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White Sturgeon Spawning and Recruitment Evaluation

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FISHERY RESEARCH

KOOTENAI RIVER WHITE STURGEON SPAWNING AND RECRUITMENT EVALUATION

ANNUAL PROGRESS REPORT
April 1, 2003 to March 31, 2004

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IDFG Report Number 04-30
November 2004

Kootenai River White Sturgeon Spawning and Recruitment Evaluation

Project Progress Report

April 1, 2003 to March 31, 2004

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

ABSTRACT

The objective of this research was to determine the environmental requirements for successful spawning and recruitment of the Kootenai River white sturgeon *Acipenser transmontanus* population. Annual tasks include monitoring and evaluating the various life stages of Kootenai River white sturgeon. Sampling for adult Kootenai River white sturgeon in 2003 began in March and continued through April. Eighty-one adult white sturgeon were captured with 3,576 hours of angling and set-lining effort in the Kootenai River. Discharge from Libby Dam and river stage at Bonners Ferry in 2003 peaked in May and early June. Flows remained above 500 m^3/s throughout June, decreased rapidly through mid July, and increased back to near 500 m^3/s after mid July and through mid August. By late August, flows had decreased to below 400 m^3/s. We monitored the movements of 24 adult sturgeon in Kootenay Lake, British Columbia (BC) and the Kootenai River from March 15, 2003 to August 31, 2003. Some of the fish were radio or sonic tagged in previous years. Twelve adult white sturgeon were moved upstream to the Hemlock Bar reach (rkm 260.0) and released as part of the Set and Jet Program. Transmitters were attached to seven of these fish, and their movements were monitored from the time of release until they moved downstream of Bonners Ferry. Eight additional radio-tagged white sturgeon adults were located in the traditional spawning reach (rkm 228-240) during May and June. Sampling with artificial substrate mats began May 21, 2003 and ended June 30, 2003. We sampled 717 mat d (a mat d is one 24 h set) during white sturgeon spawning. Three white sturgeon eggs were collected near Shortys Island on June 3, 2003, and five eggs were collected from the Hemlock Bar reach on June 5, 2003. Prejuvenile sampling began June 17, 2003 and continued until July 31, 2003. Sampling occurred primarily at Ambush Rock (rkm 244.0) in an attempt to document any recruitment that might have occurred from the Set and Jet Program. Sixteen larval fish were collected, but no prejuvenile white sturgeon were collected. Juvenile white sturgeon sampling started July 14, 2003 and continued through September 18, 2003. A total of 330 h of gillnetting effort captured 238 hatchery white sturgeon and three wild white sturgeon.

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OBJECTIVE

1. Our study objective was to determine environmental requirements for successful spawning and recruitment of Kootenai River white sturgeon *Acipenser transmontanus*.

STUDY SITE

The Kootenai River originates in Kootenay National Park, British Columbia (BC), Canada. The river flows south into Montana and turns northwest at Jennings, near the site of Libby Dam, at river kilometer (rkm) 352.4 (Figure 1). Kootenai Falls, 42 km downstream of Libby Dam, is thought by some to be an impassable barrier to Kootenai River white sturgeon. As the river flows through the northeast corner of Idaho, there is a gradient transition at Bonners Ferry. Upriver from Bonners Ferry, the channel has an average gradient of 0.6 m/km, and the velocities are often higher than 0.8 m/s. Downstream from Bonners Ferry, the river slows to velocities typically less than 0.4 m/s, and the average gradient is 0.02 m/km; the channel deepens as the river meanders north through the Kootenai River Valley. The river returns to BC at rkm 170 and enters the South Arm of Kootenay Lake at rkm 120. The river leaves the lake through the West Arm of Kootenay Lake and flows to its confluence with the Columbia River at Castlegar, BC. A natural barrier at Bonnington Falls (now a series of four dams) has isolated the Kootenai River 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 (Bonde and Bush 1975). Regulation of the Kootenai River following the construction of Libby Dam in 1974 changed the natural hydrograph of the river. Spring flows have been reduced by about a third, and flows during winter are now three to four times higher (Figure 2). Since 1991, Libby Dam has released spring flows intended to benefit Kootenai River white sturgeon (hereafter white sturgeon) spawning by increasing discharge and river stage (Figures 2 and 3).

METHODS

Water Levels and Temperature

Kootenai River discharge and water temperature data were obtained from the United States Army Corps of Engineers (USACE). In January 2003, the USACE adopted the use of VARQ (variable discharge or variable Q) flood control operations for interim use. VARQ was intended to meet multiple water uses by reducing wintertime reservoir drawdown at Libby and other dams for flood control storage and improving reservoir refill in summer. Preliminary models indicate that VARQ would increase storage in reservoirs in normal and below normal water years and provide for more assurance of flow augmentation for fish, but not to the point of causing flooding downstream. Higher runoff years would result in normal reservoir and flood control operations (USACE 1998).

Adult White Sturgeon Sampling

Adult white sturgeon were captured with rod and reel or setlines from March 10, 2003 to April 16, 2003, following the methods of Paragamian et al. (1996). Biopsies were performed to determined sex and gonad stage, and adult white sturgeon expected to spawn in 2003 were

tagged with both a depth sensitive radio transmitter and a sonic transmitter, then monitored to determine movements during the spawning season.

Set and Jet Experiment

Kootenai River white sturgeon are currently spawning over sand substrates (rkm 228.0-240.0) where egg mortality is thought to be high. This may be a leading factor in the well-documented recruitment failure of this population. Substrates at the Hemlock Bar reach (rkm 260) more closely resemble spawning and rearing substrates of other successfully recruiting white sturgeon populations (Parsley and Beckman 1994; Auer and Baker 2002). The Set and Jet experiment (hereafter Set and Jet Program) was designed to test the feasibility of moving sexually mature white sturgeon long distances to different habitat types. We also monitored the behavioral response of the transported fish to document spawning in this new habitat. If fish spawned, we monitored the subsequent life stages as part of the Idaho Fish and Game Monitoring and Evaluation Program.

Fish were captured with setlines and angling as part of the Adult White Sturgeon Sampling mentioned in the previous section. We attached radio and sonic transmitters to the dorsal fin, and tissue samples were taken for future genetic analysis. Individuals were either moved upstream to the Hemlock Bar reach directly or held in a holding pen at the Kootenai Tribal hatchery facility (rkm 242.5) until they were transported upstream at a later date.

Fish were held in the net pen for two reasons. At lower river stages, jetting by boat is dangerous and often impossible. Under these conditions, fish were temporary held in the holding pen, then trucked in 200 liter hatchery tanks to the boat ramp at the mouth of the Moyie River (rkm 259.0) and jetted the remaining distance. Individual fish were also held at the hatchery facility overnight to facilitate moving multiple fish upstream together to incorporate any group behavioral response, which may increase the chances that individuals would stay upstream. All transmittered fish were tracked weekly as part of the Idaho Fish and Game Monitoring and Evaluation Program. Current velocity, water depth, geographic position, and water temperature were recorded at each telemetry location.

Habitat use by adults in the Hemlock Bar reach was assessed by personal observation at each daytime telemetry location. Physical habitat variables have not been formally assigned to the Kootenai River, and habitat availability is unknown. Physical habitat was defined by current velocity, relative water depth, use of riffles, runs (or glides) or pools, and association with other physical structures (rock faces, boulders, etc.).

Adult White Sturgeon Telemetry

White sturgeon that were fitted with transmitters as part of the Set and Jet Program and moved out of the Hemlock Bar study area, and white sturgeon with transmitters still active from previous years, were monitored by boat, fixed station, and fixed wing aircraft telemetry.

Boat Telemetry

Movements and migration of adult white sturgeon fitted with sonic and radio transmitters (not in the Hemlock Bar reach or a part of the Set and Jet Program) were monitored monthly by

boat from the Kootenai River at Bonners Ferry to the river's delta at Kootenay Lake. The main objective was to locate late vitellogenic females and reproductive males migrating upstream to staging and spawning reaches. Each transmitter location was recorded to the nearest 0.1 rkm, and UTM (Universal Transverse Mercator) geographic coordinates were recorded. Effort to monitor sturgeon movement and activity varied with season. Less effort was provided during winter months when most fish moved less frequently. Increased movement of tagged fish during the prespawning and spawning seasons required more frequent monitoring. Reaches above Copeland, Idaho (Figure 1) were monitored more intensively than downstream or Kootenay Lake, especially during the prespawning and spawning periods when mature sturgeon moved upstream.

Fixed Receiver Telemetry

Each fixed receiver station consisted of a scanning receiver (Advanced Telemetry Systems [ATS] model R2100), data logger (ATS model DCCII), 3-element Yagi antenna, and 12-volt deep-cycle battery to operate the system. Antennas were mounted on 1.8 m (6 ft) metal fence posts, horizontal to and affording a clear 180-degree view of the river. Selected sites were all on straight reaches of the river to facilitate reception of radio frequencies of potential male and female spawners programmed into the receivers. Data loggers were set to record only those frequencies matching tagged white sturgeon. Each receiver was upgraded to conform to the depth sensitive tags, yielding the time (milliseconds) to record 10 incoming signals and, therefore, a calculation of fish depth as it passed by. Radio test tags were deployed periodically to validate incoming signals.

Fixed location receivers detected movements at specific locations and documented the date and time of the movement. Three fixed receivers were stationed between rkm 173.0 and 244.5. Site 1 was located near Boundary Creek Wildlife Management Area (rkm 173.0). This site is 51 kilometers below the nearest upstream site and provides the opportunity to gain movement and location data on fish moving rapidly downstream. Site 2 was located near Flemming Creek (rkm 224.0-225.0). This site was selected because of its historical precedence, its location in the middle of the study reach that is downstream of a spawning reach. Site 3 was located just upstream from Ambush Rock (rkm 244.5) on the south side of the Kootenai River. This upstream location was chosen in 1999 to detect fish movements upstream of Ambush Rock (rkm 244.4).

Fixed Wing Telemetry

Two loop antennas were mounted on the wing struts of a Cessna 182 for fixed wing aerial telemetry. Flights followed a route downstream from Bonners Ferry or Leonia to Kootenay Lake at an altitude of 152-305 m above the river and speeds of 60 to 80 knots. The radio frequencies of 13 potential spawners were cycled through an ATS model R2100 scanning receiver and deleted as fish were detected. The frequency cycling rate was 2-4 seconds to facilitate maximum numbers (13) of fish cycled without sacrificing detection range. Fish locations in the river were estimated to the nearest 0.1 rkm.

Depth Sensitive Radio Telemetry 2002 and 2003

Depth sensitive radio transmitters were attached to four late vitellogenic females captured as a part of the adult white sturgeon sampling methods discussed previously to determine their vertical location in the water column during the prespawn and spawning seasons. The purposes of this research were threefold. First, we wanted to establish the relation of fish location to current velocities before, during, and after the spawning period. Second, we wanted to determine at what depth, with respect to the water column and with respect to the available depth, sturgeon are spawning. Finally, we wanted to more precisely determine specific behaviors before, during, and after the spawning season, and determine the feasibility and most suitable locations for creating spawning structures or some type of spawning habitat enhancement.

Depth sensitive radio transmitters are pressure responsive, and the depth of the tag can be determined by the pulse frequency, with frequency increasing with increasing depth. A stopwatch was used to determine the number of seconds for 10 pulses (period). The period reading was multiplied by 100 to give the elapsed time in milliseconds. The average of three readings was recorded, and this was entered into a regression equation to calculate depth. To provide more precise depth estimates for each fish, a regression equation was prepared for each radio, prior to attachment of the radio, by submersing the radio to known depths and timing 10 incoming pulses. The river depth at the fish location was determined using a recreational grade depth finder and was recorded to the nearest foot (later converted to metric). Similarly to 2002, we chose one individual fish and followed it exclusively throughout the study. Each day was divided into three, eight-hour time blocks (0000-0759 hours, 0800-1559 hours, 1600-2359 hours), with sampling days and sampling blocks randomized. Individual locations and depth in the water column were recorded approximately three times per hour for each eight-hour sampling block.

Artificial Substrate Mat Sampling

Artificial substrate mats were used to document white sturgeon spawning in the Kootenai River (McCabe and Beckman 1990). Post-Libby Dam sturgeon spawning locations in the Kootenai River have been well documented (Paragamian et al. 2002). By sampling near these well-defined areas, we can effectively predict the beginning of the spawning period and use it as an index to document the initiation of spawning. This information may be used as a trigger for the USACE to initiate the release of water from Libby Dam to increase the survival of naturally produced white sturgeon embryos.

Twenty substrate mats were placed at the Shortys Island reach (near rkm 231.0) until eggs were collected, marking the beginning of the spawning season. After the spawning period was documented, focus shifted to documenting spawning in the Hemlock Bar reach from females transferred upstream as part of the Set and Jet Program.

Prejuvenile Sturgeon Sampling

Young sturgeon were classified as prejuveniles when they had yet to develop ossified elements in the fins, had flattening of the ventral surface, and development of a toothless highly protrusible mouth. Based on the classification of Richmond and Kynard (1995), prejuveniles

were further classified as hatchlings (<1 day old), embryos (1-8 days old), and larvae (9 days and older).

Prejuvenile white sturgeon sampling was conducted using half-meter nets at midwater depths and the surface, and D-ring nets set on the bottom of the Kootenai River. Lead weights ranging from 2.7-9.1 kg were attached to midcolumn and bottom nets to reach the desired depths. We attached flow meters to the mouth of each net and measured current velocity, which when combined with total sampling time and respective net mouth dimensions gave the total volume of water sampled.

Prejuvenile white sturgeon sampling in 2003 focused on documenting recruitment in the Hemlock Bar reach as part of the Set and Jet Program. Most of the sampling was conducted at Ambush Rock at night. This sampling location was chosen because it closely modeled the sampling locations of Auer and Baker (2002) who collected prejuvenile lake sturgeon in similar habitats at similar times. Limited sampling occurred downstream of rkm 231 in an attempt to collect larvae from any recruitment that might have occurred in the traditional spawning reach. All downstream sampling was conducted during the daytime, and study design and locations followed that of Rust et al. (In review).

Juvenile White Sturgeon Sampling

We used weighted multifilament gill nets with 3.8, 5.1, 7.6, 10.2, and 15.2 cm stretch mesh to sample juvenile and young-of-the-year (YOY) sturgeon from July to September 2003 (Paragamian et al. 1996). Gill net sampling was conducted at 17 different sites between rkm 182.0 and 245.5. Gill nets were set during the day and checked every hour. Sampling was stratified by location, and 75 percent of the sampling was conducted at five locations (index sites) thought to be prime juvenile sturgeon habitat. The remaining 25 percent of the effort was directed toward locations thought to be marginal juvenile habitat.

Fifteen juvenile hatchery-reared white sturgeon collected in gillnets were euthanized and their stomachs removed for food content analysis. Pectoral fin ray sections were removed from 37 hatchery juvenile white sturgeon and sent to the University of Idaho (Dennis Scarnecchia) to validate the quality of current ageing techniques.

RESULTS

Water Levels and Temperature

In January 2003, the USACE adopted use of the VARQ flood control operation for interim use. Based on the January water supply forecast at Libby of 6007 hm^3 (78 percent of average) for the April through August period, the end of January VARQ flood control target elevation was 739.8 m, and the March 15 target flood control elevation was 744.2 m.

The February and March water supply forecasts remained well below average, and the flood control target elevations remained well above reservoir elevations that could physically be achieved. Libby Dam continued to release minimum outflow of 112 m^3/s through March and into April and was unable to refill to the flood control elevation. There was some increase of inflow to the reservoir in April, and although Libby continued to release only 112 m^3/s in April, the

reservoir only refilled to elevation 735.2 m. However, low inflow since January kept the reservoir drafting, and the actual elevation of Libby Reservoir was as low as 733 m at the end of March, 13.4 m below the VARQ flood control elevation. During May, the inflow to Libby increased somewhat and the peak of the freshet was slightly greater than 1512 m^3/s on May 30. The dam continued to release only 112 m^3/s in May and refilled to elevation 743 m on May 31, only 7.2 m from full.

In June and July 2003, the operating strategy shifted to meet operations for Kootenai River white sturgeon by the USFWS BIOP (Biological Opinion). To meet those objectives, the USACE was to release 988 hm^3 from Libby in excess of minimum flow of 112 m^3/s and try to refill the reservoir by June 30 and not spill. These objectives were achieved by increasing the outflow from Libby to near 700 m^3/s (maximum powerhouse outflow) by June 7 and maintaining that outflow for 12 days before reducing slightly to 532 m^3/s. At the end of June, inflow to the reservoir was at or slightly less than powerhouse outflow capacity, and the Lake Koocanusa elevation was at 749.3 m, 0.43 m from full. Lake Koocanusa filled to within one foot of full on July 2 and remained in the top foot through July 15, when the reservoir began to draft to meet the August 31 draft limit for the BIOP elevation of 743.6 m. Outflow from Libby was held between 392 m^3/s and 504 m^3/s for the remainder of July and August to draft to this elevation. An agreement was not reached for a Libby-Arrow storage exchange in 2003 because of unfavorable hydrologic conditions in Canada. In September 2003, the outflow was reduced to no lower than 168 m^3/s to maintain wetted habitat in the Kootenai River downstream of Libby, and the reservoir drafted to near elevation 742 m.

Water temperatures at Bonners Ferry, Idaho remained below 8°C until May 12. Temperatures increased slowly through May, reaching 10°C by the end of the month. Temperatures increased through June, approaching 13°C by July 1. July and August were the warmest months, with water temperatures averaging 16°C. Temperatures for the period ranged from 3.0-18.2°C from April through September.

Adult White Sturgeon Sampling

We spent 3,576 hours of effort to capture 48 adult white sturgeon angling and 33 with setlines between March 10 and September 18, 2003 (Table 1). The catch per unit effort (CPUE) for angling and setline gear was 0.067 and 0.016 fish/rod or setline h, respectively.

Sixty-nine (85%) of the 81 adult sturgeon were recaptures from previous years (Table 1). Twenty-six adult white sturgeon were biopsied to determine sexual maturity and stage of ovaries and testes. Sonic and depth sensitive radio tags were attached to six reproductively mature females and four mature male white sturgeon. Three of the females were fitted with depth sensitive radio transmitters for a project to determine depth preference and location in the water column. The remaining seven individuals were fitted with transmitters and transported upstream as part of the Set and Jet Program.

Set and Jet Program

Twelve white sturgeon (nine males, three females) were moved upstream to the Hemlock Bar reach as part of the Set and Jet Program in 2003. Radio and sonic transmitters were attached to four males and three females (Table 2). The first white sturgeon were moved upstream on April 3 and the last on June 19.

Female white sturgeon movement patterns varied. Only one of the three females stayed in the Hemlock Bar reach for longer than one week. The other two females spent only a few days in the release area before moving downstream. Female 5388 was captured on March 11 at rkm 215.5 and was released at rkm 262.0 on June 17. She stayed in the Hemlock Bar reach until June 23, then moved upstream and was located at rkm 270.2 on June 27. By June 30, she was located downstream at 259.5, and by July 2 had moved down to rkm 244.5. On August 5, she was located downstream near the Creston, BC delta by aerial telemetry. Female 2247 was captured June 8 at rkm 229.1 and released at rkm 262.1 on June 9. By June 13, she had moved downstream to rkm 244.5, and by June 23, she was located at rkm 188.4. Female 715 was captured May 29 at rkm 227.4 and was held in the Kootenai Tribal Hatchery facility prior to release at rkm 261.4 on June 2, 2003. She stayed near the study reach between rkm 260.0 and 256.0 until June 5, before moving down to near rkm 245.3 where she stayed until June 9.

Of the four males transported upstream, two exhibited no movements for several months after release and probably shed their transmitters. Male 664 was collected on May 7 at rkm 217.9, jetted upstream directly, and released on that date at rkm 265.5. On May 12, he was located upstream at rkm 266.7, and by May 14, he had dropped downstream to rkm 257.2. On May 20, he was located at rkm 244.5 before steadily dropping downstream to rkm 212.4 by August. Male 976 was captured on May 5 at rkm 217.9. He was held in a holding pen overnight at the Kootenai Tribal Hatchery facility before being moved upstream and released at rkm 261.5 on May 6. After release, he moved almost immediately downstream to rkm 244.5. By May 12, he was located near rkm 236.0 where he stayed until August 12. Once individuals moved out of the Hemlock Bar study reach, telemetry effort decreased, and their locations and movements were summarized below in the Adult White Sturgeon Telemetry section of this report.

Most of the white sturgeon located in the Hemlock Bar reach were associated with deep pools, with occasional use of runs or glides and rare use of shallow riffles. Most individuals were found in the lowest current velocities available and rarely used areas with high current velocities. Additionally, individuals were often associated with rock faces or rock outcrops. When considering the selected habitat variables together, during the daytime, most white sturgeon were near rock faces, with relatively deep water and relatively low current velocities.

Adult White Sturgeon Telemetry

Migration of Monitored Sturgeon in 2003

We monitored the movements of 24 adult white sturgeon (13 females, 10 males, one of undetermined sex) from September 1, 2002 to August 31, 2003 (Figure 4, Table 3 and 4, and Appendices 1-4). Many of these individuals were tagged prior to 2003; this summary includes those fish as well as individuals tagged this year, which includes fish in Kootenay Lake, BC, and the Kootenai River in Idaho and BC. Twenty-two of the 24 adult sturgeon were monitored in the Kootenai River (Table 4). Of these, 16 (eight females, seven males and one adult of undetermined sex) moved or were moved into the spawning reach from various staging or overwintering areas (Appendices 1-4). Seven fish, four males (209, 664, 976, and 2252) and three females (715, 2247, and 5388), were part of the Set and Jet Program. These fish were captured downstream at various locations and taken by boat upriver for release at points above rkm 261.0 (movements within the Hemlock Bar reach discussed previously). Eight fish (females 318, 715, 1453, and 2368, males 209, 664, and 2252, and one adult of undetermined sex, 859) were located in the spawning reach (rkm 228.0-246.0) during times when spawning was

estimated to have occurred (Table 4). These eight fish and eight more (females 292, 812, 2247, and 5388 and males 43, 504, 880, and 976) are thought to have spawned (Table 4, "suspected spawners") based on their development from biopsies at capture and/or their movements during the spawning season. Males 43, 504, and 880, and 859 the adult of undetermined sex, were thought to have spawned in 2002 based on movement data. Male 43 was captured at rkm 215.0 on March 6, 2002 and sexed as a male at nonreproductive stage 7. He moved upstream to rkm 243.0 (just downstream of Ambush Rock) June 18, 2002, then downstream to the Trout Creek area (rkm 213.2) to overwinter. Number 43 was recaptured March 17 and 23, 2003 near Rock Creek (rkm 215.0), moved upstream to rkm 241.0 (just above Deep Creek) June 9, and back downstream to overwinter. Male 504 was captured April 15, 2002 at Ferry Island (rkm 204.5) and sexed at male 7. He moved upstream to rkm 239.0 several times by the end of May and in June 2002, overwintered near Deep Creek (rkm 240.0) and again moved upstream to rkm 244.5 (Ambush Rock) in June 2003 before dropping downstream to rkm 173.0 by July 23, 2003. Male 880 was captured March 13, 2002 at rkm 215.0 and sexed at male 7. He moved upstream to rkm 240.0 (Deep Creek) by April 2002 and stayed until May 9, 2002, moving back downstream to Flemming Creek (224.5) and staying through May 16, 2002. He shifted back upstream to rkm 244.5 (Ambush Rock) May 19 through July 18, dropped downstream below rkm 225.0 by August 14, 2002, and overwintered. Number 880 was detected again at rkm 244.5 March 21, 2003 and remained there until July 11 when he moved downstream below rkm 225.0 until August 12 when he was detected upstream again at rkm 241.0. Fish 859 was captured at rkm 215.0 (Rock Creek) March 6, 2002 and not sexed. It moved upstream to the Flemming Creek area (rkm 224.0-225.0) in June 2002 and overwintered near Rock Creek. In 2003, it moved upstream as high as rkm 242.4 before dropping back downstream to Rock Creek by June 23, 2003.

Boat Telemetry

Boat telemetry for white sturgeon locations occurred from September 1, 2002 through August 31, 2003 (Figure 4). We made 124 trips totaling 228.5 h, and made 389 detections. We spent more than 117 hours and made 245 detections in May and June 2003 when white sturgeon were moving between staging and spawning areas of the river.

Fixed Receiver Telemetry

Fixed site 1 (rkm 224.5) logged data April 22 through August 1, 2003. Site 2 (rkm 173.0) operated May 27 through August 1, 2003. Site 3 (rkm 244.5) collected data April 8 through August 1, 2003. These dates corresponded to the period of upstream movements of spawning fish as noted by current boat, aerial and fixed station telemetry. The only locations discussed in our analysis are those verified by boat or aerial telemetry or those occurring at more than one fixed station. The 3-element Yagi antennas detected the movements of 12 fish past one or more of the three fixed stations, including seven females (fish numbers 292, 318, 715, 1453, 2247, 2368, and 5388), four males (262, 664, 880, and 976), and one adult of undetermined sex. All seven of the females, three of the males, and the adult of undetermined sex were suspected spawners in 2003. Seven fish were detected at the site 3 (Ambush Rock, rkm 244.5) between April 9 and July 2, 2003: four females (292, 715, 2247, and 5388; all were suspected spawners) and three males (664, 880, and 976; all suspected spawners). Eight fish were detected at site 1 (Flemming Creek, rkm 224.5) between May 5 and July 19, 2003: five females (318, 1453, 2247, 2368, and 5388), two males (664 and 880), and the one adult of undetermined sex. Five fish

were detected at site 2 (rkm 173.0), including one male (262) and four females (318, 2247, 2368 and 5388). These fish were detected between June 4 and July 28, 2003.

Fixed Wing Telemetry

Fixed wing flights occurred from September 3, 2002 through August 21, 2003. Many flights occurred in conjunction with tracking flights for tagged bull trout *Salvelinus confluentus* and rainbow trout O*ncorhynchus mykiss* (Walters, in review). Twenty sturgeon detections were made during four flights, consisting of approximately 16.5 hours. This accounted for 50% of the fish tags for which we searched. Fourteen different white sturgeon were detected: 14 suspected spawners (eight females—fish #'s 292, 318, 715, 812, 1453, 2247, 2368, and 5388 and six males—209, 504, 664, 880, 976, and 2252). The majority of the flying occurred from Bonners Ferry (rkm 245.0) to the Canadian border (170.0), but also down to the Kootenai River Delta and South Arm (rkm 106.0-122.0).

Depth Sensitive Radio Telemetry 2002 and 2003

Depth sensitive radio transmitters were attached to one female white sturgeon in both 2002 and 2003. Each sampling day was divided into three eight-hour sampling periods. Sampling days and times were randomized and movements were monitored about three times per hour for eight consecutive hours.

Study fish from 2002 and 2003 were similar in size and weight, and based on egg development, both were probably going to spawn the year they were studied (Table 5). Each year, movements were monitored from the prespawn period (when fish were still in the staging areas) to postspawn when fish began moving back to Kootenay Lake. Temperatures during each study period were similar (Table 5). The range of river used during each study period was similar between years, but the average river kilometer used between years was different (Table 5); however, this may be an artifact of disproportionate early over-sampling in the staging area. The range of current velocities at each location and the average velocities for all locations were considerably different between 2002 and 2003 (Table 5).

Fish were contacted 178 times in 2002 and 117 times in 2003. During both years, fish spent most of the time near the bottom of the river (Figure 5). In 2002, 89% of the contacts were made in the bottom 1/3 of the water column compared to 69% in 2003. Calculated depth within the water column based on transmitter pulse frequency from 2002 and 2003 averaged 8.8 meters and 7.3 meters, respectively (Table 5). River depth at each location from 2002 and 2003 averaged 9.7 meters and 10.3 meters, respectively (Table 5).

Generally, most of the movement activity occurred during low light periods (dusk or dawn) with minimal movement during the day. Vertical movements happen quickly and are difficult to quantify. The greatest horizontal or lateral movement from 2002 occurred on the evening of June 4 between 1957 hours and 2029 hours, when fish 2227 moved 900 meters in 34 minutes. The greatest horizontal movement from 2003 occurred on May 29 between 10:30 and 10:55, when fish 1453 moved 1100 meters in 25 minutes. For each year, there were several sampling periods with little or no horizontal or vertical movement for the entire eight hours, and other sampling periods when the fish never stopped moving, with most of the movements being within a few 100 meters.

Artificial Substrate Mat Sampling

We sampled 717 mat days on the Kootenai River from May 21 to June 30, 2003 (Table 6). Most of the early sampling occurred in the traditional spawning reach (rkm 227 to 246). On June 3, three white sturgeon eggs were collected at Shortys Island (rkm 230.7) at a depth of 10.3 meters. Water velocities at the egg collection site averaged 0.39 m/s and ranged from 0.65 m/s (2 meters below the surface) to 0.12 m/s (1.7 meters off the bottom). Secchi disc measurement on that date was 2.0 meters (Table 7).

Once eggs were found and spawning was verified, sampling in the traditional spawning reach ceased, and all the effort shifted to documenting spawning in the Hemlock Bar reach (rkm 261.0 to 262.5). On June 5, five white sturgeon eggs were collected below Hemlock Bar (rkm 261.6) at a depth of 7.5 meters. Depth and flow characteristics at the egg collection site and within the egg deposition vicinity were measured (Appendix 5). Water velocities at the egg collection site averaged 1.2 m/s and ranged from 1.3 m/s (1.5 meter below the surface) to 1.2 m/s (1.5 meters above the bottom) (Appendix 5). Secchi disc measurement on that date was 2.1 meters (Table 7).

Prejuvenile White Sturgeon Sampling

Sampling for white sturgeon embryos and larvae began on June 17 and continued until July 31. Effort was distributed evenly between D-ring samples and half-meter nets fished on the surface and in the midwater column (Table 8). Most of the sampling was conducted at Ambush Rock (rkm 244.0) in an attempt to document recruitment from the Set and Jet Program. Sixteen larval fish were collected, but no larval white sturgeon were collected (Table 8).

Juvenile White Sturgeon Sampling

Juvenile sturgeon sampling started July 14 and continued through September 18, 2003. Two hundred thirty-eight hatchery juveniles and three wild juveniles were captured in gillnets with 330 hours of sampling effort (Tables 9 and 10). Most (75%) of the sampling effort was on the five prime juvenile rearing areas, and 25% of the effort was on seven marginal habitat sites. The highest catch rates were from the 1 inch stretch gillnets followed by 3 inch stretch gillnets (Table 9). Ferry Island (rkm 205.5) and Rock Creek (rkm 215.5) had the highest catch rates; no juveniles were collected at several sites (Table 10). Of the 241 individuals sampled, 37 families (from the KTOI hatchery) were represented, and 18 individuals were from family BC 86. The 1999 year-class was well represented with 95 (39%) individuals collected.

The average fork and total lengths of the 238 hatchery juveniles sampled was 35.6 cm and 41.3 cm, respectively, and weight averaged 0.33 kg (Table 11). Details on sizes and numbers of hatchery white sturgeon stocked in the Kootenai River since 1990 are given in Appendix 6, and specific growth parameters of the juvenile white sturgeon captured in 2003 are listed in Appendix 7.

All three wild juvenile white sturgeon were captured at Ferry Island (rkm 205.0) (Appendix 8 and 9). Two of the individuals were captured in 15.2 cm stretch mesh and one was captured in 5.1 cm stretch mesh. Total length was 61.5, 75.0, and 84.1 cm, fork length was 71.7, 85.1, and 99.0 cm, and weight was 1.5, 3.9 kg, and unknown, respectively.

Fifteen hatchery white sturgeon were euthanized and their stomachs removed for food habit analysis. Chironomid larvae were the most common food item in the sturgeon stomachs.

Pectoral fin ray sections were removed from 37 hatchery-reared juvenile white sturgeon to determine the accuracy of current ageing techniques. Three of the fin rays could not be used; therefore, 34 fin rays were aged. Twenty-six of the fin rays were from the 1995 year-class, five were from the 1992 year-class, and three were from the 1991 year-class (Appendix 10). Only fourteen (41%) of the fin rays were correctly aged, but 19 out of the 20 (95%) incorrectly aged fin rays were within one year of the correct age. Additionally, ages for 17 of the 20 (85%) incorrectly aged fin rays were overestimates (Appendix 10).

DISCUSSION

Sixteen of the 22 telemetered fish moved into the Shortys Island spawning reach in 2003. Eggs were collected at Shortys Island on June 3, 2003, but sampling strategies did not include documenting the number of events that occurred throughout the spawning period as in previous years. White sturgeon spawning events during the years 1994 through 2000 were compared to daily average flow and daily average temperature at Bonners Ferry for each event. White sturgeon often spawned during decreasing seasonal flows, and the number of events detected each year ranged from nine to 20, with the number of days during the spawning period ranging from 17 to 31 days (Paragamian and Wakkinen 2002). The most consistent year of Kootenai River white sturgeon spawning was 1996, when spawning was detected from egg mat sampling during 18 of 19 days; flow ranged from 891-1,259 m^3/s and averaged about 1,131 m^3/s for the first 11 events before there was a day of undocumented spawning. Average daily water temperature during spawning ranged from 7.5-14°C. Most of the spawning (48%) occurred when water temperature was 9.5-9.9°C. Average daily flow for spawning events ranged from 141-1,265 m^3/s, but most (63%) spawning took place when flow exceeded 630 m^3/s (Paragamian and Wakkinen 2002). The Kootenai River White Sturgeon Recovery Plan (USFWS 1999) recommends that for optimum white sturgeon spawning in the Kootenai River, flows should be held above 630 m^3/s and water temperature from 9.5-12°C, for a duration of 42 d. The most consistent spawning took place at an average of 1,131 m^3/s.

Depth sensitive radio telemetry studies have provided information on where white sturgeon reside in the water column during the spawning season; however, specific movements and habitat uses during actual spawning events could not be determined. Actual spawning may occur in a relatively short time period, and even with intense sampling effort, movements or behavior based on point estimates may be too large of a time scale to actually document spawning events and associated behavior. Two years of detailed telemetry studies following one female white sturgeon for each spawning season has shown that there are periods of vertical movement, but sturgeon are spending most of their time near the substrate a few meters off the bottom. It would be valuable to compare habitat availability data for the upper Kootenai River so habitat preference, in terms of substrate, velocity, and/or depth, could be quantified.

Kootenai River white sturgeon spawn in an area that we believe is inhospitable to egg or larval recruitment, and telemetered adults have not moved upstream of Bonners Ferry (rkm 245.0) to more suitable habitat. Other white sturgeon populations within the Columbia River basin have shown a preference for spawning over gravel and cobble substrates (Parsley and Beckman 1994). The Set and Jet Program was designed to move sturgeon to more suitable

spawning habitat as a short mechanistic measure to increase recruitment. We documented spawning from the 2003 Set and Jet Program, but the eggs were collected too early in development to determine if fertilization occurred.

Prejuvenile sampling failed to document any white sturgeon recruitment from the Hemlock Bar reach as a result of the Set and Jet Program. Since most of the larval sampling focused on recruitment from Set and Jet females, unless other females spawned upstream naturally, the numbers of drifting larvae were probably low, and when taken in combination with the large water volume (400 m^3/sec), the chances of collecting any drifting larvae is thought to be very low. Whether there is broad application to moving low numbers of spawning males and females to "better" spawning habitat is uncertain. Unless we can eventually change the behavior of individuals to migrate in mass to the Hemlock Bar reach or other areas upstream with proper spawning substrate, we are still selecting which individuals will spawn, similar to a hatchery situation. One of the primary applications of this research may be to determine specifically what type of substrate the females select for spawning after they are moved to the Hemlock Bar reach, especially if larval recruitment is documented. This may provide valuable information on what types of microspawning habitat to create if we begin spawning habitat restoration in the traditional (post-Libby dam) spawning reach.

Most of the fish that were moved to the Hemlock Bar reach moved back downstream of Bonners Ferry (rkm 245.0) in a matter of a few weeks. A more specific study design is needed to try to determine the optimal time for moving fish upstream. The 2003 study was a pilot study, and the 2004 Set and Jet Program should include moving more fish, tagging all fish moved upstream, and moving some fish early (several weeks prior to spawning) and some fish late (close to spawning). We can then assess the spawning success and recruitment of fish moved early and late.

Data obtained from over 10 years of intense substrate mat sampling has provided information on spawning timing, spawning duration, specific spawning locations and extent, and percent viable eggs. Since we now have a good understanding of these concepts, we can use artificial substrate mat sampling as an index to document the initiation of spawning and redirect our focus on other monitoring programs or research efforts.

Most of our larval sampling at Ambush Rock occurred at night. Sampling times and location (rkm 244.5) were loosely modeled after research done by Auer and Baker (2002), who collected larval lake sturgeon along a gradient from directly below the egg collection sites to as far as 60 km downstream of the egg collection sites. No larval white sturgeon were collected in 2003, and it is disconcerting how few nontarget prejuvenile fish have been collected over the past 10 years as part of the larval monitoring program. With such poor success in collecting wild produced larval white sturgeon, it may be time to either increase sampling effort substantially, modify sampling designs, or experiment with other types of larval sampling gears such as light traps.

Gillnet sampling for juvenile white sturgeon has been a successful way to measure relative abundance of hatchery juveniles and year class strength, and has provided test fish for many other studies. In the past, gillnet sampling has also been used to evaluate distribution and movements of hatchery and wild juvenile white sturgeon. Understanding these behavioral differences, habitat preferences, and movements of hatchery and wild juvenile white sturgeon between the Kootenai River in Idaho and British Columbia, and Kootenay Lake in British Columbia may help resolve future stocking rate and stocking location issues. Recent advances

in sonic telemetry (VEMCO) have provided a more efficient, cost-effective method for determining this information.

RECOMMENDATIONS

1. As soon as water temperature reaches 7°C after April 1, provide 425 m^3/s flow at Bonners Ferry with stable or increasing temperature to initiate and maintain spawning migration of Kootenai River white sturgeon.

2. Provide minimum flows of 630 m^3/s for 42 d (as prescribed for spawning and rearing in the Kootenai River White Sturgeon Recovery Plan) at Bonners Ferry once water temperatures of 8°C-10°C are reached to stimulate spawning and optimize egg/larval survival of Kootenai River white sturgeon.

3. Unite up to 20 mature white sturgeon with suitable spawning substrates by moving them during the prespawning and spawning season to the Hemlock Bar reach (rkm 262.0). Move 10 of these sturgeon early in the spawning period when temperatures are below 10°C and 10 when temperatures are above 10°C to determine the optimal movement timing for promoting spawning and recruitment.

4. Experiment with light traps or other gear types to try to find alternative methods to monitor white sturgeon abundance and recruitment. Incorporate passive VEMCO sonic telemetry techniques into standard adult and juvenile white sturgeon movement and behavioral monitoring to gather seasonal or yearly movement patterns, and phase out standard point location monitoring with current radio and sonic telemetry techniques.

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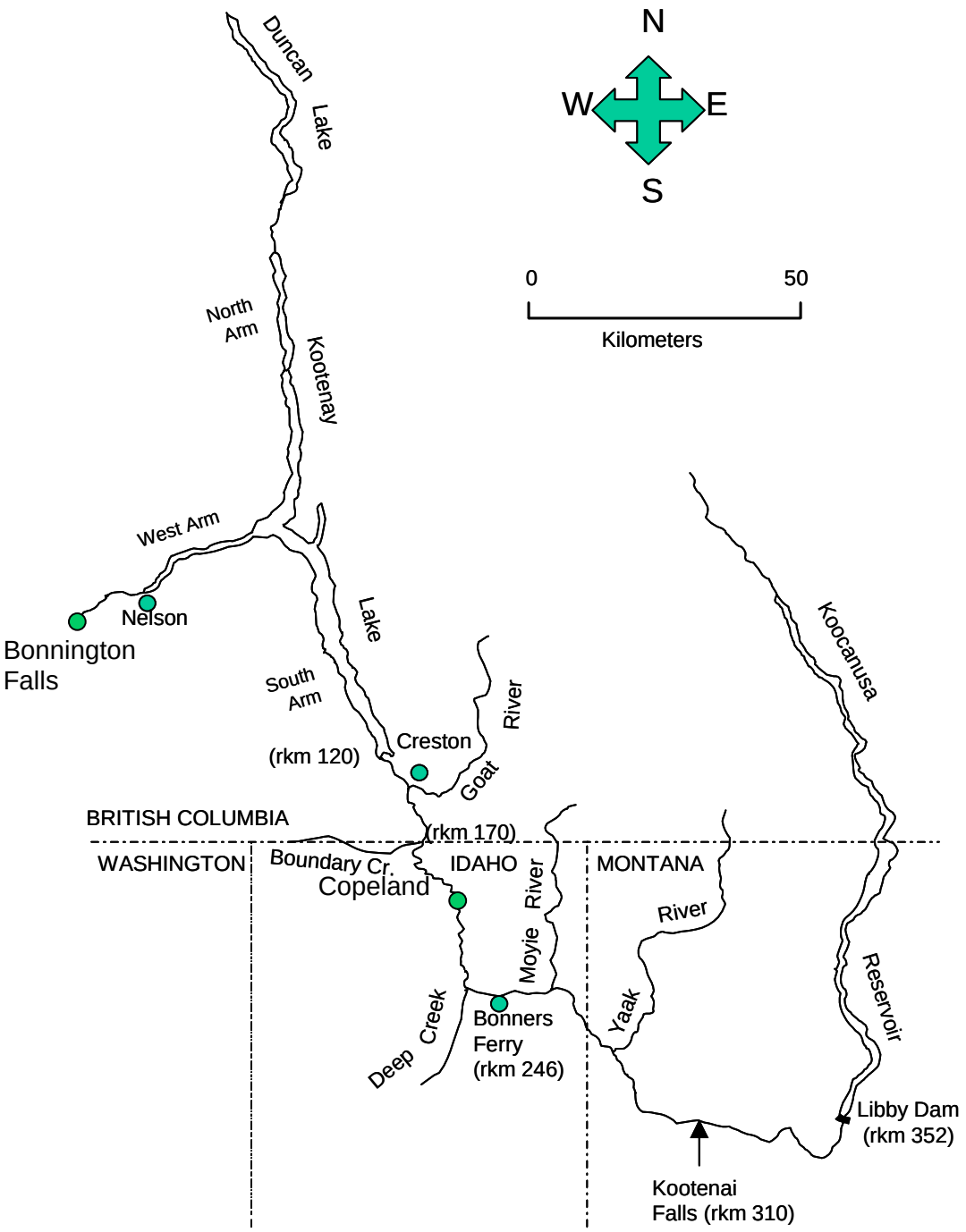


Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

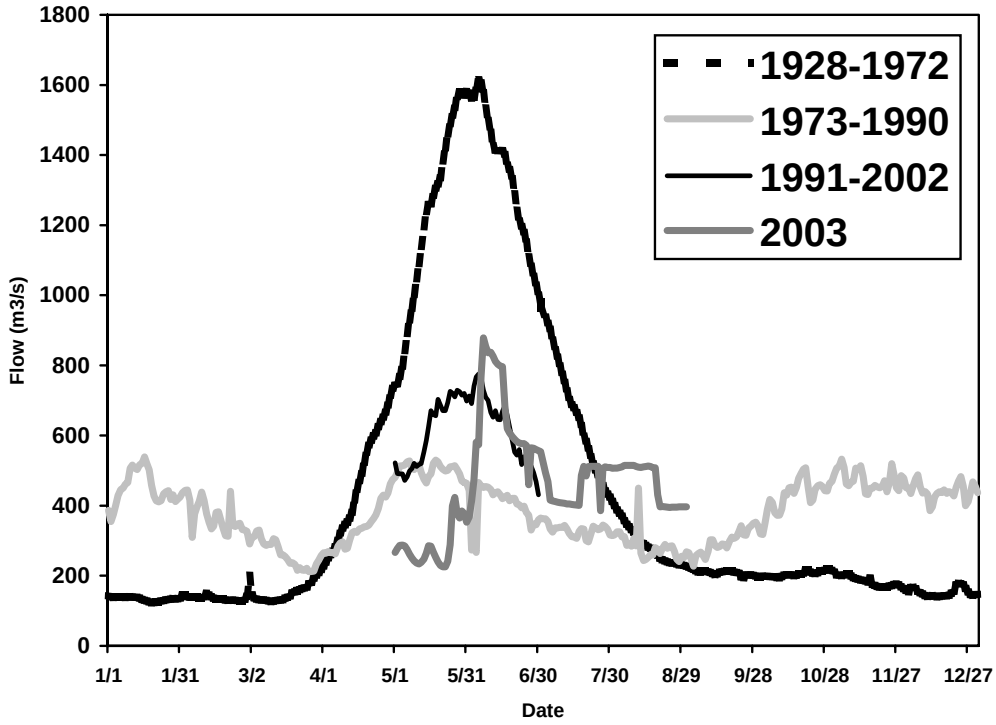


Figure 2. Mean daily flow patterns in the Kootenai River at Bonners Ferry, Idaho from 1928-1972 (pre-Libby Dam), 1973-1990 (post-Libby Dam), 1991-2002 (post-Libby Dam with augmented flows, May 1 through June 30), and 2003 (May 1 through August 31).

Figure 3. Mean daily stage (meters) in 2003 for Kootenai River at Leonia, Idaho.

Table 1. Sampling effort and number of adult and juvenile white sturgeon caught by the Idaho Department of Fish and Game in the Kootenai River, Idaho, March 10, 2003 to September 18, 2003.

	Hours of effort	Number of juvenile sturgeon caught	Number of adult sturgeon caught (No. of recaptures)	Juvenile CPUE (fish/h)	Adult CPUE (fish/h)
Gillnet	329.7	241	0	0.731	0
Angling	494.0	1	33(27)	0.002	0.067
Setline	3,082.0	0	48(42)	0	0.016
Total		242	81(69)		

Table 2. Vital statistics from Kootenai River white sturgeon moved upstream as part of Set and Jet Program.

Male	Female	Total length (cm)	Weigh t (kg)	Captur e date	Release date	Release rkm	Sonic code	Radio frequency
2252		172	28	4/1/03	4/3/03	262.5	2734	30.342
209		182	32	4/2/03	4/3/03	262.5	3547	30.410
1465		156	21	5/1/03	5/1/03	261.0	na	na
976		186	27	5/5/03	5/6/03	261.5	3387	31.322
664		178	36	5/7/03	5/8/03	265.5	3367	31.382
	715	190	43	5/29/03	6/2/03	261.4	3467	31.303
677		162	unk	6/4/03	6/4/03	261.4	na	na
	2247	203	48	6/8/03	6/9/03	262.1	3447	31.362
329		200	41	6/7/03	6/9/03	262.1	na	na
	5388	193	57	3/11/03	6/17/03	262.0	3487	31.161
2301		202	50	6/19/03	6/19/03	262.0	na	na
1459		199	61	6/19/03	6/19/03	262.0	na	na

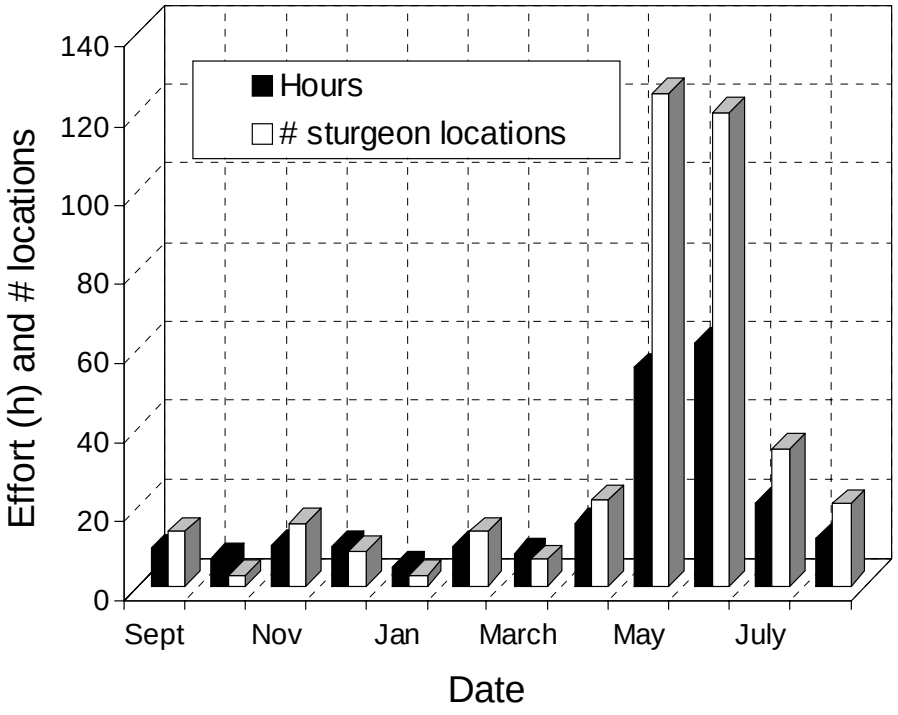


Figure 4. Telemetry effort (hours) and number of times white sturgeon were located monthly from September 1, 2002 to August 31, 2003, Kootenai River, Idaho.

Table 3. White sturgeon tracked to sections of the Kootenai River, Idaho where sturgeon eggs were collected, 2003.

		Fish Numbers		
Location	**Spawning date[a]**	**Males**	**Unknown**	**Females**
Lower Shortys Island (rkm 227-229.5	Not observed (N/O)	N/O	N/O	N/O
Middle Shortys Island (rkm 229.6-231.5)	June 1-3 (eggs collected June 3)	664	859	318, 1453, 2368
Wildlife Refuge (rkm 234.0-240.0)	N/O	N/O	N/O	N/O
Bonners Ferry (rkm 240.1-245)	N/O	N/O	N/O	N/O
Hemlock Bar (rkm 261.0-262.5)	June 3-5 (eggs collected June 5)	209, 2252	N/O	715

[a] This assumes that eggs were spawned in the same river reach where they were collected.

Table 4. Upriver locations of white sturgeon monitored in the Kootenai River from March 1, 2003 through August 31, 2003 (some fish moved out of Kootenay Lake, BC).

Fish #			Tagging location		Highest rkm (date)		Last date above
Male	Unknown	Female	(rkm)	Tag date	>120<225	>225	rkm 225
43[a,e]		—	215.0	3/6/02	[b]	241.0(6/9)	6/19
87[c]		—	205.0	4/19/01	221.5(6/4)[b]	—	—
145[c]		—	215.7	3/21/02	224.6(6/12)[b]	—	—
209[c,d,e,f]		—	205.5[g,i]	4/2/03	—	262.5(4/2)	6/23
262[c]		—	205.0	4/10/01	[b]	—	—
—		284[c]	215.5	3/14/01	218.5(7/8)[b]	—	—
—		292[d,e?]	215.5	3/15/01	[b]	245.6(4/7-7/31)[h]	7/31
—		318[c,d,e]	215.5[i]	4/3/03	—	230.8(5/28)	5/28
504[a,e]		—	204.5	4/15/02	—	244.5(6/23)[b]	6/23
664[d,e,f]		—	217.9[i]	5/7/03	—	266.7(5/12)	6/9
—		715[d,e,f]	227.4[i]	5/29/03	—	261.4(6/2-6/3)	6/9
—		812[a,c,e?]	214.6	4/23/01	[b]	242(4/30,5/12, 27,6/9)	8/12
—	859[a,e?]	—	215.0	3/6/02	[b]	242.4(6/9)	6/9
880[a,c,e]		—	215.0	3/13/02	[b]	244.5(3/21-7/8)	8/12
976[d,e,f]		—	217.9[i]	5/5/03	—	261.5(5/6)	8/12[h]
—		990	215.7	3/7/02	[b]	—	—
—		996[c]	215.7	4/9/02	[b]	—	—
—		1453[c,d,e]	215.3	4/3/03	—	231.4(5/27)	[j]
—		1581[c]	215.6	4/12/02	[b,k]	—	—
—		2227[c]	215.8	4/23/02	[b,k]	—	—
—		2247[d,e,f]	229.1	6/8/03	—	262.1(6/9)	6/16
2252[c,d,e?,f]		—	215.5	4/1/03	—	262.5(4/3)[h]	[j]
—		2368[c,d,e]	215.5	4/3/03	—	244.5(5/20-21)	5/27
—		5388[d,e?,f]	215.5	3/11/03	—	270.2(6/27)	7/2
n = 10	n = 1	n = 13	Combined (n = 24)				
n = 7	n = 1	n = 8	Suspected Spawners (n = 16)				
n = 3	n = 0	n = 5	Non-spawners (n = 8)				

[a] Fish thought to have spawned in 2002 (based on movements), but also made movements in 2003 which suggests spawning in 2003.
[b] These fish overwintered in this section.
[c] These fish were tagged with depth tags (n = 14 active, n = 6 male, n = 8 female).
[d] These fish were expected spawners (assessed by their development in 2003).
[e] These fish were suspected spawners (determined by their movements in 2003).
[f] These fish were part of the set and jet project (captured downstream released upriver > rkm 261.0).
[g] This fish was recaptured (first radio tagged 4/18/94 @ rkm 205.0, spawned 1994).
[h] Probably a shed tag.
[i] These fish were recaptured.
[j] These fish never dropped below river kilometer 225.
[k] These fish made no upriver movements out of Kootenay Lake in 2003.

Table 5. Vital statistics for depth sensitive tagged white sturgeon from 2002 and 2003.

Year	Fish Number	Development Stage	Capture Date	Fork Length (cm)	Total Length (cm)	Weight (kg)
2002	2227	F4	23-Apr-02	165	187	37
2003	1453	F4	3-Apr-03	166	191	43

Year	Telemetry Start date	Telemetry End Date	Depth Use Range (m)	Depth Use Average (m)	River Depth Range (m)	River Depth Average (m)
2002	12-May-02	17-Jun-02	3.3 – 19.7	8.8	4.8 – 24.2	9.7
2003	01-May-03	06-Jun-03	2.4 – 15.8	7.3	5.5 – 25.2	10.3

Year	Current Velocity Use Range (m/s)	Current Velocity Use Average (m)	River Kilometer Use Range	River Kilometer Use Average	Temperature Range °C	Temperature Average °C
2002	0.39 - 1.0	0.73	215 - 241	232	8 - 12	9
2003	0.23 - 0.77	0.33	215 - 231	220	7 - 12	9

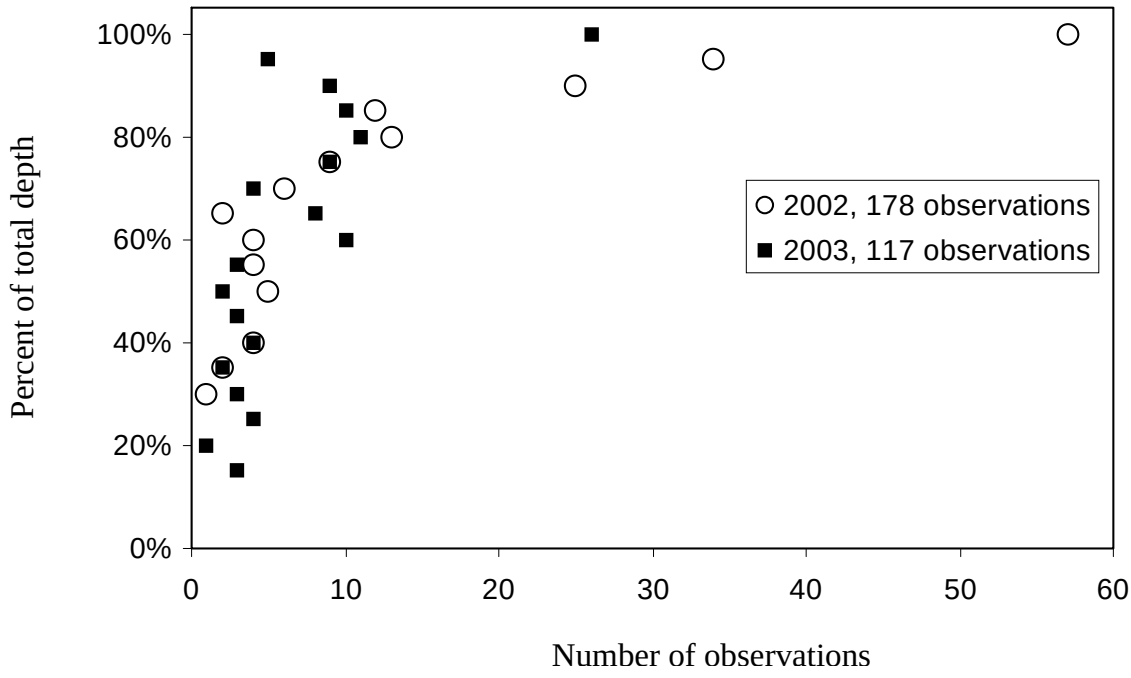


Figure 5. Frequency distribution of white sturgeon relative depth use from Kootenai River depth sensitive telemetry studies, from 2002 and 2003.

Table 6. Location (rkm), depth (m), effort, and white sturgeon egg catch by standard artificial substrate mats, Kootenai River, Idaho, 2003.

Geographical description	River location (rkm)	Depth range (m)	Total mat days[a]	Number white sturgeon eggs
Middle Shortys Island	229.6-231.5	6.1-16.5	160	3
Refuge	234.8-237.5	7.9-17.7	72	0
US Hwy 95	244.7-246.6	1.8-7.9	70	0
Moyie River	258.5.260.9	1.8-12.5	35	0
Hemlock Bar	261.0-262.5	0.9-21.6	381	5
All Sections	229.6–262.5	0.9-21.6	717	8

[a] One mat day is one 24-hour set.

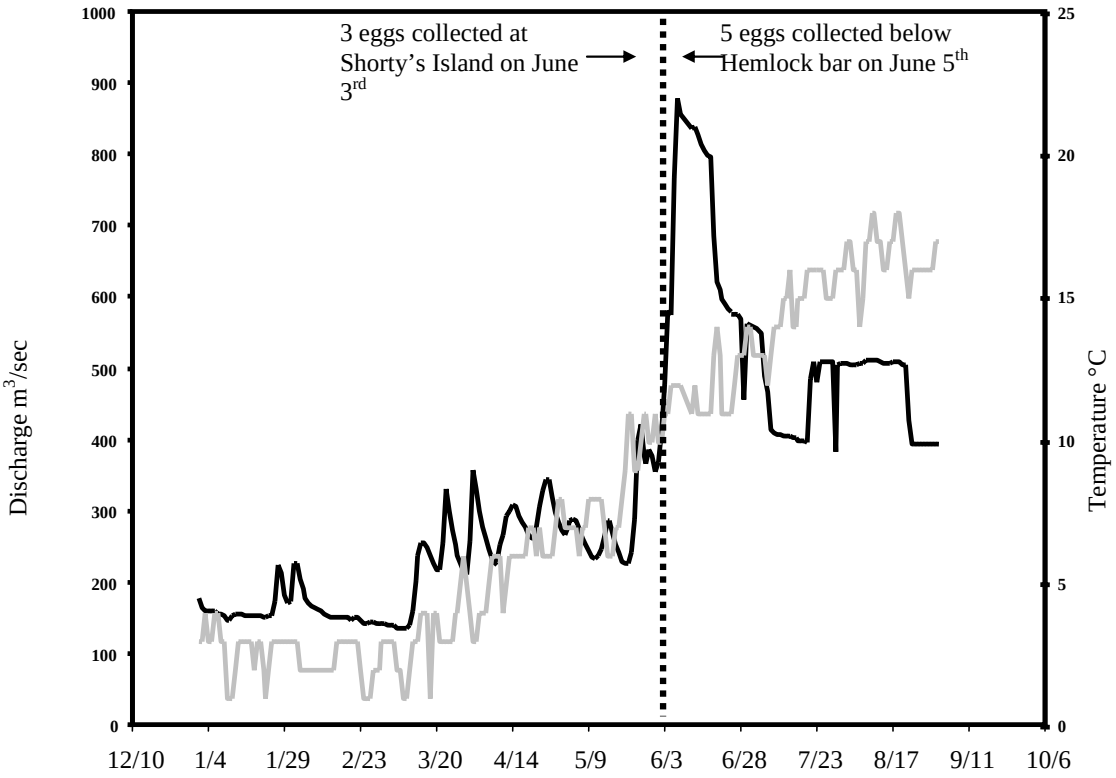


Figure 6. Discharge at Leonia and egg collection dates in the Kootenai River, Idaho, 2003.

Table 7. Secchi disk measurements in the Kootenai River, Idaho during egg mat sampling, 2003.

	River Kilometer					
Date	**230.0**	**240.0**	**244.5**	**259.5**	**261.0**	**262.0**
5/19/03	4.6*		4.8			
5/21/03	4.6		4.6			
5/27/03			0.6			
5/30/03	1.4	1.4	1.4			
6/2/03	2.3	2.1	1.8			
6/3/03	2.0	1.8	1.2			
6/4/03	1.8	1.7	1.2			1.1
6/5/03		2.3	2.1			
6/7/03			1.5		1.4	
6/8/03			1.9			1.7
6/9/03		2.1	2.1			1.6
6/10/03			2.1			1.8
6/12/03			2.3			
6/13/03			2.3		2.1	
6/15/03			2.7			2.6
6/17/03						2.7
6/20/03			2.4			2.7
6/23/03			2.7			3.1
6/26/03			2.7			3.2
6/30/03			2.7	3.1		

* Secchi disk reading in meters

Table 8. Summary of 2003 white sturgeon larval sampling effort and volume sampled by gear type and location, Kootenai River, Idaho.

	Location			**Effort (hours)**			**Volume (m^3) sampled**		
Gear type	**(river kilometer)**	**Sampling dates**	**Catch**	**No. sites**	**Mean (SD)**	**Total**	**No. sites**	**Mean (SD)**	**Total**
Surface and mid-column ½ meter net	258.5	6/17	0	1	0.9	0.9	1	13,156.7	13,156.7
	244.5	6/18-7/10	15*	72	2.6 (1.4)	189.0	67	2,530.1 (2,572.9)	169,514.5
	229.0	7/22 and 7/31	0	4	4.2 (1.3)	16.6	4	4,326.8 (1,403.6)	17,307.1
	Gear total	6/17-7/31	15	77	2.7 (1.4)	206.5	72	2,777.5 (2,819.1)	199,978.4
Benthic D-ring	244.5	6/18-7/10	1#	33	2.7 (1.5)	90.4	31	141.2 (308.0)	4,378.2
	229.0	7/22	0	1	3.0	3.0	1	2,291.7	2,291.7
	228.5	7/31	0	1	5.4	5.4	1	4,186.9	4,186.9
	Gear total	6/18-7/31	1	35	2.8 (1.6)	98.4	33	329.0 (841.8)	10,856.8
Combined	All	6/17-7/31	16	112	2.7 (1.5)	305.3	105	2,007.9 (2,635.9)	210,835.2

* 13 catostomidae larvae, 2 unidentifiable fish species
\# 1 mountain whitefish larvae

Table 9. Idaho Department of Fish and Game juvenile white sturgeon gill net sampling effort by mesh size for July and September 2003.

Gillnet mesh size	Number of sets	Hours of effort	Number of adults captured	Number of juveniles captured	Sturgeon catch per unit of effort [a]
3.8 cm stretch	25	41.5	0	40	0.9639
5.1 cm stretch	97	167.6	0	120	0.7160
7.6 cm stretch	7	9.8	0	9	0.9184
10.2 cm stretch	35	57.3	0	41	0.7156
15.2 cm stretch	32	53.5	0	31	0.5794

[a] Catch per effort is number of sturgeon sampled per net.

Table 10. Idaho Department of Fish and Game juvenile white sturgeon gill net sampling effort by sampling location for July through September 2003.

River kilometer	Number of sets	Hours of effort	Number of adults captured	Number of juveniles captured	Sturgeon catch per unit of effort [a]
175.0	7	12.8	0	0	0
182.0	17	33.6	0	7	0.2083
190.0	9	18.0	0	3	0.1666
195.8	9	12.4	0	13	1.0484
205.0	29	51.6	0	82	1.5891
205.5	6	12.2	0	18	1.4754
213.2	15	25.5	0	18	0.7059
213.5	6	13.8	0	8	0.5797
215.5	18	28.2	0	30	1.0638
224.0	9	17.7	0	10	0.5650
225.0	52	71.0	0	45	0.6479
228.3	1	0.6	0	0	0
228.4	1	0.4	0	0	0
228.5	1	1.1	0	1	0.9090
230.5	3	5.4	0	0	0
235.0	6	14.7	0	0	0
244.5	7	11.0	0	5	0.4545

[a] Catch per effort is number of sturgeon sampled per net.

Table 11. Vital statistics of recaptured juvenile hatchery white sturgeon (N = 238) recaptures from 2003 gillnet sampling by the Idaho Department of Fish and Game.

Statistic	Fork Length (cm)	Total Length (cm)	Weight (kg)
Average	35.6	41.3	0.33
Standard deviation	10.9	12.6	0.38
Minimum	18.2	20.6	0.04

Maximum	84.0	100.0	3.10

LITERATURE CITED

Auer, N. A., and E. A. Baker. 2002. Duration and drift of larval lake sturgeon in the Sturgeon River, Michigan. Journal of Applied Ichthyology 18 (2002), 557-564.

Bonde, T. H., and R. M. Bush. 1975. Kootenai River water quality investigations, Libby Dam pre-impoundment study 1967-1972. U.S. Army Corps of Engineers.

McCabe, G. T., and L. G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76 (4):248-250.

Northcote, T. C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report Number 2, Ann Arbor, Michigan.

Paragamian, V. L., G. Kruse, and V. D. Wakkinen. 1996. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Boise, Idaho.

Paragamian, V. L., and V. D. Wakkinen. 2002. Temporal distribution of Kootenai River white sturgeon spawning events and the effect of flow and temperature. Journal of Applied Ichthyology 18 (2002), 542-549.

Paragamian, V. L., G. Kruse, and V. Wakkinen. 2002. Spawning location and movement of Kootenai River white sturgeon. Journal of Applied Ichthyology 18 (2002), 608-616.

Parsley, M. J., and L. G. Beckman. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River. North American Journal of Fisheries Management 14, 812-827.

Richmond, A. M., and B. Kynard. 1995. Ontogenetic behavior of shortnose sturgeon *Acipenser brevirostrum*. Copeia 1995(1):172-182.

Rust, P. J., V. Paragamian, and V. Wakkinen. In review. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Boise, Idaho.

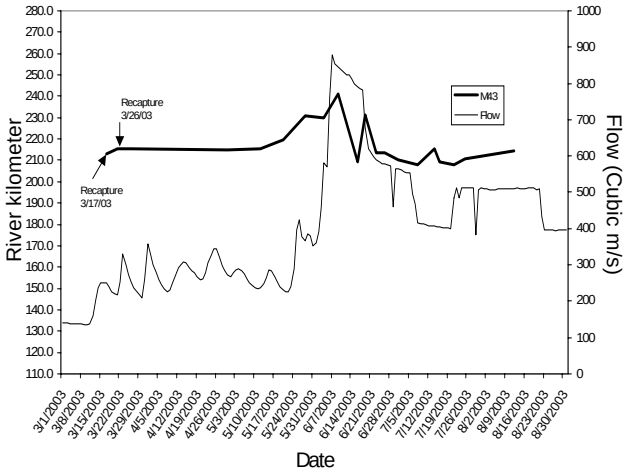
USACE, 1998. The effects of VARQ at Libby and Hungry Horse on Columbia River System Flood Control. U.S. Army Corps of Engineers, Northwest District, North Pacific Region, Portland, Oregon.

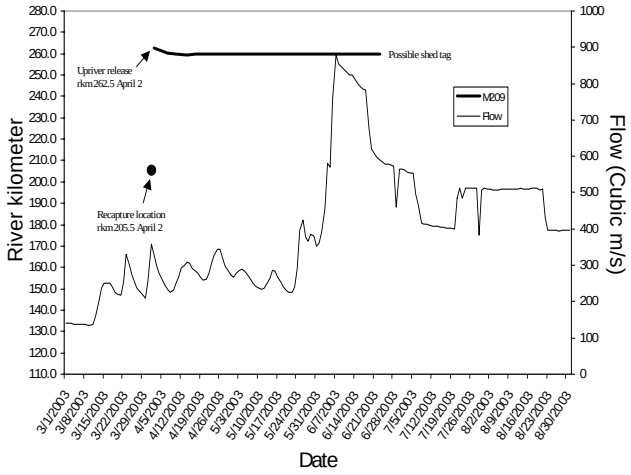
USFWS, 1999: Recovery plan for the Kootenai River population of the white sturgeon *Acipenser transmontanus*. Region 1, U. S. Fish and Wildlife Service, Portland, Oregon.

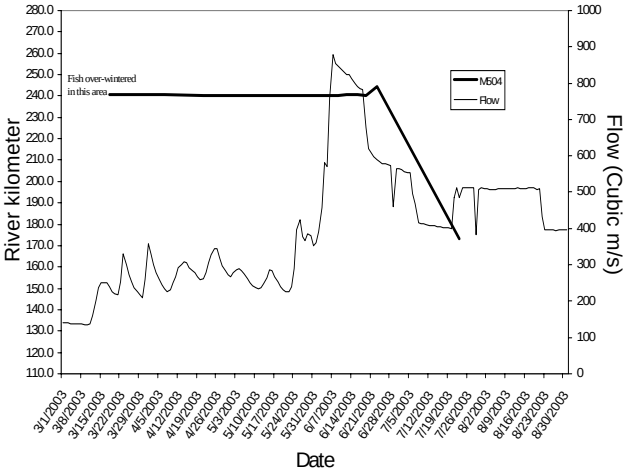
Walters, J. In review. Kootenai River Fisheries Investigations: trout studies. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Boise, Idaho.

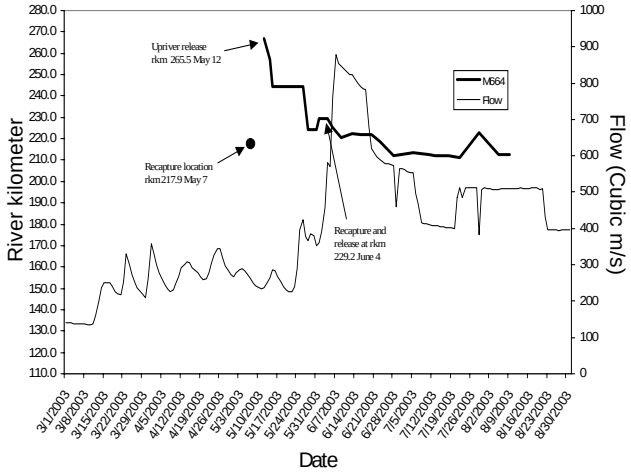
APPENDICES

Appendix 1. Migration and flow (m^3/s) for four of seven male white sturgeon, all four of which are believed to have spawned in the Kootenai River, Idaho, 2003.

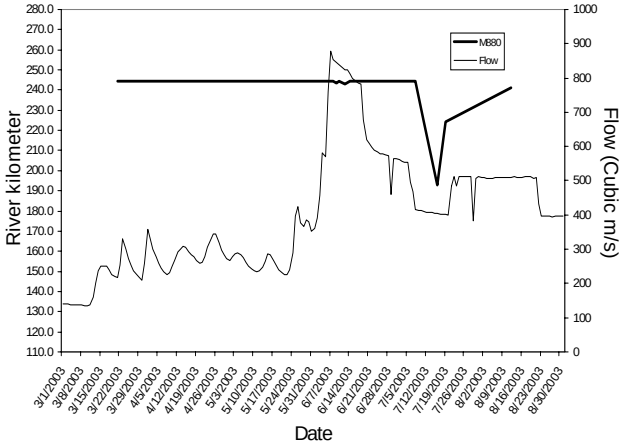


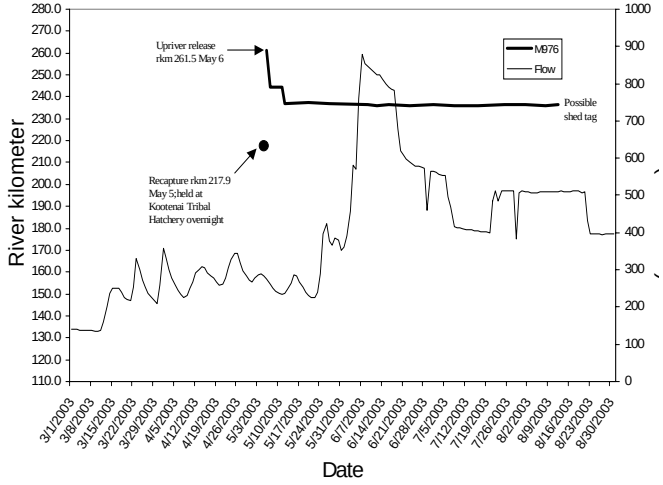


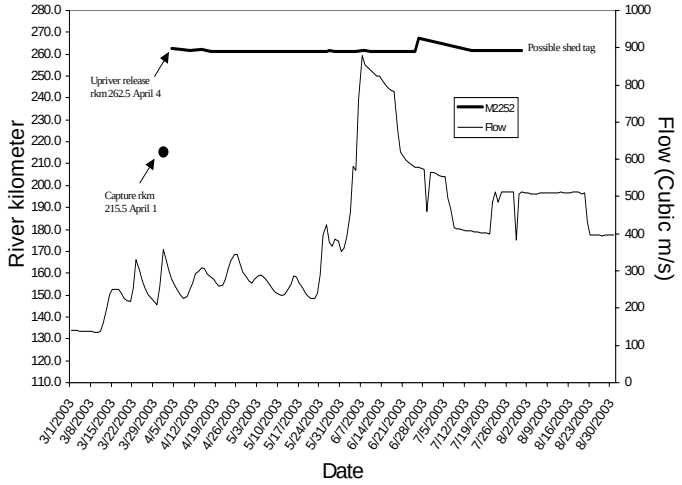


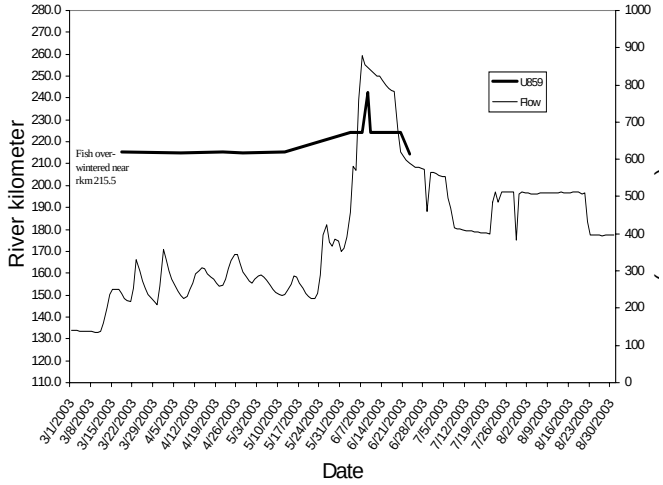


Appendix 2. Migration and flow (m^3/s) for three of seven male white sturgeon and one adult of undetermined sex, all of which are believed to have spawned in the Kootenai River, Idaho, 2003.

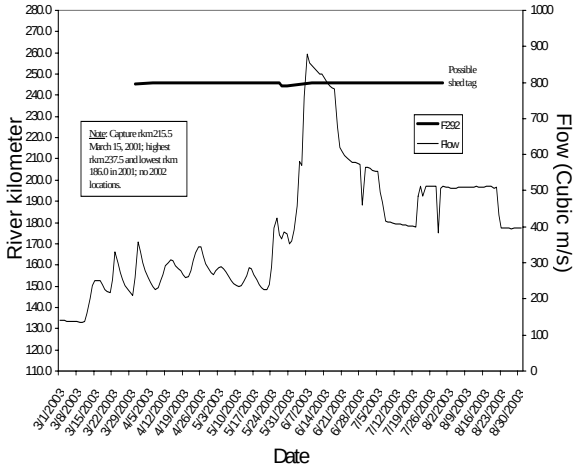


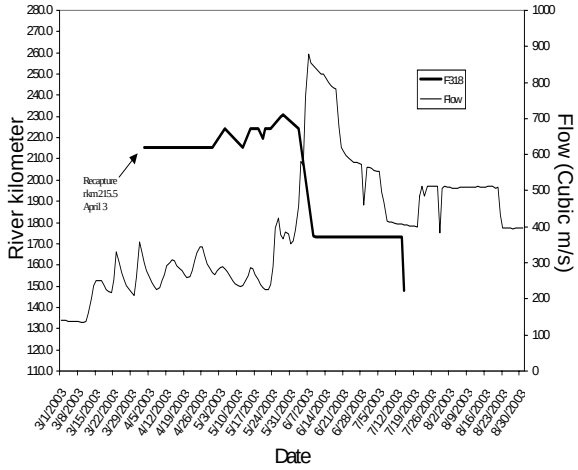


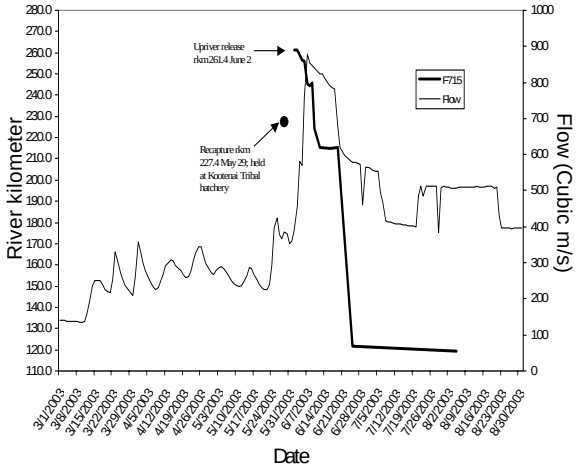


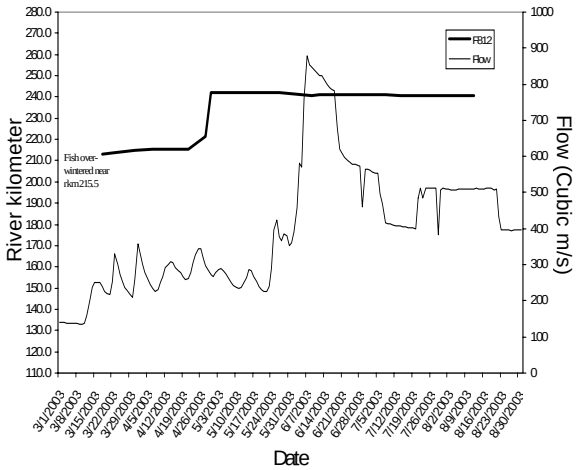


Appendix 3. Migration and flow (m^3/s) for four of eight female white sturgeon, all of which are believed to have spawned in the Kootenai River, Idaho, 2003.

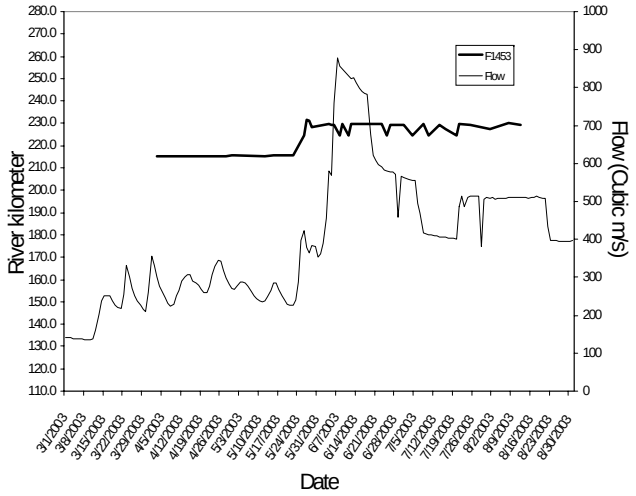


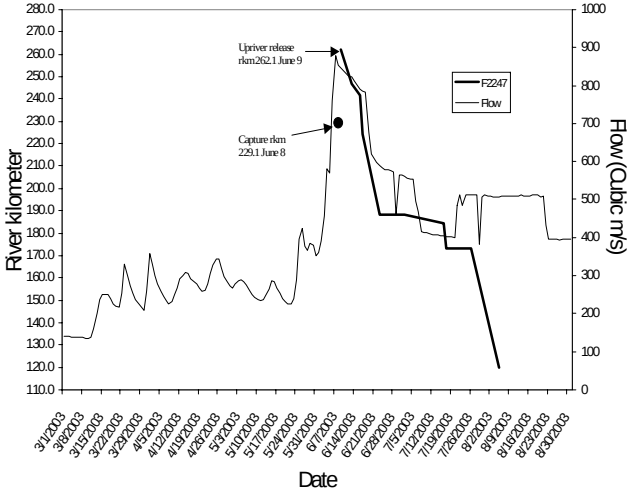


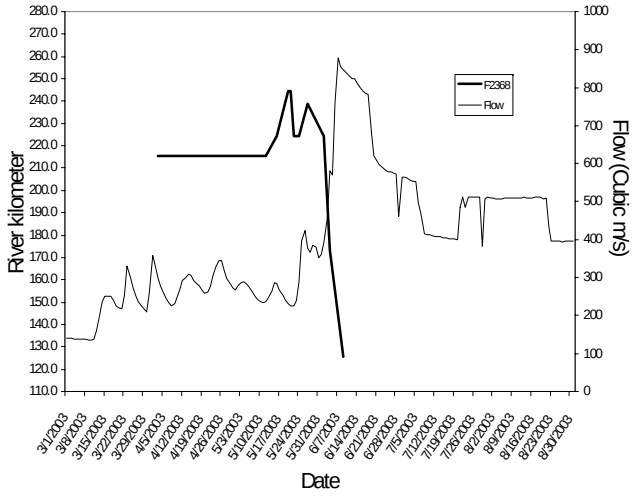


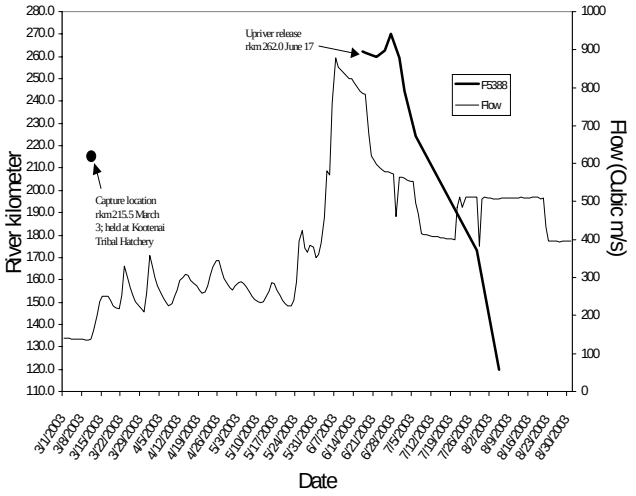


Appendix 4. Migration and flow (m^3/s) for four of eight female white sturgeon, all four of which are believed to have spawned in the Kootenai River, Idaho, 2003.









Appendix 5. River velocities at 20% and 80% of total depth for 10 sites above and below Hemlock Reach egg collection site, 2003.

River kilometer	River location	Depth (ft)	Velocity (m/s)		
			20%	80%	Mean
262.0	Left bank	26	0.06	0.07	0.065
	Thalweg	25	0.60	0.07	0.335
	Right bank	10	0.76	0.77	0.765
261.9	Left bank	30	0.33	0.46	0.395
	Thalweg	30	0.35	0.72	0.535
	Right bank	13	0.76	0.12	0.44
261.8*	Left bank	34	0.60	0.33	0.452
	Thalweg	22	0.02	0.52	0.27
	Right bank	34	0.09	0.40	0.295
261.7	Left bank	14	0.53	0.30	0.415
	Thalweg	12	1.20	0.55	0.875
	Right bank	20	0.34	0.42	0.38
261.6	Left bank	12	1.20	0.20	0.60
	Thalweg	11	1.01	1.5	1.255
	Right bank	4	1.7	0.46	1.08
261.5	Left bank	6	1.85	2.21	2.03
	Thalweg	12	1.12	1.66	1.395
	Right bank	19	0.24	0.63	0.435
261.4	Left bank	10	0.59	0.23	0.41
	Thalweg	20	1.38	0.90	1.19
	Right bank	27	1.64	1.20	1.42
261.3	Left bank	23	1.15	0.70	0.93
	Thalweg	12	1.52	1.41	1.465
	Right bank	8	0.88	0.70	0.79
261.2	Left bank	24	1.19	0.20	0.695
	Thalweg	14	0.24	0.21	0.305
	Right bank	7	0.02	0.02	0.15
261.1	Left bank	42	0.16	0.34	0.25
	Thalweg	21	0.29	0.23	0.26
	Right bank	12	no data	no data	no data

* – Egg collection site

Appendix 6. Numbers and recapture rates of hatchery produced white sturgeon juveniles (progeny of wild brood stock) released into the Kootenai River and Kootenay Lake in Idaho, Montana, and British Columbia between 1992 and 2003 (adapted from Kootenai Tribe of Idaho and Idaho Department of Fish and Game Annual Reports 1992-2002).

Year class	Hatchery facility[a]	Release number	Mean total length (mm) at release (SD)	Mean weight (g) at release (SD)	Release season & year	Percent (#) of all recaptures
1990	KTOI	14	456.9 (53.0)	320.8 (112.3)	Summer 1992	0.55%(10)
1991	KTOI	104	254.7 (17.4)	66.1 (13.2)	Summer 1992	5.65%(103)
1992	KTOI	123	482.6 (113.0)	549.3 (482.9)	Fall 1994	5.49%(100)
1995	—	—	—	—	?[b]	0.44%(8)
1995	KTOI	1,075	228.5 (27.0)	47.3 (16.6)	Spring 1997	20.93%(384)
1995	KTOI	889	343.6 (43.8)	147.9 (64.0)	Fall 1997	20.58%(375)
1995	KTOI	96	410.7 (68.2)	288.5 (137.8)	Summer 1998	3.02%(55)
1995	KTOI	25	581.5 (40.5)	863.3 (197.9)	Summer 1999	0.66%(12)
1998	KTOI	309	260.1 (41.9)	79.0 (44.4)	Fall 1999	2.13%(39)
1999	KTOI	828	256.1 (22.2)	70.6 (18.2)	Fall 2000	16.02%(294)
1999	KH	1,358	248.1 (32.9)	67.2 (27.6)		
1999	KTOI	491	284.3 (54.4)	107.6 (60.1)	Spring 2001	16.08%(295)
1999	KH	1,583	306.5 (40.4)	55.9 (39.5)		
2000	KTOI	2,286	244.0 (38.9)	64.2 (31.0)	Fall 2001	5.56%(102)
2000	KH	1,654	240.0 (23.2)	57.7 (16.4)		
2000	KH	2,209	283.1 (28.7)	99.3 (30.2)	Spring 2002	0.05%(1)
2000	KH	30	365.4 (14.0)	195.3 (19.9)	Summer 2002	—(0)
2000	KTOI	214	409.4 (53.5)	294.1 (109.8)	Fall 2002	0.44%(8)
2000	KTOI	908[c]	334.2 (36.9)	192.9 (62.7)	Winter 2003	1.04%(19)
2001	KTOI	2,672	200.1 (37.9)	33.0 (15.6)	Fall 2002	1.47%(27)
2001	KH	4,469	227.4 (24.2)	51.6 (16.6)		
2001	KH	1,715	258.2 (52.9)	71.8 (24.2)	April 2003	—(0)
2002	KH	5,864	217.7 (37.3)	41.3 (14.2)	May 2003	—(0)
unk[d]		—	—	—	—	0.16%(3)
Total		28,916	—	—	—	6.34%(1835)

[a] Hatchery facility refers to the rearing hatchery: Kootenai Tribal Hatchery in Idaho (KTOI) or Kootenay Hatchery in British Columbia (KH).

[b] Year class determined by scute removal; fish had shed PIT tag or PIT tag was not matched in database to determine stock year.

[c] Ten fish held over for later upriver release with transmitters.

[d] These juvenile white sturgeon had no PIT tag; year class could not be determined by scute removals.

Appendix 7. Year class, number captured, capture locations, fork length (cm), total length (cm), and weight (kg) of hatchery released juvenile sturgeon captured with gill net from the Kootenai River, Idaho 2003.

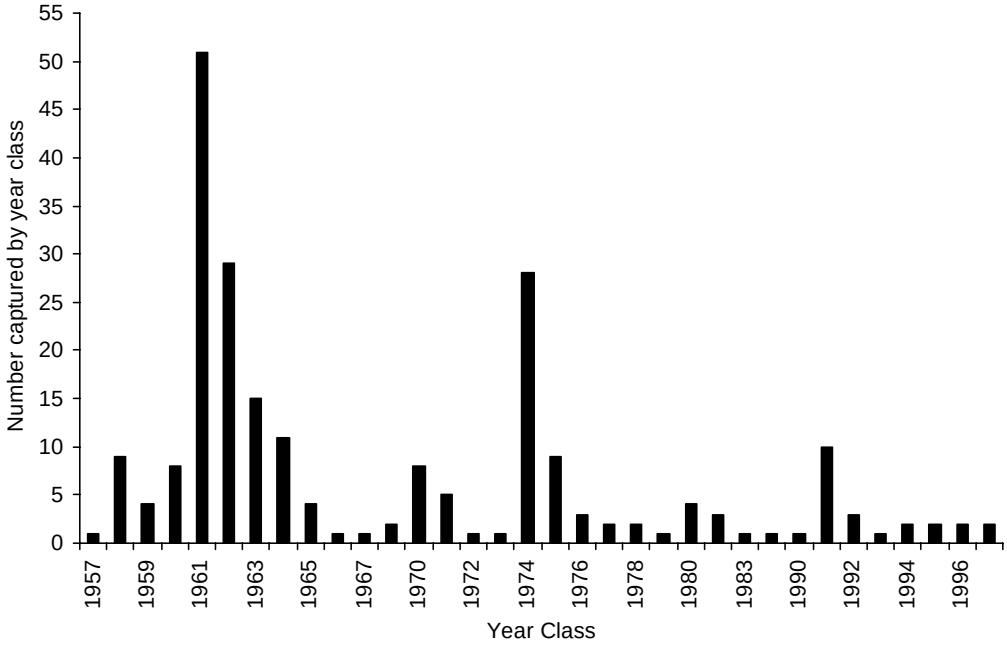
Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (Kg)
1990	1	120.0	76.5	88.0	3.00
	1	205.0	81.4	95.0	—
1991	2	120.0	86.0-102.5	99.0-118.5	4.15-6.65
	2	205.0	67.9-84.0	72.8-100.0	1.71-3.10
1992	1	205.0	68.6	79.2	—
	1	205.5	69.0	79.1	2.27
1995	1	119.0	—	63.2	1.19
	5	120.0	59.4-78.5	69.2-92.0	1.30-3.20
	1	123.0	—	70.1	1.30
	1	130.0	—	55.8	0.68
	1	141.0	53.8	60.4	0.83
	11	205.0	45.5-60.3	53.2-70.5	0.51-1.75
	7	205.5	48.1-57.0	55.2-65.4	0.71-1.15
	2	213.2	51.4-58.1	60.2-67.0	0.85-1.17
	1	213.5	58.6	67.6	1.27
	5	215.5	50.9-57.6	58.9-65.9	0.75-1.28
	1	224.0	61.2	70.9	1.32
	1	224.9	52.9	61.2	0.89
	2	225.0	43.5-50.2	50.7-57.6	0.44-0.78
	1	244.5	48.2	56.6	0.65
1998	1	205.0	40.4	47.0	0.36
	1	213.2	35.5	41.5	0.243
	1	224.0	32.5	38.7	0.20
	3	225.0	30.5-38.5	36.5-44.6	0.18-0.36
	1	244.5	40.7	47.4	0.35
1999	2	119.0	—	39.0-45.2	0.24-0.38
	5	120.0	33.5-47.5	39.0-55.3	0.24-0.62
	1	123.0	39.5	45.7	0.32
	2	130.0	32.5	38.0-43.2	0.22-0.37
	2	134.0	34.6	40.0	0.26
	1	137.0	28.3	33.4	0.14
	1	145.0	—	37.1	0.24
	4	157.0	31.2-35.0	36.9-40.0	0.19-0.27
	1	163.0	—	33.1	0.18
	2	165.0	27.2-30.0	31.0-34.5	0.14-0.17
	2	167.0	32.1-32.7	37.1-38.1	0.16-0.20
	5	182.0	30.1-38.5	35.6-44.5	0.15-0.29
	2	190.0	35.0-35.9	40.6-41.6	0.22-0.23
	5	195.8	29.9-36.0	34.5-42.0	0.16-0.27
	43	205.0	28.7-40.9	33.1-47.2	0.14-0.48
	5	205.5	31.9-37.8	37.2-44.2	0.19-0.32
	4	213.2	29.6-40.6	33.6-47.3	0.15-0.35
	1	213.5	31.0	36.1	0.18
	13	215.5	30.7-37.9	35.4-44.5	0.16-0.39
	14	225.0	24.5-36.7	32.5-42.5	0.14-0.27
	3	244.5	27.5-33.1	30.5-37.7	0.11-0.20
2000	4	120.0	26.3-32.9	30.9-38.6	0.12-0.21
	2	130.0	25.1-26.0	29.3-30.0	0.09-0.10
	2	145.0	31.1	33.2-35.8	0.15-0.17

	1	150.0	29.3	34.0	0.21
	3	157.0	23.5-27.8	27.0-31.9	0.09-0.11

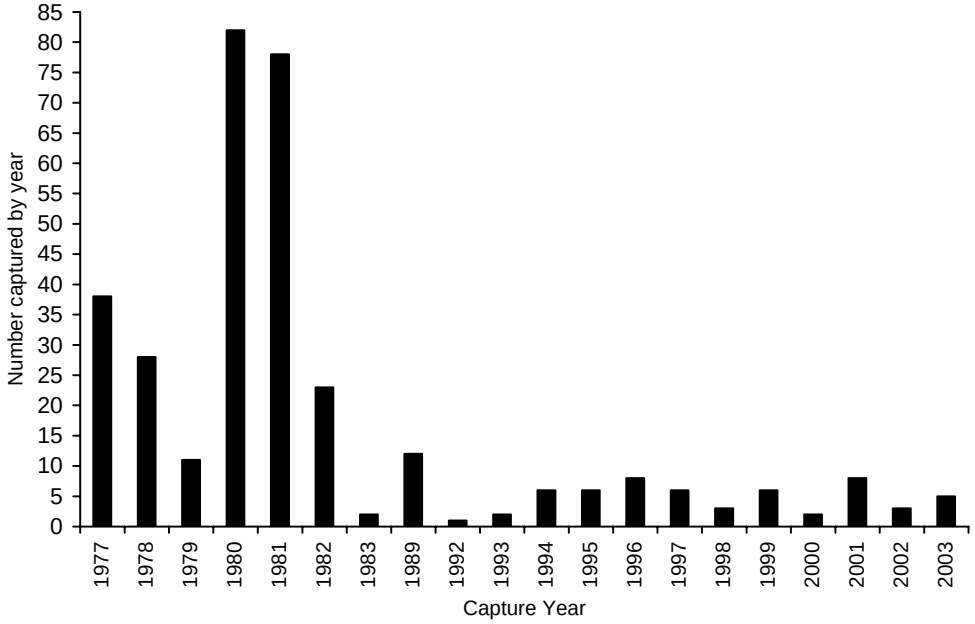
Appendix 7. Continued.

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (Kg)
	2	161.0	23.5	27.0-32.3	0.07-0.16
	2	163.0	25.5-26.5	29.6-31.5	0.13-0.14
	6	165.0	26.0-27.6	29.7-31.9	0.09-0.14
	1	167.0	27.2	31.4	0.10
	2	182.0	29.2-29.4	33.5-34.7	0.13-0.15
	1	190.0	26.1	30.6	0.09
	5	195.8	26.5-34.2	32.3-40.2	0.07-0.27
	9	205.0	23.4-43.1	26.2-50.0	0.11-0.54
	3	205.5	29.5-40.3	34.6-46.6	0.14-0.36
	10	213.2	26.0-35.3	30.2-41.1	0.10-0.29
	4	213.5	28.0-32.5	32.0-38.6	0.12-0.19
	4	215.5	28.7-33.2	33.7-37.9	0.14-0.16
	6	224.0	29.6-38.0	34.3-44.0	0.15-0.31
	14	225.0	26.1-41.8	30.5-48.5	0.09-0.40
2001	1	161.0	18.9	21.9	0.04
	2	195.8	21.9	25.2	0.05-0.06
	3	205.0	25.0-28.0	28.2-31.6	0.08-0.11
	1	205.5	23.6	27.2	0.08
	1	213.2	23.0	26.5	0.07
	1	213.5	24.5	28.9	0.09
	6	215.5	21.2-25.6	24.4-29.5	0.05-0.09
	2	224.0	22.9-26.1	26.6-30.4	0.07-0.09
	2	224.9	22.3-24.8	25.8-28.6	0.06-0.08
	7	225.0	18.2-25.8	20.6-30.0	0.04-0.09
	1	228.5	22.7	26.6	0.06
2002	2	120.0	29.1-41.5	33.9-48.0	0.16-0.42
	1	130.0	34.0	39.0	0.24
	1	150.0	30.1	34.9	0.19
	1	161.0	29.6	34.7	0.16
	1	190.0	32.5	37.2	0.20
	1	195.8	34.2	38.0	0.20
	7	205.0	31.0-71.5	35.9-83.0	0.16-1.18
	1	205.5	27.7	31.7	0.13
	1	213.5	37.7	43.2	0.28
	2	215.5	21.8-36.4	24.7-42.9	0.07-0.25
	3	225.0	23.1-24.9	26.7-29.4	0.07-0.09
	1	?	Na	Na	Na

Appendix 8. Number of aged wild juvenile white sturgeon captured by year class in the Kootenai River, Idaho since 1977.



Appendix 9. Number of wild juvenile white sturgeon captured in the Kootenai River, Idaho since 1997.



Appendix 10. PIT-tagged hatchery juveniles captured in gillnets from the Kootenai River, Idaho in 2002 that were used to verify ageing techniques.

ID number	PIT Tag No.	Date	RKM	Fork Length (cm)	Total Length (cm)	Weight (kg)	Age	Known age	Year class
28	504D1F2E21	8/7/2002	215.5	475	550	0.563	7	7	1995
26	504D25315F	6/17/2002	205	480	547	0.7	7	7	1995
32	504D2B3C1C	7/17/2002	205	460	538	0.6	8	7	1995
27	504D2C0D3D	7/22/2002	205	480	553	0.7	8	7	1995
20	504D2D186E	7/19/2002	215.5	508	589	0.7	7	7	1995
35	504D690432	8/7/2002	215.5	435	515	0.49	7	unk	unk
36	504D7F1276	8/7/2002	215.5	418	483	0.445	7	7	1995
9	504E036E7C	8/7/2002	215.5	525	615	0.85	7	7	1995
30	504E0E4676	7/22/2002	205	463	544	0.55	7	7	1995
23	504E106D74	8/7/2002	215.5	490	565	0.735	7	7	1995
19	504E116712	8/7/2002	215.5	514	594	0.68	8	7	1995
18	504E5B5324	8/5/2002	205	545	640	1.02	7	7	1995
10	504E5E3B00	7/22/2002	205	526	615	0.9	7	7	1995
22	504E5F7959	8/7/2002	215.5	490	695	0.695	7	7	1995
21	504E624156	7/17/2002	205	490	558	0.8	8	7	1995
24	504E624F3E	8/7/2002	215.5	490	565	0.709	8	7	1995
31	504E626913	8/7/2002	215.5	461	531	0.59	7	7	1995
13	504E6C0D4F	9/24/2002	234.5	520	602	0.826	7	7	1995
1	504E6C335A	7/19/2002	215.5	545	631	1.05	8	7	1995
2	504F6E392B	7/18/2002	225	555	650	1.1	8	7	1995
29	504F775D64	7/19/2002	215.5	473	526	0.73	8	7	1995
33	504F7C7C60	7/31/2002	205	457	530	0.618	7	7	1995
37	505E4C3F37	7/31/2002	205	318	360	0.191	8	7	1995
11	505E4F746C	7/25/2002	205	526	604	0.85	8	7	1995
17	505E616F68	7/18/2002	225	539	615	0.9	7	7	1995
3	5062083B43	7/22/2002	205	575	666	1.25	8	7	1995
25	50622B000B	7/29/2002	227.4	483	548	0.651	8	7	1995
7	7F7D07384A	8/12/2002	205	720	835	2.84	10	unk	unk
6	7F7D0F3125	7/19/2002	215.5	705	810	2.1	10	11	1991
14	7F7D0F7841	8/5/2002	205	710	830	2.268	12	11	1991
16	7F7D10024F	7/16/2002	215.5	740	846	3.366	12	11	1991
8	7F7D27007F	8/12/2002	205	645	757	1.7	11	10	1992
4	7F7D37570D	7/19/2002	215.5	600	692	1.5	8	10	1992
15	7F7D382D6F	7/28/2002	205	640	731	1.6	9	10	1992
12	7F7D3F6F5F	8/28/2002	205	624	710	1.27	11	10	1992
5	7F7D40754F	7/16/2002	215.5	619	732	1.75	11	10	1992
34	7FFD376B02	7/22/2002	205	443	520	0.55	8	unk	unk

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