REPORT D

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

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

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ABSTRACT

During 1994, the National Marine Fisheries Service sampled white sturgeon (*Acipenser transmontanus*) eggs, larvae, and juveniles in the Columbia River downstream from Bonneville Dam (River Mile (RM) 145). A total of 2,175 white sturgeon eggs was collected with plankton nets and artificial substrates between RM 120 and 145. Viable white sturgeon eggs were collected first on 19 April, and last on 5 July. The sampling site near Ives Island (RM 143) was used as the primary index station to monitor white sturgeon spawning throughout the season. Between 19 April and 5 July, white sturgeon egg densities near Ives Island (in plankton nets) ranged from 0.0 to 58.4 eggs/1,000 m^3 of water sampled, with the highest density on 23 May. Based on egg collections, I estimated that white sturgeon spawned on at least 40 days in 1994, beginning on 18 April and ending on 5 July. Spawning was estimated to have occurred at Bonneville Dam discharges (mean hourly discharge by day) ranging from 3,713 to 6,594 m^3/s, and water temperatures ranging from 11 to 17°C. A total of 42 white sturgeon larvae was collected in plankton nets between RM 120 and 145. Larvae were first collected on 3 May, and last collected on 20 June. Densities of larvae near Ives Island ranged from 0.0 to 4.6 larvae/1,000 m^3 of water sampled.

In September 1994, 183 juvenile white sturgeon were collected with a 7.9-m (headrope length) semiballoon shrimp trawl between RM 31 and 132 in the Columbia River downstream from Bonneville Dam. Distributions of juvenile white sturgeon were patchy; not only were there differences in catches among different areas of the river, but also differences in catches between parallel transects within the same area. We collected 19 young-of-the-year (YOY) white sturgeon between RM 61 and 132; YOY comprised about 10% of the total catch of juvenile white sturgeon. Densities of YOY white sturgeon at 13 index sampling stations averaged 0.6 fish/hectare during the first survey (1-9 September) and 2.3 fish/hectare during the second survey (19-22 September); the mean for both surveys combined was 1.4 fish/hectare.

INTRODUCTION

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

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

METHODS

Egg and Larval Sampling

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

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

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

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

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

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

Juvenile Sampling

A 7.9-m (headrope length) semiballoon shrimp trawl, identical to that used from 1987 through 1993, was used to collect juvenile white sturgeon, including YOY. Mesh size in the trawl was 38 mm (stretched measure) in the body; a 10-mm mesh liner was inserted in the cod end of the net. Shrimp trawl efforts were normally 5 to 7 min in duration in an upstream direction. The trawling effort began when the trawl and the proper amount of cable were deployed, and the effort was considered ended when 5 to 7 min had elapsed. We estimated the distance the net fished during each sampling effort using a radar range-finder.

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

Fishes captured in the shrimp trawls were identified and counted. White sturgeon from each sampling effort were generally measured (total and fork lengths (mm)) and weighed (g).

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

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

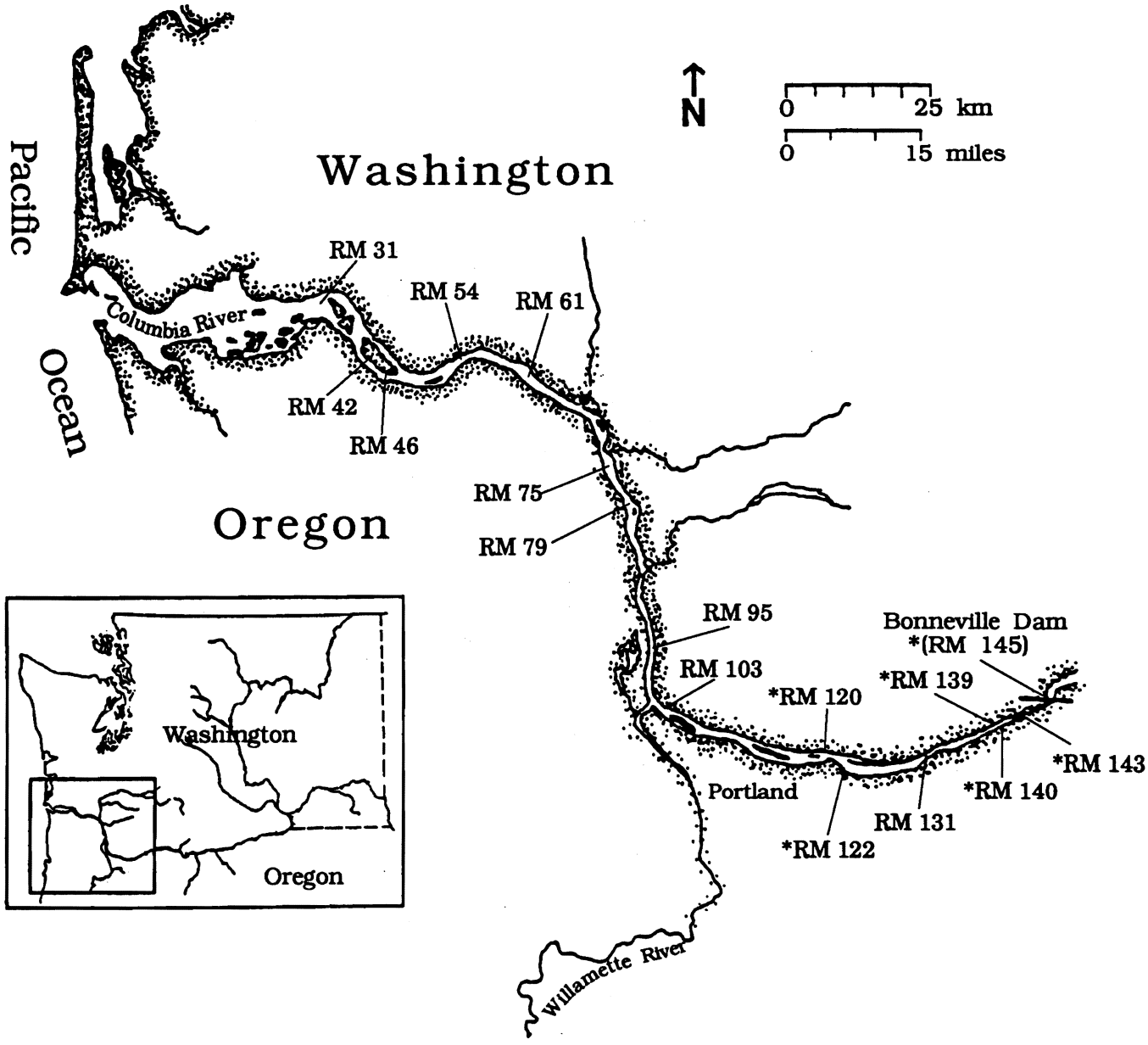

Figure 1. Locations of white sturgeon sampling stations in the Columbia River downstream from Bonneville Dam. Stations at RMs preceded by asterisks were sampled with plankton nets. Thirteen index trawling stations were sampled at RMs not preceded by asterisks; at RMs 79, 95, and 131 two stations were sampled. All index trawling stations were sampled with a shrimp trawl.

Other fish species collected were released. I routinely examined juvenile white sturgeon for the nematode parasite *Cystoopsis acipenseri* (Chitwood and McIntosh 1950; McCabe 1993). When present, the parasite is encased in blister-like cysts under the skin.

From 18 October to 10 November, NMFS collected juvenile white sturgeon between RM 131 and 132 for ODFW with the 7.9-m shrimp trawl described above. The ODFW is evaluating the feasibility of collecting juvenile white sturgeon in the Columbia River downstream from Bonneville Dam and transporting them to impoundments upstream from The Dalles Dam (see Report A for further details and results of the ODFW study).

Physical Conditions

The following physical parameters were measured in conjunction with biological sampling: bottom depth (m) (minimum and maximum); bottom-water temperature (°C); bottom-water turbidity (NTU); and water velocities at 0.2 of the total depth, 0.8 of the total depth, and about 0.6 m above the bottom. Mean water-column velocity was calculated by averaging water velocities measured at 0.2 and 0.8 of the total depth (Buchanan and Somers 1969). Water velocities were measured only during egg and larval sampling. Depth was measured with electronic depth sounders, and velocity with a Price Type "AA" current meter attached to a 45.4-kg lead fish. A Van Dorn water bottle was used to collect water samples just above the bottom. The water temperature of each sample was measured immediately after collection, and a subsample of water was removed and placed in a glass bottle. The turbidity of the sample was determined in the laboratory using a Hach Model 2100A Turbidimeter within 4 days after collection.

Data Analyses

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

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

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

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

RESULTS

Egg and Larval Sampling

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

The sampling station near Ives Island was used as the primary index station to monitor white sturgeon spawning during 1994 (Table 3). White sturgeon eggs were collected at this station on 8 of the 13 sampling days from 19 April to 12 July. The abundance (density) of white sturgeon eggs at Ives Island was highest on 23 May (58.4 eggs/1,000 m^3). At Ives Island, stage 2 (freshly fertilized) eggs represented 91% of the total eggs collected in plankton nets and were collected on 6 of the 8 sampling days when eggs were collected at this location (Table 4). Stage 2 eggs were first collected on 19 April and last collected on 23 May.

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

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

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

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

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

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

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

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

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

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

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

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

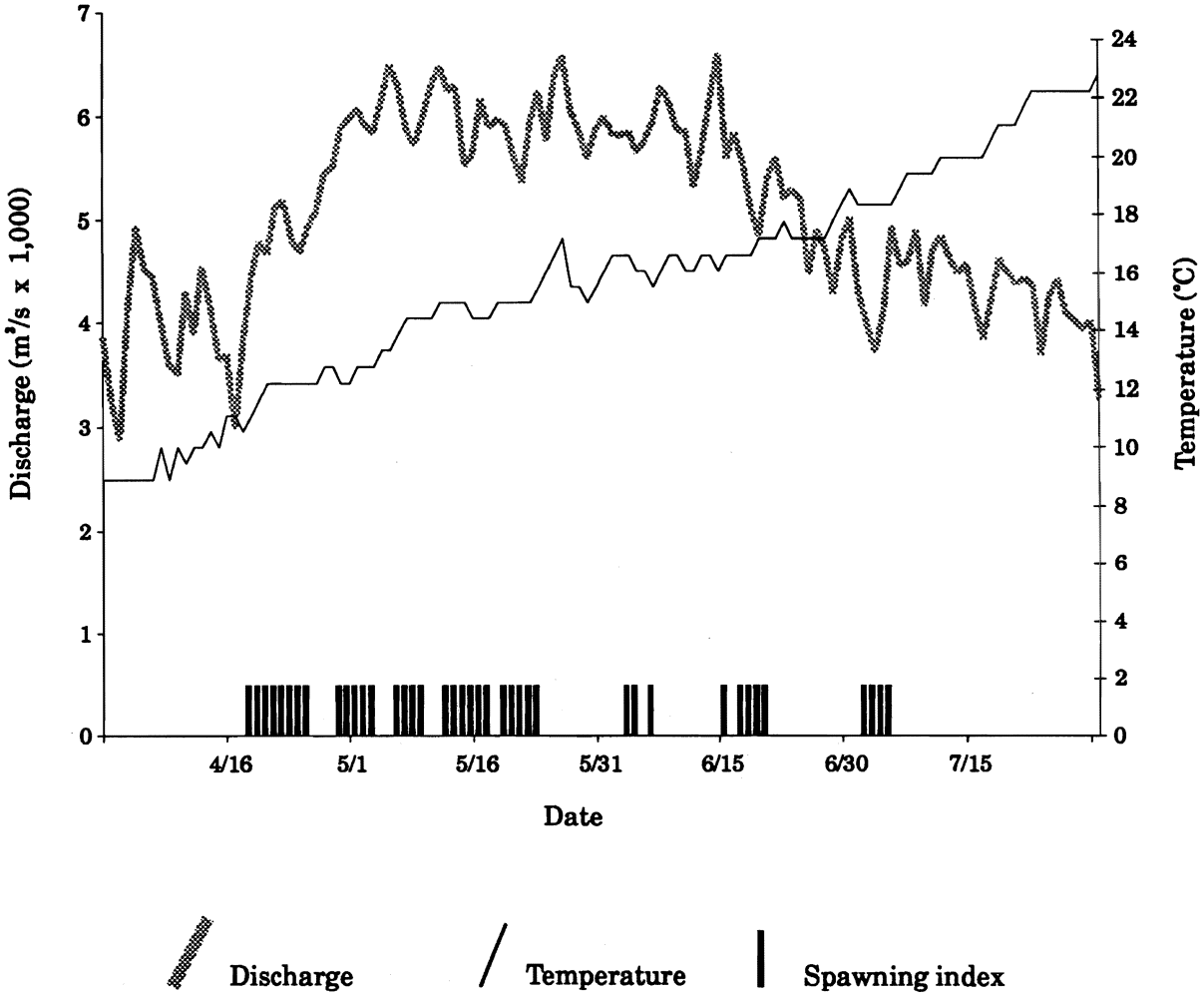

Figure 2. Water temperatures (°C) and Bonneville Dam discharges (mean hourly water discharges by day) from 1 April through 31 July 1994; discharge is shown as m^3/s x 1,000. Water temperatures were measured at Bonneville Dam. The spawning index shows the days on which I estimated that white sturgeon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

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

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

Juvenile Sampling

In September 1994, 183 juvenile white sturgeon were collected between RM 31 and 132. Distribution of juvenile white sturgeon in this section of the river was patchy. There were differences in catches among different areas of the river and between parallel transects at the same river mile.

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

In 1994, 19 YOY white sturgeon were collected between RM 61 and 132; YOY comprised about 10% of the total catch of juvenile white sturgeon. Densities of YOY white sturgeon at 13 index sampling stations averaged 0.6 fish/hectare during the first survey (1-9 September) and 2.3 fish/hectare during the second survey (19-22 September); the mean for both surveys combined was 1.4 fish/hectare (Table 6).

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

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

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

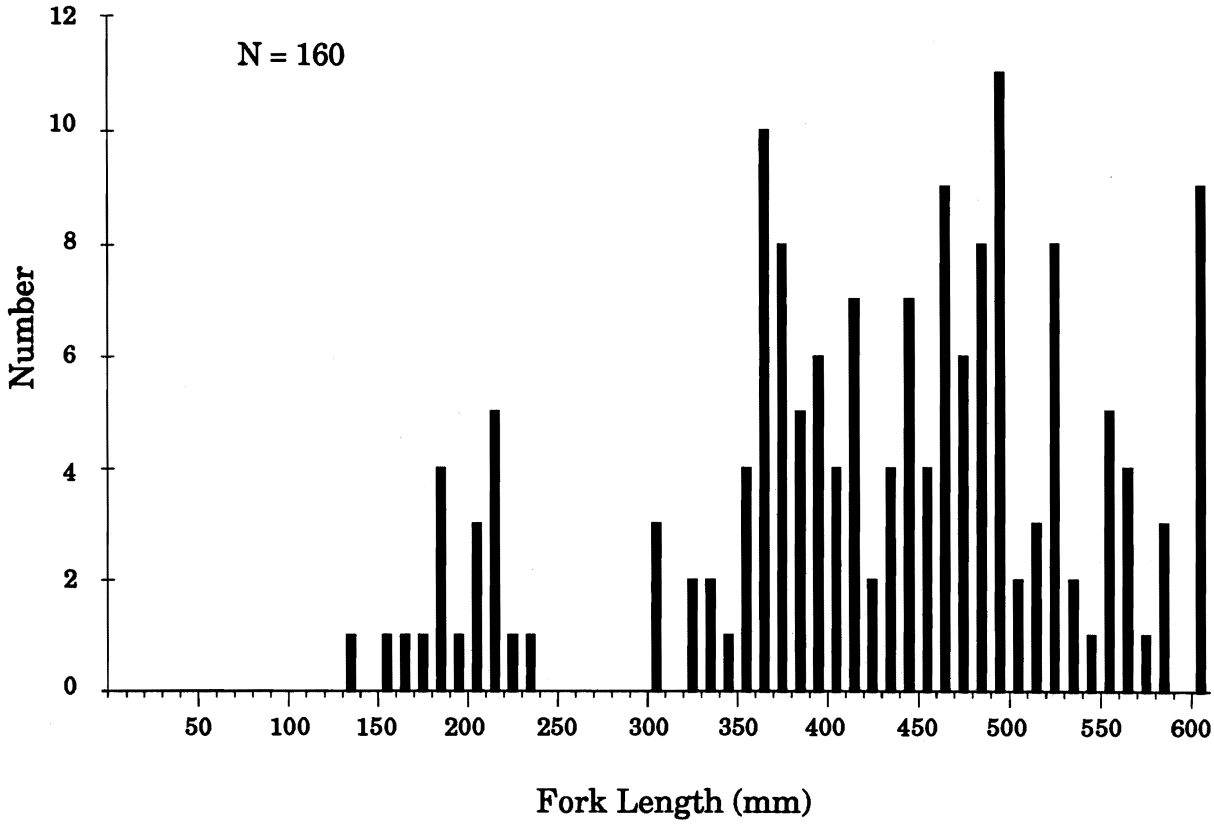

Figure 3. Length-frequency histogram for juvenile white sturgeon collected in the Columbia River downstream from Bonneville Dam, 1994. White sturgeon longer than 600 mm are included in the 600-mm interval.

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

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

DISCUSSION

Egg and Larval Sampling

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

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

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

Young-of-the-Year

Catches (number/hectare) of YOY white sturgeon at 13 index trawling stations in late September 1994 were not significantly different (Kruskal-Wallis, $P = 0.08$) than catches at the same sites in late September of 1991 and 1993. Catches at the 13 sites averaged 6.7, 9.0, and 2.3 YOY/hectare in 1991, 1993, and 1994, respectively. In all years, catches at 31% or more of the stations were zero. Young-of-the-year white sturgeon were not collected over as large a geographic area in September 1994 as in September of 1991 and 1993. In 1994, YOY white sturgeon were collected between RM 61 and 132; whereas in 1991 and 1993, YOY white sturgeon were collected between RM 28 and 131. In addition, no white sturgeon YOY were captured at RM 75 (side channel near Goble, Oregon) in September 1994; however, in past years this has been a productive sampling site for white sturgeon YOY.

Plans for 1995

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

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