KOOTENAI RIVER WHITE STURGEON INVESTIGATIONS ANNUAL PROGRESS REPORT

CHAPTER 1: KOOTENAI RIVER WHITE STURGEON SPAWNING AND RECRUITMENT EVALUATION

Period Covered: January 1, 1995 to December 3 1,1995

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CHAPTER 2: ESTIMATING ABUNDANCE OF LARVAL AND ADVANCED YOUNG-OF-THE-YEAR STURGEON AND BURBOT IN THE KOOTENAI RIVER AND KOOTENAY LAKE

Period Covered: April, 1995 to October, 1995

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IDFG 96-8
Project Number 88-65
Contract Number DE-BI79-88BP93497

December 1995

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CHAPTER 1: Kootenai River White Sturgeon Spawning and Recruitment Evaluation

ABSTRACT

The Kootenai River white sturgeon was listed as an endangered species on September 4, 1994. The U.S. Fish and Wildlife Service issued a formal Biological Opinion on the Kootenai River white sturgeon to the U.S. Army Corps of Engineers and Bonneville Power Administration in relation to spring discharge below Libby Dam. These agencies were asked in the Biological Opinion to work adaptively to obtain flow conditions that were conducive to white sturgeon recruitment. The U.S. Army Corps of Engineers, in agreement with Bonneville Power Administration, provided a release of 2.09 billion cubic meters (1.7 million acre-feet) of water above minimum flow from Libby Dam from April 29 to July 17, 1995. This release of water and local inflow provided up to 1,082 m^3/s (38.2 thousand cubic feet per second [kcfs]) discharge in the Kootenai River at Bonners Ferry, Idaho, on May 18, 1995. This study was designed to monitor and evaluate these flow conditions for white sturgeon spawning and recruitment.

Between February and early April 1995, a total of 38 adult sturgeon (13 males and 25 females) were monitored with radio and sonic telemetry, including 7 females and 6 males in known late vitellogenic stage. Two males and 11 females remained in Kootenay Lake during the experimental flow release. An additional 3 males and 3 females made brief movements out of the lake and into the lower river. The remaining 19 fish moved to locations upstream of Rock Creek (river kilometer [rkm] 215). Most of these sturgeon migrated to suspected spawning locations in the upper Kootenai River.

Monitoring of the 1995 test flow indicated Kootenai River white sturgeon spawned, but we are still uncertain as to the survival of eggs and larvae. Two thousand one hundred and eleven mat samples collected 163 eggs. The majority (71 eggs) were collected in the Myrtle Creek section from rkm 233.5 to 234.7. Sixty-three were collected in the middle Shorty's Island section (rkm 229.6 to 231.5), 16 eggs were collected in the Wildlife Refuge section (rkm 234.8 to 237.5), and 13 eggs were collected in the lower Shorty's Island section (rkm 228.0 to 229.5). One hundred twenty-seven (78%) of the eggs were viable. Stages of egg development ranged from 12 to 25, with 80% of the eggs at stage 20 or earlier. Most eggs were probably captured soon after spawning events. White sturgeon spawned during a minimum of 16 days of the 42-day test flow in 1995. Three distinct spawning intervals were noted; May 22 to 23, May 27 to June 6, and June 11 to 13, 1995.

White sturgeon spawned in slow-moving water ranging from 0.06 to 1.2 m/s (0.2 to 3.9 ft/s) and averaged 0.18 m/s (0.6 ft/s) in sand substrate. This spawning habitat is thought to be unsuitable in comparison to habitat utilized by white sturgeon in the Columbia River.

Sampling for juveniles from August 1, 1994 to August 31, 1995 resulted in a catch of 43 white sturgeon (33 in gill nets, 3 by rod and reel, and 7 on set lines). They ranged from 30 to 102 cm fork length and 35 to 120 cm total length. This catch included six wild sturgeon of the 1991 year class.

We believe augmented discharge from Libby Dam should reach a minimum of 708 m^3/s (25 kcfs). If local inflow were equal, the magnitude of flow at Bonners Ferry would nearly equal the 1991 discharge that produced the last notable cohort with the lowest discharge since Libby Dam was activated. We continue to recommend incremental increases in flow of 57 m^3/s (2 kcfs). Much of the decision to initiate the augmented flow to stimulate sturgeon spawning will be based on the migration behavior of sturgeon and rise in river temperature to 9°C (48.2°F)

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INTRODUCTION

Data collected during 11 years of white sturgeon *Acipenser transmontanus* investigations on the Idaho portion of the Kootenai River (Figure 1), 5 years on the Montana portion, and 5 years in British Columbia, Canada, suggested very little spawning was occurring. Studies of white sturgeon spawning in the Columbia River system reported water temperatures of 14°C to 17°C (57.2°F to 62.6°F), suitable water depths of at least 3 m (± 10 ft), and a discharge with velocities of at least 0.5 m/s (1.6 ft/s) over a substrate of bedrock, cobble, or gravel were utilized for reproduction. Prior to completion of Libby Dam in 1972, the Kootenai River had suitable habitat for a self-sustaining population of white sturgeon. A sample of 185 adult sturgeon examined between 1977 and 1980 revealed 79% (144) of the 185 fish were 15 to 27 years old. Thus, the majority of this sample of 185 fish were hatched between the years 1951 and 1965. Hydrographic records indicated these were wet years with better than average runoff. Historic pre-dam flows ranged from 1,699 to 2,832 m^3/s (59,992 to 99,998 cfs) during the sturgeon spawning period. Peak flows of the Kootenai River after Libby Dam were generally in the 250 to 450 m^3/s (8,828 to 15,890 cfs) range (Apperson and Anders 1991), but occasionally higher.

Based on the previously mentioned information and more, our experiment was to test flows and determine if white sturgeon would spawn. We collected 213 white sturgeon eggs in 1994 during an experimental test flow that had a peak discharge of 632 m^3/s (22 kcfs). The Bonneville Power Administration and U.S. Army Corps of Engineers provided 2.09 billion m^3 (1.7 million acre-feet) of water from Libby Reservoir (Lake Koocanusa) to produce a peak discharge in the river at Bonners Ferry of 1,082 m^3/s (38.2 kcfs) during the spring of 1995. This document summarizes the movements and spawning behavior of white sturgeon in the Kootenai River prior to and during this experimental discharge period.

STUDY SITE

The Kootenai River originates in Kootenay National Park, British Columbia. The river flows south into Montana and turns northwest at Jennings, the site of Libby Dam, at river kilometer (rkm) 352.4 (Figure 1). Kootenai Falls, 40 km (24.8 mi) below Libby Dam, is thought to be an impassable barrier to sturgeon. As the river flows though the northeast corner of Idaho, there is a transition at Bonners Ferry. Upriver from Bonners Ferry, the channel has an average gradient of 0.6 m/km (3.15 ft/mi), with velocities higher than 0.8 m/s (2.6 ft/s). Downriver from Bonners Ferry the river slows with velocities less than 0.4 m/s (1.3 ft/s). Average gradient declines 0.02 m/km (.1 ft/mi), the channel deepens, and the river meanders though the Kootenai Valley back into British Columbia and enters the south arm of Kootenay Lake. The river leaves the lake though the west arm to its confluence with the Columbia River at Castlegar, British Columbia. A natural barrier at Bonnington Falls (now a series of four dams) has isolated the Kootenai white sturgeon from other populations in the Columbia River basin for approximately 10,000 years (Northcote 1973). The basin drains an area of 49,987 km^2 (19,300 mi^2) (Bonde and Bush 1975).

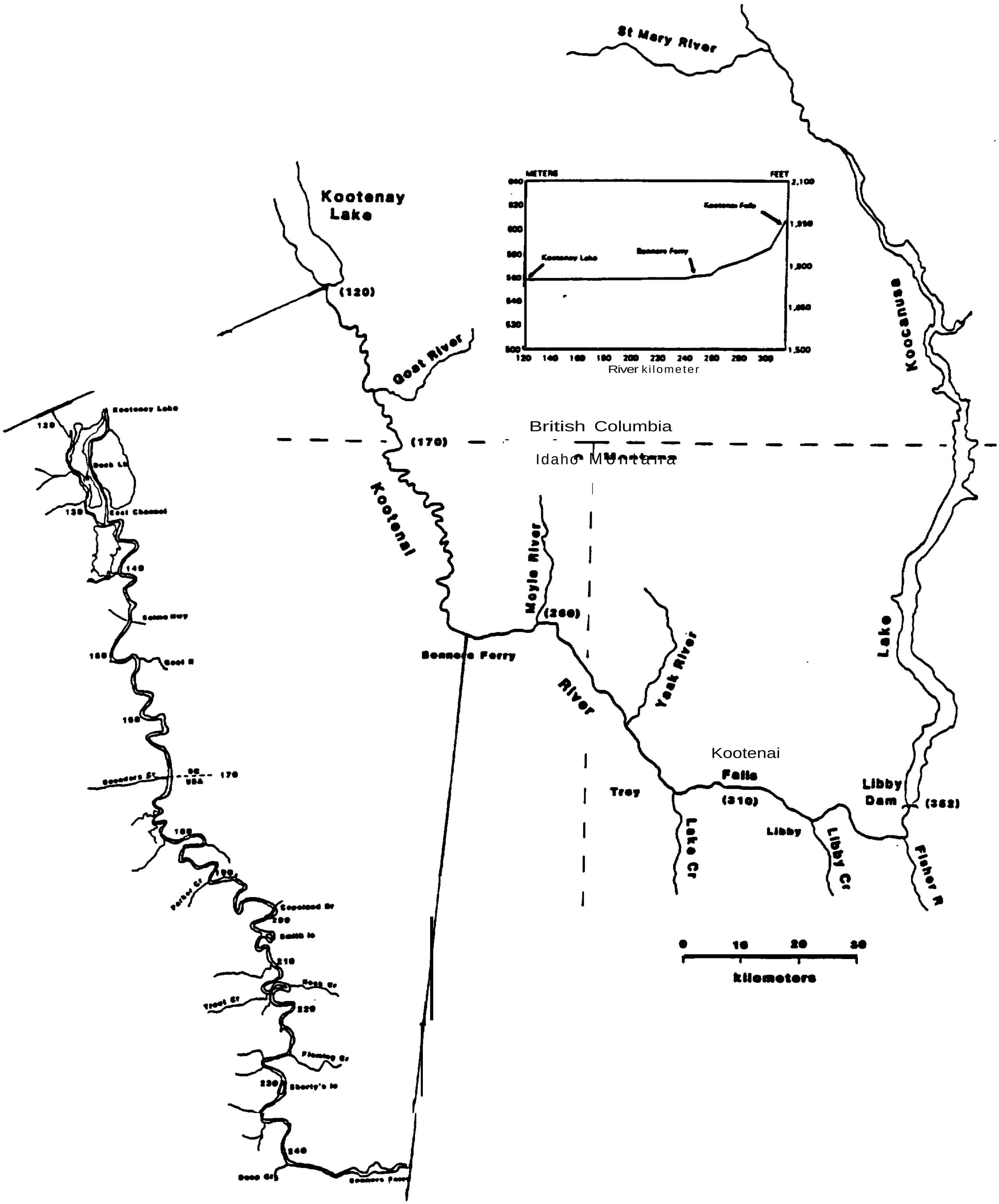

Figure 1. **Map of the Kootenai River with a schematic of river gradient and notable points of reference from Bonners Ferry to Kootenay Lake. Complete study area was from southern Kootenay Lake upriver to Kootenai Falls.**

OBJECTIVE

1. Determine environmental requirements for adequate spawning and recruitment of white sturgeon by 1998.

METHODS

Discharge and Water Temperature

The discharge formula for the Kootenai River at Bonners Ferry, Idaho was calculated by the U.S. Army Corps of Engineers (Pat McGrain, personal communication). The instantaneous discharge of the Kootenai River at Bonners Ferry was calculated from a reading of the discharge at Leonia gauge six hours earlier + 2.25 x Yaak River gauge three hours earlier. Six hours was considered the time water from Leonia reaches Bonners Ferry, a distance of 30.2 km (18 mi). The travel time for water at Moyie to Bonners Ferry was three hours. The two (2.01, in the formula, was the gauge at Yaak River which had essentially the same drainage area of the Moyie River (Yaak River = 198 hectares, Moyie River 196 hectares) and approximately the same mean annual discharge (Yaak = 24.4 m^3/s [0.861 kcfs], Moyie 25.1 m^3/s [0.886 kcfs]). The .25, in the formula, is the balance of local waters between Leonia and Bonners Ferry estimated from the gauge on the Yaak River.

Water temperatures were recorded at the U.S. Geological Survey Gauging station at the U.S. Highway 95 bridge in Bonners Ferry. The Bonneville Power Administration and U.S. Army Corps of Engineers received a flow design from the U.S. Fish and Wildlife Service in a Biological Opinion Report. This discharge design was to encourage white sturgeon to spawn in the Kootenai River. The following criteria were proposed:

1. On or about April 15 (when water temperature is about 7°C at Shorty's Island) increase flows at Bonners Ferry at a constant rate from ambient flow to achieve 425 m^3/s (15 kcfs) on May 1.

2. From May 1 to either the date of initial sturgeon spawning or June 1 (whichever occurs first), maintain flows at Bonners Ferry at a minimum of 425 m^3/s (15 kcfs).

3. On the date of initial sturgeon spawning or June 1 (whichever occurs first) regulate flows from Libby Dam to achieve the maximum discharge possible (> 567 m^3/s (> 20 kcfs]) under present operational constraints. Obtain these flows by up-ramping within the number of days required by suitable ramping rates that take into consideration public safety. Such flows will be obtained using a combination of discharge through the turbines and spill.

Additional wording took into account; discharge would be through the four operational turbines, concern for public safety, and there were operational exceptions should another turbine fail. The action agencies indicated they would key on water temperature of 9°C (48.2°F) as a determinant for a request for flows for sturgeon spawning. The end result for the timing of the augmentation of discharge at Bonners Ferry was based on sturgeon location and temperature.

Adult White Sturgeon Sampling

Adult white sturgeon were captured with rod and reel or set lines from August 1, 1994 to August 31, 1995. Rod and reel gear consisted of 6/O hooks and 34 kg (75 lb) test line. Set lines consisted of a 23 m (75 ft) bottom line equipped with 6 baited hooks of various sizes (12/0, 14/0, 16/0) and bait types.

Captured sturgeon were placed into a hooded stretcher and covered with water during data collection. Fork length (FL), total length (TL), and weight (kg) were recorded for each sturgeon. Age estimates of some fish were made from a section of the pectoral fin ray. White sturgeon were examined for previously removed scutes, fin clips, miscellaneous tags or marks, and any notable abnormalities. Old Floy tags were removed from recaptured fish to reduce risk of infection, and a Passive Integrated Transponder (PIT) tag was inserted into the right side of the dorsal fin on fish that did not have one.

Some fish over 130 cm (52 in) were examined surgically to determine gender and stage of sexual maturity. In order to minimize handling and surgeries, other candidates not examined surgically were identified by size and fullness of the abdomen. Suspected spawners captured between February and mid-April 1995 were fitted with radio (24-month) and ultrasonic (50-month) transmitters attached through the dorsal fin. All transmitters were attached with 1.4 mm (.055 in) wire leader through the proximal portion of the dorsal fin and crimped on.

White Sturgeon Telemetry

Adult white sturgeon fitted with sonic and radio transmitters were monitored for movement throughout the Kootenai River and Kootenay Lake. The main objective was to locate late vitellogenic females and males moving upstream to staging and spawning reaches. Location of each transmitter was recorded to the nearest 0.1 river kilometer (rkm) (0.06 mi) for each fish. Water temperature was measured daily with a hand-held thermometer.

Effort required to monitor transmitters varied between seasons. Less effort was required during winter months because fish congregated in deep water and moved less than in other seasons. As spawning season approached, increased activity among transmittered fish required a greater degree of monitoring. Upriver locations were monitored more intensively than downriver or lake locations.

White Sturgeon Egg Sampling

We used artificial substrate mats to document white sturgeon spawning. Substrate mats consisted of furnace filter material (latex-coated animal hair) bolted to 62 x 75 cm (24.8 x 30 in) angle iron frames (McCabe and Beckman, 1990). Mats were held in position on the substrate by the weight of the frame and an anchor. An orange buoy with an identification number was attached to each mat. Mats were set in the river from May 1 to July 12, 1995. Mats were deployed in the river from Rock Creek to U.S. Highway 95 bridge (rkm 215.0 to 246.6). The river reach where egg mats were deployed (rkm 215 to 246.6) was divided into 12 sections based on distinct habitat features. The 12 sections are as follows: Rock Creek (rkm 215 to 216), Lower Flemming Creek (rkm 222.6 to 224.5), Flemming Creek (rkm 224.6 to 225.5), Lower Shorty's Island (rkm 228 to 229.5), Middle Shorty's Island (rkm 229.6 to 231.5), Upper Shorty's Island (rkm 231.6 to 233.4), Myrtle Creek (rkm 233.5 to 234.7), Refuge (rkm 234.8 to 237.5), Deep Creek (rkm 237.6 to 240.5), Hatchery (rkm 240.6 to 243.9), Ambush Rock (rkm 244 to 244.6), and U.S. Highway 95 (rkm 244.7 to 246.6). Mats were also set in respect to locations and movement of radio- and sonic-tagged adult sturgeon that were potential spawners in 1995. Time, depth, temperature, and location were recorded at deployment and retrieval for each mat. Mats were retrieved to the boat by pulling the line from an attachment point fixed to the downriver side of the mat frame to minimize flushing of contents. Mats were pulled and examined for presence of eggs daily until June 7, after which they were checked every 2 to 5 days though July 12. Surface and bottom velocities were recorded at egg collection sites.

Eggs were removed from mats and stored in labeled vials containing formalin or alcohol solution. White sturgeon spawning dates and times (± 4 hours) were back-calculated from all viable white sturgeon eggs using an exponential function involving water temperature and embryonic development described by Wang et al. (1985) and Beer (1981). Embryonic stages of white sturgeon eggs were distinguished visually with a dissection microscope using the embryological criteria developed by Beer (198 1). Spawning dates or times could not be estimated for non-viable and unfertilized white sturgeon eggs.

Juvenile White Sturgeon Sampling

Researchers sampled for juvenile sturgeon from Ambush Rock (rkm 244.5) to Kootenay Lake (rkm 118), between August 1, 1994 and August 31, 1995. Juvenile sturgeon are defined as ≤ 120 cm TL and ≤ 1 15 cm FL. This definition is based on length measurements of the majority of non-reproductive fish captured by Apperson and Anders (1991).

Nine gear types were utilized to catch juvenile sturgeon partially in conjunction with the young-of-the-year (YOY) sampling efforts (detailed in Chapter 2). The gear types were: 2.5 to 10 cm (l-4 in) mesh sinking multifilament gill nets, large set lines with 12/0, 14/0, and 16/0 hooks, small set lines with 6/0 hooks, 91 cm and 61 cm diameter baited hoop nets, minnow traps, slat traps, and rod and reel gear. Gear was fished within a 5 km section of the river for 3 days, after which it was moved to the next 5 km section. Hoop nets, set lines, and traps were fished from Ambush Rock (rkm 244.5) to the Canadian border at Porthill, Idaho (rkm 170). They were checked and rebaited daily. Gill nets were fished at various locations between Ambush Rock (rkm 244.5) and Kootenay Lake (rkm 118). They were set during the day and checked every hour.

Captured sturgeon were placed into a hooded water-tight stretcher and covered with water during data collection. Fork length, total length, and weight (kg) were recorded for each sturgeon. As a method of age verification, a section of pectoral fin ray was taken from most juvenile fish. Juvenile sturgeon were examined for previously removed scutes, fin clips, miscellaneous tags, or marks and any notable abnormalities. Old Floy tags were removed from recaptured fish and a PIT tag was inserted into fish which did not have one.

Particular attention was given to location of existing PIT tags and missing scutes because they indicated whether the fish was of wild or hatchery origin. Hatchery fish were marked with a PIT tag in the head and had the second left and ninth right lateral scutes removed. Fish that did not have any marks or tags were assumed wild. Each capture of a hatchery fish was considered a recapture since it was previously measured and marked.

Juvenile White Sturgeon Telemetrv

Ten juvenile white sturgeon that were fitted with sonic tags and released from the Kootenai Tribal Hatchery in 1994 (Marcuson et al. 1995) were tracked to document movement and habitat preference. We assumed habitat choice of hatchery juveniles could be an indicator of habitat selection in wild juvenile sturgeon.

Aqe and Growth of White Sturqeon

Ages of adult and juvenile white sturgeon were determined by pectoral fin ray analysis. Fin rays were removed from the fish with a hacksaw, cut into thin sections, sanded smooth and viewed under a dissecting microscope to determine ages. Fish collected in early spring prior to annulus formation were assumed to have an annulus on the outer edge of the ray. Average ages were calculated from individual age estimates made by three or more readers.

RESULTS

Discharge and Temperature

Migration behavior of tagged white sturgeon and a rise in river temperature to 9°C (48.2°F) were the principal means to determine the onset of the discharge test provided by the U.S. Army Corps of Engineers. Augmentation for the test began on April 29 with an eventual discharge from Libby Dam of 566 m^3/s (20 kcfs) for a 42-day period (Figure 2).

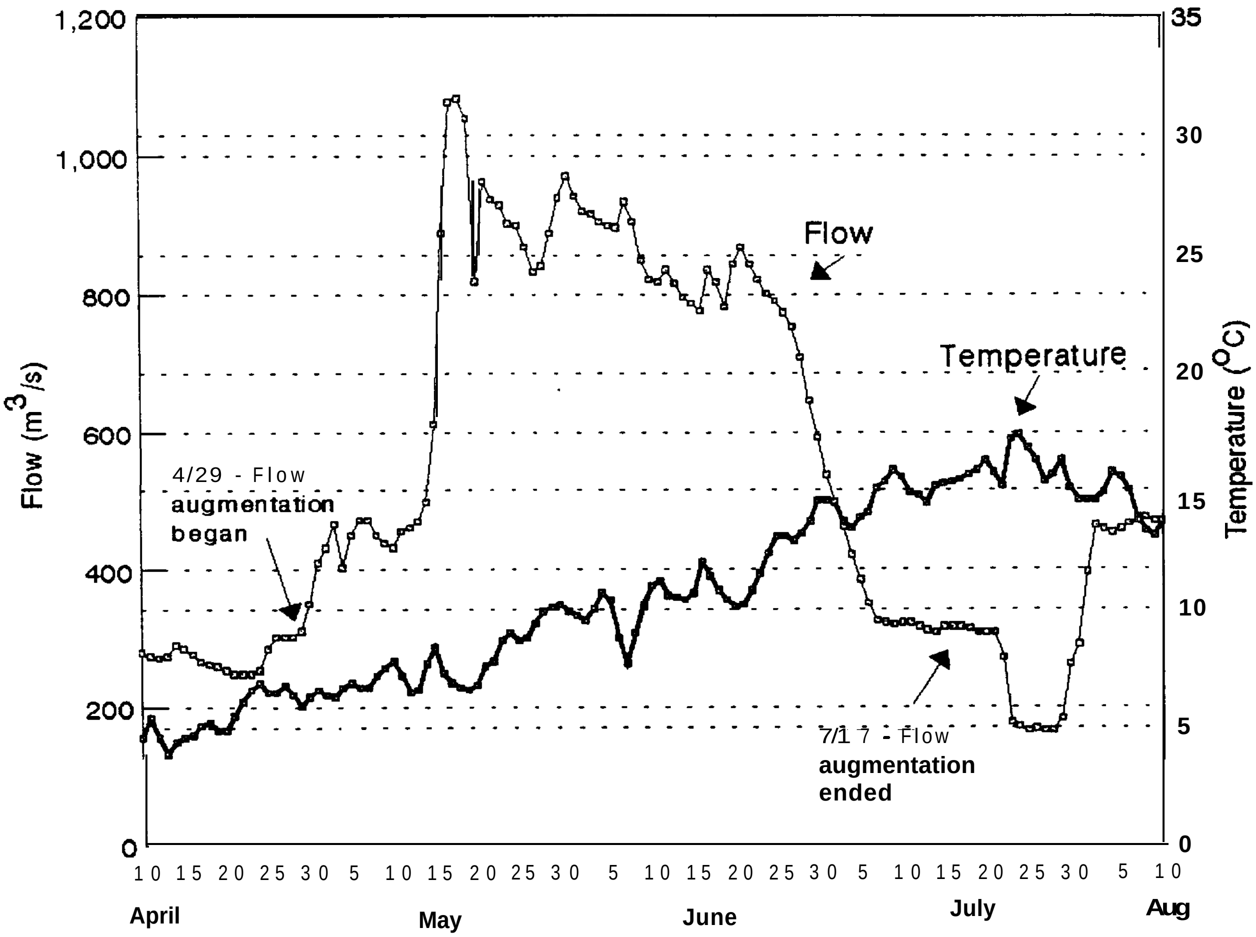

Figure 2. Temperature (°C) and flow (m^3/s) on the Kootenai River at Bonners Ferry, Idaho during 1995.

Estimated total amount of water provided for the white sturgeon study was about 1.7 million acre-feet (2.09 billion m^3) above minimum flow (113 m^3/s [4 kcfs]). Discharge from Libby Dam the day prior to the augmentation was 1 19 m^3/s (4.2 kcfs). Discharge was ramped up at about 57 m^3/s (2 kcfs/day) for three days to 283 m^3/s (10 kcfs), but daily discharge varied thereafter from about 113 m^3/s to 282.5 m^3/s (4 to 9 kcfs). Local inflow during this initial period maintained a discharge at Bonners Ferry of 425.1 to 481.7 m^3/s (15 to 17 kcfs).

When temperature was expected to approach the target of 9.0°C (48.2°F) on May 12, releases from Libby Dam were ramped up 56.6 m^3/s (2 kcfs) for two days then 170.0 m^3/s (6 kcfs) each of the following two days to reach the established discharge and start date of the test flow on May 16 (Figure 2). A drop in temperature of several degrees was noted during the rapid ramp-up of discharge.

About 566 m^3/s (20 kcfs) was released from Libby Dam for the 42-day period, but local inflow brought the peak discharge at Bonners Ferry to 1081.8 m^3/s (38.2 kcfs) on May 18. Four turbines were used at 141.7 m^3/s (5 kcfs) each while a fifth turbine was inoperable. River temperature at the peak discharge at Bonners Ferry was 6.7°C (44.1°F), but gradually increased to 10.1°C (50.1°F) by May 29 and 13.1°C (55.5°F) at the end of the test.

Several spikes of local inflow brought on natural increases in discharge at Bonners Ferry during the 42-day period, but none caused the discharge to exceed 992.1 m^3/s (35.0 kcfs) after May 20 (Figure 2). Each spike was followed by a drop in temperature and gradual rise. Starting June 17, discharges from Libby Dam were reduced at the rate of about 28.3 m^3/s (1 kcfs/day) for the following ten days. The last day of the Kootenai River white sturgeon flow regime was July 17, 1995 at 317.2 m^3/s (11.2 kcfs) at Bonners Ferry and 15.5°C (59.9°F). The maximum recorded water temperature at Bonners Ferry was 17.4°C (63.3°F) on July 24.

Adult White Sturgeon Captures

One hundred seventy adult white sturgeon were captured between August 1, 1994 and August 31, 1995; 33 by the Kootenai Tribe of Idaho for broodstock collection, 12 in a joint effort with British Columbia Ministry of Environment and Idaho Department of Fish and Game at the Kootenay River Delta in Kootenay Lake, and 125 by Idaho Department of Fish and Game researchers (Appendix A). We expended 20,033 hours of effort using nine gear types to sample 125 adults (Table 1). Fifty-nine (46.4%) of the 125 sturgeon captured by us and 1 1 (32%) of the remaining 45 fish caught with other agencies were recaptures.

In 1995, a Section 10 Permit was issued to us by the U.S. Fish and Wildlife Service for a capture of 50 adult white sturgeon. This number was exceeded because many additional adults were captured when we were targeting the capture of juvenile sturgeon.

Independent of our effort, an additional 125 adult white sturgeon were captured by the British Columbia Ministry of Environment between July 28, 1994 and July 27, 1995 (Appendix A). Thirty-six (29%) of these 125 fish were recaptures. Twenty-eight had been previously marked by us and eight by Canada.

Table 1. **Sampling effort and number of juvenile and adult white sturgeon caught in** the **Kootenai River, January 1, 1995 to August 31, 1995.**

Gear Type	Hauls	Hours of Effort	Number of Juvenile Sturgeon Caught	Number of Adult Sturgeon Caught	Juvenile CPUE (fish/h)	Adult CPUE (fish/h)
Gillnet (2.5-7.6 cm mesh)[a]	--	277	33	10	.12	.04
91 cm Hoopnet	--	262	0	--	0	--
61 cm Hoopnet	--	5,858	0	--	0	--
Minnow Trap	--	1,677	0	--	0	--
Rod & Reel[a]	--	389	3	20	.01	.05
Setlines[a]	--	10,538	7	95	.001	.01
Slat Trap	--	1,032	0	--	0	--
Seine	13	--	0	--	0	--
TOTAL	13	20,033 [b]11.204	43	125	.002	.01

a Gear targeted at adult white sturgeon.
b Total adult effort.

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We performed surgery on 28 adult sturgeon (11 females and 17 males) (Appendix B). Because mature fish were targeted for surgery, the majority were stage 7 and 8 males and stage 4 females. Sonic and radio tags were attached to seven female and six male fish during this effort.

White Sturgeon Telemetry

We monitored 38 white sturgeon with active transmitters for a total of 461.5 h from August 1, 1994 to August 31, 1995 (Figures 3 and 4). From April 1 through July 31, 1995, with 346 h of telemetry effort, 35 of the 38 transmittered fish were monitored specifically for prespawn and spawning activities. Two hundred'and eight visits were made to five sections throughout the study site during the prespawn and spawning period in 1995. Eighteen visits were focused on the section from Kootenay Lake Delta to Creston, 14 from Creston to Porthill, 36 from Porthill to Copeland, 72 from Copeland to Flemming Creek, and 68 from Flemming Creek to the confluence of the Moyie River (Figure 5).

Migration of Monitored Sturgeon in 1995

Thirteen adult males and 25 adult females carried transmitters in 1995. Two males (#'s 581, 349) and 11 females (#'s 548, 363, 378, 403, 426, 432, 436, 438, 555, 568, 569) remained in Kootenay Lake during the experimental flow release. Of the above complement of lake dwelling fish, three were tagged in 1991, two in 1992, three in 1993 and five in 1994. An additional three males and three females made brief movements out of the lake and into the lower river (Table 2). We tracked the remaining 19 fish to locations upstream of Rock Creek (rkm 215). Most of these sturgeon migrated to suspected spawning locations in the upper Kootenai River. The upriver locations and prevailing river discharge during the migration and spawning period is displayed for 15 monitored fish in Appendix C.

One female (#560) traveled up to but not beyond Rock Creek (rkm 215.8). Eighteen fish (7 males, 11 females) traveled upriver of Flemming Creek (rkm 225). Fourteen of these fish traveled within river sections where eggs were collected (rkm 229 to 240) (Appendix D). All eggs were collected between the lower end of Shorty's Island (rkm 229.0) and the Kootenai River National Wildlife Refuge (rkm 237.1). Locations of egg collections are discussed in the egg sampling section of this report.

Sturgeon Tracked to Locations Upriver of Deep Creek (rkm 240)

Three males were tracked to locations upriver of Deep Creek (rkm 240) (Table 2, Appendix C). All were predicted spawners tagged during 1995; two at Rock Creek and one at Ferry Island. After being tagged on March 20, male #621 moved 30 km downriver, and by May 13, he had returned upriver as far as rkm 241.1. Male #626 was tagged on March 29 and moved up to Lower Shorty's Island (rkm 228.7) by May 1. Then he moved between Shorty's Island and Deep Creek until June 13, traveling as far upriver as rkm 240.3. Male

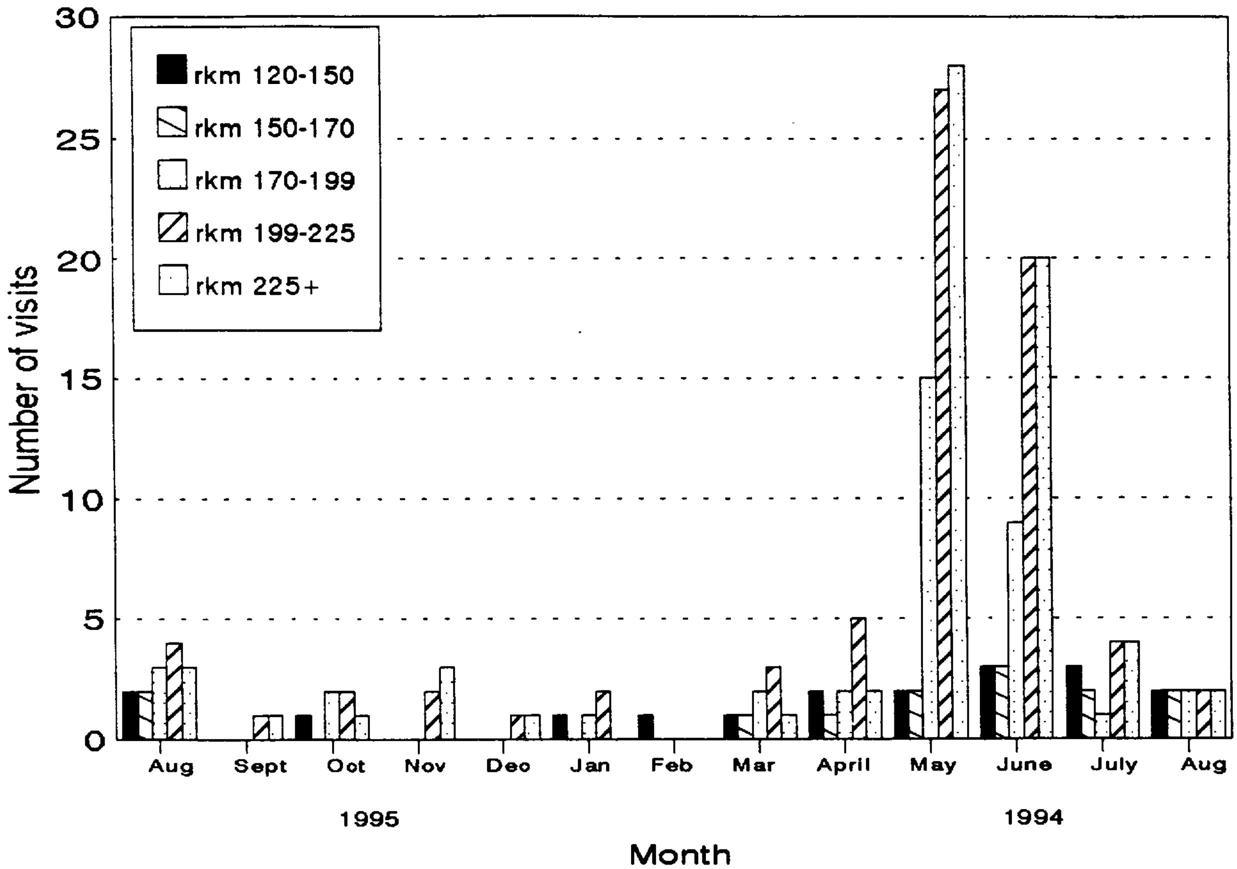

Figure 3. Telemetry effort by section on the Kootenai River for August 1, 1994 to August 31, 1995.

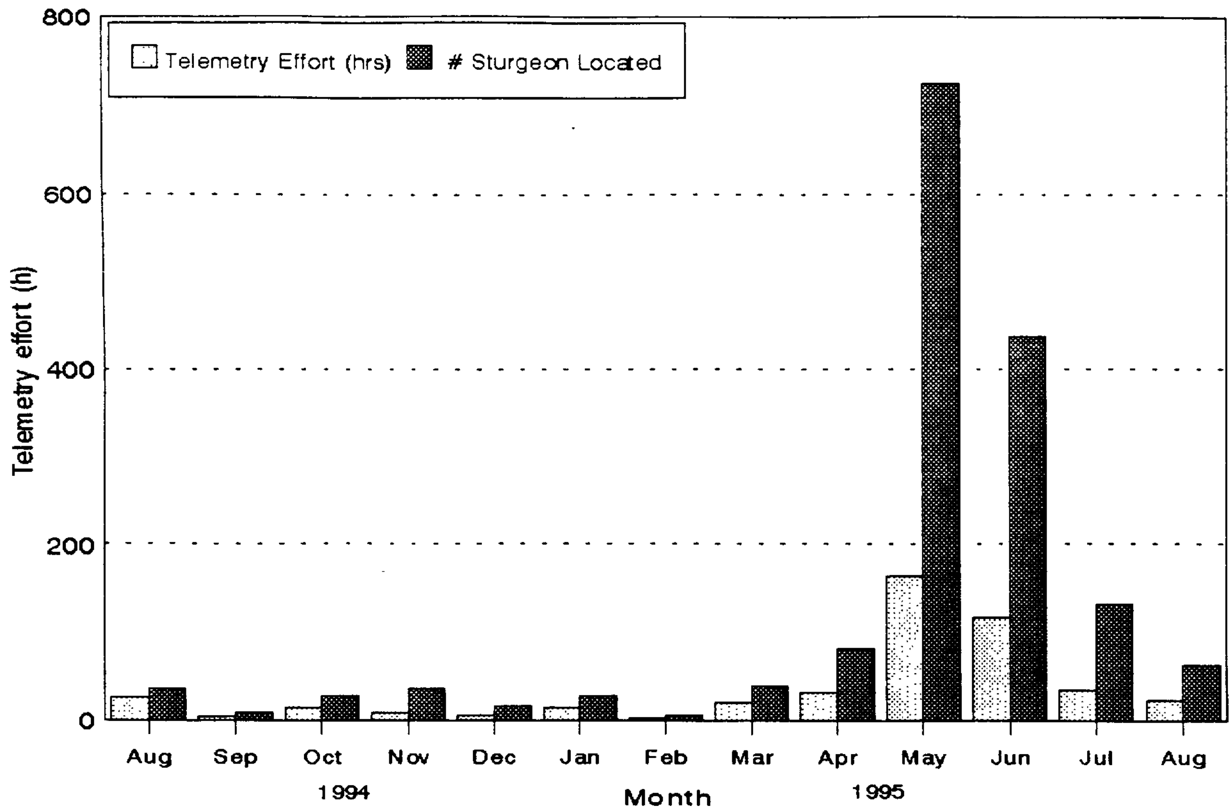

Figure 4. Telemetry effort (h) and number of white sturgeon located monthly from August 1, 1994 through August 31, 1995.

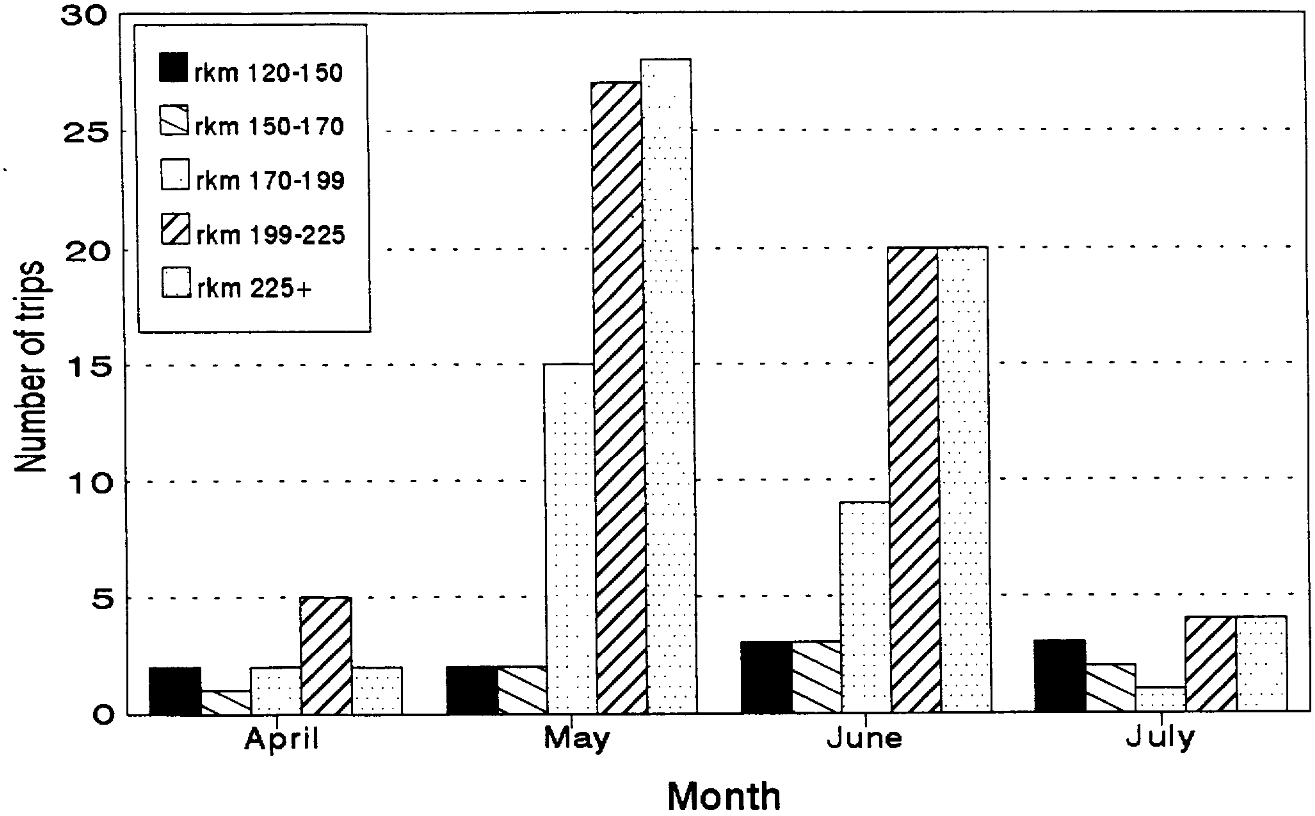

Figure 5. Telemetry effort (h) by section on the Kootenai River for April 1, 1995 to July 31, 1995.

Table 2. Upriver locations of monitored white sturgeon that moved out of Kootenay Lake during the experimental flow test, April 1, 1995 to July 31, 1995.

Fish #		Tagging Location (rkm)	Date Tagged	Highest rkm (Date)			Last Date Located Above rkm 225
Male	Female			>122≤203	>203≤225	> 225	
--	636[a]	205	4/4/95	--	4/4	243(5/29)	7/14
637[a]	--	205.3	4/4/95	--	4/4	243.8(5/31)	6/24
621[a]	--	215	3/22/95	4/12	5/14	241.1(6/3)	6/24
626[a]	--	215	3/29/95	--	--	240.3(6/10)	6/13
624[a]	--	215.4	3/24/95	--	4/12	239.8(5/24)	6/17
--	649[a]	205	4/12/95	4/26	5/25	239.5(5/31)	6/7
--	623[a]	215.4	3/25/95	4/12	5/17	238.7(5/26)	6/9
2057[a]	--	215	3/29/95	--	3/31	237.3(5/23)	5/28
335[a]	--	225.1	4/3/91	--	b	236.7(6/1)	6/24
--	163[a]	215	4/26/94	--	b	236.2(6/1)	6/1
--	628[a]	215	3/29/95	--	4/12	236.2(5/23)	5/29
585[a]	--	203	4/19/94	--	--	235.5(5/17)[b]	5/26
--	625[a]	215	3/24/95	--	4/11	234.5(5/26)	5/29
--	619[a]	215	3/20/95	--	4/12	232(5/31)	6/3
--	629[a]	215	3/29/95	5/21	4/12	234.8(5/16)	5/18
--	576	215	3/31/94	--	--	230.4(6/9)[b]	8/24
574	--	215	3/31/94	--	--	229.7(6/24)[b]	8/24
--	348	203	4/19/94	--	b	227.4(6/4)	6/13
--	560	204.9	3/18/94	--	215.8(5/17)	--	--
620[a]	--	205	3/31/95	181(4/12)	--	--	--
583	--	215.5	4/8/94	165.5(6/2)	--	--	--
565	--	193	3/19/94	140.2(7/11)	--	--	--
--	530[a]	118	2/12/94	140.2(6/22)	--	--	--
--	370	121	8/7/91	126(7/11)	--	--	--
--	550	216	3/2/94	123.6(4/17)	--	--	--
n = 11	n=14			n=6	n = 1	n=18	

[a] Suspected spawner in 1995.
[b] These fish overwintered in this river section - all others were either tagged during 1995 or overwintered in the Kootenay Lake.

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#637 was tagged on April 4 and was located at Shorty's Island on May 15. He traveled to within 0.5 km of Ambush Rock by May 31, moving between Shorty's Island and Deep Creek through June 24, then by June 28 he was in the lower river at rkm 185.5.

Female #636 was tracked upriver of Deep Creek (rkm 240) (Table 2, Appendix C). She was tagged on April 4, 1995 at Ferry Island (rkm 205). On May 24 she was located at Shorty's Island. Her upriver location was 1.5 km below Ambush Rock (rkm 243.0) on May 29. She moved between Shorty's Island and Deep Creek through July 14. By July 21 she had dropped down to Upper Krausse Hole (rkm 209.2).

Sturgeon Tracked to Locations Bevond Flemming Creek (rkm 225) but Below Deep Creek (rkm 240)

Four males (#'s 335, 585, 624, 2057) and eight females (#'s 163, 348, 619, 623, 625, 628, 629, 649) traveled to locations beyond Flemming Creek (rkm 225) but below Deep Creek (rkm 240) (Table 2, Appendix C). Two males and five females were tagged during 1995. The three remaining fish were tagged prior to 1995.

One male (#574) and one female (#576) overwintered in the river near the spawning area (rkm 229). Two females (#'s 348,163) that overwintered at Rock Creek (rkm 215) were tagged during 1994 and were also predicted spawners for 1994. They stayed below Flemming Creek throughout the 1994 flow experiment (Marcuson et al. 1995), but moved upriver with spawners in 1995. Male #585 moved up to the spawning areas in 1994 and 1995.

This group of fish began to move into suspected spawning grounds by May 7, and all had moved out by June 17. Eighty-seven eggs were collected between May 27 and June 13 at six different locations within this section (see Artificial Substrate Mat Sampling).

Sturgeon Tracked out of Kootenay Lake Delta (rkm 1221 and into the River but not Beyond Flemming Creek (rkm 225)

A female predicted to have spawned during 1994, fish #560, overwintered in the vicinity of Ferry Island, rkm 205 (Table 2, Appendix C). This fish began upriver movement during the experimental flow test, traveling as far as Rock Creek (rkm 215.8) on May 17, before she promptly returned to Ferry Island.

Three females (#'s 370, 530, 550) and three males (#'s 565, 583, 620) remained in the river below Copeland (rkm 199.5) throughout the flow test (Table 2, Appendix C). Female #530 and male #620 were predicted to spawn in 1995.

Artificial Substrate Mat Sampling

We collected 2,111 mat samples in the Kootenai River during the 1995 flow test (Table 3). The total sampling time for egg mats was 78,662 hours to collect 163 eggs in 12 river sections. Egg collection catch effort was 0.002 eggs/h.

Artificial substrate mat depth ranged from 0.9 to 22 m (3 to 71 ft) for all mats and 8 to 16 m (25 to 51 ft) for mats that collected eggs. Average set time for all mats was 38 hours and 32 hours for mats containing eggs. Average temperature at egg collection sites was 11.3°C. Surface velocities at 35 of 37 egg collection sites ranged from 0.12 to 0.61 m/s (0.4 to 2.0 ft/s) and averaged 0.21 m/s (0.7 ft/s). Velocities near the river substrate ranged from 0.06 to 1.2 m/s (0.2 to 3.9 ft/s) and averaged 0.18 m/s (0.6 ft/s) (Appendix E).

One hundred and sixty-three white sturgeon eggs were collected from 37 individual substrate mats at 16 different locations during 1995. The majority (71 eggs) were collected in the Myrtle Creek section from rkm 233.5 to 234.7. Sixty-three eggs were collected in the middle Shorty's Island section (rkm 229.6 to 231.5). Sixteen eggs were collected in the Wildlife Refuge section (rkm 234.8 to 237.5). Thirteen eggs were collected in the lower Shorty's Island section (rkm 228.0 to 229.5). No eggs were collected between Rock Creek and Flemming Creek (rkm 215 to 225.5) in the upper Shorty's Island section (rkm 231.6 to 233.4) or in sections above the Wildlife Refuge (rkm 237.6 to 246.6) (Appendix E).

The three largest egg collections from individual mat samples took place June 16 at rkm 234 (43 eggs), June 13 at rkm 237.1 (12 eggs), and June 15 at rkm 231.1 (13 eggs) (Figure 6, Appendix F). Flows on these collection dates were fluctuating around 800 m^3/s (28.2 kcfs). Other mat samples yielded from 1 to 11 eggs each.

One hundred and twenty-seven (78%) of the 163 white sturgeon eggs were viable. Stages of egg development and date of fertilization were estimated. Development ranged from stage 12 to 25, with 80% of the eggs at stage 20 or earlier (Appendix F). Back-calculation of viable eggs indicated white sturgeon spawned during a minimum of 16 days of the 42-day test flow in 1995. Three distinct spawning intervals were noted; May 22 to 23, May 27 to June 6, and June 11 to 13, 1995 (Figure 7, Appendix F). Most eggs were probably captured soon after spawning events because 77% of the eggs were less than a day old, 6% were 25 to 48 hours old, 12% were 49 to 72 hours old, and only one egg was older (< 1%). The oldest egg was estimated at 107 hours old, or about 4.5 days.

Juvenile White Sturgeon Sampling

Between August 1, 1994 and August 31, 1995, 16,622 hours of sampling effort was directed at collecting juvenile white sturgeon (≤ 120 cm TL, ≤ 115 cm FL) with ten gear types (Table 1). A total of 43 juvenile white sturgeon, ranging in length from 30 to 102 cm FL and 35 to 120 cm TL, were captured (33 in gill nets, 3 by rod and reel, and 7 on set lines) (Appendix G). Hoop nets, minnow and slat traps did not capture any sturgeon. Thirty-four fin ray samples were taken for age verification.

Table 3. **Location, depth, effort and white sturgeon egg catch of artificial substrate mats, Kootenai River, Idaho, 1995.**

Geographical Description	River Location (rkm)	Number of Mat Samples	Average Depth (m)	Total sample hours	Number white sturgeon eggs
Rock Creek	215.0-21 6.0	171	45	4,080	0
Lower Flemming Creek	222.6-224.5	48	28	1,104	0
Flemming Creek	224.6-225.5	85	4 9	2,041	0
Lower Shorty's Island	228.0-229.5	428	35	13,779	14
Middle Shorty's Island	229.6-231.5	466	32	15,051	62
Upper Shorty's Island	231.6-233.4	82	35	2,977	0
Myrtle Creek	233.5-234.7	72	37	2,760	71
Refuge	234.8-237.5	223	30	14,402	16
Deep Creek	237.6-240.5	128	30	3,625	O
Hatchery	240.6-243.9	65	27	2,978	O
Ambush Rock	244.0-244.6	66	38	4,249	O
US 95	244.7-246.6	277	20	11,617	O
ALL SECTIONS	215.0-246.6	2,111	33	78,662	163

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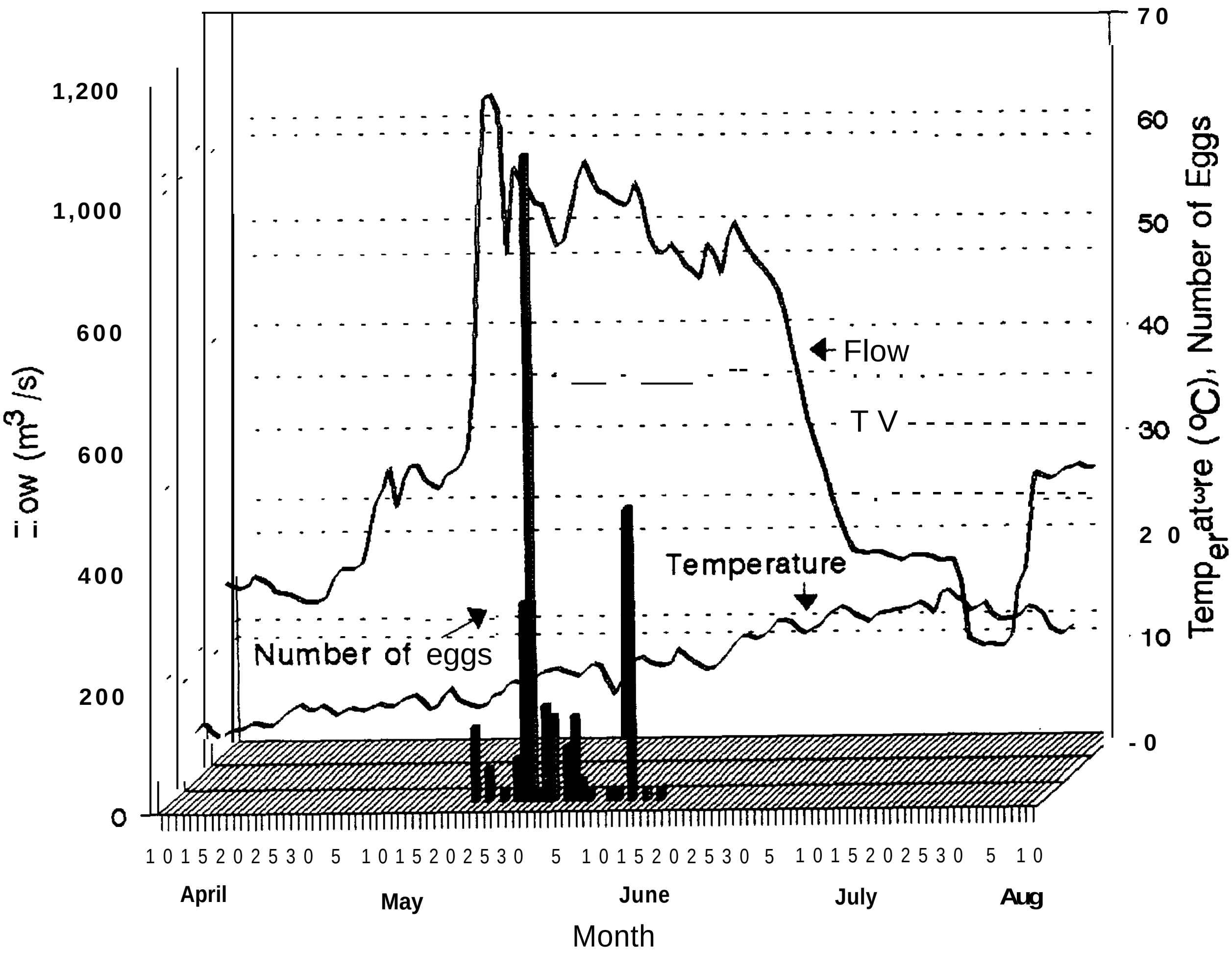

Figure 6. **Collection date, number of eggs (n = 163), temperature (°C), and flow (m^3/s) on the Kootenai River at Bonners Ferry, Idaho, during 1995.**

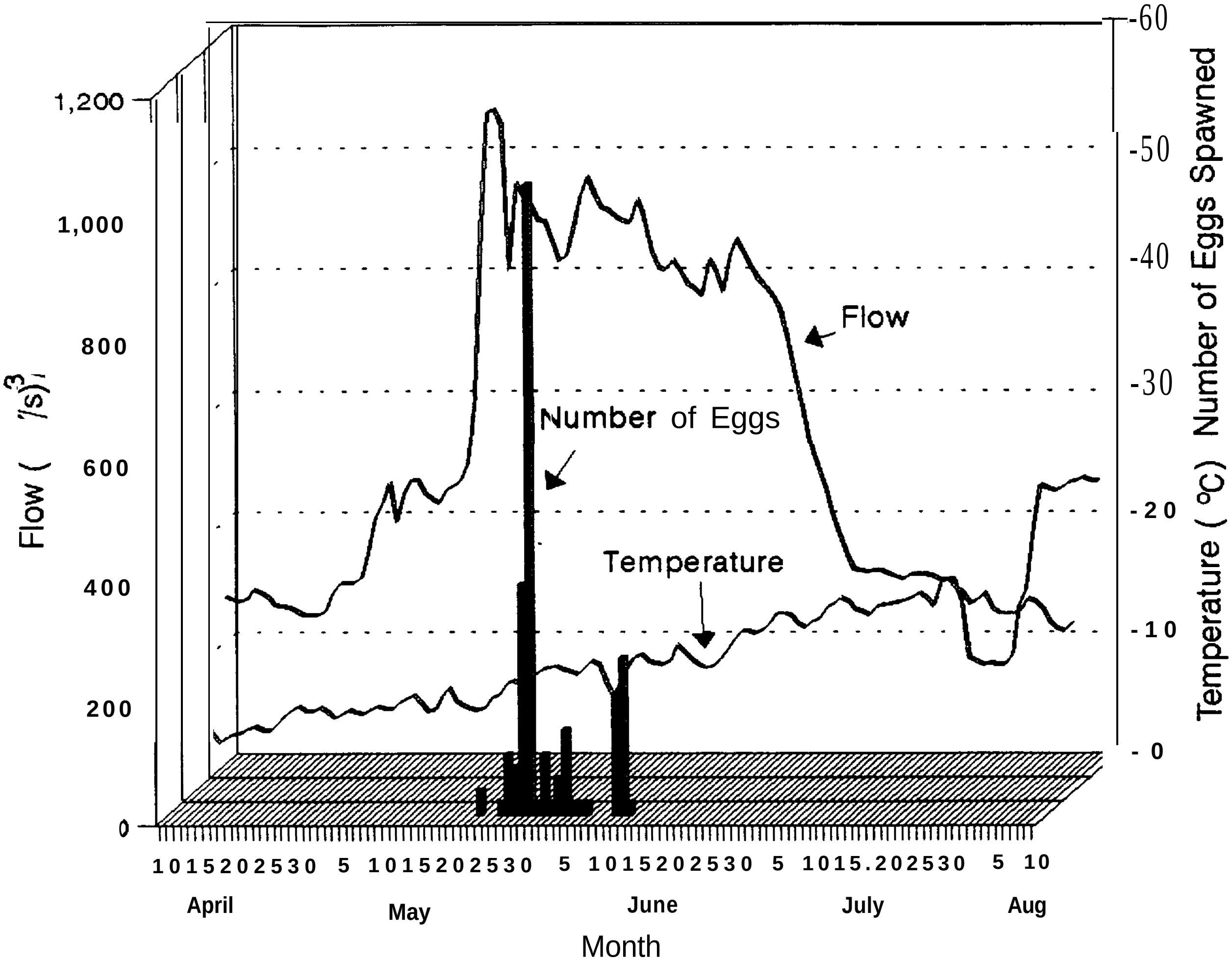

Figure 7. Spawning date, number of eggs spawned (n = 127), temperature (°C), and flow (m³/s) on the Kootenai River at Bonners Ferry, Idaho during 1995.

Thirty-six (84%) of the 43 small sturgeon were recaptures (31 hatchery and 5 wild). Fifteen of the hatchery recaptures were from brood year 1992 and stocked in 1994; and 15 were from brood year 1991 and stocked in 1992. One fish (brood year 1992), assumed to be a hatchery fish, had a PIT tag but no record of the year it was stocked (Appendix G). Three of the wild recaptures were actually small adults originally marked in 1989; one was captured three times in 1995. Five unmarked juveniles were small adults and two were wild juveniles.

Juvenile sturgeon were caught in water ranging from 28 to 65 feet deep, the majority being captured in deep holes at Rock Creek (rkm 215) and Flemming Creek (rkm 225). Wild and hatchery fish appeared to congregate in groups, as several were often caught together in gill nets.

We examined predator fish stomachs during spawning and juvenile sampling. No sturgeon larvae or eggs were found in any of the stomachs of other fish species captured. This task was also carried out by the Kootenai Indian Tribe of Idaho (Anders, in progress).

Juvenile White Sturgeon Telemetry

Nineteen hatchery-released juvenile sturgeon were tracked from the time they were released in the fall of 1994 (Marcuson et al. 1995) until August 31, 1995. All fish were either released below Bonners Ferry or had moved into the river below town by late October 1994. Two fish migrated to the Kootenay River Delta after release. The remaining 17 stayed between rkm 195.7 and 245. None of these juveniles made extreme movements up or downriver during the experimental flow test. Four of the 19 radio-tagged juveniles were recaptured during juvenile sampling.

Age and Growth of Adult White Sturgeon

Length measurements of adult sturgeon ranged between 121 to 245 cm TL (47.6 to 96.5 in) and 108 to 212 cm FL (42.5 to 83.5 in). A length frequency histogram of these fish was graphically similar to histograms from 1989 through 1994 (Figure 8). Forty-four of the 48 fin rays taken from adult sturgeon were ageable. Ages of these adult sturgeon ranged from 15 to 44 years (Appendix H). These adults were all from 1980 or prior year classes. Seventeen percent of the 44 adult sturgeon aged in 1995 were from year classes following the construction of Libby Dam.

Growth rates of adult sturgeon captured between 1978 and 1980 averaged 3.3 cm TL (1.32 in) per year (SD=6.2) (Marcuson et al. 1995). Over the seven-year period from 1989 to 1995, 750 adult fish were caught. Fish were identified with Floy tags, PIT tags, or both. Growth rates were calculated from 126 recaptures with known fork lengths and 125 recaptures with known total lengths. Growth rates averaged 1.1 cm/year FL (0.4 in) and 1.8 cm/year TL (0.7 in) (SD = 5.9 for FL and 6.1 for TL). Time intervals for measurements ranged

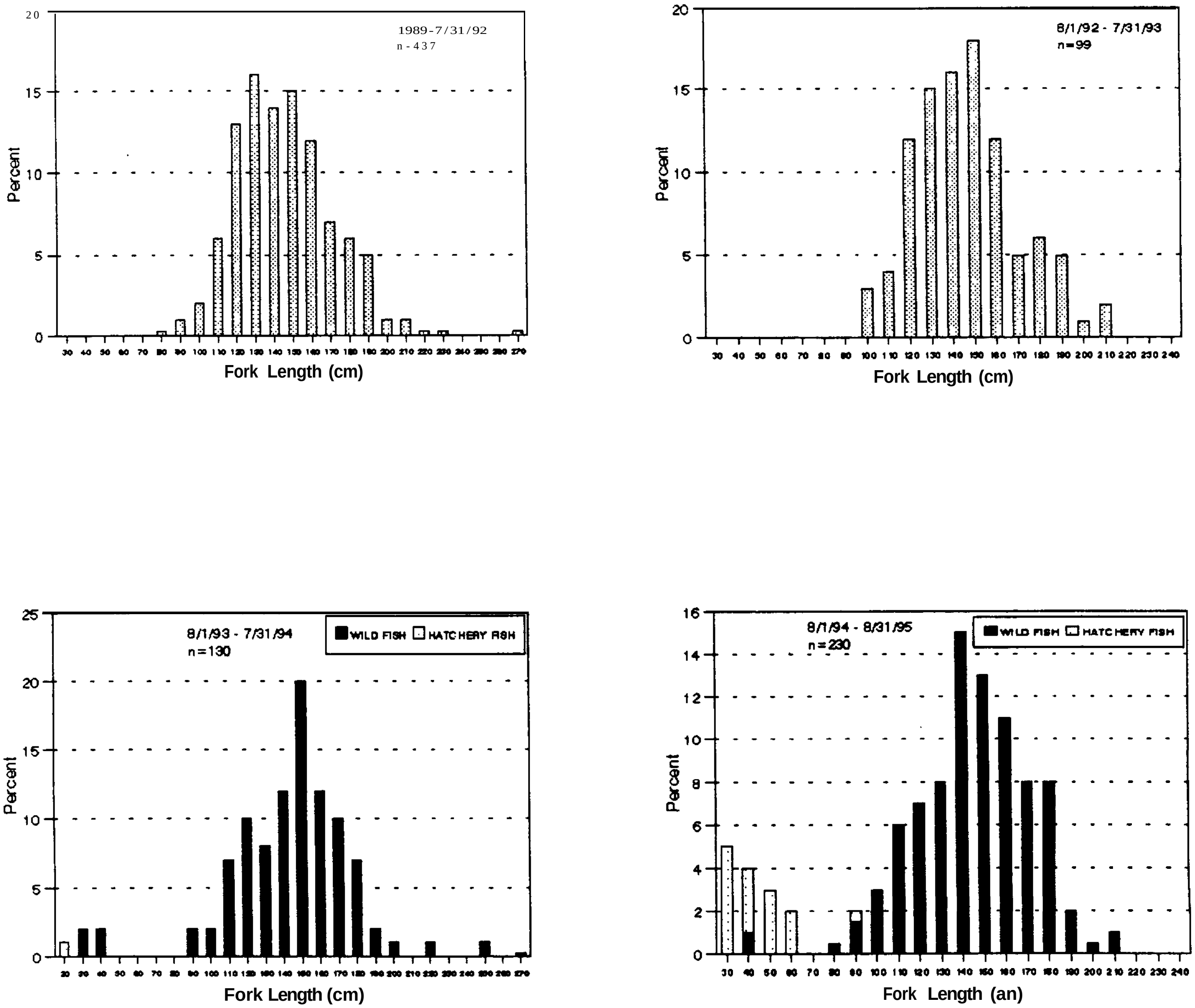

Figure 8. **Length frequencies of Kootenai River white sturgeon captured from 1989 to August 1, 1995.**

from 26 to 2,302 days. The maximum measurable annual growth was 32 cm FL (12.8 in) and 30 cm TL (12 in).

Twenty-five adult fish were captured more than once during the two periods of the study (1978 through 1982 and 1989 through 1994). Fifteen were caught two times, five were caught three times, two were caught four times, two were caught six times, and one fish was captured seven times. Using both fork and total length, growth for these fish averaged 3.0 cm (1.2 in) per year (SD = 1.1). Intervals between multiple captures ranged from 2,610 to 5,536 days. Calculated growth (FL and TL) ranged from 0.8 to 5.5 cm (0.3 to 2.2 in) per year. These fish should have had ample time between capture and recaptures to compensate for any influence of the fish's behavior due to the stress of handling and marking.

Age and Growth of Juvenile White Sturgeon

Lengths of juvenile white sturgeon captured between August 1, 1994 and August 31, 1995 ranged from 30 to 90 cm (1 1.8 to 35.4 in) (Figure 8). Ages of 10 wild juvenile sturgeon ($\leq$ 120 cm TL, $\leq$ 115 cm FL) ranged from 4 to 28 years, placing them into year classes between 1975 and 1991. Fin ray sections from 25 hatchery juveniles were used for verification of accuracy in aging procedures. Of the 25 hatchery juveniles, 13 were age 4 from the 1991 year class and 12 were age 3 from the 1992 year class (Appendix H).

After aging six of the eight larger wild juveniles (as defined by length), we discovered they were actually old enough to be adults ranging from 12 to 28 years (Table 5). Four of these fish were captured at least twice since 1989, two of them having been captured twice between August 1, 1994 and August 31, 1995. The remaining two wild juvenile sturgeon were age four, from the 1991 year class (Table 4 and 5).

Growth rates were calculated from lengths of 27 juvenile white sturgeon that were captured more than once. Average growth per year was 4.92 cm FL (1.9 in) (SD = 3.99) and 6.52 cm TL (2.6 in) (SD=3.86). Growth rates for 7 small adults that were in the juvenile length category were 2.23 cm/year FL (0.9 in) (SD = .95) and 2.43 cm/year TL (1.0 in) (SD = 1.43).

DISCUSSION

Monitoring of the 1995 test flow indicated Kootenai River white sturgeon spawned, but we are still uncertain as to the survival of eggs and larvae. At the onset of local runoff and augmented discharge from Libby Dam, sturgeon migrated upstream in the Kootenai River. Sturgeon spawning commenced at about 9.5°C (49.1°F) on May 22 and continued through June 17. Sturgeon spawned on at least 16 days within that period. Spawning coincided with relatively stable flows ranging from 776 m^3/s to 963 m^3/s (27.4 to 34 kcfs). The maximum discharge at Libby Dam during this test flow was only 567 m^3/s (20 kcfs), while the requested amount was a minimum of 708 m^3/s (25 kcfs). The requested value could not be met in 1995 because the fifth turbine was under repair. Historic springtime flows before Libby Dam during May to July ranged from about 1,416 m^3/s (50 kcfs) to nearly 2,832 m^3/s (100 kcfs).

Table 4. Length, age and brood year of wild juvenile white sturgeon captured in the Kootenai River, Idaho, August 1, 1994 to August 31, 1995.

Fish #	Date of Capture	Length at Capture FL/TL (cm)	Age	Brood year
3255	7/25/95	40/48	4	1991
3249	7/28/95	45/51	4	1991

Table 5. Age and growth of small adult white sturgeon that fit the length definition of juvenile sturgeon captured in the Kootenai River, Idaho, August 1, 1994 to August 31, 1995.

Fish #	Date of Capture #1	Length at Capture #I (FL/TL cm)	Age	Date of Capture #2	Length at Capture #2 (FL/TL cm)	Age	Date of Capture #3	Length at Capture #3 (FL/TL cm)	Age
587	4/I 5195	92/I 06	ND	5/9/95	92/109	ND	7/5/95	95/109	ND
20	4/1 2/89	88/1 10	12	3/30/95	100/117 1	8			
212	9/26/89	104/1 18	15	7/24/95	113/120 2	1			
645	4/6/95	86/1 00	12						
3257	7/25/95	95/1 04	18						
3253	7/24/95	97/1 02	15						
622	3/24/95	94/1 08	15						
68	6/7/89	95/1 09	22	8/20/94	102/120	27	4/5/95	102/120	28

Although, it is encouraging that sturgeon responded to and spawned during the test discharges in 1994 (Marcuson et al. 1995) and 1995. A higher discharge is still necessary to replicate the 1974 and 1991 discharge at Bonners Ferry that produced the two most important cohorts since completion of Libby Dam. Thus, the test flow was still far below what is believed to be the necessary peak total discharge of about 1,416 m^3/s (50 kcfs) for suitable sturgeon spawning, available habitat, and survival of eggs and larvae.

Still remaining are questions as to the suitability of the location of spawning in 1994 and 1995 and survival of eggs and larvae, and the affect of handling stress caused by the angling of adults for brood fish. A search for a technique to document the abundance of larval or YOY sturgeon in a companion study failed to produce evidence of survival (Chapter 2). Numerous types of active and passive gears were used in all habitats. We still need to search for young sturgeon recruitment.

Kootenai River white sturgeon spawning during 1994 and 1995 took place in habitat thought to be unsuitable by Columbia River standards. Parsley and Beckman (1994) created microhabitat criteria curves depicting the suitability of temperature, water depth, mean column velocity, and substrate. Clean cobble, boulder, and bedrock was the most suitable substrate, whereas Kootenai River white sturgeon spawned over sand in 1994 and 1995. The most suitable mean column velocity ranged from 1.5 to 2.3 m/s (4.9 to 7.5 ft/s) in the Columbia River, but Kootenai River white sturgeon spawned in velocities from 0.1 to 0.6 m/s (0.3 to 2.0 ft/s) (Figure 9). Kootenai River white sturgeon spawned at temperatures ranging from 7.0oC to 17°C (44.6°F to 62.6°F) from 1991 through 1995 (Figure 9), while the majority of spawning in the Columbia River took place at warmer temperatures of 12°C to 17°C (53.6°F to 62.6°F). Water depths of at least 4 m (13 ft) are the only similarities in egg collection sites, but water depth may be the least important variable. It is not known if the disparity in habitat for spawning by Kootenai River white sturgeon and their counterparts in the Columbia River are due to evolutionary traits for survival, or that sturgeon in the Kootenai River spawned in less suitable habitat because they are compelled to.

The 1995 test discharge may have been compromised by the capture of brood stock by the Kootenai Indian Tribe of Idaho during the study. Nearly 50 adult sturgeon were captured and examined for suitability as broodstock for the hatchery while the study was taking place. A total of nine adult sturgeon were removed from the river and brought into the hatchery; six males and three females. Marcuson et al. (1995) cautioned that past activity of this nature may have influenced the extent of spawning in 1993 when only two eggs were collected. In addition, the only known female in the vicinity of suitable spawning habitat (Ambush Rock) in 1995 was removed from the river and brought into the Kootenai Tribal Hatchery. We believe the excessive stress caused by angling during a spawning run may cause unnatural behavior. The continued capture of broodstock during the flow tests is undesirable and may only delay a valid evaluation of test flows for white sturgeon spawning.

The shape of the spring hydrograph in the Kootenai River may be important to sturgeon spawning. Examination of spring through summer hydrographs for 1991 through 1995 showed some similarities in flow attributes in some years (Figure 10). The years 1992 and 1993 showed several similarities that did not prove beneficial for sturgeon migration. These two years demonstrated rapid rises in discharge caused by local runoff, soon followed by rapid reduction in flow, and then with a ramp up period that we thought was insufficient for sturgeon spawning. Adult sturgeon telemetry during these two years indicated sturgeon were

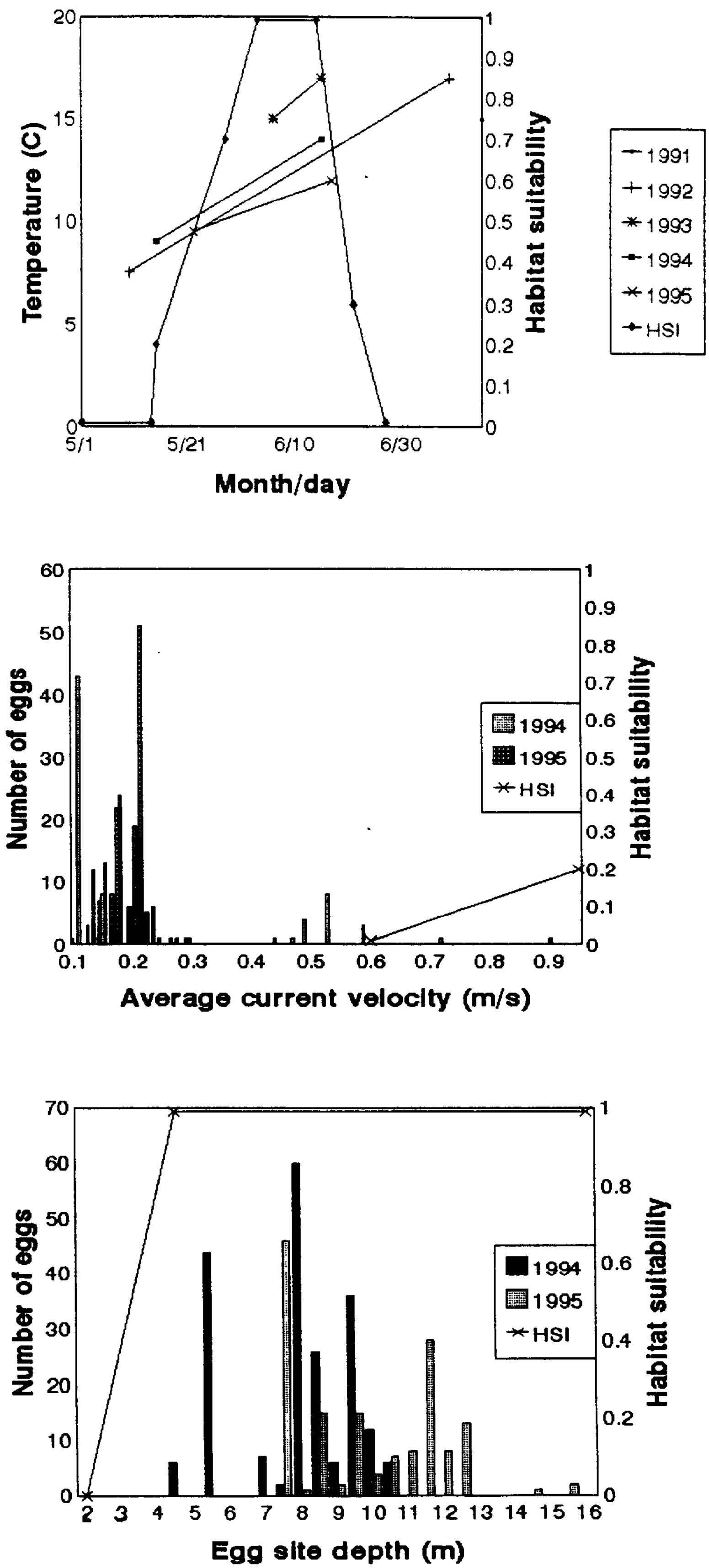

Figure 9. Habitat suitability curves (Parsley and Beckman 1994) and habitats utilized by white sturgeon in the Kootenai River, Idaho, 1991-1995. Top figure is temperature, middle figure is average current velocity, and bottom figure is depth.

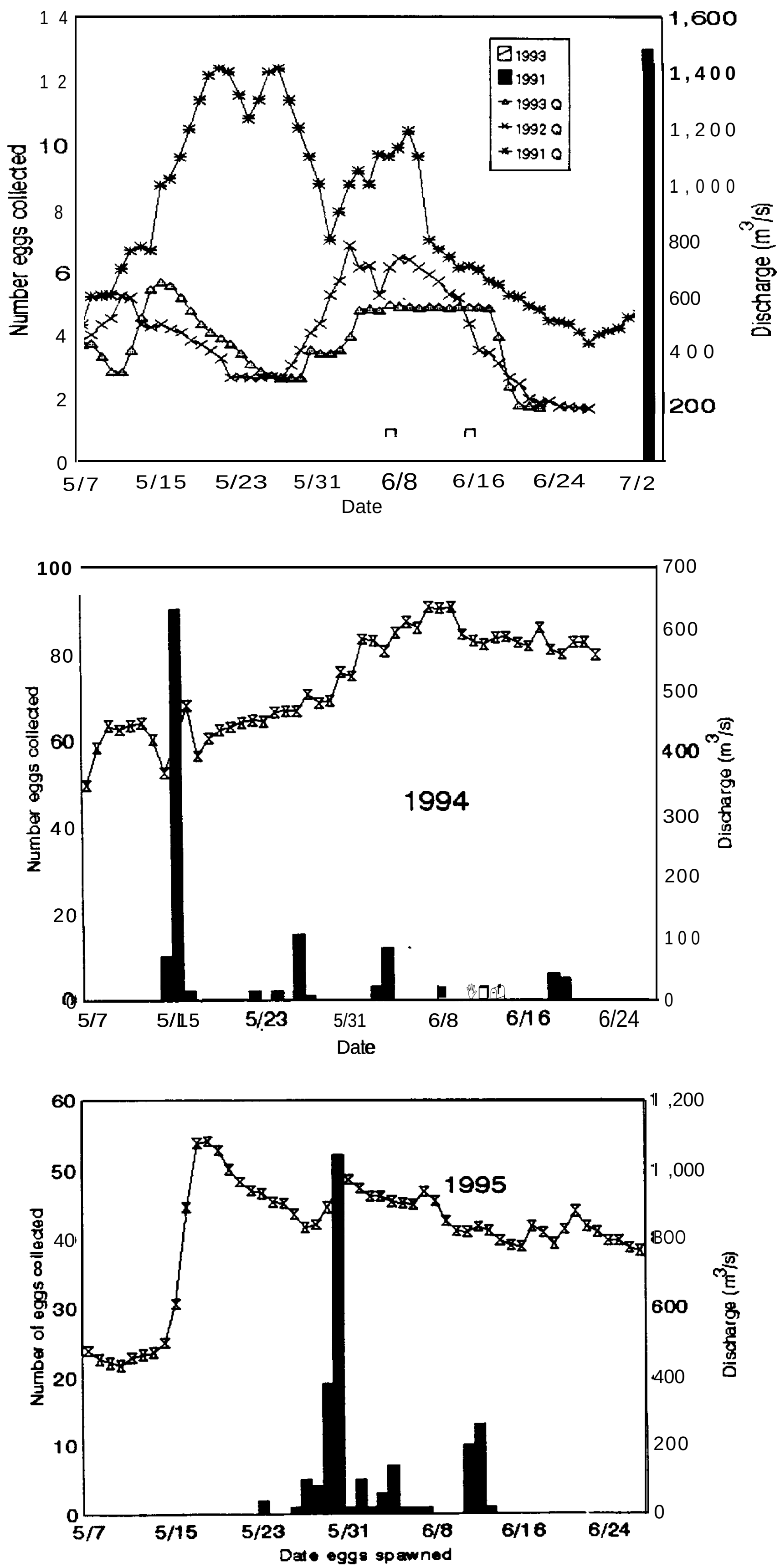

Figure 10. Top figure is date eggs were collected, number of eggs collected, and discharge for 1991-l993. Middle figure is date eggs were spawned, number of eggs collected, and discharge for 1994. Bottom figure is date eggs were spawned, number of eggs collected, and discharge for 1995.

drawn to spawning areas, but withdrew to the lower river and lake when the hydrograph began to fail. When river discharge increased, half each of the female and male component did not return (Apperson 1993; Marcuson et al. 1994). The former condition was avoided in 1994 and 1995, and substantially more eggs were collected even though discharge remained low by natural standards. It should be noted that sampling effort also increased in 1994 and 1995. The most recent successful years for sturgeon reproduction and survival since 1974 was 1991. Heavy spring rains in June brought two peaks in discharge at Bonners Ferry, both at about 1,445 m^3/s (51 kcfs). The hydrograph was very similar to a natural distribution with a rise in flow with low and high elevation runoff. Although there was a rapid decline in discharge after June 19, it did not drop below about 808 m^3/s (28 kcfs), and was soon followed by a second rapid rise to well over 1 ,133 m^3/s (40 kcfs).

We compared a length frequency distribution of Kootenai River white sturgeon and noted several important characteristics in the distribution from the late 1970s to the 1990s (Partridge 1983, Apperson 1992) (Figure 8). Most of the population is comprised of adult sturgeon as expected. The distribution has been moving gradually to the right as fish age. The typical recruitment of younger cohorts is nearly nonexistent, though not absent. At least eight year classes of sturgeon have joined the distribution since Libby Dam was constructed (Appendix H), including the 1974 year class which has fully recruited to the sampling gear. Evident too is the recruitment of the wild/hatchery component of the population from the 1991 year class. The proportion of large fish in comparison to a population in the Columbia River is substantially higher (Beamsderfer et al. 1989). This fact is most likely due to the protection of older harvestable fish in the Kootenai River from exploitation (harvest has been illegal since 1984) and lack of small fish.

Small mesh gill nets (25.4 to 50.8 mm [1 to 2 in]) have proven effective in capturing and measuring the abundance of juvenile white sturgeon in the Kootenai River. Two hundred and five juvenile white sturgeon were released from the Kootenai Tribal Hatchery from 1991 to 1994. Sampling with small mesh gill nets in 1994 and 1995 resulted in the catch of 4 and 25 sturgeon, respectively. Prior to 1994, a single hatchery fish was caught in a baited hoop net (Paragamian 1994). Lack of identifying marks indicated small mesh gill nets documented the presence of 4 wild white sturgeon in 1994 and 2 in 1995, these fish were all of the 1991 cohort. Age analysis of subsamples of hatchery and all wild fish indicated they first recruited to the small mesh gill nets at age 3. Therefore, until a method is developed to adequately sample larval sturgeon, it will take a minimum of three years to fully evaluate each test flow.

Arguments continue as to the status of the Kootenai River white sturgeon population: whether or not the population is stable or on the decline. Partridge (1983) estimated a total population of 1,148 fish (907 to 1,503, 95% C.I.) from Porthill to Bonners Ferry, while ten years later Apperson (1992) estimated 880 fish (638 to 1,211, 95% C.I.) within the Bonners Ferry to Kootenay Lake reach. Since Partridges' estimate fell within the 95% C.I. of Apperson's, it could be assumed that there has been no change since the first estimate. To confound both estimates, it is now known from telemetry studies that white sturgeon appear to move quite freely between the Kootenai River and Kootenay Lake. In addition, at least eight cohorts have recruited to the population since construction of Libby Dam, although many of these cohorts are very weak (Appendix H). Thus, we recommend a system-wide population estimate be made in 1996 using the mark and recaptures of white sturgeon in our present data base from 1989 through 1996 to determine the estimate of the total population.

Our goal is to stimulate Kootenai River white sturgeon migration, spawning, and recruitment. The end result is a self-sustained white sturgeon population. Recent test discharges appear to have stimulated spawning. But because the fate of eggs and larvae remain unknown, we believe augmented discharge from Libby Dam should be 708 m^3/s (25 kcfs). An equal amount of local inflow would provide 1,416 m^3/s (50 kcfs) at Bonners Ferry. Local inflow is totally dependent on natural phenomenon. This magnitude of discharge would replicate the 1991 discharge (Figure 9) that produced the last notable cohort. It is also the lowest discharge since Libby Dam became operable to produce a cohort. Much of the decision to initiate the augmented flow to stimulate sturgeon spawning will be based on the migration behavior of sturgeon and rise in river temperature to 10°C (53.6°F) in 1996. We acknowledge there should be continued consideration of gas saturation at the dam and the concern for downstream landowners.

RECOMMENDATIONS

1. On or about April 15 (when water temperature is about 8°C (46.4°F), maintain a minimum spring runoff of 425 m^3/s (15 kcfs).

2. Provide between 708 m^3/s (25 kcfs) from Libby Dam for 42 days when water temperatures approach 10°C to 12°C (40°F to 53.6°F).

3. Provide discharge of 311.5 m^3/s(11 kcfs) for 30 additional days in July to early August. We believe it is needed to maintain sufficient habitat for rearing of larval sturgeon.

4. Calculate a system-wide population estimate of white sturgeon based on mark and recaptures of adult white sturgeon from 1993 through 1996.

5. Develop a standardized sampling regimen for juvenile white sturgeon based on time of year, location, and effort using small mesh gill nets. With this standardized sampling design researchers should be capable of detecting statistical differences in cohort abundance.

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APPENDICES

Appendix A. Number of adult and juvenile sturgeon caught, recaptures and effort for agencies involved in white sturgeon sampling from August 1, 1994 to August 31, 1995, Kootenai River and Kootenay Lake, Idaho and British Columbia, Canada.

Agency Name	Number of Fish Caught	CPUE (fish/h)	Number of Recaptures (%)
Idaho Fish and Game	168	.008[b]	59 (46.4)
Kootenai Indian Tribe of Idaho	33	ND	7 (21)
BC Ministry of Environment	126[a]	ND	37 (29)
Interagency Effort	12	ND	4 (33)

a Data for BC was collected between 28 July 1994 and 27 July 1995.
b Includes all gear types for juvenile and adult sampling.

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Appendix B. **Sexual development of white sturgeon sampled by IDFG in the Kootenai River, Idaho, 1989 through 1995.**

Categories of Sexual Development		Percent (number) of Sample by Year						
Category/Sex	Description of Development	1989	1990	1991	1992	1993	1994	1995[1]
O/Unknown	Gonad undifferentiated or not seen	32 (58)	14 (15)	6 (3)	2 (1)	0	24 (14)	0
1/Female	Previtellogenic: No visual signs of vitellogenesis; eggs present but have average diameter <0.5 mm	14 (25)	12 (13)	8 (4)	12 (5)	0	5 (3)	11 (3)
2/Female	Early vitellogenic: Eggs are cream to gray; average diameter 0.6-2.1 mm	7 (12)	7 (8)	4 (2)	2 (1)	5 (1)	2 (1)	0
3/Female	Late vitellogenic: Eggs are pigmented and attached to ovarian tissue; average diameter 2.2-2.9 mm	6 (10)	5 (5)	8 (4)	9 (4)	53 (10)	2 (1)	0
4/Female	Ripe: Eggs are fully pigmented and detached from ovarian issue; average diameter 3.0-3.4 mm	2 (3)	5 (5)	4 (2)	9 (4)	11 (2)	14 (8)	25 (7)
5/Female	Spent: Gonads are flaccid and contain some residual fully pigmented eggs	3 (5)	1 (1)	2 (1)	0	5 (1)	0	3.5 (1)
G/Female	Previtellogenic with attritic oocytes: Eggs present but have an average diameter < 0.5 mm; dark pigmented tissue present that may be reabsorbed eggs	2 (3)	0	0	0	0	0	0
R/Female	Reabsorbing eggs	0	0	0	2 (1)	0	0	0
7/Male	Non-reproductive: Testes with translucent smokey pigmentation	3 (6)	27 (30)	29 (15)	26 (11)	0	19 (11)	36 (10)
8/Male	Reproductive: Testes white with folds and lobes	32 (58)	28 (31)	18 (9)	16 (7)	21 (4)	35 (20)	21 (6)
S/Male	Ripe: Milt flowing; large white lobular testes	0	3 (3)	14 (7)	21 (9)	5 (1)	0	0
S/Male	Spent: Testes flaccid; some residue . of milt	0	0	8 (4)	0	0	0	3.5 (1)

1 Surgeries during 1995 were carried out on fish that externally appeared to be candidated for spawning. In previous Years, surgeries were more randomly distributed among fish > 130cm.

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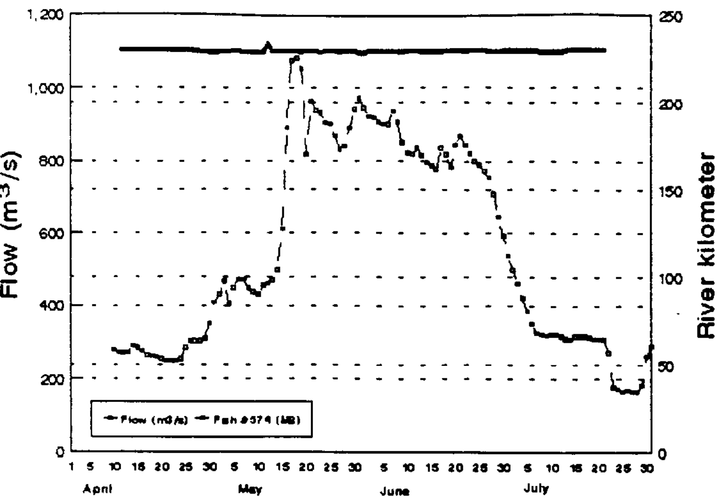
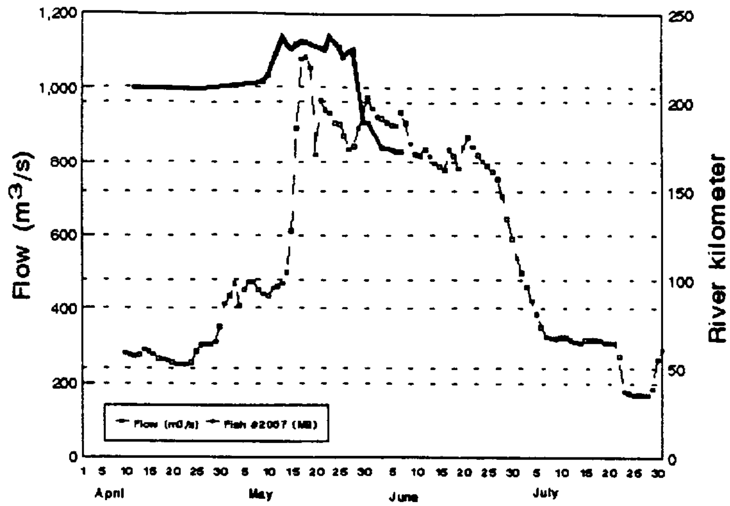
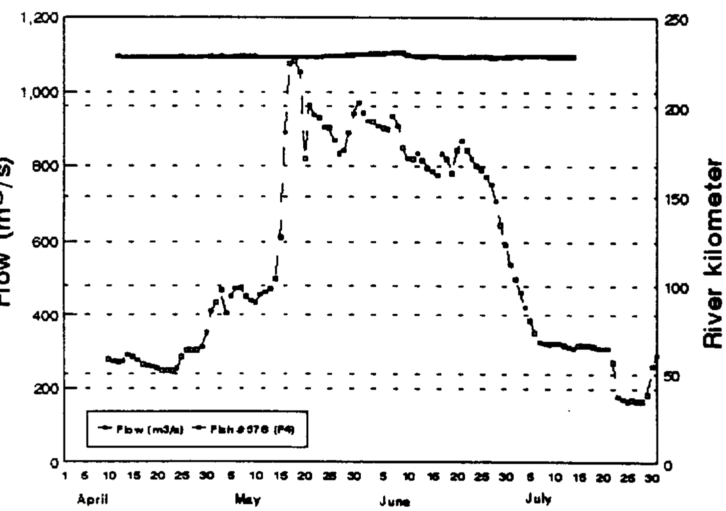
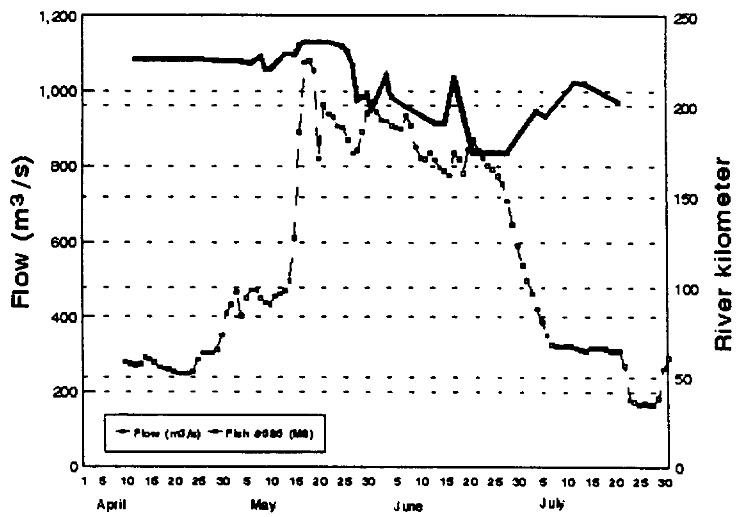
Appendix C. Flows (m^3/s) and migration behavior of white sturgeon April 1, 1995 to July 31, 1995, Kootenai River, Idaho. Fish #'s 574, 2057, 576, 585.

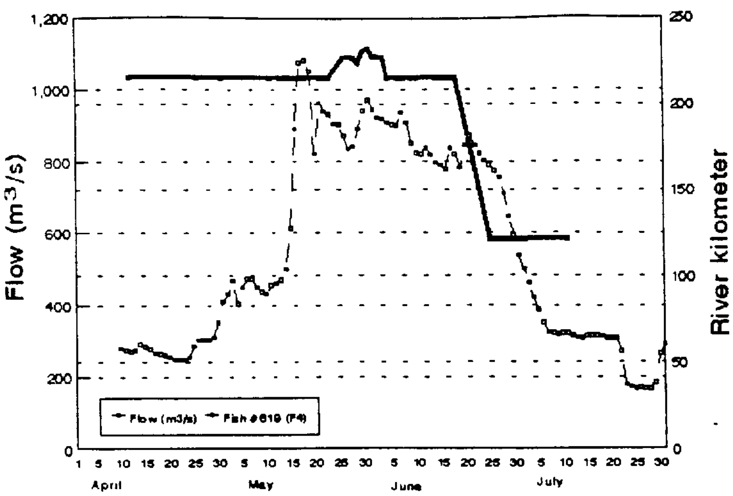


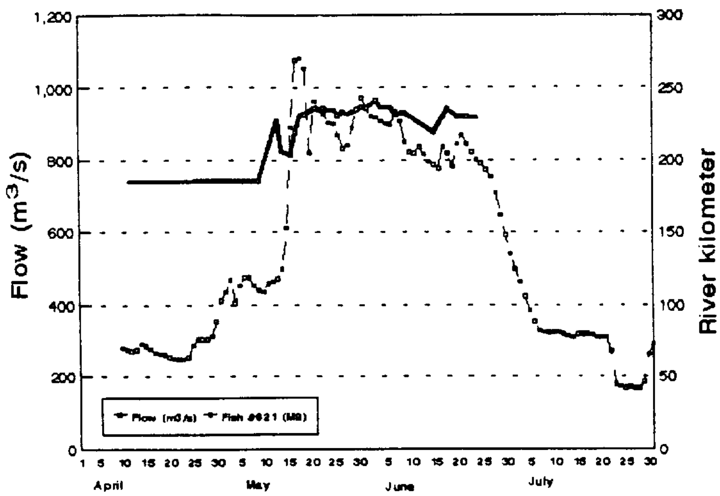


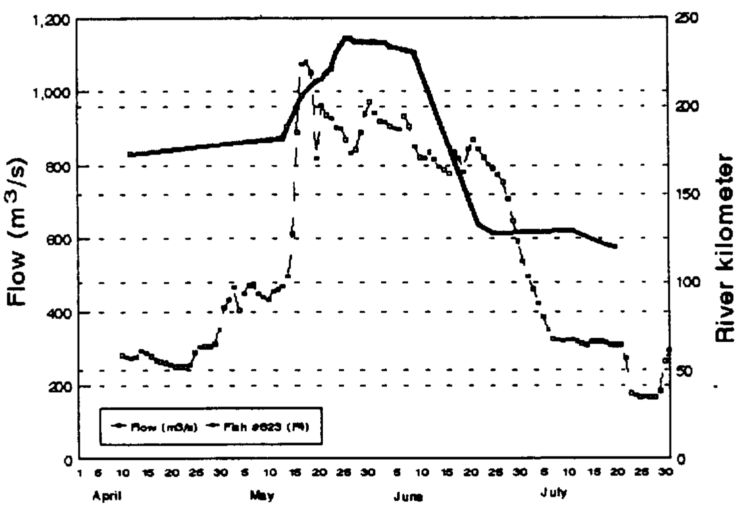


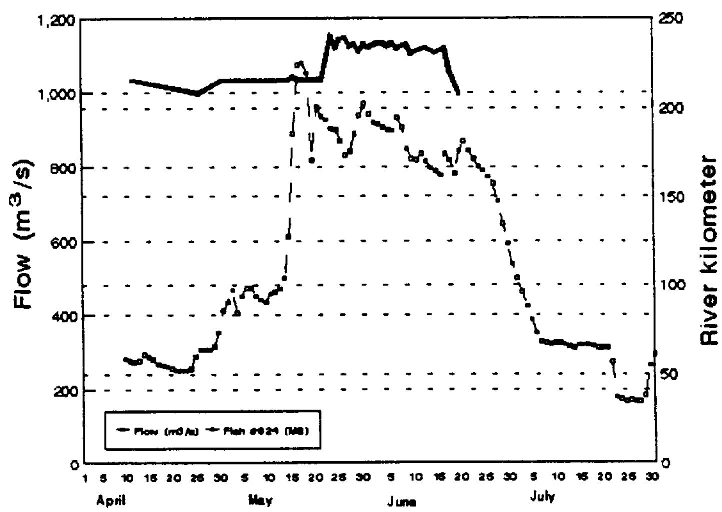


Appendix C. Continued. Fish #'s 619, 621, 623, 624.

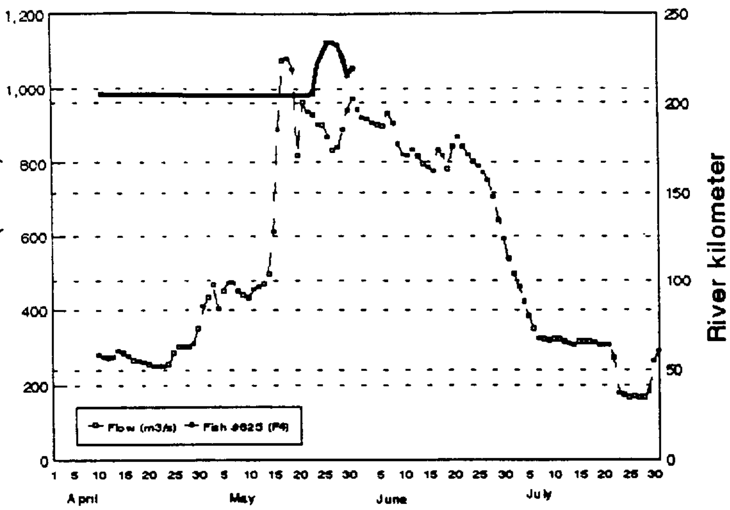


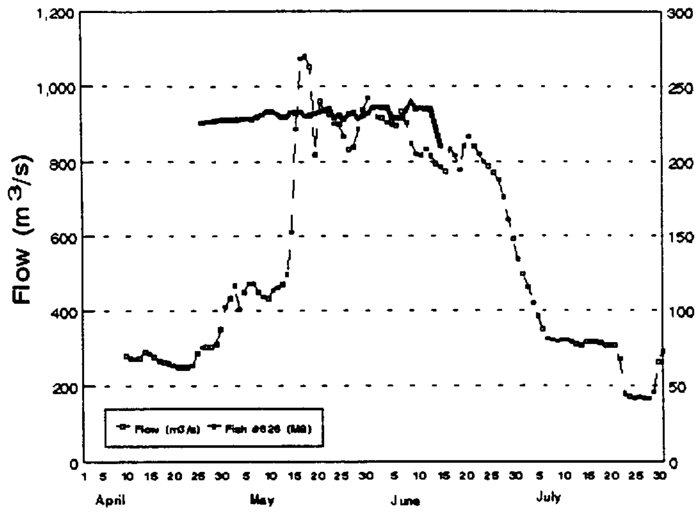


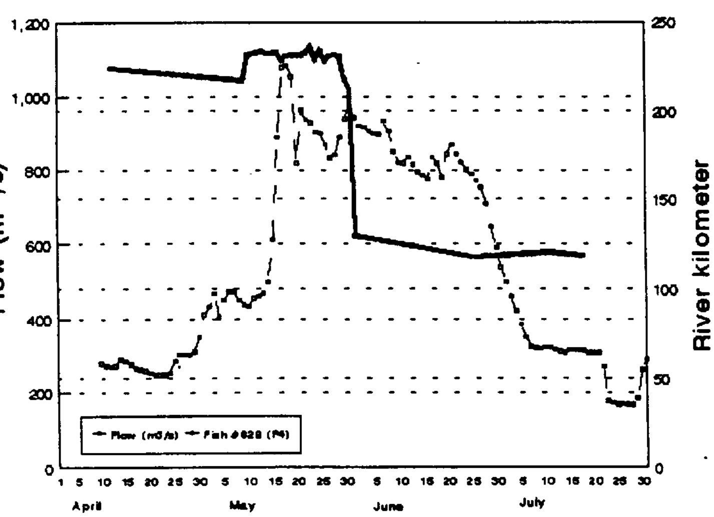


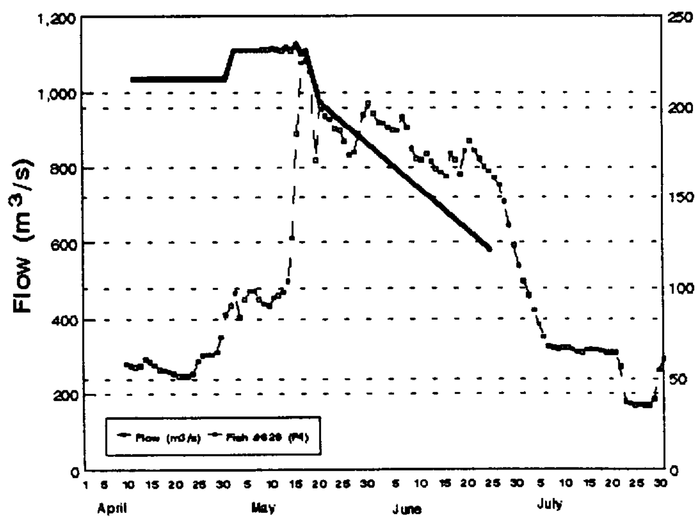


Appendix C. Continued. Fish #'s 625, 626, 628, 629.

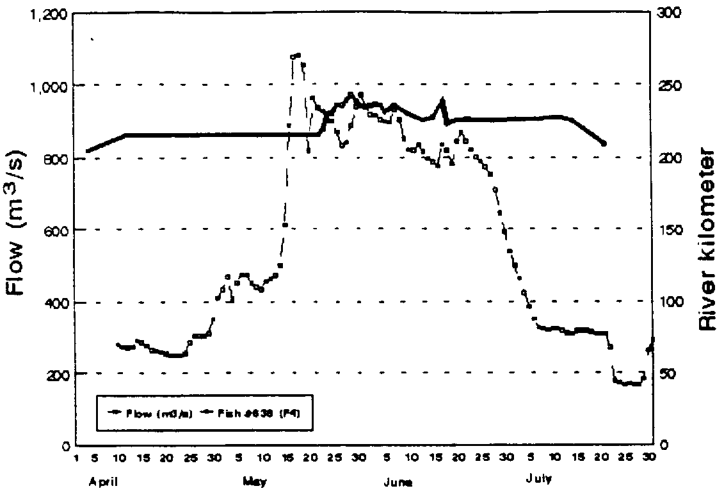


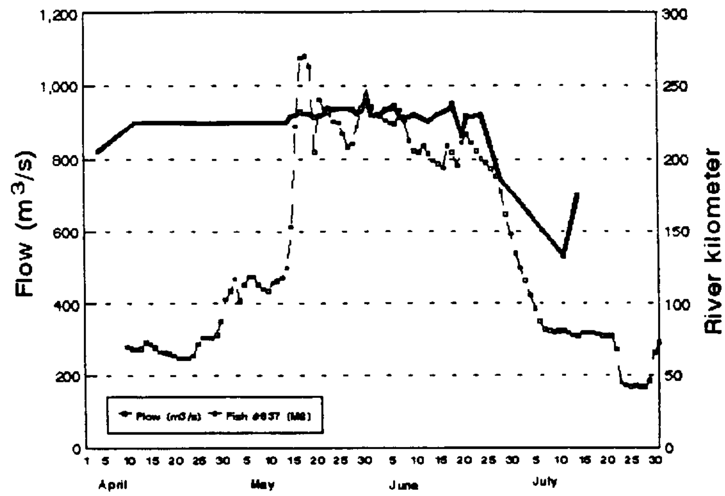


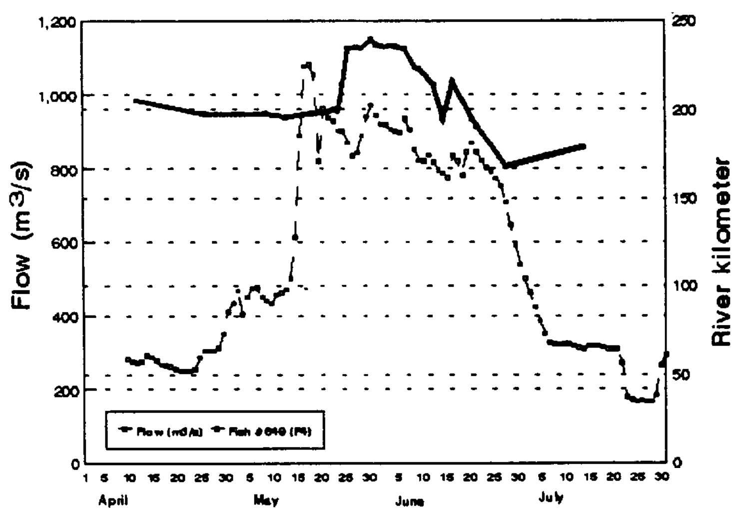




Appendix C. Continued. Fish #'s 636, 637, 649.







Appendix D. **Fish tracked to sections of the Kootenai River, where white sturgeon eggs were collected, within 24 hours preceding egg collection.**

Location	Egg Collection Dates	Fish # Males	Fish # Females
Lower Shorty's Island	5/22 6/5 5/24	2057	619
(rkm 228-229.5)	6/13		626
	6/1		628
Middle Shorty's Island	5/26 6/4	585	619
(rkm 229.6-231.5)	5/28 6/5	624	621
	5/29 6/6	2057	626
	5/30 6/7		628
	5/31 6/13		636
	6/1 6/17		637
	6/2		
Myrtle Creek	5/28 6/2	335	621 637
(rkm 233.5-234.7)	5/30 6/13	585	625
	6/1	624	626
Wildlife Refuge	6/5 6/15	335	621 636
(rkm 234.8-237.5)	6/13	624	623 637
			626 649

Appendix E. River location, number of eggs, depth, temperature and velocity at sites where white sturgeon eggs were collected, Kootenai River, Idaho, 1995.

River section (rkm)	# mats w/eggs	Depth range (m)	Mean temp. (°C)	.2 velocity (m/sec)	.8 velocity (m/sec)	Mean velocity (m/sec)
234.8-237.5	4	30-41	13	0.6	0.4	0.5
233.5-234.7	7	25-49	11	0.7	0.6	0.65
229.6-231.5	19	25-51	11	0.6	0.5	0.55
228.0-229.5	7	25-48	10.6	0.9	1.1	1.0
ALL LOCATIONS	37	25-51	11.3	0.7	0.6	0.65

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Appendix F. **Number of eggs, number of mats, flow, temperature and stage of egg development for white sturgeon eggs collected at Lower Shorty's Island (rkm 228-229.5), Kootenai River, Idaho, 1995.**

						Stage															
Date	Spawn Date[1]	Number of Eggs	Number of Mats	Flow (m^3/s)	Temp	Lost	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	--	7	2	937	7.8	2	5														
5/24	5/23	3	2	878	8		1						1	1							
6/1	5/31	1	1	943	9.7							1									
6/5	--	2	1	892	10.4		2														
6/13	6/12	1	1	816	10.6										1						
		n=14	n=7																		

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Appendix F. Continued. Middle Shorty's Island (rkm 229.6-231.5).

Date	Spawn Date	Number of Eggs	Number of Mats	Flow (m^3/s)	Temp	Stage															
						Lost	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25
5/26	5/24	1	2	869	8.8																
5/29	5/27 5/28 5/29	19	4	889	10.1		6	2		1	7		2		1						
5/30	5/28 5129 5/30	18	2	940	10.2		2	3	2	2		7	1				1				
5/31	–	1	1	971	9.9		1														
6/1	5/30	4	1	943	9.7		2										2				
612	–	1	1	920	9.8		1														
6/4	6/3 6/4	5	1	906	10.7			1	2												
6/5	6/3 6/4	5	3	892	10.4		3								1	1					
6/6	6/4	2	1	898	8.8												2				
6/7	6/7	1	1	935	7.7																
6/10	6/6	1	1	793	11.0																
6/11	6/11	1	1	818	11.2				1												
6/13	–	2	1	816	10.6		2														
6/17	6/13	1	1	770	10.7		1														
		n=62	n=20																		

Appendix F. Continued. Myrtle Creek (rkm 233.5-234.7)

Date	Spawn Date	Number of Eggs	Number of Mats	Flow (m^3/s)	Temp	Lost	Dead	Stage 12	13	14	15	16	17	18	19	20	21	22	23	24	25
5/28	5/27	4	1	841	9.9								4								
5/30	5/28 5/29 5/30	44	2	940	10.2			6	36					1			1				
6/1	5/30	4	1	943	9.7		3										1				
6/2	6/1 6/2	7	1	920	9.8		1	1				2	2	1							
6/13	6/11	12	2	816	10.6		3										9				
		n=71	n=7																		

Appendix F. Continued. Wildlife Refuge (rkm 234.8-237.5)

								Stage													
Date	Spawn Date	Number of Eggs	Number of Mats	Flow (m^3/s)	Temp	Lost	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25
6/5	6/4 6/5	2	1	892	10.4			1					1								
6/13	*6/12*	13	2	816	10.6		1					10	2								
6/15	--	1	1	770	10.7												1				
		n=16	n=4																		

Appendix G. Brood year, stock year, release site and recapture site for hatchery juvenile white sturgeon released into the Kootenai River, Idaho, and recaptured between August 1, 1994 and August 31, 1995. n = 31

Fish #	Brood Year	Stock Year	Release rkm	Length at Release FL/TL	Recapture Date	Length at Capture FL/TL	Age at Capture	Gear Type	Recapture rkm
3256	1992	ND	ND	ND	7/25/95	35/44	3	Gill net	225.0
3032	1991	1992	204.3	24/26	8/28/95	50/55	4	Gill net	225.5
3037	1991	1992	204.0	22/26	8/21/95	54/63	4	Gill net	215.5
3044	1991	1992	243.0	23/26	8/21/95	46/54	4	Gill net	215.5
3050	1991	1992	243.0	23/26	7/26/95	35/43	4	Gill net	227.0
3061	1991	1992	204.0	22/24	8/21/95	54/62	4	Gill net	215.5
3071	1991	1992	204.0	23/27	8/21/95	50/59	4	Gill net	215.6
3080	1991	1992	243.0	23/29	8/28/95	52/61	4	Gill net	225.5
3084	1991	1992	243.0	22/26	7/26/95	38/46	4	Gill net	225.0
3089	1991	1992	204.0	23/26	7/26/95	38/45	4	Gill net	225.0
3096	1991	1992	243.0	22/26	7/28/95	45/50	4	Gill net	225.0
3097	1991	1992	204.0	22/26	7/26/95	33/42	4	Gill net	217.1
3115	1991	1992	204.0	21/24	8/22/95	50/57	4	Gill net	215.0
3130	1991	1992	243.0	21/24	8/16/95	39/46	4	Gill net	215.7
					8/22/95	40/47	4	Gill net	215.0
3132	1991	1992	243.0	21/24	7/28/95	44/50	4	Gill net	225.0
3024	1992	1994	310.1	58/68	8/21/95	61/72	3	Gill net	215.6
3193	1992	1994	ND	35/41	7/26/95	34/48	3	Gill net	225.0
3151	1992	1994	241.5	31/36	7/26/95	30/35	3	Gill net	217.1
3153	1992	1994	244.6	40/46	9/15/94	45/52	3	Rod & Reel	120.0
3224	1992	1994	ND	42/49	8/22/95	50/59	3	Gill net	215.0

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Appendix G. Continued.

Fish #	Brood Year	Stock Year	Release rkm	Length at Release FLITL	Recapture Date	Length at Capture FLITL	Age at Capture	Gear Type	Recapture rkm
3164	1992	1994	244.6	37/43	7/26/95	37/43	3	Gill net	217.1
3173	1992	1994	244.6	32/36	7/26/95	32/38	3	Gill net	225.0
					8/16/95	42/49	3	Gill net	215.7
3208	1992	1994	ND	40/46	7/26/95	39/46	3	Gill net	225.0
3181	1992	1994	241.5	32/36	7/25/95	31137	3	Gill net	225.0
3182	1992	1994	ND	ND	7/24/95	61172	3	Gill net	215.7
					8/4/9 5	58/69	3	ND	203.6
3025	1992	1994	310.4	62/74	7/26/95	64/75	3	Small set line	216.9
3023	1992	1994	309.8	61/73	6/14/95	61/75	3	Large set line	215.5
3030	1992	1994	304.5	64/74	6/1 1195	66/77	3	Gill net	215.7

Appendix H. Age, year class and number of hatchery reared white sturgeon captured in the Kootenai River, Idaho, 1995. n = 28

Number of Fish	Age	Year Class
15[a]	3	1992
13	4	1991

a Ages for three of these fish were not validated by fin rays

Age, year class and number of wild white sturgeon captured in the Kootenai River, Idaho, 1995. n=56

Number of Fish	Age	Year Class
1	44	1951
2	39	1956
1	35	1960
2	34	1961
1	33	1962
2	31	1964
5	30	1965
5	29	1966
5	28	1967
1	27	1968
3	26	1969
2	25	1970
7	24	1971
1	23	1971
3	22	1973
2	21	1974
1	20	1975
2	18	1977
1	16	1978
4	15	1980
2	12	1983
2	4	1991

CHAPTER 2: Estimating Abundance of Larval and Advanced Young-of-the-Year Sturgeon and Burbot in the Kootenai River and Kootenay Lake

ABSTRACT

We used a variety of sampling methods in an effort to determine if the higher spring flows during May and June of 1995 resulted in the production of larval and advanced young-of-the-year (YOY) white sturgeon *Acipenser transmontanus.* We also attempted to sample larval and older YOY burbot *Lota lota* to assess whether successful spawning occurred during the winter of 1994-95. Sampling commenced in April and extended through October 1995. Sampling equipment included conical larval fish nets, beam trawls, shrimp trawls, gill nets, hoop nets, minnow traps, electrofisher, beach seine, and rod and reel. We caught no larval sturgeon or burbot, and we caught no YOY sturgeon. One YOY burbot was captured in the lower Kootenai River in a baited minnow trap. We also caught 33 older juvenile sturgeon in small mesh gill nets, of which all but two were thought to be of hatchery origin. The minimum length captured in the gill nets was 35 cm total length (age 3+ to age 4+), which indicated that there were no sturgeon smaller than this in the system, or they are not recruited to the gill nets until they reach this length. The lack of success in sampling YOY sturgeon is not encouraging, and may be further evidence that sturgeon spawning is leading to very few juveniles. Although the methods we used have been proven effective in other systems, it is possible they are ineffective in the Kootenai system. We believe the gill nets can be used to effectively estimate the abundance of age 3+ and age 4+ sturgeon, and the flow tests can only be fully evaluated 3 to 4 years following the test, when recruits from flow test year classes are 30 to 40 cm.

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INTRODUCTION

Sturgeon spawning in the Kootenai River has been confirmed by the presence of fertilized eggs in 1991, 1993, 1994, and 1995, but embryo survival and hatching success is still unknown. Because our sampling strategies for adult sturgeon are not effective for early juveniles, successful reproduction will not be evident for several years unless we can estimate the relative abundance of larval and early juveniles. Evidence of survival to the larval and advanced young-of-the-year (YOY) stages will help determine if the observed spawning episodes were successful, and ultimately determine the magnitude of flow necessary for sufficient sturgeon reproduction. The purpose of this phase of the project was to develop methodologies to sample young life stages of sturgeon and burbot.

GOAL: Restore the sturgeon and burbot populations in the Kootenai River to a level that can support a fishery.

Objective: Determine if higher spring flows and the lack of power peaking resulted in production of larval and advanced YOY sturgeon, and if successful burbot spawning occurred in the 1994-95 spawning season.

The depressed populations of sturgeon and burbot in the Kootenai River make *in situ* development and evaluation of sampling methods difficult. No larval or YOY sturgeon and burbot sampling efforts have yet been successful in the Kootenai River. The low abundance, or possible absence of, young sturgeon and burbot in the Kootenai River required that we review literature from other systems to provide direction and confirmation that we are using the best possible methods and are looking in the appropriate habitats.

LITERATURE REVIEW

Sturgeon

Several studies have examined early life history of white sturgeon in various systems throughout their range and in controlled laboratory environments. Although the studies clearly show that behavior can vary between systems, they do provide general trends in behavior and gear effectiveness that we can use in our sampling efforts on the Kootenai River.

In a simulated river environment, Brannon et al. (1985) observed newly hatched white sturgeon under a range of variables. They found that sturgeon underwent a series of stages after hatching. Although the occurrence of the stages was consistent, their duration varied with water velocity. During the first few days post-hatch, larval sturgeon swam up into the water column where they faced the current, appearing to regulate their downstream drift, then swam back down to the substrate where they rested for a few seconds before repeating the cycle. In the faster velocity arena (7.9 cm/s), this behavior lasted only through the first day, whereas in the slower velocity arena (2 cm/s), the behavior lasted two to five days. Following this up/down swimming stage, sturgeon became photonegative and moved to the substrate where they wedged themselves into gravel interstices, or "hid" under plants or detritus. There, larval sturgeon remained motionless, except for an oscillating tail, for one to two weeks apparently absorbing their yolk sacs. The duration of this period seemed to be developmentally related and dependent on absorption of the yolk sac. Once the yolk sac was absorbed, larval sturgeon began actively swimming and searching for food along the substrate or in the water column. They were distributed evenly over a variety of substrates including sand, gravel, rocks, and plants; however, they seemed to rest only in the sandy areas. During this stage, larval sturgeon were not affected by different velocities. Because of the larval sturgeon's downriver dispersing behavior, sampling gears fished passively from stationary boats have been effective in many systems. D-ring nets were very effective in capturing larval white sturgeon in the lower Columbia River. In 1990, Miller et al. (1991) caught a mean of 6.7 larvae/h in Bonneville Pool, 7.4 larvae/h in John Day Pool, and 0.88 larvae/h in The Dalles Pool. From 1988 to 1991, 504 white sturgeon larvae were collected below Bonneville Dam in 4 to 29 m of water (McCabe and Tracy 1993). In the Sacramento River, California, Kolhorst (1976) had catch rates of 5.6 larvae/h using D-ring nets. McCabe and Tracy (1993) caught larval white sturgeon over 175 km downriver from where spawning was thought to take place below Bonneville Dam, indicating extensive downstream dispersal. These authors found no significant difference between daytime and nighttime catch rates. Larval sturgeon grow rapidly following the initial "dispersal" and "hiding" stages. From 1988 through 1991, mean total length in August of YOY sturgeon below Bonneville Dam ranged from 97 mm to 176 mm (McCabe and Tracy 1993). During this time, Parsley et al. (1993) found YOY white sturgeon preferred areas with depths greater than 12 m, sandy substrate, and velocities of 0.3 to 0.6 m/s. Other studies have also indicated a preference for deeper water and sandy substrate (McCabe and Hinton 1991; Lepla 1994).

Post-larval YOY sturgeon were effectively sampled in the lower Columbia River using a variety of trawls. In the section of river below Bonneville Dam, McCabe and Tracy (1993) used a beam trawl and two sizes of shrimp trawl (4.9 and 7.9 m head ropes). They found beam trawling was effective for small YOY, but for larger YOY, the 7.9-m shrimp trawl was more effective. In 5-min tows in an upstream direction, they captured as many as 15 YOY in a single haul. Most YOY were captured over a sandy bottom ranging from 11 to 15 m in depth. Palmer et al. (1988) found a shrimp trawl with a 6.2-m head rope was more effective. than a beam trawl for capturing juvenile sturgeon in The Dalles Pool section of river. Their efforts throughout the summer resulted in a mean catch per unit of effort (CPUE) of 1.2 juvenile sturgeon per 15-min tow. Although their methods proved effective in catching juvenile sturgeon, none of the fish they captured were YOY.

Lepla (1994) sampled YOY and older juvenile sturgeon primarily with gill nets in the Lower Granite Pool of the Snake River. He caught YOY sturgeon as small as 10.3 cm (FL), using nets with bar mesh sizes from 2.5 to 15 cm. He found that small sturgeon were significantly more vulnerable to gill nets than set lines; however, he did not believe gill nets were highly effective gear for capturing YOY sturgeon. Based on mark and recapture, Lepla estimated that, in spite of his success at capturing occasional YOY, sturgeon did not recruit to the smallest mesh until they were about 40 cm (FL).

Juvenile sturgeon were more abundant in deeper water and were usually captured in the thalweg of the channel, as opposed to bench areas, in both the Columbia (Palmer et al. 1988; Parsley et al. 1993) and the Snake rivers (Lepla 1994). Young-of-the-year sturgeon did not appear to occupy shallow, backwater, or vegetated littoral areas in either system. Several beach seine efforts for YOY in the lower Columbia River failed to produce sturgeon in littoral areas adjacent to deepwater areas that produced sturgeon (McCabe and Tracy 1993). Neither Parsley et al. (1993) nor Lepla (1994) found evidence to suggest that young sturgeon forayed into shallow water at night to feed, based on night sampling efforts.

Burbot

Existing research provides a basic understanding of juvenile burbot behavior, even though published information on burbot is limited in comparison to some higher profile species. A few studies were designed to investigate the ecology of larval and YOY burbot, and in several cases large numbers of larval burbot were encountered incidentally to the study of another species.

It is well documented that burbot spawn during the cold part of the year, typically in January or February (Chen 1969; Sorokin 1971; Garlov 1992), but the habitat they utilize, and the actual behaviors involved, are not thoroughly understood. Scott and Crossman (1973) describe burbot spawning grounds as being 0.3 to 3 m deep, primarily in shallow bays or shoals of a lake with either a sandy or cobble substrate. They also note that burbot sometimes spawn in rivers. Based on available literature, river spawning appears to be very common, and in addition to several accounts of lake spawning burbot, there are many published descriptions of fluvial and adfluvial stocks of burbot (Chen 1969; Sorokin 1971; Hudd et al. 1983; Ponton et al. 1993). In the Kootenai River-Kootenay Lake system, burbot are known to have historically spawned in large numbers in tributaries to the Kootenai River. Biologist Paul Jeppson captured over 40 adult burbot in Deep Creek in the winter of 1958 (IDFG, unpublished data). Partridge (1983) reported that burbot were historically seen spawning in Kootenai River tributaries beneath the ice, but speculated that significant spawning also occurred in backwaters and side channels of the main river. In 1994 and 1995, Paragamian (1994, 1995) captured several burbot at the mouths of Deep Creek, Smith Creek, and the Goat River. In the winter of 1995, he tracked sonic-tagged burbot from the delta area of the lake upriver to the mouth of the Goat River where they either ascended the tributary or temporarily resided at the mouth. These studies are evidence that burbot in the Kootenai system historically resided largely in Kootenay Lake, but migrated up the Kootenai River to spawn in its tributaries, and perhaps the main river.

Burbot are highly fecund, and a female weighing 2.8 kg can produce in excess of 1.3 million eggs (Scott and Crossman 1973). Females of a more typical size (1.2 kg) produced 0.5 to 0.8 million eggs (Chen 1969). The eggs have a large oil globule that provides some buoyancy. Scott and Crossman (1973) characterized the eggs as "semi-pelagic," however Chen (1969) described them as demersal. Sorokin (1971) reviewed the characteristics of burbot eggs in detail and reported they had a buoyancy reserve of +0.12, which means eggs will begin to float at a velocity of 4 cm/s, and at 8 cm/s eggs will easily be carried away. In waters void of any current, burbot eggs will sink to the bottom, although they are not adhesive. Based on Sorokins' description, burbot eggs in the Kootenai River or its tributaries would be functionally pelagic.

The incubation period in water temperatures typical of burbot spawning habitat (1°C to 4°C) is 1.5 to 2.5 months, depending on the temperature. In temperatures more comparable to those of the post-Libby Dam Kootenai River, incubation at 6°C was 30 days (Bjornn 1940).

Larval burbot begin appearing between March and June, depending on water temperature and when spawning occurs (Mansfield et al. 1982; Hudd et al. 1983; Ghan and Sprules 1991; Ponton et al. 1993). The newly-hatched larvae, which are about 3 to 5 mm in length (Mansfield et al. 1982; Ryder and Pesendorfer 1992), are initially pelagic and found near the surface where they apparently school, feeding primarily on zooplankton (Ryder and Pesendorfer 1992). During this pelagic stage, larval burbot were successfully sampled in many systems using a variety of methods. The most common sampling method was to tow a 0.3- to 1-m diameter Wisconsin style plankton net or conical larval fish net horizontally. Tows were typically made from the surface to depths of 11 m. Mansfield et al. (1982) conducted horizontal tows from the surface to the bottom in nearshore areas throughout Lake Michigan and found that in depths up to 9 m, burbot larvae were evenly distributed. At some sites, they estimated densities of 6 to 24 larvae/m^3, and the burbot were sufficiently abundant to be successfully collected by one person towing the larval fish net by hand while wading along the shoreline. Hudd et al. (1983) found densities of nearly 8 larvae/m^3 at the mouth of the Kyronjoki River, Finland. Ghan and Sprules (1991) calculated densities from 1 to 2 larvae/m^3 based on 5-min tows at both offshore and nearshore sites in Oneida Lake, New York. In that study, as well as an earlier study on Oneida Lake (Clady 1976), the depth distribution of larval burbot was fairly homogenous until late May, at which time the burbot were found in greater abundance near the surface. Ghan and Sprules (1991) suggested the initially passive burbot moved more actively toward the surface as they became stronger swimmers. In an unusual sampling effort, Ponton et al. (1993) collected larval burbot at the mouth of the subarctic Great Whale River in Canada. Because of the extreme conditions, they used a snowmobile to pull a net under the ice in early spring, and then used a float-mounted helicopter for towing the net during ice breakup. They captured over 100 burbot in spite of the sampling complexity, and estimated densities of 1 to 5 larvae/l00 m^3 In Lake Shebandowan, a Precambrian Shield lake in Ontario, Ryder and Pesendorfer (1992) found sufficient densities of burbot larvae to capture several hundred using a small home aquarium type dip net (10 x 1 1 cm) through holes cut in the ice and around docks where the ice had melted. These studies all suggest that in systems where burbot were abundant, larvae were fairly widely distributed and easily caught with standard (or improvised) larval fish collection gear.

Young burbot are then thought to shift to a benthic-littoral habitat following the pelagic stage. Occurrence of this shift was supported by the disappearance of larval burbot from the pelagic zone in early to late June (Clady 1976; Mansfield et al. 1982; Ghan et al. 1991; Ponton et al. 1993), and by several studies that sampled larger YOY burbot from benthic-littoral areas later in the summer. This shift was further supported by a laboratory study that documented a change from a photopositive to photonegative orientation of larval burbot at around 40 mm (Girsa 1972).

Several methods have been used, both intentionally and incidentally, to capture post-larval YOY burbot. Ryder and Pesendorfer (1992) used snorkeling and SCUBA equipment to collect burbot from nearshore areas of both the mainland and islands once they became solitary and benthic. In this study, divers collected numerous burbot by hand, generally in depths less than 4 m, and reported a surprising ubiquity throughout the shoreline areas. Young-of-the-year burbot observed by the divers during the daytime were always inactive and almost always concealed under some physical structure, either man-made or natural. At night, divers more commonly found young burbot actively swimming about. Based on the size of YOY burbot collected in both the pelagic and benthic zones, coupled with extensive diet analysis, these authors estimated that burbot make the transition between habitats when they are 20 to 30 mm total length. Other methods used to collect YOY burbot from littoral areas include a seine in the Yukon River, Alaska (Chen 1969) and in Lake Winnebago, Wisconsin (Priegel 1966), a DC current electrofisher in the Ottawa River, Ontario (Hanson and Qadri 1980), a trap net in Lake Sakakawea, North Dakota (personal observation), and trawl nets in both Lake Winnebago (Priegel 1966) and in Lake Roosevelt (Melo Maiolie, IDFG, personal communication). As with the larval stage, it appears that advanced YOY burbot were relatively widespread and easy to catch where a healthy population existed.

METHODS

We tested several different methods and types of equipment from April to October 1995. Because we have no confirmed methods on the Kootenai River, we did not want to rule out any possible method. At the same time, however, our time and resources were limited enough that we had to focus our efforts on the methods and areas that were most likely to be successful based on other studies. We therefore used a broad approach, whereby we tried a wide variety of methods and areas throughout the season, but focused the bulk of our efforts where we thought we would have the greatest chance for success.

Larval Sturgeon Sampling

Larval Fish Nets

In June, we began using 1 m (diameter) larval fish nets in an effort to capture larval sturgeon. We fished the nets at the following sites in the Idaho section of the Kootenai River: river kilometer (rkm) 220, rkm 200 (Copeland Bridge), and rkm 170 (Porthill). The sites were 10 to 60 km below the area of greatest sturgeon spawning activity in recent years, based on substrate mats and sonic telemetry (previous chapter), and were chosen as areas with a distinct thalweg and minimal eddies or holes. Our intention was to sample in areas where downriver drifting larval sturgeon would be naturally funnelled to the middle of the river. In addition to the Idaho section of river, we also spent two days in British Columbia, at the Canadian Pacific Railroad trestle located immediately above the Kootenai River delta (rkm 120).

We lowered two nets using hand winches mounted on a boat anchored or tied to a bridge at the four sampling areas. At each sampling area, we positioned the boat at 3 to 4 sites across the river. One net was used exclusively on the bottom, whereas the other net was used half time at I/3 the water column depth, and half time at 2/3 water column depth. The nets were usually fished for 1 h at a time, and water volume was calculated with an impeller flowmeter suspended in the mouth of the nets.

Our sampling efforts were according to a rotating schedule designed to represent both daylight and dark hours. Sampling times were morning (0700-l500), midday (1200-2000), and evening (1500-2300).

Beam Trawl

Beam trawling was conducted by a crew from Montana Department of Fish, Wildlife, and Parks. The net was fished from a stationary boat anchored in the river channel. Their specific methods and sampling schedule were reported separately.

In addition to Montana's efforts, we coordinated efforts on several occasions with the kokanee sampling crew from the British Columbia Ministry of Environment and used their 3 x 3 m midwater beam trawl in the delta area of Kootenay Lake. During the new moon in June, July, and August, we spent part of an evening trawling near the surface and midwater column just prior to, and immediately after dusk. The Canadian beam trawl was not fished passively in the current, as was Montana's net, but rather was towed at a speed of approximately 0.5 m/s.

Larval Burbot Sampling

Larval burbot sampling was conducted from April until June with a 1 m diameter larval fish net with 1.5 mm mesh and a rigid 0.3 mm cod end. The net was towed behind a single boat in a circular or zig-zag pattern to keep the net out of the prop-wash and minimize the possibility of avoidance. Tows ranged in duration from 5 to 30 min, depending on the amount of organic debris in the water. Tow volume was calculated with a General Oceanics flowmeter suspended in the mouth of the net, and water volume sampled per tow ranged from 140 to 1,400 m^3.

We systematically selected larval fish sampling sites at 5 km intervals from rkm 245 (Bonners Ferry) to rkm 170 (US/Canadian border). We also sampled the Kootenay Lake delta (rkm 1 15) and the area upriver from the delta to rkm 135. The Idaho section (rkm 245-l70) was sampled once per week from mid-April to mid-May. We discontinued the river sampling during the high discharges in May because the extreme abundance of organic debris in the water required that our tows be only 1 to 2 min. We then concentrated our efforts on the delta. The delta was sampled one or two times per week from April 19 to June 1. On May 18, we travelled to Columbia Lake, British Columbia, where we attempted to confirm the effectiveness of our gear in a system with a healthy burbot population.

We made two larval tows at each sampling site: one surface tow, and one subsurface tow (3-4 m below the surface). We did not conduct bottom tows during this period because existing burbot literature suggested a surface orientation during the larval stage. Furthermore, we believed the extensive D-ring sampling (for sturgeon eggs and larvae) conducted by the Kootenai Tribal researchers in 1995 and in past years would have resulted in the capture of larval burbot if they had been abundant near the bottom.

Young-of-the-Year Sturgeon and Burbot Sampling

Shrimp Trawl

We focused much of our effort on sampling with two different shrimp trawls. The concentration on trawling was primarily because the lower Columbia River sturgeon studies demonstrated it was an effective method of sampling post-larval YOY sturgeon. We initially used a smaller trawl with a 4.9 m head rope, but then acquired a larger trawl (7.6 m head rope) to cover a greater area. Both trawls were a two seam, slingshot balloon design with 35 mm mesh (stretch measure) body, and a 6 mm knotless cod end liner. In water less than 5 m, we used 30 m towlines, but in deeper water we increased the towline length to 45 m. Trawling speeds varied, depending on depth and currents, but generally ranged from 0.2 to 0.4 m/s. We attempted to run the trawl along the bottom, and minimized our midwater trawling efforts. We used a second boat equipped with an echosounder to determine the depth the trawl net was fishing. We estimated the bottom of the net was about 10 to 12 m deep when trawling with the 45 m towlines. These depths were consistent with the observed depths when we felt the trawl scraping the bottom.

We began trawling in Kootenay Lake near the delta on July 6. From July through September, we trawled in the river mouth and the slackwater areas around the delta and in the Idaho section of the Kootenai River (from rkm 230 to rkm 170). We attempted to trawl a variety of habitats, but we were somewhat restricted to areas no more than 12 m in depth with minimal woody debris.

Gill Nets

We expected that gill nets would be the most practical sampling method available because of their effectiveness on juvenile sturgeon in the Snake River (Lepla 1994) and the abundance of woody debris and variable river bottom that complicated trawling. We used multi-filament, sinking, experimental gill nets (2.5 to 7.6 cm bar measure panels) of either 45 or 90 m lengths. Gill nets were set in the Kootenai River from rkm 230 to the delta from June through October. Our efforts were concentrated in holes and areas where radio-tagged hatchery juveniles were frequently recorded (Fleming Creek, Rock Creek, delta), but we also sampled random "run" areas and deep holes where no juveniles had previously been located. We set the gill nets in depths ranging from 7 to 30 m and attempted to represent both the deepest portion of an area and shallower bench areas. Nets were pulled at 45 to 90 min intervals to prevent harm to the fish.

Hoop Nets

We set small hoop nets (60 cm diameter, 2.5 cm mesh) from rkm 163 to 231 from June 10 until August 3. The hoop nets were set at depths of 3 to 30 m in both run areas and adjacent to deep holes. The nets were baited with fish and set for 1- to 3-d periods.

Minnow Traps

Although minnow traps are not discussed in the literature as being an effective method for sturgeon, both baited and unbaited traps have been used to capture YOY burbot in Lake Sakakawea, North Dakota (Chuck Parken, University of Idaho, personal communication). From June through August, we set standard size minnow traps (23 cm diameter, 0.63 cm mesh) from rkm 185 to 227. Traps were baited with a variety of materials including fish, bread, turkey, and cat food, and were set on the bottom in depths ranging from 1 to 20 m. The traps were generally left overnight and pulled after 24 h. We also set three baited minnow traps near the delta in 3 to 5 m of water from August 22 to August 30.

Beach Seine

The shift of burbot from the pelagic stage to near shore and shallow areas in other systems (Ryder and Pesendorfer 1992) led us to believe that sloughs and backwater areas of the Kootenai River might be important rearing habitat for YOY burbot. We were not optimistic that beach seining would be effective for YOY sturgeon because of the lack of evidence that YOY sturgeon use sloughs and backwaters, and the efforts were primarily directed at burbot. From June 23 to July 24, we made a total of 13 hauls with a 30 m beach seine in the sloughs and shallow backwaters created during the high discharges. Seine efforts were primarily in Jerome Slough (rkm 192), behind Ferry Island (rkm 204), and at the Hops Farm slough (rkm 209.5). We continued to use the beach seine through mid-July when the low discharge decreased the depth of the sloughs.

Electrofishing

On September 26, we used a Smith-Root, boat-mounted electrofisher (direct current pulse) in an effort to capture young burbot in the shallow littoral areas near the Kootenay Lake Delta, along the rocky shoreline of the South Arm, and in the lower river (including the east channel) immediately above the delta. We sampled in the daylight (1100-1400)and after dark (1830-2100). Electrofishing efforts were directed primarily at burbot, as we did not expect YOY sturgeon to be in near-shore or shallow areas where they would be vulnerable to electrofishing.

Rod and Reel

Throughout the sampling season, we spent over 100 h sampling fish with conventional fishing equipment. The fishing was usually done in conjunction with other sampling efforts (i.e., when larval nets were being passively fished from an anchored boat). Size 4-6 hooks, baited with worms or cut fish bait, were fished on the bottom in a wide range of depths and velocities from the delta upstream to Bonners Ferry. Although the main goal of rod and reel sampling was to collect nongame species for stomach analysis, we were hoping for an incidental catch of YOY sturgeon and burbot.

RESULTS

Larval Sturgeon

We caught no larval sturgeon in all of our sampling efforts in 1995.

In total, we expended 148 h of effort with the larval fish nets and sampled approximately 267,700 m^3 of water (Table 1). We collected larval fish of other species ranging in size from 6 to 12 mm (TL) from all depths sampled. Our success with other species confirmed the ability of the nets to capture both pelagic and benthic drifting larval fish.

Larval Burbot

We caught no larval burbot in all of our 1995 sampling efforts in the Kootenai River, Kootenay Lake, or Columbia Lake. As with the sturgeon efforts, we collected a variety of non-target larval fishes (Table 2).

Young-of-the-Year Sturgeon and Burbot

In all of the 1995 efforts, we caught no YOY sturgeon; however, we did collect several older juveniles in small mesh gill nets. We determined most of these fish to be of hatchery origin. Location, length, and age of these juveniles are detailed in Table 4 and Appendix G of the previous chapter. In addition to the confirmed hatchery sturgeon, we collected two sturgeon we believe were of wild origin. These two fish had no scutes removed and had no PIT tags implanted, which were the two methods used by hatchery personnel to ensure hatchery-reared fish would be identifiable. Using fin ray analysis we estimated that these presumably wild fish were four years old and from the 1991 year class.

We caught a single juvenile burbot near the mouth of Trout Creek in a minnow trap baited with fish parts. The fish was captured on June 11 in a trap resting on the bottom in about 4 m of water. The burbot was 40 mm TL, consistent with the size expected of YOY when they become littoral-benthic (Girsa 1972). No other juvenile burbot were captured during our sampling efforts. Total effort for each gear type is reported in Table 3.

Table 1. Date, time, location (rkm) duration, and volume (m^3) of larval sturgeon sampling efforts in 1995. No larval sturgeon were caught.

Date	Time	Location	Effort: Minutes	Effort: Volume	Other larval spp.: No.	Other larval spp.: #/1,000 m^3
06/05	1000-1330	215	105	2,337	0	0
06/08	1100-1500	121	187	3,164	0	0
06/12	1200-2000	200	285	7,750	0	0
06/14	1200-2000	200	205	5,227	0	0
06/15	0700- 1500	200	480	10,470	3	0.29
06/16	1500-2300	200	480	10,930	0	0
06/19	1500-2300	200	480	12,642[a]	0	0
06/21	0700- 1500	220	240	5,718	0	0
06/22	0700- 1500	220	480	12,642	0	0
06/23	0700- 1500	170	480	12,642	1	0.08
06/26	0700- 1500	220	480	12,642	3	0.24
06/27	1200-2000	200	540	14,373	0	0
06/28	1200-2000	170	510	13,507	2	0.15
06/29	0700- 1500	200	480	12,642	13	1.03
07/03	1500-2300	200	600	16,104	25	1.55
07/05	1200-2000	170	583	15,613	0	0
07/07	0700- 1500	200	540	14,373	0	0
07/10	1500-2000	170	631	17,000	3	0.18
07/13	1200-2000	200	395	10,190	0	0
07/19	1200-2000	170	540	14,373	0	0
07/20	1200-2000	120	140	2,834	0	0
Totals			8,861	227,173	50	

[a] Because of flowmeter malfunction, volume measurements after 6/16 are based on a minutes to volume conversion.

TABLES2

Table 2. Date, location, number of tows, and total volume (m^2) by date of larval burbot sampling efforts in 1995. No larval burbot were caught.

Date	Location (rkm)	Number of tows	Volume	Other larval spp. # sampled	Other larval spp. #/1,000 m3
04/12	170-200	11	1,444	0	0
04/13	205-245	18	1,841	0	0
04/26	delta-130	11	5,033	1	0.2
04/27	170-210	16	7,016	0	0
05/04	delta-130	11	4,432	51	11.5
05/05	170-200	8	2,366	0	0
05/11	delta-135	10	3,603	1	0.28
05/12	200-210	5	1 ,162	0	0
05/17	delta	9	4,913	5	1.02
05/18	Columbia Lake	7	4,325	1	0.23
05/25	delta	9	5,392	4	0.74
05/26	delta	6	4,166	0	0
06/01	delta	8	6,070	0	0
Total		129	51,763	63	

Table 3. Amount of effort expended and the species collected with various methods during the 1995 YOY sampling effort.

Sampling gear	Amount of effort	Species collected
Shrimp trawl (16 ft)	353 min	largescale sucker, longnose sucker, sculpin, mountain whitefish, pumpkinseed, yellow perch, northern squawfish, peamouth, chiselmouth, speckled date
Shrimp trawl (25 ft)	431 min	largescale sucker, longnose sucker, mountain whitefish, yellow perch, peamouth
Gill nets	288 h	white sturgeon, northern squawfish, largescale sucker
Hoop nets	5,860 h	norther squawfish
Minnow traps	2,253 h	burbot
Slat traps	1,032 h	none
Beach seine	15 hauls	rainbow trout, kokanee salmon, largescale sucker, pumpkinseed, yellow perch, largemouth bass, chiselmouth, peamouth, redside shiner, northern squawfish, speckled date
Electrofishing	6 h	bull trout, rainbow trout, kokanee salmon, largescale sucker, longnose sucker, mountain whitefish, pumpkinseed, yellow perch, northern sauawfish, oeamouth. redside shiner

TABLES2

DISCUSSION

Our lack of success with larval and YOY sturgeon and burbot, while not encouraging, should not be construed as conclusive evidence that spawning events are not leading to successful reproduction. Our failure to capture YOY sturgeon and burbot seems to indicate a lack of reproduction, but does not prove their nonexistence. The most extensive larval and YOY white sturgeon sampling efforts have been in the Columbia River--a much larger and different system from the Kootenai River. Our methods were largely based on their successes, and it is possible that the methods proven to be effective in the Columbia, Sacramento, Snake, and other rivers are not effective in the Kootenai River. There are several plausible explanations for non-transferability of gear effectiveness. The differences in the size and structure of the rivers offer the most likely explanations. The Kootenai River is substantially smaller than the other rivers studied, particularly the Columbia River. Velocity downriver from suspected spawning sites from May through July is less than in the other rivers, and larval and YOY sturgeon may be more likely to move out of the thalweg and into adjacent benches and backwaters not used in the Columbia River. The spawning and rearing areas in the Columbia River are better identified because of the greater number of sturgeon in the system and the length of time researchers have studied the early life stages. Although we believe we have identified the area currently used for spawning, we do not yet know where to focus our larval and YOY efforts, other than downstream of the spawning areas. In addition, the Kootenai River does not lend itself well to many sampling methods. The extensive woody debris throughout the lower river prohibited successful trawling in many areas and limited the effectiveness of hoop nets and gill nets. Not surprisingly, we were occasionally required to use SCUBA gear to recover equipment.

We were encouraged by our success in capturing juvenile sturgeon once they achieved a size of 35 to 40 cm. The fish we aged in this size range were from the 1991 and 1992 year classes, suggesting we can effectively evaluate the outcome of a flow test, but it may take three to four years. We cannot yet say whether our methods are effective on one or two year old sturgeon because no hatchery fish were released from the 1993 or 1994 year classes, and we do not know whether any sturgeon were produced naturally in those years.

We believe the methods and gear we used are the most effective given the complexities of the Kootenai River. Researchers should continue to use these methods (and any other likely methods that become available) to document successful reproduction, or lend further support to the hypothesis that for whatever reason, the fertilized eggs produced are not successfully producing large numbers of larval and YOY sturgeon.

The failure to document larval burbot in the lower Kootenai River or Kootenay Lake might initially seem to say little about the burbot population. The size of Kootenay Lake and the uncertainty regarding the timing (i.e., when we could expect larval burbot to be passing through the lower river and the delta) might make the prospect of actually capturing larval burbot seem remote. However, as we discussed in the Literature Review section of this report, in systems with healthy burbot populations, researchers intentionally targeting burbot larvae have found them to be widespread and easily sampled with a wide variety of methods. Our lack of success in Columbia Lake, while disappointing, can probably be attributed to the amount of effort put forth. We actively sampled for only a few hours on a cool, windy day,

and burbot may not have been swimming actively near the surface. In contrast, we sampled the Kootenai River and Kootenay Lake over the course of six weeks and were out during a wide range of times and weather conditions.

A large number of burbot larvae, in conjunction with the observed near absence of juveniles, might have indicated burbot are spawning successfully in large numbers, but then are limited by a high larval mortality, possibly because of the decreased productivity of the system. Conversely, the absence of larval burbot is evidence that spawning or hatching success is very limited. To confirm the lack of spawning and/or hatching success, we recommend drift nets be set in tributary mouths in an effort to collect burbot eggs and/or larvae.

The single YOY burbot collected in 1995 is evidence, though not conclusive, that burbot spawning still occurs in the Idaho reach of the Kootenai River. The location of capture of the YOY burbot (near the mouth of Trout Creek in shallow water), and documentation of adult burbot in the same general area (Paragamian 1994), supports the possibility that it immigrated from the tributary. However, the high flows throughout May and June may have resulted in the downstream migration of burbot produced below Libby Dam, and/or entrained young burbot from Libby Reservoir. Future studies should continue to address all stages of burbot life history. Drift nets, in conjunction with continued adult trapping and telemetry, and further efforts with minnow traps will all contribute to our understanding of the behavior and factors limiting the remnant burbot population.

ACKNOWLEDGEMENTS

The following people contributed to the larval and YOY sturgeon and burbot sampling efforts: Dave Fryda, Derek Marks, Mark Pray, Gretchen Kruse, Kara Hilwig, Dave Overman, Ken Kitzer, and Brian Sukauskus. Don Miller conducted the beam trawl efforts in conjunction with Kootenay Lake kokanee sampling. Dianne Wakkinen assisted with the data analysis. Chip Corsi, Melo Maiolie, Rick Westerhof, and Kim Apperson reviewed and edited drafts of this report.

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