	2	6	
CPT	0.0				0.55	0.27		0.32
CPHA	0.0				1.70	0.72		0.92
All Locations								
Number	1				8	3	12	
CPT	0.14	-	-	-	0.60	0.22		0.35
CPHA	0.35	-	-	-	1.69	0.54		0.92

relative growth rates (h) and instantaneous population growth rates (G) were not made due to insufficient sample size.

Other Species

Fifteen fish species other than white sturgeon were identified from catches in The Dalles Pool in 1990. Numbers of American shad caught were greater than for any other species followed by cyprinids (Table 12).

John Day Pool

Environmental Conditions

Hourly discharge of water through McNary Dam ranged from 1.82 to 12.29 kcms (64.2 to 434.3 kcfs) during April through July (Figure 9). The hourly hydrograph shows that the discharge was erratic, with periods of relatively stable discharge often followed or proceeded by short intervals of either (relative) high or low discharge. The highest sustained discharges occurred in June.

Water temperatures in the McNary Dam tailrace ranged from 6.6°C on 1 April, to 20.3°C on 31 July. Water temperatures considered optimal for white sturgeon spawning occurred between 16 June and 9 July (Figure 10). Mean daily turbidities ranged from 3.7 to 9.0 NTU (Figure 10).

Egg Collections

During 1990, 71 white sturgeon eggs were collected in John Day Pool between RM 290.3 and RM 291.6 (McNary Dam tailrace) from 5 June through 3 July (Table 13); eggs-in 16 of the 19 developmental stages (Beer 1981) were collected on 6 days at depths ranging from 5.8 to 10.7 m. Mean water column velocities ranged from 1.46 to 1.68 m/s during collections with D-shaped larval nets from tows which collected eggs. Back-calculated ages of eggs indicated that white sturgeon spawning occurred on at least 10 days from 27 May through 12 June. Adhesive eggs, evidence that spawning occurred within three hours of collection, were found on 5, 7, and 11 June: mean daily water temperature was 13°C on each of these three days. Non-viable (dead or fungused) eggs comprised 14% of all eggs collected in John Day Pool in 1990.

Larval Collections

Eighty white sturgeon larvae were collected in John Day Pool between RM 287.2 and 291.6 from 11 June through 16 July (Table 13); similar sampling in the same area during 1989 collected only 6 larvae (Duke et al. 1990). Seventy-nine of the 80 larvae and

Table 12. Number and catch per unit effort (CPT = catch/15 min; CPHA = catch/hectare) of fishes other than white sturgeon collected with the high-rise trawl, beam trawl and D-shaped larval nets in The Dalles Pool from April through September 1990.

Species	High-rise trawl No.	High-rise trawl CPT	High-rise trawl CPHA	Beam trawl No.	Beam trawl CPT	D-shaped larval net No.	D-shaped larval net CPT	D-shaped larval net $C/1000m^3$	Total
Pacific lamprey	0			3	<0.01	0			3
American shad	6602	11.2	444.03	12	<0.01	3	0.02	0.03	6617
Chinook salmon	3	<0.01	0.20	1	<0.01	0			4
Common carp	10	0.02	0.67	0		0			10
Peamouth	55	0.09	3.70	0		0			55
Northern squawfish	40	0.07	2.69	7	<0.01	0			47
Lagescale sucker	27	0.05	1.82	2	<0.01	0			29
Bridgelip sucker	9	0.02	0.61	0		0			9
Sand roller	25	0.04	1.68	0		0			25
Smallmouth bass	117	0.20	7.87	0		0			117
Walleye	9	0.02	0.61	0		1	<0.01	0.01	10
White crappie	2	<0.01	0.14	0		0			2
Black crappie	18	0.03	1.21	0		0			18
Yellow perch	9	0.02	0.61	0		0			9
Prickly sculpin	37	0.06	2.49	73	0.03	91	0.50	0.91	201
UID[a] cyprinid	0			196	0.08	41	0.22	0.41	237
UID sunfish	3	<0.01	0.20	0		0			3
UID bullhead	0			0		1	<0.01	0.01	1
UID sucker	3	<0.01	0.20	59	0.03	12	0.07	0.12	74
UID fish	0			13	0.01	0			13
Total	6,969			366		149			7,484

[a] UID = unidentified spp.

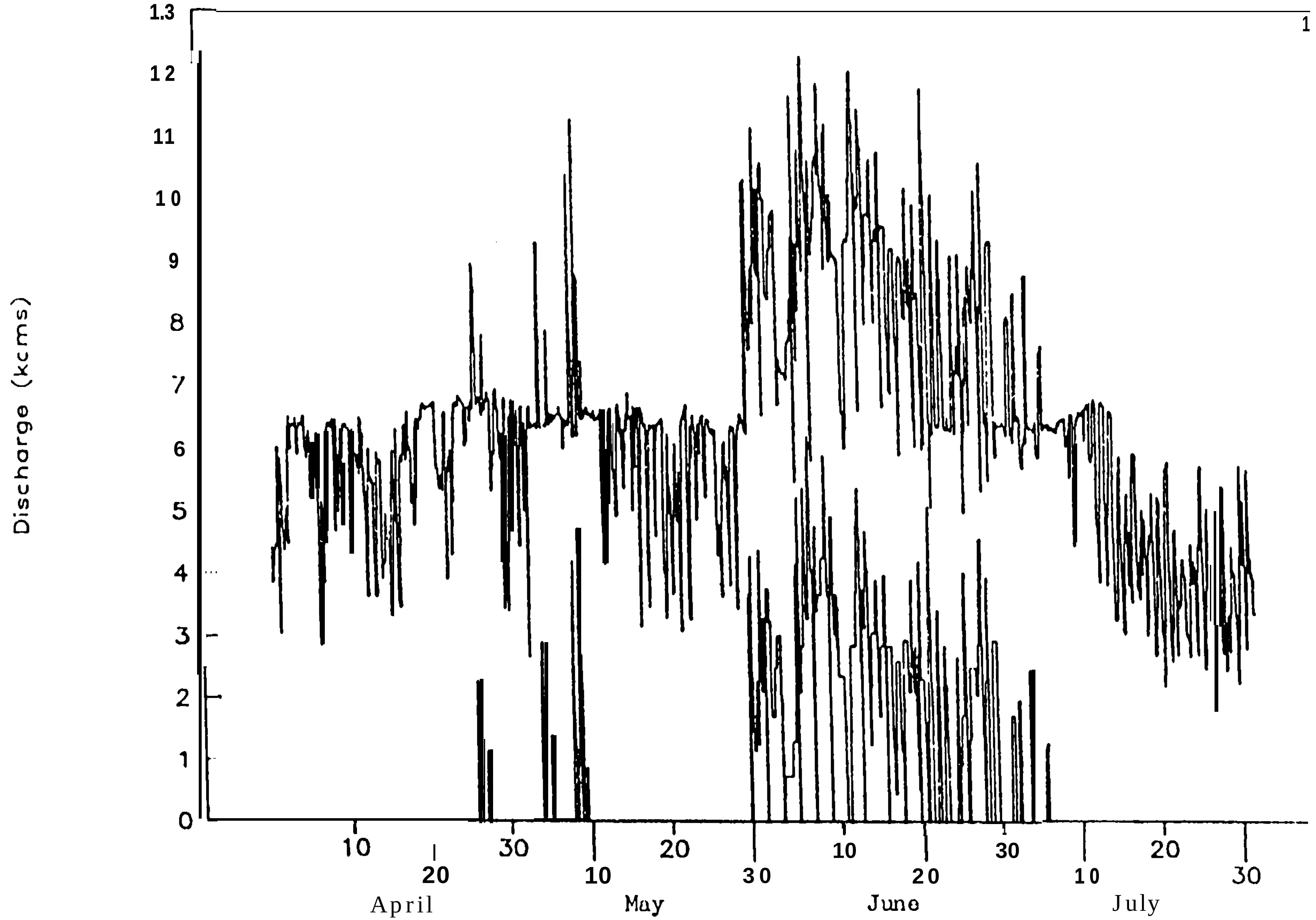

Figure 9. Hourly discharge through McNary Dam, April through July, 1990. The upper line indicates total discharge, the lower line indicates spill discharge.

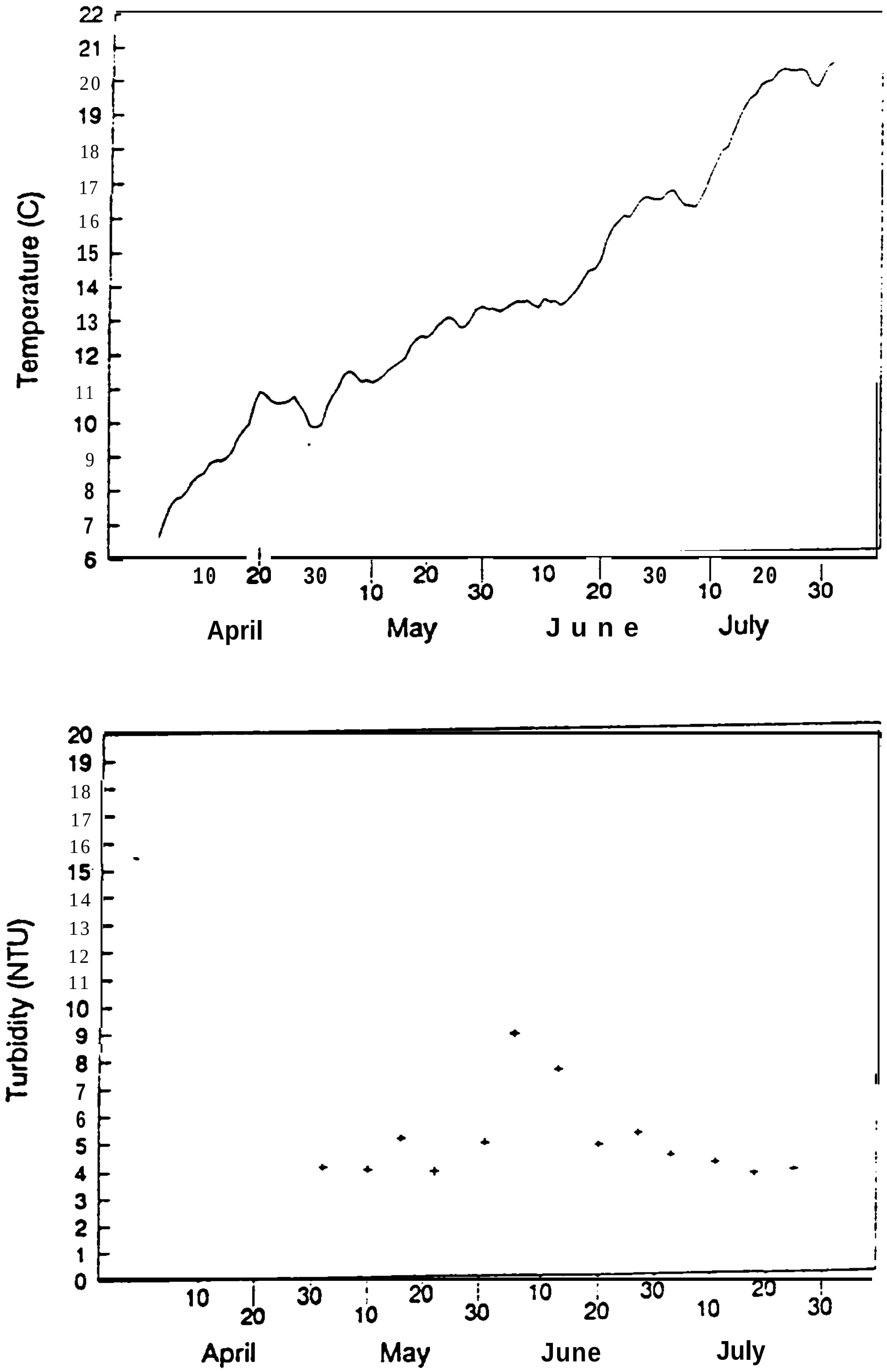

Figure 10. Mean daily water temperatures and turbidities from the McNary Dam tailrace, 1990.

Table 13. Number and catch per unit effort of white sturgeon eggs and larvae collected with the D-shaped larval net and beam trawl in John Day Pool between RM 287.2 and 291.6 from 5 June to 16 July 1990.

	Eggs			Larvae
Gear	Viable	Dead	Total	Total
D-shaped larval net				
Number	21	5	26	48
Catch/1000 m^3	1.11	0.26	1.37	6.80
Catch/15 min	0.27	0.06	0.33	1.85
Beam trawl				
Number	40	5	45	32
Catch/l5 min	1.48	0.19	1.67	0.56
Combined gear				
Total	61	10	71	80

66 of the 71 eggs collected in John Day Pool were captured at sites on the Oregon side of the river within 1.3 miles of McNary Dam. Ninety-seven percent of all eggs were collected within one mile of the dam. Developmental stages of collected larvae ranged from post-hatch to approximately 5 days post-hatch (51% were post-hatch). Total length ranged from 11 to 17 mm (mean 13 mm).

Larvae were collected from the bottom at depths of 6.1 to 11.2 m with 89% collected at depths of 7.6 to 9.1 m. Mean water column velocities ranged from 1.07 to 1.49 m/s and bottom velocities ranged from 0.88 to 1.49 m/s during tows with D-shaped larval nets which collected larvae.

Young-of-the-Year Collections

As in 1989, in 1990 no YOY white sturgeon were collected in John Day Pool, though efforts were nearly identical to those expended in Bonneville and The Dalles pools.

Juvenile Collections

Three juvenile white sturgeon were captured with the high-rise trawl during 1990. One of the fish was aged (VI); fork lengths were 600, 604, and 644 mm, indicating that age I-III fish probably were not captured. One of these white sturgeon was recaptured by ODFW personnel with a setline 1.7 miles downstream from the initial tagging site after 10 months at large. The recaptured fish had increased 11 mm FL but its weight had not changed. Parasites were not observed on any of the white sturgeon captured.

Sample size was insufficient to address juvenile distribution in John Day Pool except that, consistent with 1989, no white sturgeon were captured in the lower twenty miles of the pool (Table 14; Appendix C-4).

The three juvenile white sturgeon captured with the high-rise trawl in John Day Pool were collected at depths ranging from 30.2 to 36.0 m. Efforts with the high-rise trawl occurred at depths of 5.2 to 37.5 m. Two of the juveniles were captured over a mud/soft clay and sand substrate. The other juvenile was captured over a gravel substrate. No trawl effort occurred over boulder or bedrock substrates.

Weight-length relation and condition factors were not calculated due to insufficient sample size. Age for one juvenile white sturgeon collected in John Day Pool in September, 1990 was VI (600 mm FL).

Other Species

Eighteen fish species other than white sturgeon were identified from catches in John Day Pool in 1990. Numbers of american shad caught were greater than for any other species followed by prickly sculpin and sand rollers (Table 15).

Table 14. Number, catch per 15 minutes (CPT), and catch per hectare (CPHA) and overall catch per unit effort (CPUE) by month of white sturgeon captured with the high-rise trawl in the lower (RM 218-244), middle (RM 244-268), and upper (RM 268-293) reaches in John Day Pool. No sampling occurred during May, June, or July

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE All Months
Lower								
Number	0				0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
Middle								
Number	0			-	2	1	3	
CPT	0.0	-	-	-	0.25	0.13		0.15
CPHA	0.0	-	-	-	0.57	0.28		0.33
Upper								
Number	0			-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
All Locations								
Number	0				2	1	3	
CPT	0.0	-	-	-	0.12	0.06		0.07
CPHA	0.0	-	-	-	0.30	0.15		0.16

Table 15. Number and catch per unit effort (CPT = catch/15 min; CPHA = catch/hectare) of fishes other than white sturgeon collected with high-rise trawl, beam trawl and D-shaped larval nets in John Day Pool from April through September 1990.

Species	High-rise trawl			Beam trawl		D-shaped larval net			
	No.	CPT	CPHA	No.	CPT	No.	CPT	$C/1000m^3$	Total
Pacific lamprey	0			5	<0.01	0			5
American shad	16023	24.0	845.0	3	<0.01	7	0.04	0.96	16033
Chinook salmon	9	0.01	0.48	1	<0.01	0			10
Bullhead	3	<0.01	0.16	0		0			3
Common carp	213	0.32	11.24	0		0			213
Goldfish	9	0.01	0.48	0		0			9
Peamouth	5	<0.01	0.26	0		0			5
Chiselmouth	2	<0.01	0.11	0		0			2
Northern squawfish	7	0.01	0.37	0		0			7
Mountain whitefish	1	<0.01	0.05	0		0			1
Largescale sucker	92	0.14	4.68	0		0			92
Bridgelip sucker	1	<0.01	0.05	0		0			1
Channel catfish	3	<0.01	0.16	3	<0.01	0			6
Sand roller	835	1.30	44.08	23	0.01	0			858
Smallmouth bass	81	0.12	4.28	1	<0.01	0			82
Walleye	7	0.01	0.37	1	<0.01	0			8
Pumpkinseed	22	0.03	1.16	0		0			22
UID Sunfish	2	<0.01	0.11	0		0			2
Black crappie	2	<0.01	0.11	0		0			2
UID Crappie	64	0.10	3.39	0		0			64
Yellow perch	18			0		0			18
Prickly sculpin	1532	2.3	80.8	669	0.30	7	0.04	0.96	2208
UID cyprinid	0			11	0.01	10	0.06	0.14	21
UID sucker	73	0.11	3.85	25	0.01	9	0.05	0.12	107
UID fish	0			3	<0.01	2	0.01	0.03	5
Total	19,004			745		35			19.785

[a] UID = unidentified spp.

stomach Contents

Digestive tracts were examined from 67 YOY white sturgeon collected in Bonneville Pool The samples were collected from 11 July to 25 September between RM 150 and 183. Amphipods of the genus Coroohium were the primary food item. They were found in every YOY white sturgeon stomach examined and accounted for 84% of consumed prey by weight (Appendix C-5). Secondary prey items included Neomvsis mercedis (39%), Gammarids (27%), Chironomid larvae (19%), and Cladocera (13%). Nematodes were found in 69% of examined stomachs. The mean fullness index value was 5 (stomach fullness = 51-75%) and the mean digestion index value was 4 (most food items identifiable).

Digestive tracts were examined from five YOY white sturgeon collected in The Dalles Pool. The samples were collected from 3 August to 31 October between RM 199 and 213. The primary food items of YOY white sturgeon collected in The Dalles Pool were also amphipods of the genus Coroohium, found in 4 of 5 sampled stomachs accounting for 97% by weight of prey consumed (Appendix C-6). Other prey were Neomvsis mercedis (40%), Gammarids (40%), Corbicula manilensis (20%), Chironomid larva (20%) and Ephemeroptera (20%). Fullness index values for four of the five YOY sturgeon guts were 4 or 5, with accompanying digestion index values of 4 to 6; the fifth fish had fullness and digestion index values of 2. Other contents observed from YOY white sturgeon stomachs from Bonneville and The Dalles pools included digested material, plant material, various crustacean and insect appendages and sand and gravel.

Habitat Quantification

Impoundment of the Columbia River has increased the surface area and deepened the channel of the river, inundating many rapids and shallow water areas, increasing the amount of deep water habitat and slowing the water velocity. Approximately 40% of the unimpounded river downstream from Bonneville Dam is shallower than 3.66 m (12 ft) and only 27% of that reach is deeper than 9.15 m (30 ft). In contrast, deepwater habitats predominate in the impounded areas (Tables 16 and 17). In Bonneville Pool, about 20% of the pool is shallower than 3.66 m (12 ft) and about 44% of the pool is deeper than 9.14 m (30 ft). In The Dalles Pool, only about 9% of the pool is shallower than 3.66 m (12 ft) and about 57% of the pool is deeper than 9.14 m (30 ft). In the John Day Pool, approximately 25% of the pool is shallower than 4.57 m (15 ft) and about 54% of the pool is deeper than 10.67 m (35 ft).

DISCUSSION

White sturgeon spawning occurred during 1990 in Bonneville, The Dalles, and John Day pools, although numbers of eggs collected and CPUE varied among pools. Eggs were collected only

Table 16. Surface areas of depth classes downstream from Bonneville Dam, in Bonneville Pool and in The Dalles Pool. Areas were determined from NOAA navigation charts by using a geographic information system. Numbers in parenthesis indicate the percent of the total surface area of each area that is occupied by each depth class.

	Area (ha)					
Depth (ft)	Downstream from Bonneville Dam		Bonneville Pool		The Dalles Pool	
0 - 6	11206.0	(23.7)[1]	1036.0	(13.6)	195.1	(5.4)
6 - 12	8282.8	(17.5)	498.6	(6.5)	139.2	(3.8)
12 - 18	6904.8	(14.6)	1010.0	(13.2)	336.1	(9.2)
18 - 30	8099.8	(17.2)	1747.9	(22.9)	896.0	(24.6)
30 - 60	12005.2	(25.4)	2992.2	(39.2)	1484.6	(40.8)
> 60	710.4	(1.5)	346.0	(4.5)	587.2	(16.1)
Total Area	47209.0		7630.7		3638.2	

[1] Does not include 13975.0 ha labeled as shoals on NOAA navigation charts.

Table 17. Surface areas of depth classes in John Day Pool. Areas were determined from NOAA navigation charts by using a geographic information system. Numbers in parenthesis indicate the percent of the total surface area of each area that is occupied by each depth class.

Depth (ft)	Area (ha) John Day Pool	
0 - 5	2499.0	(12.6)
5 - 15	2503.0	(12.7)
15 - 25	2227.7	(11.3)
25 - 35	1935.1	(9.8)
35 - 45	1588.6	(8.0)
45 - 65	2982.1	(15.1)
> 65	6040.4	(30.5)
Total Area	19775.9	

in the upper three miles of each pool. In a pattern seen in 1990 for the third consecutive year, the number of eggs collected in Bonneville Pool was more than twice that of The Dalles or John Day pools (Table 18); efforts were nearly identical for each pool.

River discharges were higher in 1990 than in the three previous years and egg collections and CPUE increased . More than seven times as many eggs were collected in Bonneville Pool in 1990 than in 1989, and more than thirteen times as many eggs were collected in The Dalles Pool in 1990 than in 1989; the number of eggs collected in John Day Pool was nearly identical between these two years (Table 18).

The percentage of eggs collected which were non-viable in 1990 was more than two times higher in The Dalles Pool than in Bonneville Pool and four times higher in The Dalles Pool than in John Day Pool. From 1987 through 1990 percentages of non-viable eggs in The Dalles Pool ranged from 20% to 87% with a mean value of 52% (Table 18).

White sturgeon spawning in Bonneville, The Dalles, and John Day pools from 1987 through 1990 occurred only in tailrace areas characterized by high mean water column velocities (Table 19). McCabe et al. (1989) reported water column velocities of 0.7 m/s to 2.6 m/s in -white sturgeon spawning areas during spawning periods downstream from Bonneville Dam in 1989 (Table 19). We have collected white sturgeon eggs in velocities ranging from 0.5 to 1.92 m/s. However , it should be noted that water velocities where spawning is actually occurring are likely to be higher than those reported here. Our gears are sampling the drift and collecting eggs downstream from where spawning is occurring. For safety reasons and due to the mechanical inability of our vessel to retrieve the D-shaped larval nets from swift water, we do not sample with this gear in areas where the water velocity exceeds 2.44 m/s. During 1990, we measured water velocities in suspected spawning areas that exceeded 3.66 m/s. We must sample downriver or adjacent to these areas.

During 1990 white sturgeon spawning occurred more often in Bonneville Pool than in The Dalles or John Day pools. White sturgeon spawned on at least 31 days in Bonneville Pool between 23 May and 7 July, on at least 20 days in The Dalles Pool between 4 June and 2 July, and on at least 10 days in John Day Pool between 27 May and 12 June.

In 1990, white sturgeon spawning occurred at similar temperatures in Bonneville, The Dalles, and John Day pools. Mean daily water temperatures recorded during the estimated white sturgeon spawning period ranged from 13.0 to 17.7°C in Bonneville Pool, 13.7 to 17.4°C in The Dalles Pool, and 12.9 to 17.9°C in John Day Pool. The range of temperatures for all three pools (12.9 to 17.9°C) was within the range reported for the same locations in 1989 (12.6 to 20.1°C) by Duke et al. (1990). White sturgeon spawning occurred in the Bonneville Dam tailrace at temperatures ranging from 12 to 18°C (McCabe et al. 1989). Kohlhorst (1976) estimated white sturgeon spawning in the Sacramento River to occur at water temperatures of 7.8 to 17.8°C, peak spawning was at 14.4°C. In 1990, as in 1989, more white

Table 18. Number of white sturgeon eggs collected and percentages of non-viable eggs in Bonneville, The Dalles, and John Day pools from 1987 through 1990. Numbers in parenthesis indicate the percent that were non-viable. Dashes indicate years that no sampling occurred.

Year	Bonneville	The Dalles	John Day
1990	772 (21%)	310 (53%)	71 (14%)
1989	104 (35%)	25 (20%)	69 (9%)
i988	156 (10%)	25 (44%)	
1987		132 (87%)	
Total	1,032 (21.1%)	492 (60.2%)	140 (11.4%)

Table 19. Mean water column velocities measured in sturgeon spawning areas during sturgeon egg collection in the Columbia River, 1988 through 1990.

Location	Year	Mean water column velocity (m/s)	Source
Downstream from Bonneville Dam	1990	0.7 - 2.6	McCabe and Hinton 1990
	1989	1.2 - 2.8	McCabe et al. 1989
Bonneville Pool	1990	0.67 - 1.58	This study
	1989	0.50 - 1.51	Duke et al. 1990
	1988	0.52 - 1.71	Parsley et al. 1989
The Dalles Pool	1990	1.34 - 1.92	This study
	1989	1.11 - 1.89	Duke et al. 1990
	1988	0.88 - 1.40	Parsley et al. 1989
John Day Pool	1990	1.46 - 1.68	This study
	1989	0.81 - 1.60	Duke et al. 1990

than downstream from John Day or McNary dams. The numbers of larvae caught were three times higher in 1990 than in 1989 in Bonneville Pool and The Dalles Pools and 13 times higher in John Day Pool between the two years. Larval distribution in Bonneville Pool appeared to be the same during 1990 as in 1989. Larval sturgeon were collected further downstream in The Dalles and John Day pools during 1990 than in 1989. This may be due to the increased water flows during 1990. Downstream dispersal of larval white sturgeon in the Sacramento-San Joaquin Delta was positively related to increasing river flows (Stevens and Miller 1970). Buckley and Kynard (1985) after observing newly hatched shortnose sturgeon (Acipenser brevirostrum), engaging in a series of vertical swimming bouts, suggested that sufficient water velocities are important to the survival of sturgeon larvae, presumably as an adaptation for downriver transport. Similar behavior has been reported for white sturgeon placed in stream tanks (Brannon et al. 1985) and for several other sturgeon species (Soin 1971, Balon 1975).

For the second consecutive year YOY white sturgeon were collected in Bonneville Pool; YOY white sturgeon *were* collected in The Dalles Pool in 1990 for the first time in this study. No YOY white sturgeon *were* captured in John Day Pool. Young-of-the-year were widely dispersed and were collected as far as 41.5 miles downstream from The Dalles Dam and 16.6 miles downstream from John Day Dam. As in 1989, most YOY white sturgeon collected in Bonneville Pool were captured between RM 159.5 and 170.6.

Young-of-the-year white sturgeon were only collected in *the* deeper areas of Bonneville and The Dalles pools. Most YOY white sturgeon were captured over smooth substrates, though trawling effort was concentrated in those areas.

Juvenile white sturgeon CPUE continued in 1990 as in 1988 and 1989, to be abundant in Bonneville Pool. CPUE for The Dalles and John Day pools were 24% and 5% of CPUE for Bonneville Pool. Juvenile white sturgeon CPUE declined 46% in Bonneville Pool from 1989 to 1990 and 76% in both The Dalles and John Day pools from 1989 to 1990. Juvenile white sturgeon catches from The Dalles and John Day pools indicate that little or no recruitment has occurred since 1986 in these pools. As white sturgeon from the 1986 year-class outgrow their vulnerability to high-rise trawling gear, catches decline. Ten age-I white sturgeon were collected in Bonneville Pool during 1990 and none were collected in 1989. Based on FL ranges reported for white sturgeon collected in The Dalles and John Day pools by Duke et al. (1990), age I to age III white sturgeon probably were not collected.

In 1988 and 1989 juvenile white sturgeon densities were highest in the upper one-third and lowest *in* the lower one-third of each pool. However, in 1990 distribution of juvenile white sturgeon appeared to be more random, perhaps due to decreased sample size.

Juvenile white sturgeon were captured only from the deeper areas of Bonneville, The Dalles, and John Day pools. Most juvenile white sturgeon were captured over smooth substrates, though effort was concentrated in those areas.

All fish recaptured in Bonneville Pool were taken at the sites of initial tagging (Table 4). The one white sturgeon recaptured in John Day Pool was taken 1.7 miles downstream from the initial tagging site.

Juvenile white sturgeon through age VIII were larger in Bonneville Pool than white sturgeon of the same age collected downstream from Bonneville Dam due to faster first year growth (Figure 11). Contrary to 1989 results from The Dalles Pool, in 1990 all recaptured tagged white sturgeon from Bonneville and John Day Pools declined or remained unchanged in body weight. Recoveries of several tagged sturgeon downstream from Bonneville Dam during 1988 also revealed weight loss or poor growth (McCabe et al. 1989). White sturgeon collected in Bonneville Pool during 1990 demonstrated considerable variation in size at each age through VII (Table 6). This finding is consistent with white sturgeon growth studies on the lower Columbia River (Hess 1984) and Sacramento-San Joaquin Estuary (Kohlhorst et al. 1980).

Young-of-the-year white sturgeon collected in Bonneville and The Dalles pools fed almost exclusively on amphipods of the genus Corophium. Seventy-one of seventy-two stomachs examined from both pools contained Corophium, accounting for 84% and 97% by weight of the food items for Bonneville and The Dalles pools (Appendix C-5 and C-6j. Other prey items identified from stomachs samples included Neomvsis mercedis, Gammaridae, Chironomid larvae, emphemeroptra, Corbicula, and Cladocera. Most stomachs were 51-75% full and most contents were identifiable. No empty stomachs were found in white sturgeon collected from either pool.

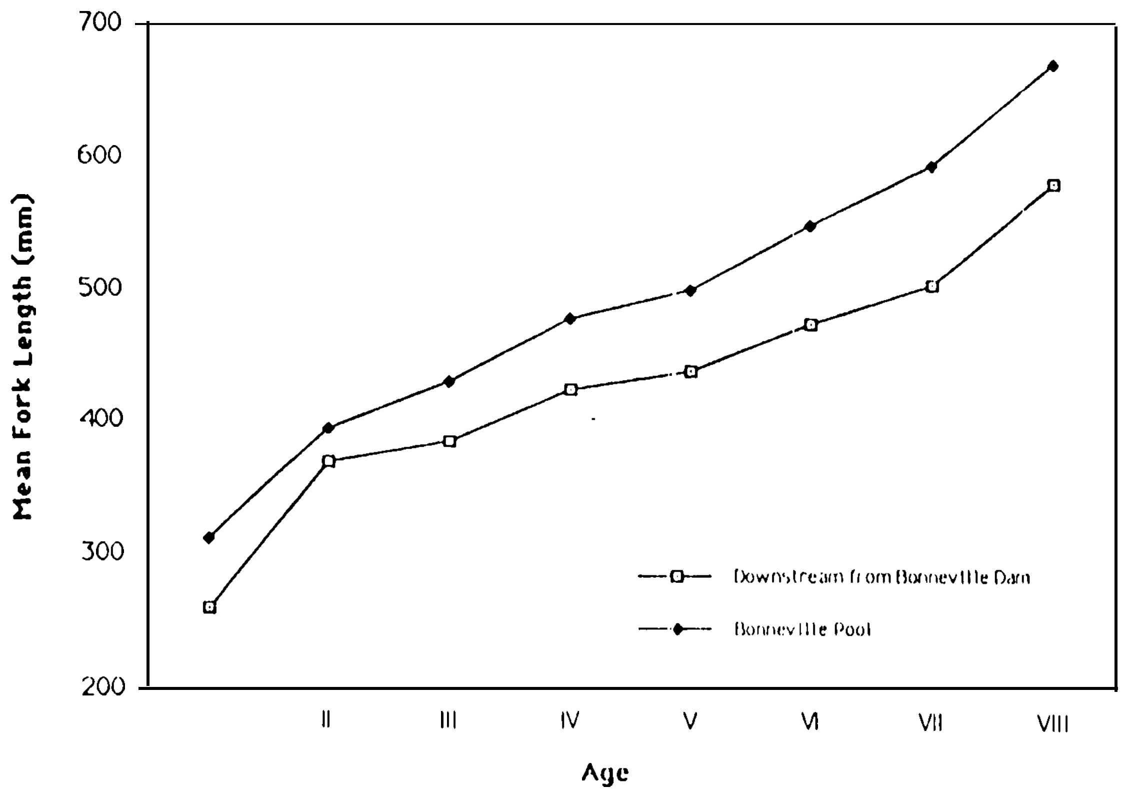

Figure 11. Mean fork length at age for white sturgeon ages I-VIII captured in Bonneville Pool and downstream from Bonneville Dam during 1990. Fork length data from downstream of Bonneville Dam were provided by NMFS. White sturgeon ages from all areas were estimated by FWS.

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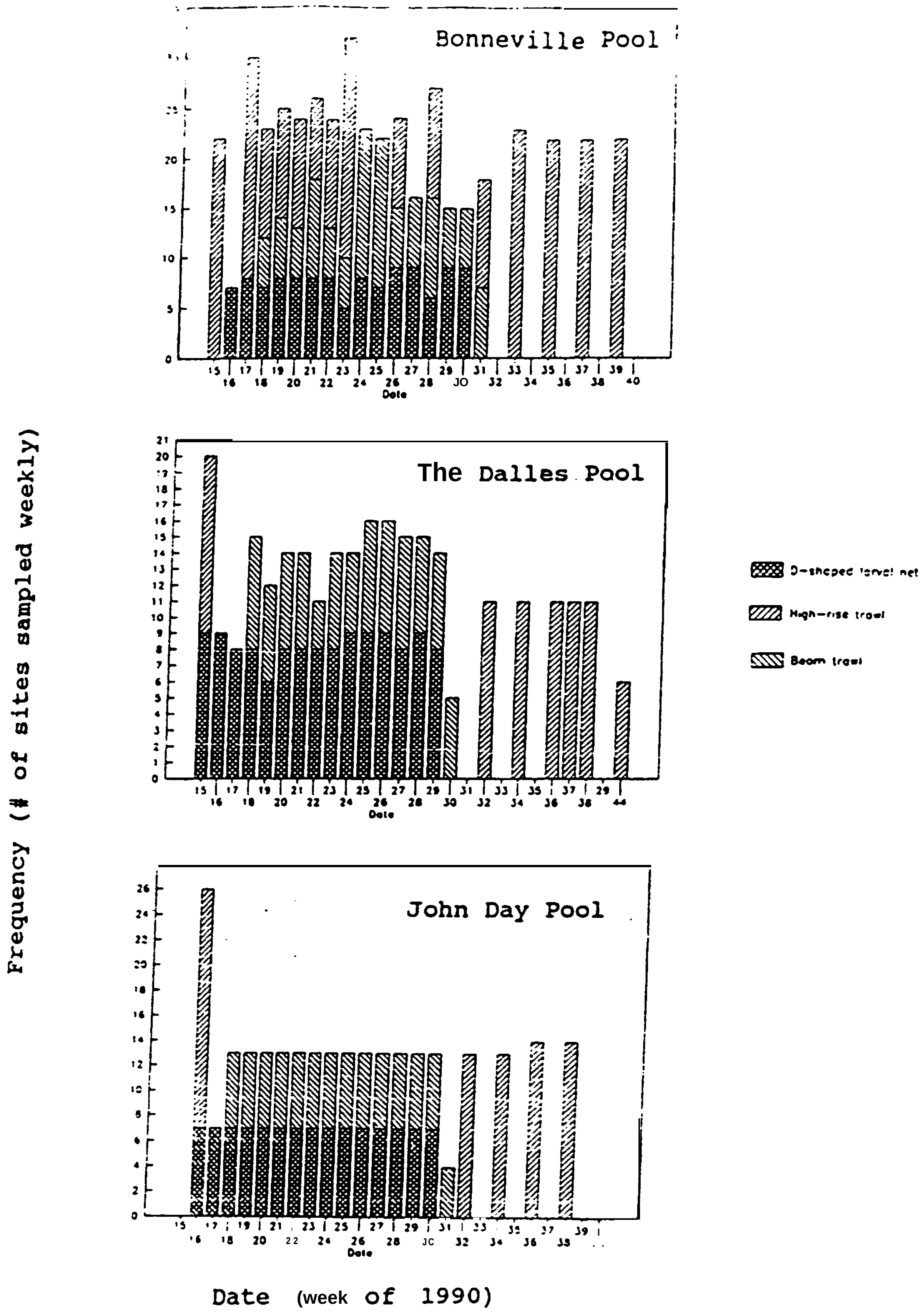

Appendix C-1. Number of sites sampled weekly using D-shaped larval nets, the beam trawl and high-rise trawl in Bonneville, The Dalles, and John Day pools during 1990.

APPENDIX C-2

Number of fish captured, mean monthly catch per 15 minute tow (CPT), mean monthly catch per hectare (CPHA) and overall monthly catch per unit of effort (CPUE) of white sturgeon captured with high-rise trawls at 22 routinely sampled locations in Bonneville Pool during 1990.

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
15052								
Number	0	0	0	1	0	0	1	
CPT	0.0	0.0	0.0	0.75	0.0	0.0		0.13
CPHA	0.0	0.0	0.0	1.92	0.0	0.0		0.32
15053								
Number	0	0	0	0	0	0	0	
CPT	0.0	0.0	0.0	0.0	0.0	0.0		0.0
CPHA	0.0	0.0	0.0	0.0	0.0	0.0		0.0
15242								
Number	0	2	0	0	0	0	2	
CPT	0.0	1.50	0.0	0.0	0.0	0.0		0.25
CPHA	0.0	3.96	0.0	0.0	0.0	0.0		0.64
15502								
Number	0	0	2	0	0	0	2	
CPT	0.0	0.0	1.50	0.0	0.0	0.0		0.25
CPHA	0.0	0.0	3.41	0.0	0.0	0.0		0.57
15734								
Number	2	0	0	2	2	1	7	
CPT	1.50	0.0	0.0	1.50	1.50	0.75		0.95
CPHA	4.63	0.0	0.0	4.02	4.02	1.89		2.69
15951								
Number	1	1	0	0	2	0	4	
CPT	0.75	0.75	0.0	0.0	1.50	0.0		0.50
CPHA	2.23	1.86	0.0	0.0	3.78	0.0		1.26

APPENDIX C-2 (continued)

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
16072								
Number	2	1	0	2	8	0	13	
CPT	1.50	0.75	0.0	1.76	6.00	0.0		1.67
CPHA	3.66	1.89	0.0	5.12	14.03	0.0		4.18
16403								
Number	0	0	0	0	0	0	0	
CPT	0.0	0.0	0.0	0.0	0.0	0.0		0.0
CPHA	0.0	0.0	0.0	0.0	0.0	0.0		0.0
16522								
Number	0	1	0	0	0	0	1	
CPT	0.0	0.75	0.0	0.0	0.0	0.0		0.14
CPHA	0.0	1.78	0.0	0.0	0.0	0.0		0.36
16851								
Number	1	1	1	0	0	0	3	
CPT	0.75	0.75	0.75	0.0	0.0	0.0		0.38
CPHA	2.23	2.31	2.01	0.0	0.0	0.0		1.05
16903								
Number	0	1	0	0	0	0	1	
CPT	0.0	0.75	0.0	0.0	0.0	0.0		0.13
CPHA	0.0	2.23	0.0	0.0	0.0	0.0		0.36
17063								
Number	4	2	1	1	2	8	18	
CPT	2.00	1.00	0.75	1.50	3.00	6.00		2.25
CPHA	4.86	2.38	1.98	3.72	8.18	14.88		5.59
17374								
Number	1	1	3	3	1	0	9	
CPT	0.75	0.50	2.25	4.50	0.75	0.0		1.13
CPHA	2.45	1.31	8.01	11.88	1.83	0.0		3.14

APPENDIX C-2 (continued)

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
17442								
Number	0	2	1	0	0	0	3	
CPT	0.0	1.00	0.75	0.0	0.0	0.0		0.36
CPHA	0.0	2.41	1.95	0.0	0.0	0.0		0.91
17852								
Number	2	1	0	0	3	1	7	
CPT	1.50	0.50	0.0	0.0	2.25	0.75		0.88
CPHA	4.30	1.26	0.0	0.0	5.84	1.92		2.29
17911								
Number	24	9	2	4	4	2	45	
CPT	18.00	4.50	1.50	6.00	3.00	1.50		5.63
CPHA	37.29	10.83	3.84	18.18	7.44	4.09		13.88
18351								
Number	4	1	2	5	25	25	62	
CPT	3.00	0.38	1.50	7.50.	18.75	18.75		7.15
CPHA	9.82	1.21	4.23	20.44	49.46	51.10		21.07
18353								
Number	0	0	1	0	0	0	1	
CPT	0.0	0.0	0.75	0.0	0.0	0.0		0.14
CPHA	0.0	0.0	1.89	0.0	0.0	0.0		0.37
18502								
Number	1	1	2	0	0	0	4	
CPT	0.75	0.50	1.50	0.0	0.0	0.0		0.50
CPHA	1.36	1.31	3.66	0.0	0.0	0.0		1.20
18523								
Number	2	1	3	0	0	0	6	
CPT	1.50	0.50	2.25	0.0	0.0	0.0		0.75
CPHA	4.31	1.38	5.93	0.0	0.0	0.0		2.07

APPENDIX C-2 (continued)

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
18982								
Number	0	3	5	0	0	1	9	
CPT	0.0	1.50	3.75	0.0	0.0	1.67		1.36
CPHA	0.0	5.50	13.05	0.0	0.0	5.34		4.56
19005								
Number	0	4	17	0	0	0	21	
CPT	0.0	3.00	51.00	0.0	0.0	0.0		4.20
CPHA	0.0	11.16	122.7	0.0	0.0	0.0		11.58

APPENDIX C-3

Number of fish captured, mean monthly catch per 15 minute tow (CPT), monthly catch per hectare (CPHA) and overall monthly catch per unit of effort (CPUE) of white sturgeon captured with high-rise trawls at 11 routinely sampled locations in The Dalles Pool during 1990. Dashes indicate months in which no sampling occurred.

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
19433								
Number	0	-	-	-	1	0	1	
CPT	0.0	-	-	-	0.75	0.0		0.30
CPHA	0.0	-	-	-	1.57	0.0		0.61
19901								
Number	1	-	-	-	3	1	5	
CPT	1.50	-	-	-	2.25	0.75		1.50
CPHA	3.72	-	-	-	5.58	1.66		3.55
20124								
Number	0	-	-	-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
20531								
Number	0	-	-	-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
20652								
Number	0	-	-	-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
20904								
Number	0	-	-	-	2	0	2	
CPT	0.0	-	-	-	1.50	0.0		0.60
CPHA	0.0	-	-	-	4.55	0.0		1.74

APPENDIX C-3 (continued)

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
20983								
Number	0				1	0	1	
CPT	0.0	-	-	-	1.50	0.0		0.38
CPHA	0.0	-	-	-	6.14	0.0		1.17
21075								
Number	0			-	0	1	1	
CPT	0.0	-	-	-	0.0	0.75		0.38
CPHA	0.0	-	-	-	0.0	1.64		0.77
21302								
Number	0			-	0	2	2	
CPT	0.0	-	-	-	0.0	1.00		0.50
CPHA	0.0	-	-	-	0.0	2.76		1.64
21402								
Number	0			-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
21501								
Number	0				0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0

APPENDIX C-4

Number of fish captured, mean monthly catch per 15 minute tow (CPT), mean monthly catch per hectare (CPHA) of white sturgeon captured with high-rise trawls at 13 routinely sampled locations in John Day Pool during 1990. Dashes indicate months in which no sampling occurred.

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
24234								
Number	0	-	-	-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
24742								
Number	0	-	-	-	2	0	2	
CPT	0.0	-	-	-	1.67	0.0		0.73
CPHA	0.0	-	-	-	3.41	0.0		1.52
25141								
Number	0	-	-	-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
25255								
Number	0	-	-	-	0	0	0	
CPT	0.0	-	-	-	0.0	0.0		0.0
CPHA	0.0	-	-	-	0.0	0.0		0.0
26272								
Number	0	-	-	-	0	1	1	
CPT	0.0	-	-	-	0.0	0.75		0.30
CPHA	0.0	-	-	-	0.0	1.86		0.73
26751								
Number	0	-	-		0	0	0	
CPT	0.0	-	-		0.0	0.0		0.0
CPHA	0.0	-	-		0.0	0.0		0.0

Location	Apr	May	Jun	Jul	Aug	Sep	Total Number	CPUE
26783								
Number	0	-			0	0	0	
CPT	0.0	-			0.0	0.0		0.0
CPHA	0.0	-			0.0	0.0		0.0
27284								
Number	0	-			0	0	0	
CPT	0.0	-			0.0	0.0		0.0
CPHA	0.0	-			0.0	0.0		0.0
27751								
Number	0	-			0	0	0	
CPT	0.0	-			0.0	0.0		0.0
CPHA	0.0	-			0.0	0.0		0.0
27904								
Number	0				0	0	0	
CPT	0.0				0.0	0.0		0.0
CPHA	0.0				0.0	0.0		0.0
27994								
Number	0				0	0	0	
CPT	0				0.0	0.0		0.0
CPHA	0				0.0	0.0		0.0
28902								
Number	0				0	0	0	
CPT	0.0				0.0	0.0		0.0
CPHA	0.0				0.0	0.0		0.0
29072								
Number	0				0	0	0	
CPT	0.0				0.0	0.0		0.0
CPHA	0.0				0.0	0.0		0.0

APPENDIX C-S

Percent occurrence, range and mean number of items per stomach, percent weight, and relative abundance of food items identified in 67 YOY white sturgeon (35-225 mm TL) collected in Bonneville Pool during 1990.

Food item	Percent occurrence	Number of items/stomach Range	Mean	Percent weight	Relative abundance
Nematoda[1]	69.0	-	-	-	-
Arthropoda					
Crustacea					
Cladocera	13.0	l-2	1.0	0.1	0.3
Mysidacea					
Neomysis mercedis	39.0	1-90	10.0	14.4	6.3
Amphipoda					
Gammaridae	27.0	l-5	1.5	0.8	0.7
Corophium spp.	100.0	l-253	57.0	84.4	92.3
Mollusca					
Corbicula manilensis	3.0	l-2	1.5	co.1	0.1
Insecta					
Chironomidae Larva/pupa	19.0	l-3	1.5	0.2	0.5
Appendicularia	45.0				
Digested matter	21.0				
Sand and gravel	7.0				

[1] Nematodes may have been parasitic instead of ingested food items.

APPENDIX C-6

Percent occurrence, range and mean number of items per stomach, percent weight, and relative abundance of food items identified in 5 YOY white sturgeon (88-252 mm TL) collected in The Dalles Pool during 1990.

Food item	Percent occurrence	Number of items/stomach Range	Mean	Percent weight	Relative abundance
Nematoda[1]	40.0				
Arthropoda					
Mysidacea					
Neomysis mercedis	40.0	1	1	0.2	0.4
Amphipoda					
Gammaridae	40.0	1-10	5.5	1.6	2.1
Corophium spp.	80.0	41-266	130	97.7	96.6
Mollusca					
Corbicula manilensis	20.0	-	3	0.1	0.6
Insecta					
Chironomidae					
Larva	20.0		1	0.1	0.2
Ephemeroptera	20.0		1	0.3	0.2
Appendicularia	80.0				
Digested matter	60.0				
Sand and gravel	20.0				

[1] Nematodes may have been parasitic instead of ingested food items.

APPENDIX C-7

Common and scientific names of fishes collected between Bonneville and McNary dams during 1990.

Common name	Scientific name
Pacific lamprey	Lampetra tridentata
American shad	Alosa sapidissima
Chinook salmon	Oncorhynchus tshawytscha
Mountain whitefish	Prosopium williamsoni
Chiselmouth	Acrocheilus alutaceus
Common carp	Cyprinus carpio
Goldfish	Carassius auratus
Peamouth	Mylocheilus caurinus
Northern squawfish	Ptychocheilus oregonensis
Redside shiner	Richardsonius balteatus
Largescale sucker	Catostomus macrocheilus
Bridgelip sucker	Catostomus columbianus
Threespine stickleback	Gasterosteus aculeatus
Channel catfish	Ictalurus punctatus
Brown bullhead	Ictalurus nebulosus
Sand roller	Percopsis transmontana
Pumpkinseed	Lepomis gibbosus
Sunfishes	Lepomis spp.
Smallmouth bass	Micropterus dolomieui
Crappies	Pomoxis spp.
Yellow perch	Perca flavescens
Walleye	Stizostedion vitreum vitreum
Prickly sculpin	Cottus asper

REPORT 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

ACKNOWLEDGMENTS

Lawrence Davis, Maurice Laird, and Roy Pettit assisted in the field sampling. The Washington Department of Fisheries determined the developmental stages of white sturgeon eggs and larvae and provided summaries of the egg and larval sampling efforts. The U.S. Army Corps of Engineers provided water temperature and water discharge information for Bonneville Dam.

ABSTRACT

During 1990, the National Marine Fisheries Service (NMFS) sampled white sturgeon *Acipenser transmontanus* eggs, larvae, and juveniles in the Columbia River downstream from Bonneville Dam (River Mile (RM) 145). In conjunction with the Washington Department of Fisheries, 2,785 white sturgeon eggs were collected with plankton nets and artificial substrates between RMs 120 and 145; virtually all the eggs were collected within 6 miles of Bonneville Dam. A white sturgeon egg was first collected on 23 April near Ives Island (RM 143), and eggs were last collected on 9 July near Ives Island. The sampling site near Ives Island was used as an index area to monitor white sturgeon spawning throughout the season. Stage 2 (freshly fertilized) eggs were collected on 9 of the 12 days that eggs were collected near Ives Island, indicating that spawning was occurring throughout the spring and early summer. Between 23 April and 25 June, white sturgeon egg densities near Ives Island (in plankton nets) averaged 32.0 eggs/1,000 m^3 of water sampled, with the highest densities on 30 April (119.6 eggs/1,000 m^3) and 14 May (116.0 eggs/1,000 m^3). Based on egg and larval collections, we estimated that white sturgeon spawned on at least 48 days in 1990, beginning on 23 April and ending on 14 July. During the spawning period, Bonneville Dam discharge (mean hourly discharge by day) ranged from 5,040 to 10,505 m^3/s. White sturgeon eggs were collected at bottom-water temperatures ranging from 11 to 19°C, bottom-water turbidities ranging from 1.9 to 7.7 NTU, mean water-column velocities ranging from 0.8 to 2.7 m/s, and water depths ranging from 3.7 to 21.0 m. A total of 190 white sturgeon larvae were collected in plankton nets (n = 152) and a 3.0-m beam trawl (n = 38) between RMs 28 and 144. Larvae were first collected on 7 May at RM 140, and the last larva was collected on 20 July at RM 79. From 23 April to 25 June, densities of larvae near Ives Island averaged 0.8 larvae/1,000 m^3 and ranged from 0.0 to 3.1 larvae/1,000 m^3.

In 1990, a total of 1,409 juvenile white sturgeon were collected with trawls, primarily a 7.9-m (headrope length) semiballoon shrimp trawl, in the Columbia River downstream from Bonneville Dam. Distributions of juvenile sturgeon were patchy; not only were there differences in catches among different areas of the river, but also differences in catches among parallel transects within the same area. The mean density of juvenile white sturgeon was highest at water depths (maximum) $\geq$18.3 m (45 $\pm$ 126 (mean $\pm$ SD) sturgeon/hectare) and lowest at depths <9.1 m (1 $\pm$ 3 sturgeon/hectare). In 1990, a total of 273 young-of-the-year white sturgeon were collected between RMs 28 and 131. Young-of-the-year preferred deeper areas of the river (mean minimum and maximum depths were 12.5 and 21.1 m, respectively).

A total of 829 juvenile white sturgeon were tagged with bird-banding tags in 1990. Five tagged sturgeon were recaptured in NMFS trawls; three of the recaptures had been tagged by NMFS in 1989 and two had been tagged in 1990.

Since the white sturgeon is a demersal species and eats benthic invertebrates, four benthic surveys were conducted at RMs 95 and 131-132 in conjunction with the juvenile sampling to provide information on interannual variability of invertebrate populations. In addition, benthic samples were collected at six newly established shallow-water stations at RMs 95 and 131-132 to determine if densities of benthic invertebrates, particularly *Corophium salmonis* (an important prey for juvenile sturgeon), were high in these areas. Densities of *C. salmonis* in shallow water at RM 95 frequently exceeded 1,200 organisms/m^2, whereas in shallow water at RM 131-132, densities generally did not exceed -76 organisms/m^2.

INTRODUCTION

Under an agreement with the Oregon Department of Fish and Wildlife (ODFW), the National Marine Fisheries Service (NMFS) 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 conducted 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, NMFS and the Washington Department of Fisheries (WDF) are attempting to determine the effect of variable flows at Bonneville Dam on spawning and the early life history of white sturgeon.

Specific research goals for 1990 were 1) to examine the spawning characteristics of white sturgeon in the Columbia River downstream from Bonneville Dam: 2) to determine the distribution of white sturgeon iarvae in the Columbia River downstream from Bonneville Dam; 3) to determine the habitat requirements or preferences of juvenile white sturgeon in the Columbia River downstream from Bonneville Dam; and 4) to begin to quantify the amount of spawning and juvenile rearing habitat available for white sturgeon downstream from Bonneville Dam. This report describes progress on NMFS's studies from March 1990 to March 1991.

METHODS

Egg and Larval Sampling

In 1990, NMFS and WDF cooperatively sampled for white sturgeon eggs and larvae in the Columbia River downstream from Bonneville Dam. Sampling began in April and ended in July; generally, sampling was conducted either biweekly or weekly (during the spawning period). A D-ring plankton net was used to collect white sturgeon eggs and larvae. This net was 0.8 m wide at the bottom of the mouth opening and was constructed of 7.9-mesh/cm nylon marquisette netting (Kreitman 1983). Depending upon the water velocity, two to six lead weights (4.5 or 9.1 kg each) were attached to the net-frame to hold the net on the river bottom. A digital flow meter (General Oceanics Model 2030[1]) was suspended in the mouth of the net to estimate the water volume sampled. Typically, two plankton nets were fished simultaneously for about 30 min from an anchored 12.2-m research vessel. When water velocities were extremely high, only one plankton net was fished, often for an hour.

Artificial substrates constructed of latex-coated animal hair were also used to collect white sturgeon eggs. The substrates were cut into 76 X 91 cm sections and secured to- an angle iron frame with strips of flat bar. The strips were held in place with nuts and bolts, allowing fast removal of the substrate from the frame. Two sections of the artificial substrate were placed back to back in each frame. Because two pieces were used in each frame, it made no difference what side of the frame rested on the river bottom. Two short sections of cable were used to attach the frame to an anchor, which held the substrate and frame in place on the bottom. A buoy line was attached to the anchor to allow retrieval of the substrate, frame, and anchor.

A 3.0-m beam trawl was used in late June, July, and August to collect white sturgeon larvae and juveniles. The beam trawi was identical to the one used by the U.S. Fish and Wildlife Service (FWS) in impoundments upstream from Bonneville Dam (Parsley et al. 1989; Duke et al. 1990). The overall width of

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

the trawl is about 3.0 m and the height is 0.5 m; the estimated fishing width of the net is 2.7 m. A 1.59-mm knotless liner was inserted in the body of the net. The beam trawl was towed slowly along the bottom for time periods ranging from 2 to 15 min.

White sturgeon egg or larval sampling was done at various sites in the lower Columbia River from River Mile (RM) 18 to 145 (Figure 1). The most frequent sampling was done at a site near Ives Island (RM 143), which has been routinely sampled in past years by WDF and NMFS, and is considered an index area for monitoring white sturgeon spawning in the lower Columbia River. On 17 May, NMFS, in conjunction with WDF and ODFW, also sampled with plankton nets in the Willamette River at Oregon City, Oregon.

White sturgeon eggs and larvae were fixed in an approximately 4% buffered formaldehyde solution and transferred to WDF. Egg and larval stages were determined by WDF based on descriptions developed by Beer (1981). The WDF's descriptions for larval stages l-7 correspond to Beer's descriptions for his stages l-day post hatch through 7-day post hatch. We were unable to estimate the number of days required to reach a specific larval stage because water temperatures in the Columbia River were not always comparable to laboratory temperatures in Beer's study. Timing of-egg deposition was estimated using an equation developed by Wang et al. (1985); the water temperature at the time of egg collection was used in the equation.

Juvenile Sampling

A 7.9-m (headrope length) semiballoon shrimp trawl, identical to that used in 1987, 1988, and 1989, was used to collect juvenile white sturgeon. Mesh size in the trawl was 38 mm (stretched measure) in the body; a 10-mm mesh liner was inserted in the cod end of the net. A 4.9-m semiballoon shrimp trawl was used once to sample for juvenile white sturgeon. Mesh size in the body of the 4.9-m trawl was 32 mm; a 10-mm mesh liner was inserted in the cod end of the net. A 3.0-m beam trawl was also used to collect juvenile sturgeon, primarily young-of-the-year (Y-O-Y) (see Egg and Larval Sampling). Shrimp trawl efforts were normally 5 min in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable were let out, and the effort was considered ended when 5 min elapsed. The beam trawl was fished for various lengths of time (2 to 15 min) depending upon water velocity, bathymetry, and bottom substrate. Using a radar range-finder; we estimated the distance the net fished during each sampling effort.

Trawling was conducted from 4 April to 25 October in the lower Columbia River between RMs 18 and 132. In 1990, much more trawling effort was expended in the river between RMs 28 and 75 than in previous years. Trawling was also conducted at established sampling stations upstream from RM 75; however, sampling was not done as frequently at these stations as in 1988 and 1989. At some areas, two or three trawling efforts were completed along parallel transects. Transect 1 was closest to the Washington shore, Transect 2 was the middle transect, and Transect 3 was closest to the Oregon shore. In certain river sections where only two transects were established, Transect 2 was closest to the Oregon shore.

On 31 July and 1 August, 15 trawling efforts (7.9-m trawl) were done from 1155 through 0800 hours at Jones Beach, Oregon (RM 46). The purpose of the sampling was to help describe the migrational characteristics of juvenile chinook salmon (*Oncorhynchus tshawytscha*); however, we also collected data on juvenile sturgeon during the sampling.

Fishes captured in the bottom trawls were identified and counted. Generally, all white sturgeon from a sampling effort were measured (total and fork lengths (mm)) and weighed (g). In instances when a large number of sturgeon was collected in a sampling effort, a subsample of at least 50 sturgeon was measured and weighed. Small Y-O-Y sturgeon do not have a fork in

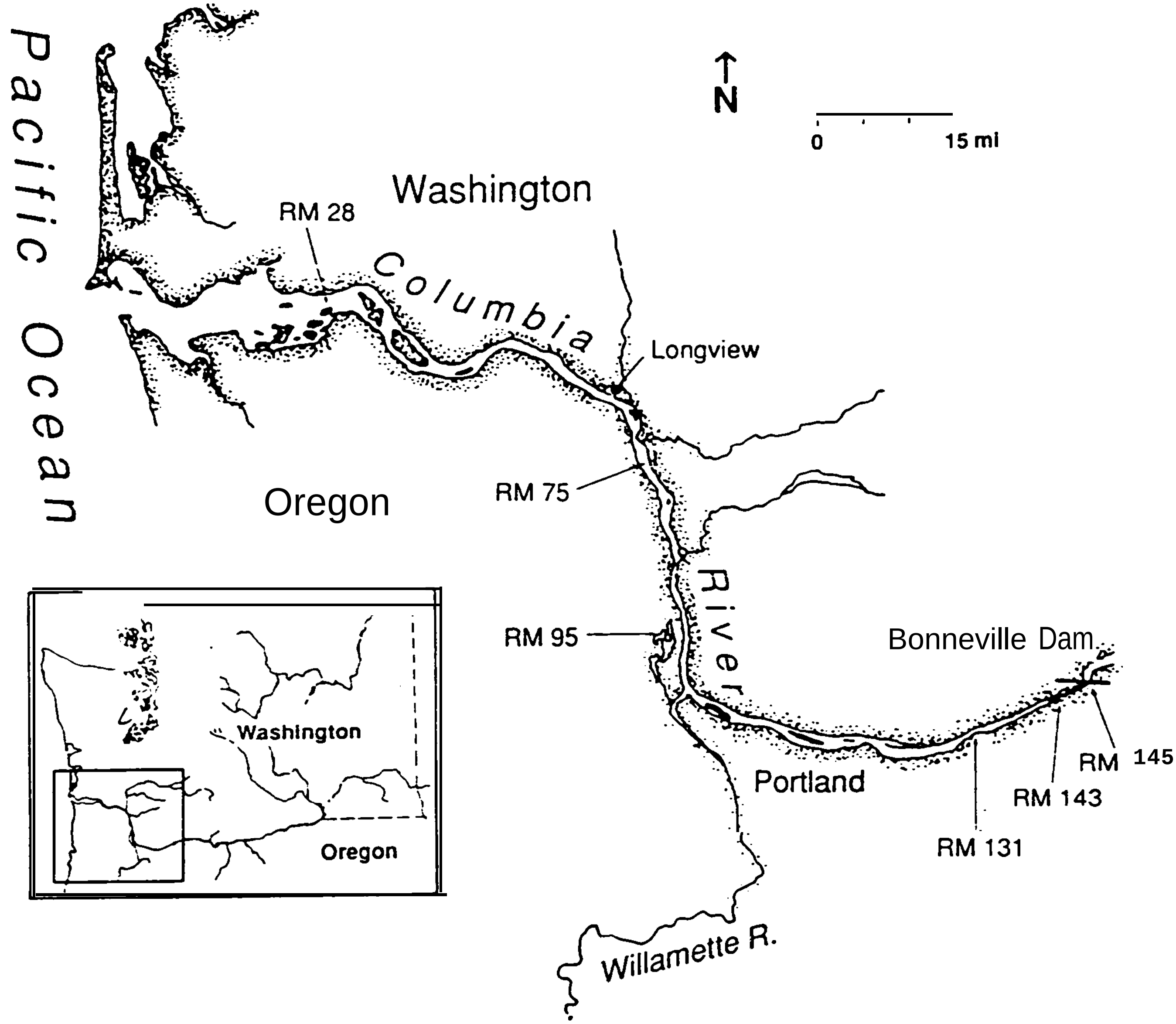

Figure 1. Map of the lower Columbia River.

their tails; therefore we estimated the fork lengths of small Y-O-Y sturgeon (less than 150 mm fork length) to ensure consistency in data analysis. All length comparisons of older juveniles have been done using fork lengths, since natural total lengths are much less reliable. On older juvenile sturgeon (those with a fork in their tails), it was observed that, if an imaginary line is extended along the lateral row of scutes (before it turns upward) onto the caudal fin, the distal end of the imaginary line approximates the location of the fork. White sturgeon were tagged to provide data on movement and growth. A Monel metal bird-banding tag was placed around the anterior ray of the right pectoral fin. Also, we routinely examined juvenile white sturgeon for the nematode parasite *Cystoopsis acipenseri* (Chitwood and McIntosh 1950). When present, the parasite is encased in blister-like cysts under the skin. From April through June, pectoral rays were removed from juvenile white sturgeon and given to FWS for age determinations. A portion of the anterior ray of the left pectoral fin was removed by cutting at or just distal to the fin articulation.

Benthic Sampling

As part of a continuing effort to determine the habitat requirements or preferences of white sturgeon, benthic invertebrate and sediment samples were collected with a 0.1-m^2 Van Veen grab sampler (Word 1976) at or near RMs 95 and 131-132, areas where juvenile sturgeon are seasonally abundant. Benthic surveys were done in these areas in both 1988 and 1989, and the results indicated that densities of *Corophium salmonis*, a very important food for juvenile white sturgeon, were reiativeiy low (generally less than 500/m^2) (McCabe et al. 1989; McCabe and Hinton 1990). Four benthic surveys. were conducted at these two areas in 1990--one each in June, July, August, and September. In each area, benthic samples were collected at two of the same stations sampled in 1988 and 1989 to orovide information on interannual variability. Also, in each area, sampling was done at three newly-established adjacent shallow-water stations. Sampling was done at the new stations to determine if densities of benthic invertebrates, particularly *C. salmonis*, were higher in these adjacent shallow-water areas. If densities of benthic invertebrates are higher in these adjacent areas, they could be important feeding areas for white sturgeon. During each survey, a total of 50 grab samples were collected at 10 sampling stations. In addition to the above sampling, benthic sampling was conducted near Goble, Oregon (RM 75), in August and September. Samples were collected in this area because Y-O-Y white sturgeon were relatively abundant here.

Five benthic invertebrate samples (replicates) and one sediment sample were collected at each sampling station. When practical, each benthic invertebrate sample was sieved through a 0.5-mm screen and the residue preserved in a buffered formaldehyde solution ($\geq$4%) containing rose bengal, an organic stain. If it appeared that most of the material would not wash through the sieve, then the entire sample was preserved and sieved at a later time. Later the samples were washed with water and preserved in a 70-90% alcohol solution to prevent the destruction of calcareous invertebrate parts by formaldehyde. Each benthic invertebrate sample was sorted and the invertebrates were identified to the lowest practical taxonomic level and counted. Sediment samples were analyzed by the U.S. Army Corps of Engineers (North Pacific Division Materials Laboratory, Troutdale, Oregon) for sediment grain size and percent total organic carbon.

Physical Conditions

Selected physical parameters, in addition to the sediment structure, were measured in conjunction with the biological sampling--depth (m) (minimum and maximum); bottom-water temperature (°C); bottom-water turbidity (NTU); and water velocities at 0.2 of the total depth, 0.8 of the total depth, and about 0.6 m above the bottom. By averaging the water velocities measured at 0.2 and

0.8 of the total depth, we calculated a mean water-column velocity. Water velocities were routinely measured only during egg and larval sampling. Depth was measured with electronic depth sounders, and velocity was measured with a Gurley current meter attached to a 45.4-kg lead fish. Turbidity was determined in the laboratory using a Hach Model 2100A Turbidimeter.

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--FWS, ODFW, NMFS, and WDF. Selected 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. The fish densities (by species) for each effort were calculated and expressed as number/hectare (ha) (10,000 m^2). The estimated effective fishing widths of the 3.0-m beam trawl and the 7.9-m semiballoon shrimp trawl were 2.7 and 5.3 m, respectively.

For data analysis, Y-O-Y white sturgeon were separated from older juvenile sturgeon using length frequencies. A Y-O-Y was defined as having developed from an egg spawned in 1990 and being $\geq$25 mm total length. Larval and Y-O-Y white sturgeon were separated by examining the dorsal fin fold. At metamorphosis the fin fold differentiates into the dorsal fin and scutes (S. I. Doroshov, University of California, Davis, personal communication). Doroshov also stated that generally metamorphosis occurs at about 25-30 mm and can vary among individuals. For this report, a white sturgeon's birth date is assumed to be 1 January, although in reality the birth date is generally later in the year.

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

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

W = weight (g) and L = length (mm, fork length). A mean condition factor and standard deviation (SD) were calculated for all white sturgeon measured and weighed.

Densities of white sturgeon in three different depth ranges--$\leq$9.0, 9.1 to 18.2, and $\geq$18.3 m--were compared using the nonparametric Kruskal-Wallis test (Elliott 1977); the data were not transformed for this test.

Benthic invertebrate data were analyzed by individual station. Information calculated for each station included the number of taxa, mean number/m^2 and SD for each taxon, mean number of invertebrates/sample and SD, and total mean number of invertebrates/m^2 and SD.

Habitat Quantification

One of the major goals of the white sturgeon study is to quantify the amount of spawning and juvenile rearing habitat for white sturgeon in the Columbia River downstream from Bonneville Dam. The NMFS and FWS have been working cooperatively to accomplish this objective. In order to quantify spawning habitat it is important to adequately describe water velocities downstream from Bonneville Dam based on discharge through the dam. The FWS will use an existing hydraulic simulation model to predict velocities in the Bonneville Dam tailrace. Field work for this objective includes establishing transects in spawning or potential spawning areas immediately downstream from

Bonneville Dam, determining depth profiles and water surface elevations, and measuring water velocities. Field work for this project began in 1989.

Another important component in the quantification of sturgeon habitat is the digitization of navigation charts of the Columbia River downstream from Bonneville Dam into a Geographic Information System (GIS). In 1990, NMFS contracted with FWS to digitize navigation charts of the lower river into a GIS based on depth and substrate type. The substrate type was determined from navigation charts, reports, and benthic samples collected by NMFS. output from the GIS will include area estimates of juvenile rearing habitat in the lower Columbia River. Also, the amount of white sturgeon spawning area will be estimated using data from the GIS and the hydraulic simulation model.

RESULTS

Egg and Larval Sampling

In 1990, a total of 2,785 white sturgeon eggs were collected between RMs 120 and 145 (Table 1); 1,804 eggs were collected with plankton nets and 981 eggs were collected with artificial substrates. A white sturgeon egg was first collected with plankton nets on 23 April near Ives Island (RM 143); unfortunately, the developmental stage of this egg could not be determined. Eggs were last collected in plankton nets on 9 July at Ives Island.

The sampling site near Ives Island was used as an index area to monitor white sturgeon spawning during 1990 (Table 2). White sturgeon eggs were collected at this site on 12 of the 13 sampling days from 23 April (when an egg was first collected) to 9 July (when eggs were last collected). The abundances (densities) of white sturgeon eggs at Ives Island were highest on 30 April (119.6 eggs/1,000 m^3) and 14 May (116.0 eggs/1,000 m^3). At Ives Island, stage 2 (freshly fertilized) eggs represented 66% of the total eggs collected in plankton nets and were collected on 9 of the 12 sampling days that eggs were collected at this location, indicating that spawning was occurring throughout the spring and early summer. Stage 2 eggs also represented at least 50% of the eggs from an individual sampling effort on 7 of the 12 sampling days. Stage 2 eggs were first collected on 30 April and last collected on 2 July (Table 3).

In areas downstream from Ives Island, only 7% of the total eggs collected in plankton nets were stage 2 eggs; also, stage 2 eggs were not as frequently collected in these areas as at Ives Island (Table 3). These data indicate that spawning intensity was much greater in the area near Ives Island. A small number of stage 2 eggs were also collected in plankton nets upstream from Ives Island, representing 16% of the total eggs collected in this area. The collection of three stage 2 eggs at RM 120 on 16 May indicates that some spawning probably occurred in this area in 1990.

Artificial substrates placed along Ives Island, just upstream from Ives Island, and downstream from the spillways at Bonneville Dam (at the lower boundary of the restricted zone) collected white sturgeon eggs. Total egg collections using the substrates at these sites were 603 for Ives Island, 51 for the site just upstream from Ives Island, and 327 for the site downstream from the spillways. The collection of white sturgeon eggs near the spillways indicates that the upper boundary of sturgeon spawning in the lower Columbia River is very close to the dam.

Based on back calculations using the developmental stages of eggs (and the collection of one egg that could not be staged on 23 April), we estimated spawning began on 23 April and ended on 9 July. During this period, spawning was estimated to have occurred on at least 47 days--6 days in late April, 22 days in May, 16 days in June, and 3 days in early July. It is likely that some spawning occurred after 9 July because post-hatch larvae were collected on 18 July at Ives Island. Considering the water temperature at this time,

Table 1. Numbers of white sturgeon eggs and larvae collected in the Columbia River downstream from Bonneville Dam, 1990; plankton nets and artificial substrates were used to collect eggs, and plankton nets and a 3.0-m beam trawl used to collect larvae. Fungus-infected eggs collected in plankton nets are shown in parentheses and are included in the numbers reported for the nets. Area refers to the geographic range in RM.

Sampling period	Eggs			Larvae		
	Area (RM)	Net	Substrate	Area (RM)	Net	Trawl
10-30 Apr	143	386	258	143	0	-
1-16 May	120-145	908 (38)	153	113-144	40	-
21-31 May	139-145	183 (7)	275	120-143	28	-
5-13 Jun	139-145	210 (8)	260	70-143	33	-
18-26 Jun	139-143	109 (20)	0	28-143	41	12
2-20 Jul	140-145	8	35	42-143	10	26
TOTAL		1,804 (73)	981		152	38

Table 2. White sturgeon egg and larval catches near Ives Island (RM 143) in the Columbia River downstream from Bonneville Dam, 1990. Water temperatures were measured just above the bottom; Bonneville Dam flows were average hourly discharges (for each day). Generally, one to two plankton net samples were collected on each sampling day.

Date	Temp.(°C)	Velocity (m/s) Mean column	Velocity (m/s) Bottom	Bonneville Dam total discharge (1,000 m^3/s)	Eggs/ 1,000 m^3	Larvae/ 1,000 m^3
10 Apr	9	1.6	1.2	7.25	0.0	0.0
16 Apr	11	1.7	1.1	5.54	0.0	0.0
23 Apr	11	1.5	1.1	6.58	0.2	0.0
30 Apr	11	2.2	1.1	6.35	119.6	0.0
7 May	12	2.6	1.7	7.58	12.8	0.0
14 May	12	2.3	1.8	6.54	116.0	2.7
15 May	12	2.1	1.4	6.78	47.8	1.5
22 May	13	1.7	1.1	5.36	0.0	0.8
29 May	14	2.3	1.4	5.97	16.9	0.0
5 Jun	15	2.5	1.7	8.28	7.2	0.3
11 Jun	15	2.4	1.5	9.28	26.2	0.3
18 Jun	15	2.7	2.1	8.94	2.0	3.1
25 Jun	17	2.5	1.7	7.54	3.8	0.0
2 Jul	18	2.1	1.2	7.18	0.3	0.0
9 Jul	19	2.2	1.1	6.32	1.0	0.0
18 Jul	20	1.8	1.1	4.39	0.0	1.7

Table 3. Numbers of white sturgeon eggs (by developmental stage) collected with plankton nets in three areas downstream from Bonneville Dam, 1990. Upstream and downstream areas were defined in relation to Ives Island.

Date (RM)	Egg developmental stage																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
UPSTREAM																		
30 Apr (143)	000010				0		0		0	0	0	0	0	0	0	0	0	1
1 May (144)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12 Jun (143)	8	0	0	3	0	3 1	1	8	0	5	8	5	0	0	3	0	0	54
Total	9	0		0	313		11	8	0	5	8	5	0	0	3	0	0	56'
IVES ISLAND																		
30 Apr	225	0	16	0	37	12	14	47	18	0	13	2	0	0	0	0	0	384
7 May	32	0		0	010		1	2	0	0	0	2	2	1	5	3	2	51
14 May	292	0	0	0	0	18	0	18	20	0	19	0	0	0	0	9	0	376
15 May	141	0	0080			0	0		0	4	0	0	4	0	0	0	0	157
29 May	39	0		012		0	2	0	2	0	0	0	2	0	0	0	0	48
5 Jun	19	0		0	010		1	1	0	0	0	1	0	0	0	1	0	24
11 Jun	23	0	4	0	9·	4	0	0	22	0	4	22	0	0	0	0	0	88
18 Jun	000000				0		0		0	0	0	0	0	0	1	3	0	4
25 Jun	2	0	0	1	1	0	1	0	1	2	0	1	0	0	0	0	0	9
2 Jul	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9 Jul	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	774	0'20		2	61	34	19	68	63	6	36	28	8	1	6	16	2	1,144[b]
DOWNSTREAM																		
1 May (140)	0	2	2	2	3	2	0	1	4	0	5	1	0	0	0	0	0	22
7 May (140)	4	0	0	0	2	0	3	4	2	0	6	5	2	15	22	28	0	93
15 May (138)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
15 May (139)	0	0	0	0	0	0	0	0	1	0	0	0		0	0	0	0	2
15 May (140)	0	5	0	0.0		0	0	'26	21	27	17	21	3:	3	5	0	0	159
16 May (120)	300000				0		0		0	0	0	0	0	0'	0	0	0	3
22 May (139)	000000				0		0		0	0	0	0	0	0	0	1	0	1
22 May (140)	000000				0		0		0	0	0	0	0	0	1	1	0	2
30 May (139)	0	0	0	0	0	0	0	0	1	1	0		0	0	0	0	0	3
30 May (140)	6	0	0	0	0	0	4	11	12	2	11	33	21	4	13	0	0	121
5 Jun (140)	600030				0		0		0	0	0	0	0	0	0	0	0	9
12 Jun (139)	1	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	5
12 Jun (140)	0	0	0	0	2	0	0	0	3	2	2	4	0	0	1	0	0	14
18 Jun (140)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
26 Jun (140)	18	0	3	0	3	0	0	3	7	0	0	7	10	7	15	0	0	73
2 Jul (140)	0	1	0	0	0	0	0	0	0	0		10	0	0	0	0	0	2
Total	38	8	5	2	14	2	8	45	51	33	43	76	68	29	59	31	0	512'

[a] *Does not include 1 egg of unknown developmental stage.*
[b] *Does not include 32 eggs of unknown developmental stages.*
[c] *Does not include 59 eggs of unknown developmental stages.*

these post-hatch larvae probably developed from eggs spawned on about 14 July. During the spawning period, water temperatures (measured at Bonneville Dam and in the field) ranged from 11 to 19°C and Bonneville Dam discharge (mean hourly discharge by day) ranged from 5,040 to 10,505 m^3/s (Figure 2). It should be noted that water temperatures measured at Bonneville Dam and temperatures measured at the egg collection sites sometimes differed.

In 1990, a total of 152 white sturgeon larvae were collected in plankton nets between RMs 70 and 144, and an additional 38 larvae were collected in the 3.0-m beam trawl between RMs 28 and 132 (Table 1). Limited larval sampling was also conducted downstream from RM 28 with the beam trawl; however, no larvae were collected in this area. Larvae were first collected on 7 May at RM 140, and the last larva was captured on 20 July at RM 79. Overall, 67% of the larvae that were staged were classified as post hatch or stage 1 (Table 4). Densities of larvae near Ives Island ranged from 0.0 to 3.1 larvae/1,000 m^3 (Table 2).

Physical conditions under which eggs and larvae were collected were generally similar. Bottom-water temperatures at sites where eggs were collected in plankton nets ranged from 11 to 19°C; bottom-water turbidities ranged from 1.9 to 7.7 NTU; mean water-column velocities ranged from 0.8 to 2.7 m/s; water velocities about 0.6 m above the bottom ranged from 0.5 to 2.4 m/s; and water depths ranged from 3.7 to 21.0 m. White sturgeon larvae were captured where bottom-water temperatures ranged from 12 to 21°C; bottom-water turbidities ranged from 2.0 to 8.5 NTU; mean water-column velocities ranged from 0.8 to 2.7 m/s; water velocities about 0.6 m above the bottom ranged from 0.5 to 2.4 m/s; and water depths ranged from 3.7 to 29.0 m. The water velocity data for larvae apply only to plankton net collections, as velocities were not measured when using the beam trawl.

No white sturgeon eggs or larvae were collected in the Willamette River at Oregon City on 17 May.

Juvenile Sampling

Abundance and Distribution

In 1990; a total of 1,409 juvenile white sturgeon were collected in 342 trawling efforts in the Columbia River downstream from Bonneville Dam. Of this total, 1,298 sturgeon were collected with the 7.9-m semiballoon shrimp trawl, 1 with the 4.9-m semiballoon shrimp trawl, and 110 with the 3.0-m beam trawl.

Distribution of juvenile white sturgeon in the Columbia River downstream from Bonneville Dam was patchy. Not only were there differences in catches among different areas of the river, but also differences in catches among parallel transects at the same river mile.

Generally, estimated mean densities of white sturgeon (no./ha) tended to be higher in the upper river (RM 75.1 to 131.6) than in the lower river (RM 27.8 to 74.7) (Figure 3). It should be noted that the data presented in Figure 3 represent various degrees of sampling intensity (i.e., the number of trawling efforts conducted in the two areas often varied monthly); therefore the data should be viewed as at best general trends. Sampling was generally done less frequently in the upper area than in the lower area because the upper area had been sampled intensively in past years; this was the first year intensive sampling was conducted in the lower river. The large catch increases in the upper area in September and October were largely due to high catches near RM 131-132. Juvenile white sturgeon tend to concentrate in this area in late summer and fall. We did not locate any areas in the lower river where sturgeon densities were even close to the high densities observed at RM 131-132. The highest catch in 1990 was made at RM 131 on 18 October when 215 white sturgeon (811 *sturgeon/ha)* were collected in a 5-min trawling effort.

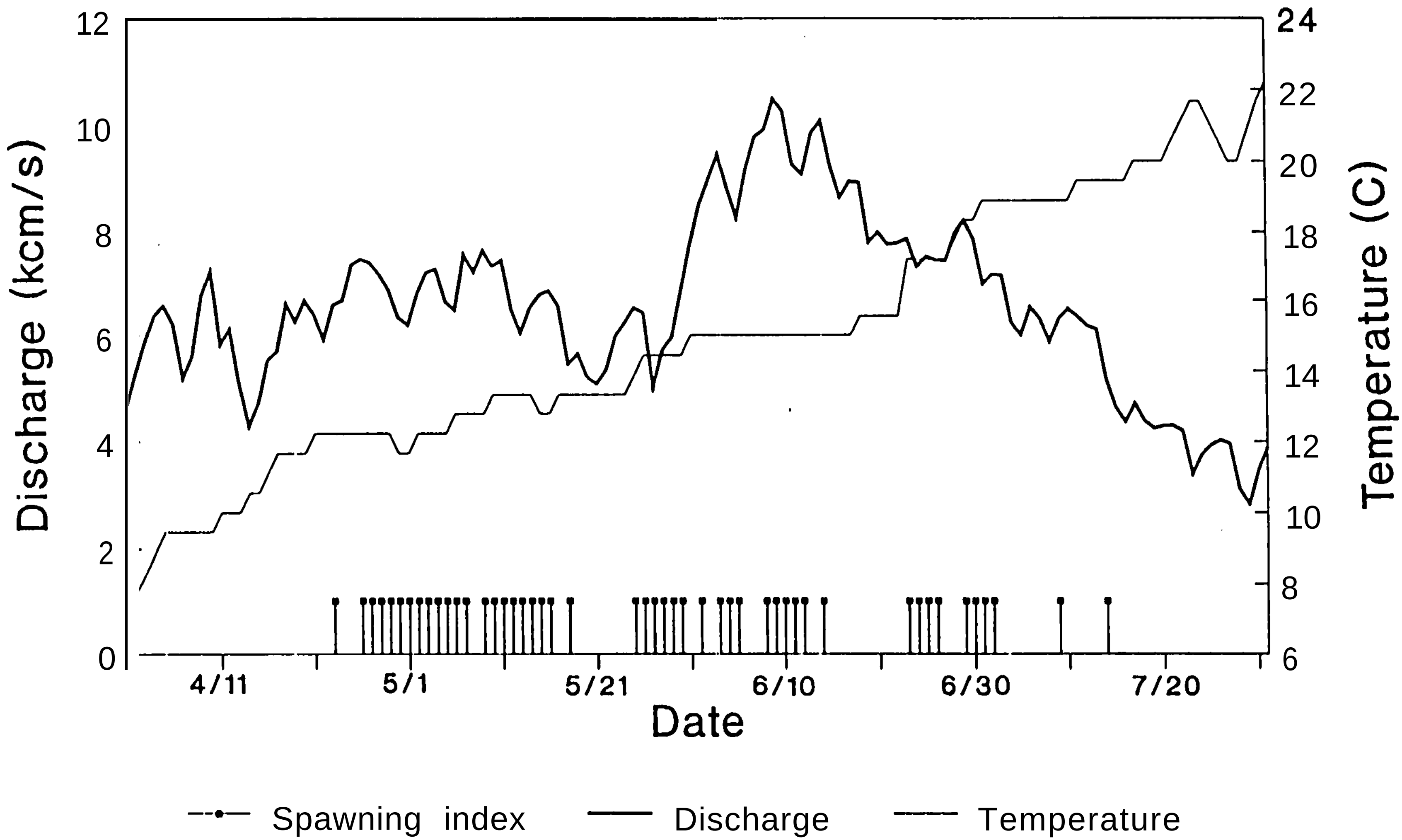

Figure 2. Water temperatures (°C) and Bonneville Dam discharges (mean hourly water discharges by day) from 1 April through 31 July 1990; discharge is shown as $m^3/s \times 1,000$. Water temperatures were measured at Bonneville Dam. The spawning index shows the days on which white sturgeon spawning waa estimated to have occurred.

Table 4. Numbers of white sturgeon larvae (by stage) captured downstream from Bonneville Dam, 1990; larvae were collected with plankton nets and a 3.0-m beam trawl.

Date (RM)	Larval stage								
	Post hatch	1	2	3	4	5	6	7	Total
IVES ISLAND									
14 May (143)	0	5	3	1	0	0	0	0	9
15 May (143)	2	1	1	0	0	0	0	0	4
22 May (143)	1	1	0	0	0	0	0	0	2
5 Jun (143)	0	1	0	0	0	0	0	0	1
11 Jun (143)	0	0	1	0	0	0	0	0	1
18 Jun (143)	3	3	0	0	0	0	0	0	6
18 Jul (143)	4	3	1	0	0	0	0	0	8
Total	10	14	6	1	0	0	0	0	31[a]
OTHER LOCATIONS									
7 May (140)	4	2	0	0	0	0	0	0	6
15 May (138)	0	0	1	0	0	0	0	0	1
15 May (139)	0	1	1	2	0	0	0	0	4
15 May (140)	0	4	3	0	0	0	0	0	7
15 May (144)	0	1	0	0	0	0	0	0	1
16 May (113)	0	1	3	1	1	0	0	0	6
21 May (120)	0	0	0	0	0	0	0	1	1
22 May (139)	2	5	0	0	0	0	0	0	7
22 May (140)	9	4	0	0	0	0	0	0	13
30 May (138)	1	0	0	0	0	1	0	1	3
30 May (139)	0	0	0	0	0	1	0	0	1
30 May (140)	0	0	0	1	0	0	0	0	1
5 Jun (139)	0	2	1	0	0	0	0	0	3
5 Jun (140)	4	15	5	0	0	0	0	0	24
8 Jun (70)	0	0	1	0	0	0	0	0	1
12 Jun (139)	0	1	0	0	0	0	0	0	1
13 Jun (120)	0	0	0	0	0	1	0	0	1
18 Jun (140)	8	16	2	0	0	0	0	0	26
21 Jun (28)	0	0	0	0	2	1	0	0	3
21 Jun (31)	0	0	0	1	0	0	0	0	1
22 Jun (61)	0	0	0	0	0	2	0	0	2
26 Jun (139)	0	0	0	0	0	1	0	1	2
2 Jul (140)	1	0	0	0	0	0	0	0	1
10 Jul (103)	0	0	0	0	0	1	0	0	1
10 Jul (131)	0	0	0	3	0	0	0	0	3
10 Jul (132)	0	1	0	2	2	1	0	0	6
11 Jul (95)	0	0	0	1	0	0	0	0	1
20 Jul (79)	0	1	0	0	0	0	0	0	1
Total	29	54	17	11	5	9	0	3	128[b]

[a] Does *not* include 7 larvae *of unknown stages.*
[b] *Does not include 24 larvae of unknown* stages.

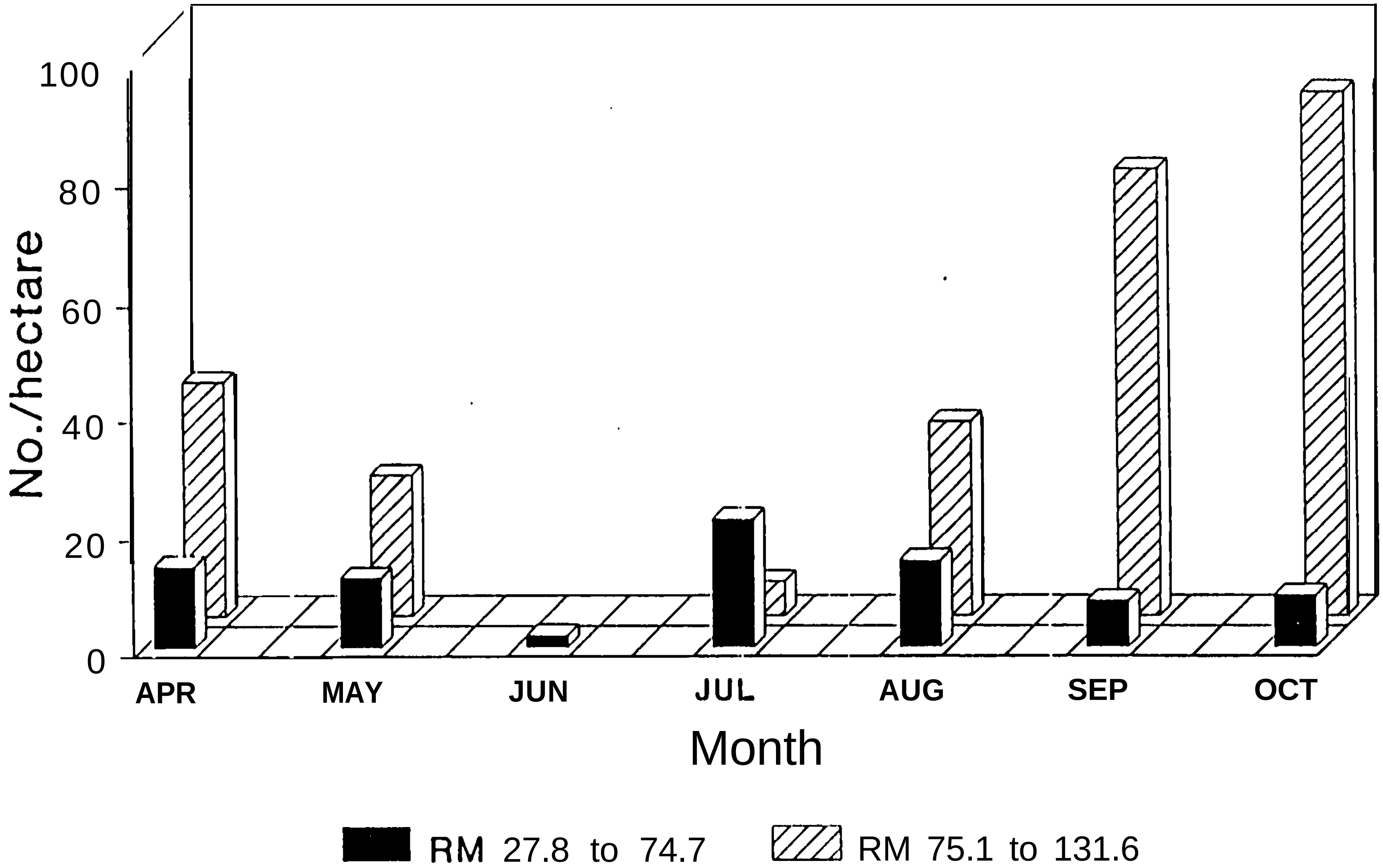

Figure 3. Estimated mean densities of juvenile white sturgeon in lower (RM 27.8 to 74.7) and upper (RM 75.1 to 131.6) areas of the Columbia River downstream from Bonneville Dam, 1990.

Size-Class structure

The monthly size ranges of white sturgeon captured in 1990 were similar from April through May, prior to the appearance of Y-O-Y white sturgeon in June (Figure 4). The Y-O-Y group is the only age group that is easily discernible in the histograms, as there is considerable overlap in the lengths of the older age groups.

Young-of-the-Year

In 1990, a total of 273 Y-O-Y white sturgeon were captured between RMs 28 and 131 (Table 5); Y-O-Y comprised over 19% of the total catch of juvenile white sturgeon. All Y-O-Y, except for one, were captured downstream from RM 104 (Port of Vancouver, Washington). The Y-O-Y were first collected on 20 June and last collected on 25 October (the last sampling day).

Beginning in late June, Y-O-Y were consistently collected in a deep area near Goble, Oregon (RM 75); maximum depths encountered during trawling efforts exceeded 22 m. The Y-O-Y catches in this area totaled 135 in 1990 and frequently exceeded 5 Y-O-Y/trawling effort. On two occasions, 23 or more Y-O-Y were captured in a single trawling effort in this area.

Overall, Y-O-Y were collected during trawling efforts where the depths ranged from to 5.8 to 38.1 m; mean minimum and maximum depths were 12.5 and 21.1 m, respectively. As indicated by the mean depths, Y-O-Y were more abundant in deeper areas of the river. The bottom substrates over which Y-O-Y were found were predominantly sand.

White sturgeon Y-O-Y grew rapidly during the summer; the mean fork length increased from 31 mm in June to 194 mm in September (Table 5). At times, there waa considerable variation in the lengths and weights of Y-O-Y white sturgeon collected on the same day.

During the 31 July-1 August sampling survey (sampled from 1155 through 0800 hours) at Jones Beach, a total of 78 juvenile white sturgeon were collected; 52 of the juveniles were Y-O-Y (Table 6). Over 78% of the Y-O-Y were collected during hours of darkness, indicating that they were more vulnerable to the trawl at night or moved into the sampling area at night. The mean length of Y-O-Y collected during the Jones Beach survey was 81.5 ± 15.6 (SD) mm. The Y-O-Y were collected at depths that ranged from 11 to 15 m.

Species Associations

Juvenile white sturgeon were commonly captured with American shad *Alosa sapidissima*, juvenile chinook salmon, eulachon *Thaleichthys pacificus*, peamouth *Mylocheilus caurinus*, northern squawfish *Ptychocheilus oregonensis*, largescale sucker Catostomus macrocheilus, threespine stickleback *Gasterosteus aculeatus*, sculpins (Cottidae), and starry flounder *Platichthys stellatus* (Appendix D-1).

Tagging

A total of 829 juvenile white sturgeon were tagged in 1990. Five tagged sturgeon were recaptured in NMFS trawls (Table 7); three of the recaptures had been tagged by NMFS in 1989 and two had been tagged in 1990. Four of the five recoveries were made in the same area where the fish were originally tagged. All three recaptures that were at large for more than 250 days showed slow growth (based on length).

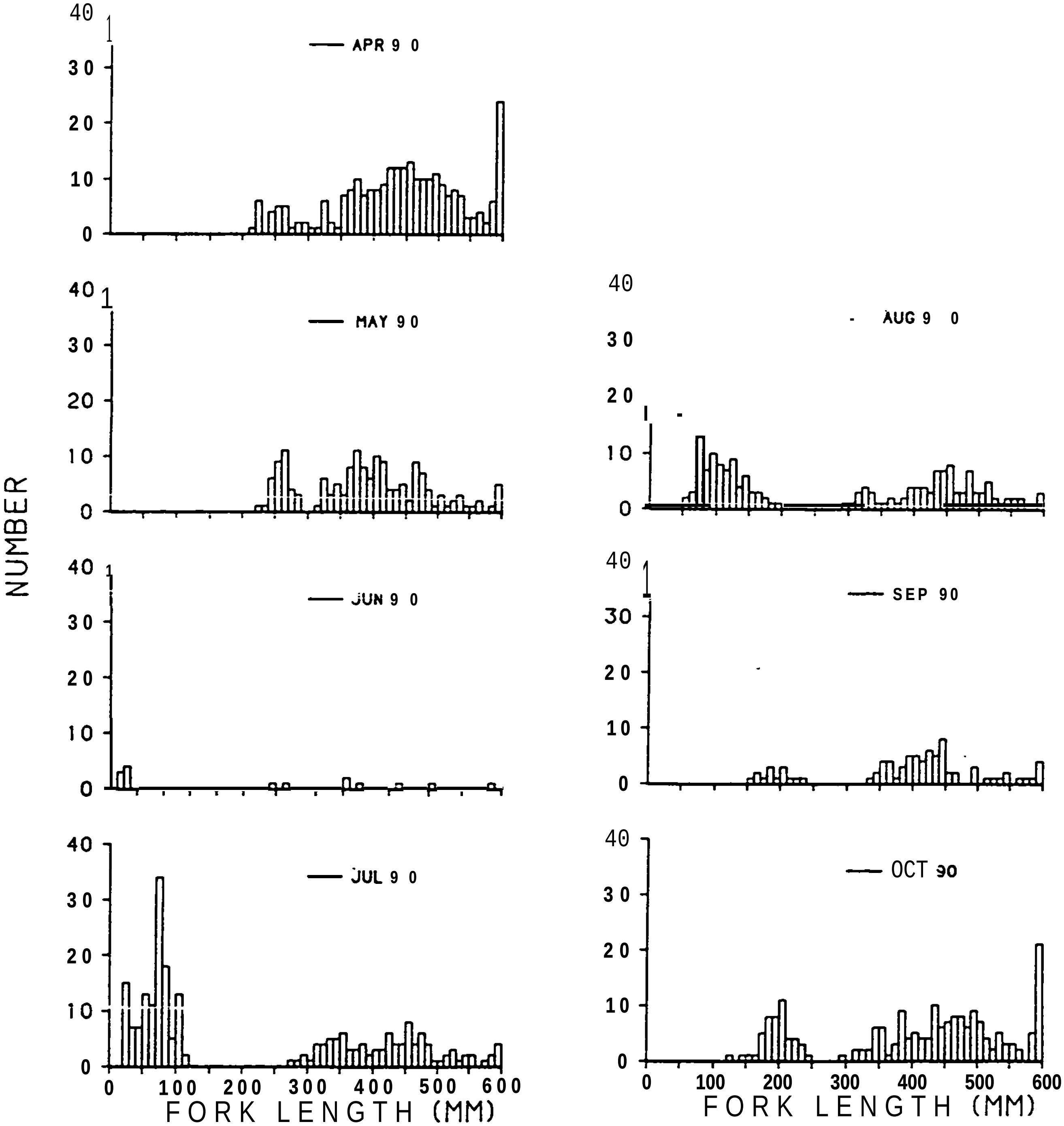

Figure 4. Length-frequency histograms for juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam, 1990. Sturgeon longer than 600 mm are included in the 600-mm interval.

Table 5. Summary of young-of-the-year white sturgeon catches in the Columbia River downstream from Bonneville Dam, 1990 (includes samples collected at Jones Beach, Oregon, on 31 July-l August).

Month	Capture location (RM)	Number	Fork length (mm)		Weight (g)	
			Mean	SD	Mean	SD
Jun	28-75	7	30.9	4.0	0.0	0.0
Jul	28-131	125	68.8	23.8	3.2	2.8
Aug	31-103	79	110.6	32.0	12.3	10.4
Sep	30-103	14	194.3	22.5	54.4	19.8
Oct	28-103	48	196.9	23.4	51.9	17.4

Table 6. Summary of white sturgeon catches during a 20-h study at Jones Beach, Oregon (RM 46), on 31 July-1 August. Sampling was done from 1155 hours on 31 July to 0800 hours on 1 August using a 7.9-m semiballoon shrimp trawl. Estimated fork lengths of young-of-the-year (Y-O-Y) sturgeon are presented, since small Y-O-Y lack indentations in their tails (see text for a description of how fork lengths were estimated).

Hour[a]	Depth range	Total no.	No. of Y-O-Y	Length range (mm) of Y-O-Y
1155	13-14 m	10	0	-
1255	6-8 m	0	0	-
1357	13-14 m	3	0	-
1533	10-15 m	0	0	
1702	13-14 m	3	1	73
1830	12-14 m	2	1	100
1933	11-14 m	6	6	71-101
2029	12-14 m	4	1	7 2
2130	12-14 m	12	12	52-107
2230	13-15 m	15	12	50-109
0030	12-14 m	15	15	56-123
0218	12-14 m	2	2	75-79
0527	13 m	0	0	
0646	12-13 m	3	2	79-101
0800	12-13 m	3	0	

[a] *Sunset on* 31 *July was* at 2047 hours; sunrise *on 1 August was at 0555 hours.*

Table 7. Individual recoveries (in 1990) of juvenile white sturgeon tagged in the Columbia River downstream from Bonneville Dam, 1989-1990.

Location (RM)		Days at large	Change in fork length (mm)	Change in weight (g)
Tagged	Recaptured			
53	53	14	-3	25
95	95	96	4	-16
131	131	268	9	51
131	29	275	15	185
132	132	340	1	-5

Parasites

In 1990, a total of 903 juvenile white sturgeon were examined for the nematode parasite Cystoopsis *acipenseri,* and of this number, 31 (3.4%) were infected. The mean fork length of the infected fish was 333 mm, with a range from to 291 to 379 mm. The condition factor of infected fish was 0.6687 ± 0.0811 (SD), and the condition factor for non-infected sturgeon in the same length range was 0.6757 ± 0.0947.

Body Measurements and Condition *Factor*

The regression equation for the length-weight relationship of juvenile white sturgeon (≥ 70 mm estimated fork length) was $\log_{10}$weight, g = -5.07 + 2.96 ($\log_{10}$fork length, nun); N = 1,052 ; r^2 = 0.99 . The mean condition factor of juvenile white sturgeon (≥ 70 mm estimated fork length) was 0.6834 ± 0.0754.

Physical Conditions

Sampling for juvenile white sturgeon with the 7.9-m trawl was conducted in depths ranging from 1.8 to 39.6 m. There was a significant difference among sturgeon densities when grouped into three depth ranges (maximum depth): ≤9.0, 9.1 to 18.2, and ≥18.3 m (Kruskal-Wallis, P < 0.01). The mean density was highest at depths ≥18.3 m (45 ± 126 sturgeon/ha) and lowest at depths ≤9.0 m (1 ± 3 sturgeon/ha); at depths from 9.1 to 18.2 m, the mean density was 6 ± 13 sturgeon/ha. . Bottom-water temperatures during juvenile white sturgeon sampling (7.9-m trawl samples) ranged from 9 to 22 °C. Sampling for juvenile sturgeon with the 3.0-m beam trawl was conducted in depths ranging from 2.7 to 35.7 m and at water temperatures ranging from 16 to 22 °C.

Benthic Sampling

Benthic invertebrate densities varied temporally and spatially (Tables 8-9, Appendix D-2) in the Columbia River downstream from Bonneville Dam. Densities of the bivalve *Corbicula fluminea* (also known as *Corbicula manilensis*) were relatively high at one or both of the two deepwater stations (Stations 1121 and 1122) at RM 95 in June, July, and September. At these two deepwater stations, densities of *Corophium salmonis* (an important prey for juvenile white sturgeon) were low, generally less than 105 organisms/m'. However, densities of *C. salmonis* at the shallow-water stations (Stations 1124, 1125, 1126) were generally much higher, frequently exceeding 1,200 organisms/m*.

At RM 131-132, total benthic invertebrate densities at individual stations tended to be lower than at RM 95. In addition, *C. salmonis* densities were generally low both at the deepwater and shallow-water stations: only in August at Stations 1272 and 1275 did densities exceed 76 organisms/m'. Densities of *Corbicula fluminea were* relatively high at Station 1274 in August (2,894/m^2) and at Station 1275 in June (1,300/m^2) and September (3,081/m^2).

At Goble, Oregon (RM 75), an important rearing area for Y-O-Y white sturgeon, *Corbicula fluminea* (6,758/m^2) and C. *salmonis* (2,289/m^2) *were* the most abundant benthic invertebrates in August. In September, *Corbicula fluminea* (3,604/m^2) and *C. salmonis* (433/m^2) were *once* again the most abundant benthic invertebrates; however, the C. *salmonis* density in September was less than 20% of August's density.

Results from the sediment analysis indicated that sand was the predominant substrate at RMs 95 and 131-132 (Table 10, Appendix D-3), although gravel and fines were present in relatively high proportions at some stations. The substrate in the deep area near Goble, Oregon (RM 75), was also composed

Table 8. Mean densities (number/m^2) and standard deviations (SD) of major taxa collected during four-monthly benthic invertebrate surveys near RM 95 in the Columbia River downstream from Bonneville Dam, 1990. The total for each station includes both major taxa and less important taxa not shown. A depth range (derived from all surveys) is shown for each station; depths at an individual station often varied among surveys due largely to changing river flows or tides.

RM-station (depth)	Taxon	June'		July	
		Mean	SD	Mean	SD
95-1121 (19-21 m)	Oligochaeta	267	0	1,712	769
	Corbicula fluminea	3,511	0	5,063	2,313
	Corophium salmonis	36	0	101	54
	Chironomidae larvae	2	0	2	5
	Heleidae larvae	956	0	1,275	290
	TOTAL	4,778	0	8,156	2,617
95-1122 (11-14 m)	Oligochaeta	8	0	124	79
	Corbicula fluminea	832	0	1,405	447
	Corophium salmonis	17	0	6	9
	Corophium spinicorne	0	0	0	0
	Chironomidae larvae	6	0	4	6
	Chironomidae pupae	0	0	2	5
	Heleidae larvae	823	0	880	924
	TOTAL	1,686	0	2,423	845
95-1124 (2-5 m)	Oligochaeta			105	47
	Corbicula fluminea			237	54
	Corophium salmonis			4,250	225
	Chironomidae larvae			69	62
	Chironomidae pupae			27	19
	Heleidae larvae			244	17
	TOTAL			4,948	189
95-1125 (3-5 m)	Oligochaeta			155	152
	Corbicula fluminea			294	155
	Corophium salmonis			363	212
	Chironomidae larvae			25	35
	Heleidae larvae			225	111
	TOTAL			1,082	597
95-1126 (3-5 m)	Oligochaeta	42	0	0	0
	Corbicula fluminea	1,002	0	174	24
	Corophium salmonis	1,201	0	1,317	761
	Chironomidae larvae	2	0	2	5
	Heleidae larvae	130	0	57	18
	TOTAL	2,379	0	1,552	771

Table 8.--Continued.

RM-station (depth)	Taxon	August Mean	August SD	September Mean	September SD
95-1121 (19-21 m)	Oligochaeta	1,231	598	1,350	384
	Corbicula fluminea	773	310	5,095	3,165
	Corophium salmonis	4	6	90	57
	Chironomidae larvae	6	9	52	36
	Heleidae larvae	378	185	489	160
	TOTAL	2,392	1,001	7,077	3,063
95-1122 (11-14 m)	Oligochaeta	15	14	147	130
	Corbicula fluminea	542	364	3,419	1,167
	Corophium salmonis	351	130	17	9
	Corophium spinicorne	63	97	0	0
	Chironomidae larvae	103	61	19	26
	Chironomidae pupae	48	22	0	0
	Heleidae larvae	645	230	743	112
	TOTAL	1,787	822	4,345	1,063
95-1124 (2-5 m)	Oligochaeta	260	112	483	384
	Corbicula fluminea	1,365	189	2,062	961
	Corophium salmonis	1,856	372	88	65
	Chironomidae larvae	78	26	6	9
	Chironomidae pupae	13	12	0	0
	Heleidae larvae	178	62	195	40
	TOTAL	3,753	523	2,837	938
95-1125 (3-5 m)	Oligochaeta	130	105	40	50
	Corbicula fluminea	1,186	857	1,403	634
	Corophium salmonis	1,516	542	603	639
	Chironomidae larvae	8	9	25	40
	Heleidae larvae	40	51	166	143
	TOTAL	2,896	1,148	2,241	1,251
95-1126 (3-5 m)	Oligochaeta	103	27	239	47
	Corbicula fluminea	1,010	780	863	113
	Corophium salmonis	3,778	1,264	3,381	480
	Chironomidae larvae	27	18	2	5
	Heleidae larvae	25	24	0	0
	TOTAL	4,979	1,997	4,507	523

[a] *Due to problems in the sorting of benthic invertebrates from substrate material for June, it was necessary to combine all replicates from each station prior to computer analysis, and in some cases not use any of these data for a station.*

Table 9. Mean densities (number/m^2) and standard deviations (SD) of major taxa collected during four monthly benthic invertebrate surveys near RM 131-132 in the Columbia River downstream from Bonneville Dam, 1990. The total for each station includes both major taxa and less important taxa not shown. A depth range (derived from all surveys) is shown for each station; depths at an individual station often varied among surveys due largely to changing river flows.

RM-station (depth)	Taxon	June[a]		July	
		Mean	SD	Mean	SD
131-1271	Oligochaeta	0	0	38	32
(15-17 m)	*Corbicula fluminea*	71	0	489	159
	Corophium salmonis	13	0	27	29
	Chironomidae larvae	0	0	2	5
	Heleidae larvae	185	0	773	206
	TOTAL	271	0	1,334	162
131-1272	Oligochaeta	0	0	2	5
(15-19 m)	*Corbicula fluminea*	103	0	624	179
	Corophium *saimonis*	36	0	65	17
	Chironomidae larvae	27	0	8	14
	Chironomidae pupae	0	0	0	0
	Heleidae larvae	187	0	206	83
	TOTAL	353	0	907	248
131-1274	Oligochaeta	279	0	38	40
(2-5 m)	Corbicula *fluminea*	19	0	162	53
	Ostracoda	0	0	0	0
	Corophium salmonis	4	0	76	24
	Chirdnomidae larvae.	13	0	50	25
	Chironomidae pupae	0	0	42	29
	Heleidae larvae	2 5	0	23	25
	TOTAL	340	0	395	76
132-1275	Oligochaeta	17	0	2	5
(l-6 m)	*Corbicula fluminea*	1,300	0	664	317
	Ostracoda	0	0	0	0
	Corophium salmonis	10	0	4	6
	Chironomidae larvae	0	0	0	0
	Chironomidae pupae	0	0	0	0
	Heleidae larvae	349	0	189	97
	TOTAL	1,678	0	867	403
132-1276	Oligochaeta			29	16
(2-6 m)	*Corbicula fluminea*			500	233
	Corophium salmonis			52	36
	Corophium *spinicorne*			0	0
	Chironomidae larvae			0	0
	Heleidae larvae			25	32
	TOTAL			609	283

Table 9.--Continued.

RM-station (depth)	Taxon	August		September	
		Mean	SD	Mean	SD
131-1271	Oligochaeta	326	174	76	73
(15-17 m)	*Corbicula fluminea*	113	143	947	291
	Corophium salmonis	4	6	17	22
	Chironomidae larvae	6	9	17	18
	Heleidae larvae	189	94	886	357
	TOTAL	638	239	1,951	586
131-1272	Oligochaeta	42	23	36	33
(15-19 m)	*Corbicula fluminea*	401	246	561	189
	Corophium salmonis	380	414	13	17
	Chironomidae larvae	136	79	105	32
	Chironomidae pupae	29	32	6	9
	Heleidae larvae	17	26	1,283	898
	TOTAL	1,029	517	2,014	1,081
131-1274	Oligochaeta	840	100	1,084	130
(2-5 m)	*Corbicula fluminea*	2,894	844	380	114
	Ostracoda	34	17	40	20
	Corophium salmonis	13	9	10	15
	Chironomidae larvae	1,306	591	334	131
	Chironomidae pupae	120	42	10	18
	Heleidae larvae	29	20	4	9
	TOTAL	5,242	1,144	1,890	294
132-1275	Oligochaeta	36	28	90	63
(1-6 m)	Corbicula *fluminea*	699	73	3,081	902
	Ostracoda	0	0	67	98
	Corophium salmonis	355	60	76	38
	Chironomidae larvae	590	178	624	161
	Chironomidae pupae	69	19	21	22
	Heleidae larvae	162	53	645	391
	TOTAL	1,924	255	4,639	1,368
132-1276	Oligochaeta	52	42	260	366
(2-6 m)	*Corbicula fluminea*	183	162	773	623
	Corophium salmonis	67	74	48	48
	Corophium spinicorne	13	12	10	18
	Chironomidae larvae	2	5	86	60
	Heleidae larvae	40	46	208	239
	TOTAL	365	241	1,415	1,074

[a] *Due to problems in the sorting of* benthic *invertebrates from substrate material for June,* it *was* necessary *to combine all* replicates *from each station prior to computer analysis, and in some cases not use any of these data for a station.*

Table 10. Summary of sediment characteristics at ten benthic sampling stations in the Columbia River downstream from Bonneville Dam, June-September 1990; see Tables 8 and 9 for the depth ranges at each station. Sediment values are percentages of total.

RM-station	June				July			
	Gravel[a]	Sand[b]	Fines[c]	TOC[d]	Gravel	Sand	Fines	TOC
95-1121	15	85	<1	1	12	88	<1	1
95-1122	<1	>97	<1	1	<1	>99	0	1
95-1124	8	91	2	1	0	96	3	1
95-1125			1	2		>99	<1	1
95-1126	4	77	19		4	93	3	1
131-1271	14	86	<1	2	6	93	1	1
131-1272	<1	>99	<1	1	4	96	<1	1
131-1274	0	88	1	1	<1	>99	<1	1
132-1275	12		<1	2	1	99	<1	2
132-1276	56	44	<1	1	20	80	<1	<1

RM-station	August				September			
	Gravel	Sand	Fines	TOC	Gravel	Sand	Fines	TOC
95-1121	5	95	<1	<1	7	93	0	1
95-1122	21	79	<1	1	<1	>97	0	1
95-1124	1	98	1	1	3	96	<1	1
								1
95-1125/95-1126	1	26/40	58/53	4	4	57	39/41	3
		90						1
131-1271/131-1272	<1	99	<1	1	1	96/98	<1	2
131-1274	0	>99	<1	1	<1	99	1	1
132-1275	6	94	<1	2	5	95	<1	1
132-1276	49	51	0	1	48	52	0	1

[a] *Grain size ≥2 mm to <64 mm.*
[b] *Grain size 0.0625 to <2 mm.*
[c] Grain size *<0.0625 mm.*
[d] **Percent** total *organic carbon.*

primarily of sand (>90% in August); Y-O-Y white sturgeon were relatively abundant here.

Habitat Quantification

All the field work needed for the hydraulic simulation model, which will be used to predict water velocities in the Bonneville Dam tailrace, was completed. Also, navigation charts of the Columbia River from the mouth to Bonneville Dam were digitized into a GIS by FWS. Results from both the hydraulic simulation model and the GIS will be included in the final report.

DISCUSSION

Egg and Larval Sampling

The total catch of white sturgeon eggs in plankton nets in 1990 (n = 1,804) was somewhat lower than the catch in 1989 (n = 2,018; McCabe and Hinton 1990); also, egg abundance near Ives Island was lower in 1990 than in 1989. The mean catch of white sturgeon eggs in plankton nets near Ives Island (RM 143) between 27 April and 28 June 1989 was 46.2 eggs/1,000 m^3, but between 23 April and 25 June 1990, the mean catch was 32.0 eggs/1,000 m^3.

In 1990, white sturgeon eggs were collected over a wider geographic range than in the two previous years. Eggs in 1988 were collected between RMs 140 and 145, and eggs in 1989 were collected between RMs 138 and 145. However, in 1990 eggs were collected between RMs 120 and 145. In a past study by WDF, white sturgeon eggs were collected as far downstream as RM 118 (Kreitman 1983).

The eggs collected just downstream from the spillways at Bonneville Dam were probably released by sturgeon spawning near the downstream section of the dam, and not by sturgeon spawning in the Bonneville Pool. The FWS sampled intensively in the Bonneville Pool in 1990 and collected sturgeon eggs between RMs 185 and 191.5 (Michael Parsley, FWS, Cook, Washington, personal communication); Bonneville Dam is at RM 145.

A total of 190 white sturgeon larvae were collected in 1990, compared to 135 collected in 1989 (McCabe and Hinton 1990); however, the 3.0-m beam trawl was used for the first time in 1990 to collect larvae. Catches of larvae in the plankton nets were similar between 1989 (n = 135) and 1990 (n = 152). From 27 April to 28 June 1989, the mean catch of larvae near Ives Island was 1.7 larvae/1,000 m^3, but from 23 April to 25 June 1990, the mean catch of larvae near Ives Island was 0.8 larvae/1,000 m^3.

The downstream distribution of white sturgeon larvae in 1990 (based on both plankton and beam trawl catches) was considerably different than distributions in the three previous years. Prior to 1990, larvae were collected no farther downstream than RM 108; however, in 1990 larvae were collected as far downstream as RM 28 with the beam trawl. Larvae were probably dispersed much farther downstream in the three previous years than indicated by our catches; the beam trawl was not used in these years. River flows in spring 1990 were higher than flows in spring of the three previous years.

Based on sampling in 1990 and past years, it appears that white sturgeon spawn in the Columbia River downstream from Bonneville Dam from late April through early July (Kreitman 1985; Kreitman and Bluestein 1985; Bluestein 1986; McCabe and McConnell 1988; McCabe et al. 1989; McCabe and Hinton 1990). White sturgeon spawning in 1990 was estimated to have occurred during a period when water temperatures (measured at Bonneville Dam and in the field) ranged from 11 to 19°C. Based on larval collections of white or green sturgeon *Acipenser medirostris*, Kohlhorst (1976) estimated sturgeon in the Sacramento

River spawn at water temperatures ranging from 7.8 to 17.8°C, with peak spawning at 14.4°C.

It is not known precisely where the larvae collected downstream-from Bonneville Dam originated, but assuming that sturgeon spawn over a boulder or cobble bottom in high velocity areas, then most of the eggs, with the exception of the ones collected at RM 120, were probably released in the area from Bonneville Dam to a point possibly about 6-7 miles downstream from the dam. River flow affects the downstream distribution of sturgeon larvae. Stevens and Miller (1970) noted a direct relationship between river flow and catches of white or green sturgeon larvae in the Sacramento-San Joaquin Delta, California. During low flows, fewer larvae were transported to the delta by river flows. Brannon et al. (1985) found that the behavior of white sturgeon larvae was affected by current velocity in laboratory experiments; there was an inverse relationship between water velocity and the amount of time larvae spent in the water column.

Sire-Class Structure

Juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam showed considerable overlap in lengths among age groups. Because of the overlaps, it was generally difficult to separate age groups other than Y-O-Y. Accurate ageing of most white sturgeon 1 year and older requires reading a cross section of a hard body part, such as a pectoral ray. Hess (1984), who aged white sturgeon using pectoral fin rays, found that those collected in the lower Columbia River showed considerable variation in length *for* a specific age group. Virtually all the sturgeon aged by Hess were age 1 and older. Hess also noted that as the age increased, the length variation tended to increase. Results from the ageing of pectoral rays collected by NMFS in 1990 will be presented in FWS's annual report.

Young-of-the-Year

Catches of Y-O-Y white sturgeon in 1990 (n = 273) were considerably higher than catches in 1987 (n = 49; McCabe and McConnell 1988), 1988 (n = 11; McCabe et al. 1989), and 1989 (n = 111; McCabe and Hinton 1990). Possible reasons for the higher catches in 1990 include increased sampling in selected deeper-areas, particularly in the river downstream from RM 75; use of the beam trawl: *or* better recruitment to the Y-O-Y stage.

Benthic Invertebrates

Total benthic invertebrate densities at RMs 95 (Stations 1121 and 11221 and 131-132 (Stations 1271 and 1272) were higher in September 1990 than in September of both 1988 and 1989 (McCabe et al. 1989; McCabe and Hinton 1990). One of the major reasons for the higher densities in September 1990 was an increase in *Corbicula fluminea* abundance.

The populations of C. *salmonis* found at the shallow-water stations at RM 95 (Stations 1124, 1125, and 1126) may represent a good food source for juvenile white sturgeon in the area. Although juvenile white sturgeon in this section of the river typically favor deeper water during daylight, they may move into shallow water at night to feed. Studies using white sturgeon that have been tagged with sonic or radio tags are needed to describe the diel movements of juvenile white sturgeon.

Plans for 1991

Plans for 1991 include sampling for white sturgeon eggs, larvae, and juveniles downstream from Bonneville Dam. Specifically, we plan to use plankton nets and artificial substrates to study the spawning characteristics of white sturgeon in the lower Columbia River. These data collected downstream from Bonneville Dam, an area designated as a control for the overall sturgeon study, will be provided to FWS, which is conducting similar research in impoundments upstream from Bonneville Dam. As in previous years, physical measurements will be made in conjunction with the egg and larval sampling, to determine, among other relationships, the relationship between river flow and egg and larval catches.

Using biological and physical data collected in 1991, we will continue to examine the specific habitat preferences or requirements of juvenile white sturgeon. Bottom trawling will be done in selected habitats downstream from Bonneville Dam, with more emphasis on the area between RMs 28 and 75 than upstream areas. Limited benthic sampling will be done at some sites.

In conjunction with FWS, we will continue quantifying spawning and rearing habitat available for white sturgeon in the Columbia River downstream from Bonneville Dam.. Other activities planned for 1991 include continued examination of juveniles for the nematode parasite *Cystoopsis* acipenseri and a preliminary description of the diel movements of juvenile sturgeon using sonic tags.

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APPENDIX D-1

Summaries of individual trawling efforts for white sturgeon in the Columbia River downstream from Bonneville Dam, 1990 (not included in basic report; available upon request to NMFS, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).

APPENDIX D-2

Summaries of benthic invertebrate studies (by station) conducted from June through September 1990 in the Columbia River downstream from Bonneville Dam (not included in basic report; available upon request to NMFS, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).

APPENDIX D-3

Summaries of sediment studies (by station) conducted from June through September 1990 in the Columbia River downstream from Bonneville Dam (not included in basic report; available upon request to NMFS, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).