
**WHITE STURGEON INVESTIGATIONS
IN THE COLUMBIA RIVER, B.C.**

1997-1998 STUDY RESULTS



RL&L

Environmental Services Ltd.

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- DATA REPORT -

Prepared for

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Cover photo: Aerial view of the upper section of the Columbia River. View is upstream toward Hugh L. Keenleyside Dam.

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1.0 INTRODUCTION

1.1 BACKGROUND

The development of the Columbia River basin for hydroelectric power generation has profoundly altered the riverine environment to a degree that may preclude the natural recovery of impounded white sturgeon populations as a result of reduced access to different habitats (Parsley and Beckman 1994). Prior to construction of dams on the Columbia River and the subsequent regulation of flows, white sturgeon ranged throughout the drainage. The construction of Hugh L. Keenleyside (HLK), Revelstoke, and Mica dams in the B.C. portion of the Columbia River has resulted in the formation of large impoundments and the segregation of white sturgeon populations. Beamesderfer et al. (1995) stated that hydroelectric developments that alter the natural hydrograph of the system and reduce spring flows have a detrimental affect on white sturgeon productivity. The adverse effect of dams on white sturgeon populations in the U.S. portion of the Columbia River has been documented by North et al. (1993). The construction and operation of dams on other rivers also has been shown to negatively affect sturgeon populations throughout the world (Khoroshko 1972; Votinov and Kas'yanov 1978; Deacon et al. 1979; Rochard et al. 1990).

White sturgeon populations in the Canadian portion of the Columbia River below HLK have been investigated annually by R.L. & L. Environmental Services Ltd. since 1990. The results of these studies have indicated problems with recruitment of white sturgeon in the region, possibly due to the presence and operations of dams on the mainstem Columbia River and on major tributaries. On the basis of results obtained in these early studies (summarized in R.L. & L. 1994), the B.C. Conservation Data Centre RED-listed white sturgeon in the Columbia with a ranking of S2 (imperiled) in 1994; this listing was revised to S1 (critically imperiled or endangered) in 1996 based on further evidence of poor recruitment and an ageing white sturgeon population (R.L. & L. 1996, 1997a).

Between 1992 and 1996, annual studies were conducted in order to identify spawning areas used by white sturgeon in the portion of the Columbia River between HLK and the Canada-U.S. border (R.L. & L. 1994, 1997a). To date, only one spawning area has been identified; this spawning area is located in the lower section of the Columbia River (defined as the area between Trail and the U.S. border) at the confluence of the Pend d'Oreille and Columbia rivers. Although one spawning area has been identified, and the behaviour of white sturgeon using this area has been monitored (R.L. & L. 1997b), there exists specific data gaps with respect to the spawning ecology of white sturgeon in the upper section of the Columbia River (HLK downstream to the confluence with Blueberry Creek). Specifically, more information is required on the location of other possible spawning areas, and the locations of important staging habitats in the upper section of the Columbia River. This information will aid in identifying whether the white sturgeon population in the Columbia River below HLK consists of one or two spawning populations.

In order to address these questions related to white sturgeon spawning ecology in the upper section of the Columbia River, the B.C. Ministry of Environment, Lands and Parks, Nelson Region (MELP) commissioned a sturgeon sampling program in late 1997. The aim of this study was to capture and sonic or radio tag pre-spawning white sturgeon in the upper section, as the first stage of a study designed to monitor movements of pre-spawning individuals. BC Hydro provided additional funds in early 1998 in order to extend the spring sampling program and to track all mature, pre-spawning white sturgeon tagged during the program.

1.2 OBJECTIVES

Specific objectives for the 1997-1998 white sturgeon sampling program were:

- to capture and tag (with sonic and radio transmitters) reproductive female white sturgeon that stage in the upper section of the Columbia River; and
- to monitor and update population trends related to growth rate, size, sex ratio, and abundance of white sturgeon in the upper section.

1.3 STUDY AREA

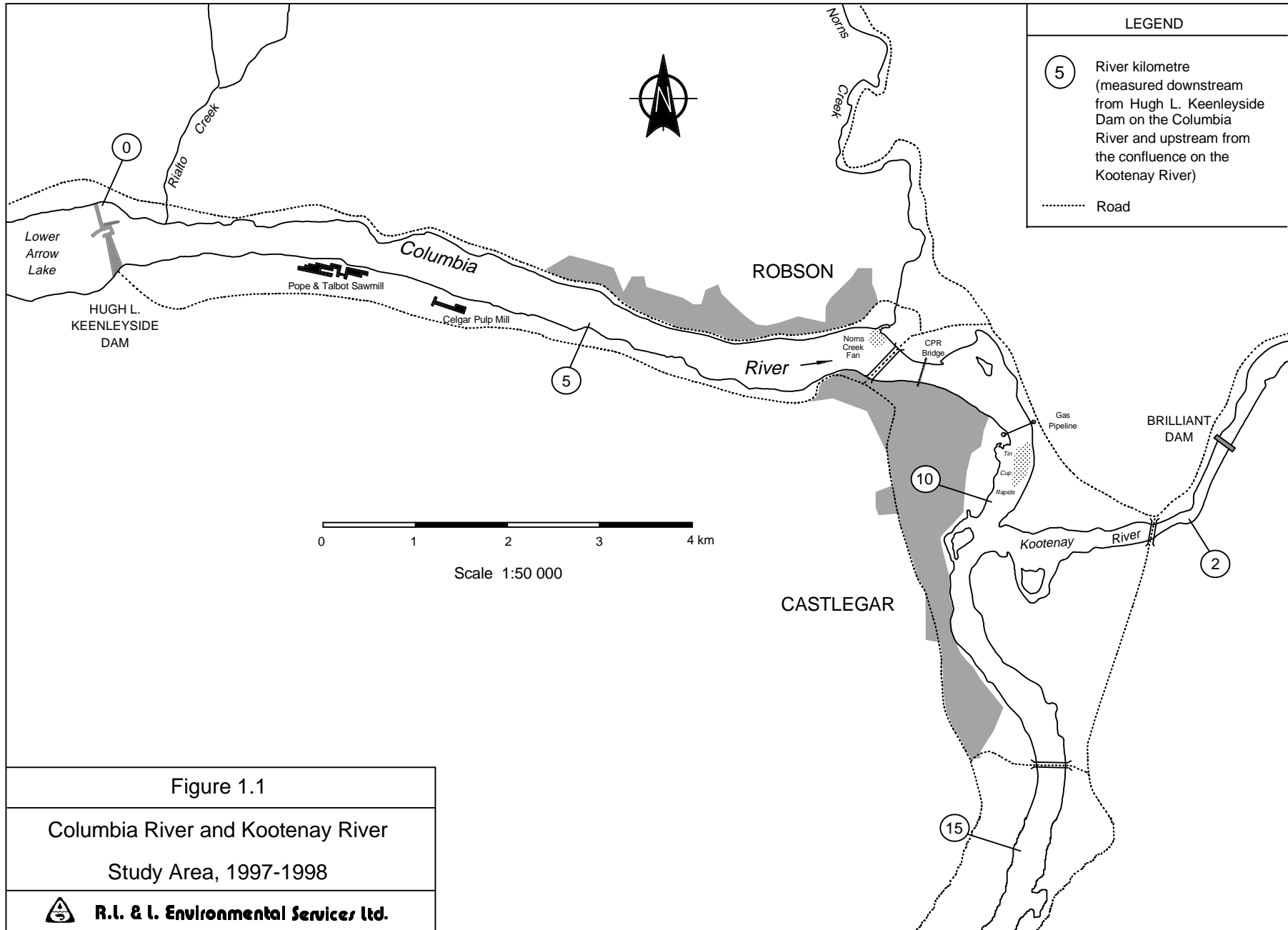
The main study area for white sturgeon in the Columbia River includes the upper (Km 0.0 to 20.0), middle (Km 20.0 to 40.0), and lower (Km 40.0 to the U.S. border at Km 56.5) sections of the river. Sampling for the 1997-1998 program occurred only in the upper section of the river, from HLK (Km 0.0) to Waterloo Eddy (Km 16.9), including 3 km of the Kootenay River mainstem below Brilliant Dam (Figure 1.1). Sampling was not conducted in the middle and lower sections of the Columbia River during the 1997-1998 study program.

1.4 STUDY PERIOD

Sampling in the Columbia and Kootenay rivers was conducted in winter (December 1997) and spring (April 1998; Table 1.1). Radio and sonic tracking occurred on an opportunistic basis between January and mid-April, and regularly (once per week) after mid-April.

Table 1.1 Summary of sturgeon sampling sessions in the upper Columbia and lower Kootenay rivers, 1997-1998.

Site	Session	Date
Columbia River	Fall	15 December to 19 December 1997
	Spring	13 April to 23 April 1998
Kootenay River	Fall	18 December to 19 December 1997
	Spring	16 April to 23 April 1998



2.0 METHODS

2.1 RIVER CONDITIONS

Columbia River water temperature data for the period from 1 December 1997 to 28 May 1998 was obtained from a thermograph located at the rock groyne below HLK. Discharge data for 1 December 1997 to 27 May 1998 was provided by BC Hydro.

2.2 CAPTURE TECHNIQUES

2.2.1 Set Lines

Set lines were the primary method used to capture white sturgeon in the Columbia River. This method provides the greatest catch-rate of white sturgeon and is less selective than other sample gear (Elliot and Beamesderfer 1990). Two set line configurations were used: medium lines (40 m length of mainline with eight hooks), and long lines (80 m length of mainline with 30 hooks). The type of set line deployed was determined by habitat conditions at each sampling location. Each set line generally consisted of a 1.3 cm diameter mainline rope with circle halibut hooks attached at approximately 3.0 m intervals. The hook lines consisted of a 0.64 cm swivel snap and a 0.5 m long dropper line tied between the swivel and the hook. Hook sizes used were 12/0, 14/0, and 16/0. Sharpened barbless hooks of each size were placed in random order on each set line. Hooks were baited with either mountain whitefish flesh, obtained during other fisheries work on the Columbia River, or kokanee flesh, obtained from Meadow Creek and Hill Creek kokanee spawning channels. To ensure the set line remained in position and the hooks rested on the bottom, 4.5 kg anchors were attached to each end of the set line during deployment. Buoys were attached to the anchors to facilitate retrieval.

Set lines were deployed from a boat and generally set overnight in nearshore areas of varying depths or in the vicinity of tributary mouths. These areas were selected based on previous work on the Columbia River, and included both index and synoptic locations. The number of set lines deployed varied according to the number of suitable locations within an area and the number of lines a crew could effectively set and retrieve.

Data recorded at each set line included date, location, set duration, water temperature, minimum and maximum depth, number and size of hooks, and catch. Catch-per-unit-effort (CPUE=no. fish/100 hook-hours) was calculated for each set.

2.2.2 Fish Handling Techniques

Captured fish were brought to the boat and guided into a 2.5 m x 1.0 m stretcher constructed of a waterproof plastic laminate material. The head of the white sturgeon was placed in a hood located at one end of the stretcher. This had a calming effect on the fish and also served to retain a sufficient amount of water so the fish could respire during processing. Fresh river water was continuously added to the stretcher during the processing period. After processing, fish were returned to the water and released once normal respiration, orientation, and swimming behaviour were observed by the study team.

2.3 SEASONAL MOVEMENT

2.3.1 Fish Marking

All of the white sturgeon captured during 1997 and 1998 in the Columbia River were marked with a numbered Floy™ T-anchor tag, a Passive Integrated Transponder (PIT) tag from Biosonics Inc., and by the removal of a section of the left pectoral fin (i.e., used for ageing purposes). The Floy tag and fin clip marking techniques used during the 1997-1998 sampling program have been in use on the Columbia River system since 1990. PIT tags were introduced as a marking system in 1992, and have since been a standard component of the fish marking program.

2.3.2 Sonic Telemetry

To assist in assessing the extent and purpose (e.g., home territory, dispersal, spawning behaviour, habitat utilization) of white sturgeon movements, internally implanted sonic transmitters were used. All captured white sturgeon in late reproductive stages of sexual development (pre-spawning) were equipped with a sonic tag.

The sonic transmitters used (Model CT-82-3-M), were manufactured by Sonotronics. The transmitters were 65 mm in length and 18 mm in diameter, weighed 8 g in air, and had a 48 month rated life span. The transmitters had unique codes and operated within a frequency range of 32 to 83 kHz. The surgical procedures used to internally implant sonic transmitters in white sturgeon followed those described in Hildebrand and English (1991). Tracking of sonic-tagged white sturgeon was conducted from a boat, using a directional hydrophone.

2.3.3 Radio Telemetry

External low frequency radio transmitters were used as a second method of tagging pre-spawning fish, in order to ensure the fish could be reliably located in a variety of water conditions and locations. A radio transmitter was applied in addition to a sonic transmitter in fish that were expected to spawn in 1998.

The radio transmitters were manufactured by Advanced Telemetry Systems Inc. and had 36 month rated life span (model 8-6). They consisted of an encapsulated “C” size lithium battery and circuit, operating on specific individual frequencies within a range of 41.000 to 42.000 MHz, and emitting 55 to 56 pulses per minute. Each transmitter was

teflon coated with 0.16 cm diameter stainless steel attachment cables anchored to the capsule. The transmitters were approximately 3 cm in diameter, 14 cm long, with a 45 cm whip antenna, and weighed 167 g (36 month tag) in air with backing plate.

Following the method described by Haynes et al. (1978), radio transmitters were externally mounted on white sturgeon and were attached to the anterior dorsal scutes of the fish. A battery operated drill was used to drill two 1.5 mm diameter holes through the dorsal scutes. The radio transmitter attachment cables were then passed through the holes in the scutes and fastened against a neoprene padded backing plate on the opposite side.

2.4 LIFE HISTORY DATA

2.4.1 Length and Weight

White sturgeon were measured for fork length (FL), snout to post-opercular edge length (SL), and total length (TL) to the nearest 0.5 cm. Girth was measured behind the pectoral fins to the nearest 0.5 cm. Weight was determined using a 135 kg capacity spring scale accurate to ± 2.3 kg.

2.4.2 Growth Characteristics

Brennan and Cailliet (1989) reported that calcified structures (pectoral fin rays, opercles, clavicles, cleithra, medial nuchals, and dorsal scutes) used to age white sturgeon did not result in significantly different estimates of age. Pectoral fin rays appeared to provide the highest accuracy and did not require sacrificing the fish.

A section from the leading left pectoral fin ray was removed from all first-time captures for ageing purposes. Fin ray sections were obtained by making two cuts with a sterilized hacksaw; the first cut was made approximately 5 mm distal from the point of articulation (knuckle) of the pectoral fin and the second was made approximately 10 mm distal from the first. Sections were then separated from the fin with a sterilized surgical knife and pliers and placed in an envelope marked with the appropriate information. Care was taken not to sever the artery close to the articulation of the fin ray. If there was any bleeding from the area of the removed fin section, the area was swabbed with an antiseptic and pressure was applied to seal the wound. Fin rays were archived for analysis at a future date.

2.4.3 Sex and Maturity

Sex and maturity of white sturgeon were determined by surgical examination; in general, only sturgeon that were considered as potential pre-spawners (i.e., greater than 1.5 cm TL with fully distended abdomens) were examined. Surgical procedures were similar to those developed for white sturgeon in the United States and described by Beamesderfer et al. (1989). The description of maturity stages generally follows the qualitative histological classifications described by Conte et al. (1988). Subjective assessments were used when the maturity stage was intermediate relative to the classification system. The following discussion presents a brief description of the surgical techniques.

The surgery was performed at the abdominal area, near the mid-ventral line three to four ventral scutes anterior to the pelvic fin insertion. The area was swabbed with Germaphine™ disinfectant and a 3.0 to 4.0 cm long incision was made with a sterile scalpel through the body wall. Mature gonads were large and often readily observed through the incision. Immature gonads or those in early stages of maturation were smaller and often more difficult to locate. If the gonads were not visible through the incision, an otoscope equipped with a veterinary head and speculum was inserted into the incision to locate and examine the gonads. Biopsy samples were removed from early development stage gonads using Allyce forceps; these samples were preserved in 5% formalin for future analysis to confirm sex and maturity classification.

All surgically examined fish were administered oxytetracycline (OTC) at an intraperitoneal dosage of 0.2 mL Liquamycin LP per kilogram of body weight and a concentration of 100 mg/mL. This dosage, equivalent to 20 mg OTC/kg of body weight, has been used successfully by U.S. researchers (Apperson and Anders 1991) during investigations of Kootenay River populations of white sturgeon and by R.L. & L. (1994) during studies on white sturgeon in the Columbia River in Canada. Oxytetracycline is an effective broad spectrum antibiotic and also serves as a marker on bony structures (i.e., fin rays) for use in age-validation studies.

The incision was closed using a half circle, CR-2 reverse cutting-edge needle, swedged to a 0 (4.0 metric) chromic gut suture. The sutures were spaced approximately 1 cm apart. Once the incision was closed, the area was swabbed with Germaphine™ and dried. A surgical adhesive (Vetbond) was sparingly applied to the incision and sutures to protect the area for a short period of time after the release of the fish.

2.4.4 Genetic Analysis

A sample of soft tissue was collected for molecular genetic DNA analysis from white sturgeon that had not previously been sampled in the Columbia River. All recaptures from the last two years were assumed to have had a DNA sample removed at first capture. A small section of the distal end of the pelvic fin was removed, cut into thin sections using surgical scissors, and preserved in labeled vials containing 99% ethanol. The DNA samples were forwarded to S. Pollard (B.C. Ministry of Environment, Lands and Parks, Victoria) for genetic analysis.

3.0 RESULTS

3.1 RIVER CONDITIONS

Water temperatures in the Columbia below HLK are provided in Appendix A, Figure A1. Temperatures steadily declined from 7.3°C at the beginning of December to 4.5°C in mid-January, and then remained at this minimum until the beginning of April when temperatures in the river began to increase. Temperatures continued to increase until late May, and then declined rapidly by over 4°C. This decline may have been the result of temperature stratification in Arrow Lakes Reservoir. The discharge data for HLK (Appendix A, Figure A1) provided by BC Hydro shows two peak flow periods (December and February-March), and several one or two-day flow reductions in January and March related to mountain whitefish spawning studies.

3.2 DISTRIBUTION AND CATCH

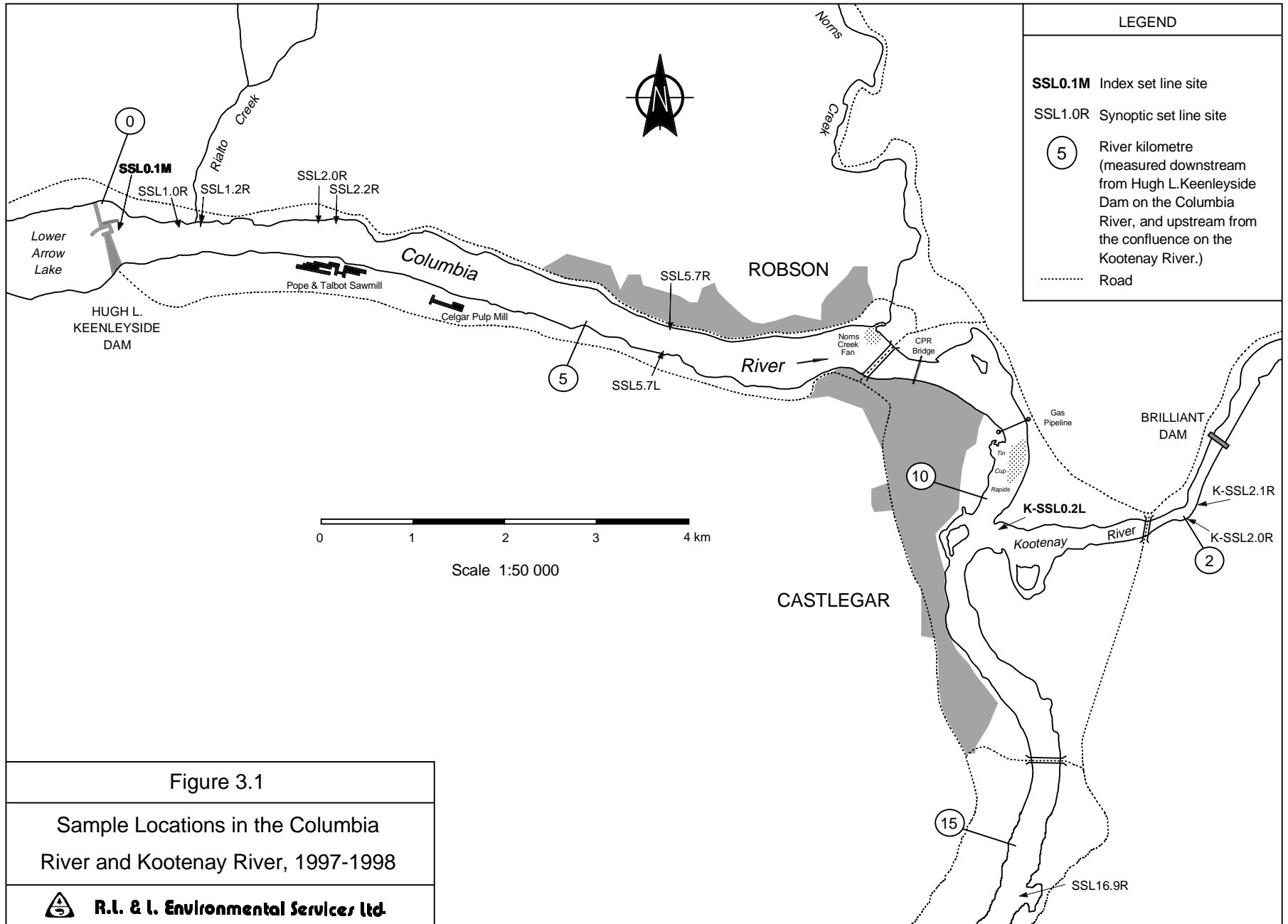
Results from previous studies on the Columbia and lower Kootenay rivers suggest white sturgeon have a localized distribution. Two locations within the upper section of the Columbia River were assigned a high use rating for holding and feeding use by white sturgeon: the Columbia River from the base of HLK to the mouth of Norns Creek and the mouth of the Kootenay River (R.L. & L. 1994, 1997a). During the 1997-1998 study, sampling was concentrated in these high use areas (Figure 3.1) in order to maximize the probability of capturing pre-spawning individuals; therefore, new conclusions could not be drawn with respect to overall sturgeon distribution within the study area.

In total, 64 white sturgeon were captured during the program in 10 853.8 hook-hours of sampling effort; 18 fish were captured in the winter sampling period (3091.0 hook-hours) and 46 fish were captured during the spring sampling period (7762.8 hook-hours; Appendix B, Table B1). The overall catch-per-unit-effort (CPUE) was similar in the winter and fall sampling periods, with 0.6 fish/100 hook-hours of sampling in each of the two seasons. Catch-rates were similar in the Columbia and Kootenay rivers in the winter session, but were slightly higher in the Columbia River during the spring session.

3.2 LIFE HISTORY DATA

3.2.1 Length-Frequency

White sturgeon captured during the 1997-1998 sampling program in the upper section of the Columbia River ranged in length from 95.0 to 280.0 cm FL (Figure 3.2; Appendix C, Table C1). The 280.0 cm FL fish was the largest white sturgeon ever captured by R.L. & L. in the upper section of the Columbia River and was estimated to weigh 210 kg using a length-weight regression for all white sturgeon captured between 1990 and 1996 (R.L. & L. 1997a). The weights of the other white sturgeon captured in 1997-1998 ranged between 7.7 and 66.4 kg (Appendix C, Table C1).



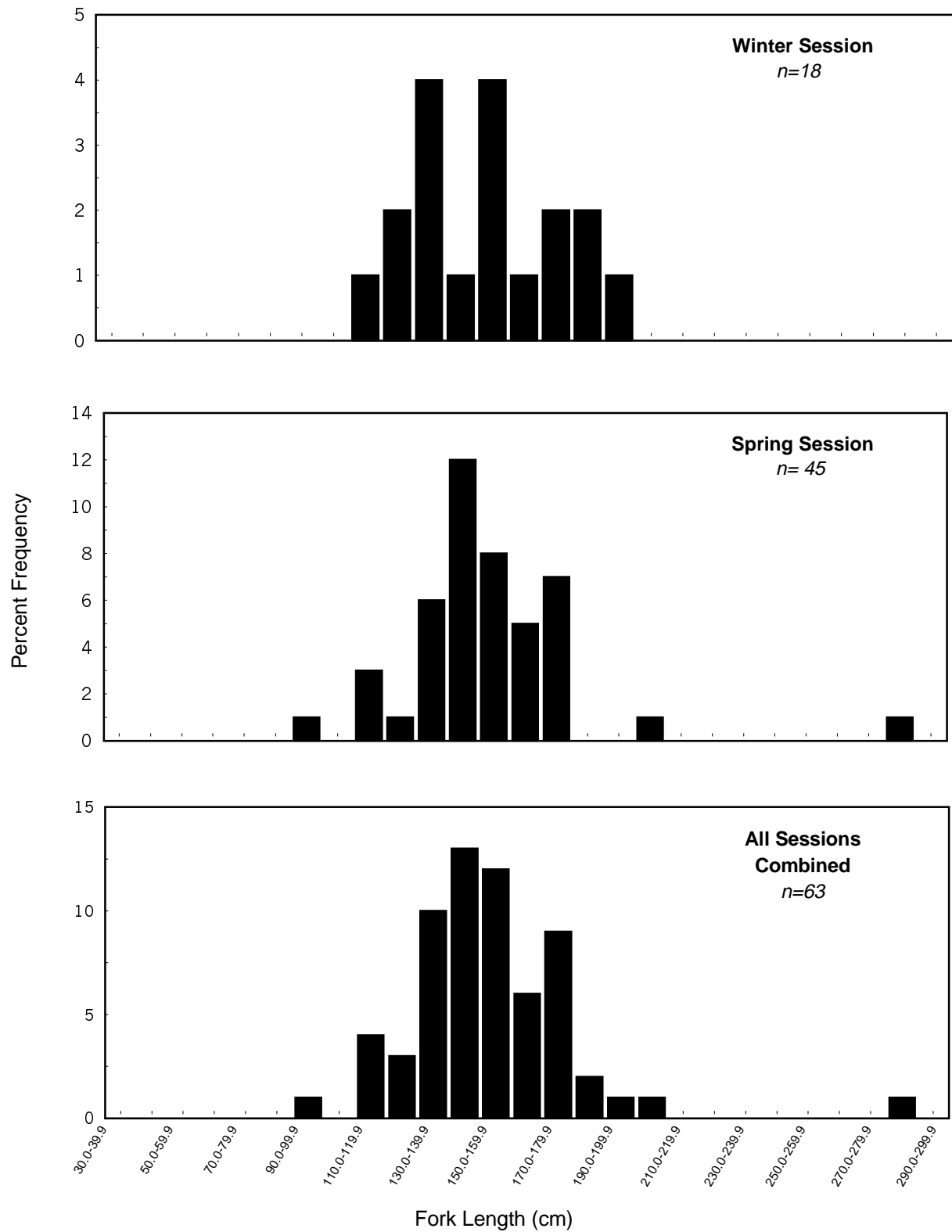


Figure 3.2 Length-frequency distribution for white sturgeon captured by set line in the Columbia River during the winter session (top), spring session (middle), and all sessions combined (bottom), 1997-1998. Data for fish recaptured within the study are not included.

The length-frequency distributions of Columbia River white sturgeon captured during 1997-1998 are presented in Figure 3.2. For discussion purposes, the juveniles, sub-adult, and adult classifications referred to in this document represent fish less than 100 cm TL (approximately 90 cm FL), between 100 and 150 cm TL (approximately 90 and 130 cm FL), and greater than 150 cm TL (approximately 130 cm FL), respectively. These classifications are based on preliminary maturity information for Columbia River white sturgeon and are subject to revision. The majority of the fish captured were adults based on size; juveniles were not captured in 1997-1998.

3.2.2 Sex and Maturity

In total, 19 fish were surgically examined to determine sex and maturity (Appendix D, Table D1). Only individuals with potential to be pre-spawners were examined. Of these, 10 fish were determined to be male and 9 fish were determined to be female (a male:female sex ratio of 1.1:1). One ripe female and one late vitellogenic female were captured; the rest of the examined fish were in early reproductive stages. The large (280.0 cm FL) white sturgeon was determined to be an early vitellogenic female with a small proportion of atretic oocytes (resorbing eggs) present, which indicated this fish may have spawned within the last two spawning seasons. All female white sturgeon captured in the course of the study were caught within 2 km of HLK, and five of the eight females with maturing gonads were captured at Km 1.2 near the mouth of Rialto Creek (Appendix C, Table C1).

3.3 MOVEMENT DATA

3.3.1 Tag Recoveries

Of the 64 fish captured, 25 were confirmed recaptures, one was a possible recapture, and 38 were first-time captures (Appendix C, Table C1). The recapture rate was 39% overall.

The number of days-at-large between captures ranged from 119 to 1993 days (Appendix E, Table E1). Only one of the recaptures moved between river sections; this fish, originally captured at Km 55.8 in November 1994, was recaptured just below HLK at Km 0.1 in December 1997. Another fish moved 10.4 km from Km 0.1 in the Kootenay River to Km 0.1 in the Columbia River. The rest of the recaptured fish exhibited net movements of less than 6.2 km between captures.

3.3.2 Sonic and Radio Telemetry

Sonic transmitters (48 month life span) were implanted in five female white sturgeon during 1997-1998 (Appendix E, Table E2). Three of these sturgeon were in an early vitellogenic reproductive stage (expected to spawn in 1999 or 2000), one was in late reproductive stage (expected to spawn in 1999), and one was in pre-spawning condition (expected to spawn in 1998). The pre-spawning (ripe) female was equipped with a radio tag to ensure that she could be tracked in a variety of locations and conditions.

Sonic and radio tracking occurred opportunistically between sample sessions, and regularly since the last sample session. All white sturgeon tagged in the last two years of sampling were located at least once during the tracking period. Fish exhibited little movement during the tracking period, with only three movements of over 5 km, all of which occurred sometime between 1996 and the current sampling program. Within two weeks of her original capture, the ripe female exhibited a 2.7 km downstream movement and remained in this area for close to a month. By 27 May 1998 this fish had moved 3.6 km upstream to an area just below HLK. The movements of this individual will be closely monitored throughout the June to July 1998 white sturgeon spawning period.

4.0 DISCUSSION

4.1 DISTRIBUTION AND CATCH

White sturgeon in the Canadian portion of the Columbia River below HLK exhibit a localized distribution, with highest concentrations located in two high use areas in the upper section of the river and two in the lower (R.L. & L. 1994). These four areas were typified by low velocities, depths exceeding 15 m, and depositional substrates. Other researchers have found that white sturgeon prefer these types of habitats in a range of different systems (Apperson and Anders 1991; Rien et al. 1991).

The high use areas in the lower section of the river, Fort Shepherd Eddy (Km 51.9 to 53.5) and Waneta Eddy (Km 55.1 to 55.8), appear to be used by sturgeon for holding, feeding, and staging purposes (L. Hildebrand, R.L. & L. Environmental Services, Castlegar, pers. comm., 1998). The high density areas in the upper section of the river are used mainly for holding, feeding, and overwintering purposes (R.L. & L. 1997a), but their potential for use as staging areas by white sturgeon have not been defined in previous studies, primarily due to a lack of data on pre-spawners in the upper section.

In the present study, sampling occurred solely in the high use areas in the upper section of the Columbia River in order to maximize the chance of capturing pre-spawning white sturgeon. The catch-rates in these areas were similar to those found in previous studies (R.L. & L. 1994, 1997a), and seasonal differences were not apparent. Catch-rates of white sturgeon have not been reliable indicators of seasonal and annual population abundance in past studies on the Columbia; the catch-per-unit effort has varied as much within season as it has between seasons (R.L. & L. 1997a).

All the females captured during the 1997-1998 study were caught in the 2 km stretch of river below HLK. Five of the eight maturing or mature females were captured near the mouth of Rialto Creek that enters the Columbia River at Km 1.2 (Figure 1.1). While the high concentration of maturing females in one location may suggest the presence of a staging area, the fact that spawning areas have not been identified in this section of the river make any conclusions very preliminary.

4.2 LIFE HISTORY DATA

4.2.1 Length-Frequency

Between the early 1980s and the early 1990s the size distribution of white sturgeon in the study area has shifted from a population composed primarily of juvenile fish to one dominated by older, larger fish (R.L. & L. 1994). Within the last seven years, there appears to have been a further shift with relatively fewer sub-adults, and relatively more adults captured (R.L. & L. 1997a). This same pattern was evident in the 1997-1998 data, where the majority of fish captured were of the adult size-class.

4.2.2 Sex and Maturity

In past studies, the sex ratio of male:female white sturgeon in the Canadian portion of the Columbia River has been found to be biased towards males, with an overall male:female sex ratio of 1.9:1 for fish captured between 1992 and 1996 (R.L. & L. 1997a). The male:female sex ratio of white sturgeon in the Columbia River downstream of Bonneville Dam, a non-impounded section of the river, was found to be 1.2:1 (DeVore et al. 1993).

In the present study, the male:female sex ratio of surgically examined sturgeon was only 1.1:1, the least biased sex ratio recorded in eight years of sampling. The explanation for the unbiased sex ratio in this study may be related to the fact that only individuals suspected of being sexually mature were examined (i.e., based on large size, distended abdominal area). These characteristics may be more indicative of females than males, leading to proportionally more females being examined than actually exist in the population as a whole. In fact, in years where similar sampling criteria were used (1992 to 1994) the sex ratio was always less biased than in years where all captured adults were surgically examined (R.L. & L. 1997a). Another possible reason for the unbiased sex ratio may be that sampling was concentrated in areas which had potential to be staging habitats; staging habitats may contain a higher proportion of female white sturgeon than the river in general.

The main objective of the 1997-1998 sampling program was to capture and tag pre-spawning white sturgeon in the upper section of the Columbia River in order to answer some long standing questions about white sturgeon spawning ecology in this section of the river. Five mature or maturing females were captured and equipped with sonic tags (and one was also equipped with a radio tag) during the course of the sampling program; one of those females is expected to spawn in 1998 and another is expected to spawn in 1999. The other three tagged fish have the potential to spawn in 2000. Careful monitoring of these tagged fish over the course of the next few years should aid in answering some of the most pressing questions related to the spawning ecology in the upper section of the Columbia River.

4.3 MOVEMENTS

White sturgeon in the Canadian portion of the Columbia River have been observed to move frequently within localized areas of less than 5 km in length, and within or between high use areas in the same section of river (R.L. & L. 1997a). Movements between the upper and lower sections of the Columbia River have been observed but are relatively infrequent (R.L. & L. 1996). Tag return data for fish recaptured during the 1997-1998 sampling program indicated white sturgeon movement patterns similar to those outlined above. Only one of the 25 recaptured fish had moved from the lower to the upper section of the Columbia River between captures; the remainder had all previously been captured in the upper section of the river. The majority of sturgeon were recaptured within 6.2 km of their previous capture locations.

5.0 RECOMMENDATIONS

The objective of the 1997-1998 sampling program was to capture and radio/sonic tag pre-spawning white sturgeon as the first stage in a study designed to collect additional information on the spawning ecology of white sturgeon in the upper section of the Columbia River. Now that a number of mature or maturing females have been equipped with sonic transmitters it is crucial that the movements of these females be monitored intensively over at least the next four years in order to:

- identify the location of possible staging and spawning habitats used by white sturgeon that reside in the upper section of the Columbia River;
- determine whether the population in the upper and lower sections of the Columbia represent one interbreeding population, or two sub-populations that do not frequently intermix; and
- obtain additional data on life history characteristics related to growth rate, size, sex ratio, and abundance of white sturgeon in the Canadian portion of the Columbia River.

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APPENDIX A

DISCHARGE AND WATER TEMPERATURE DATA

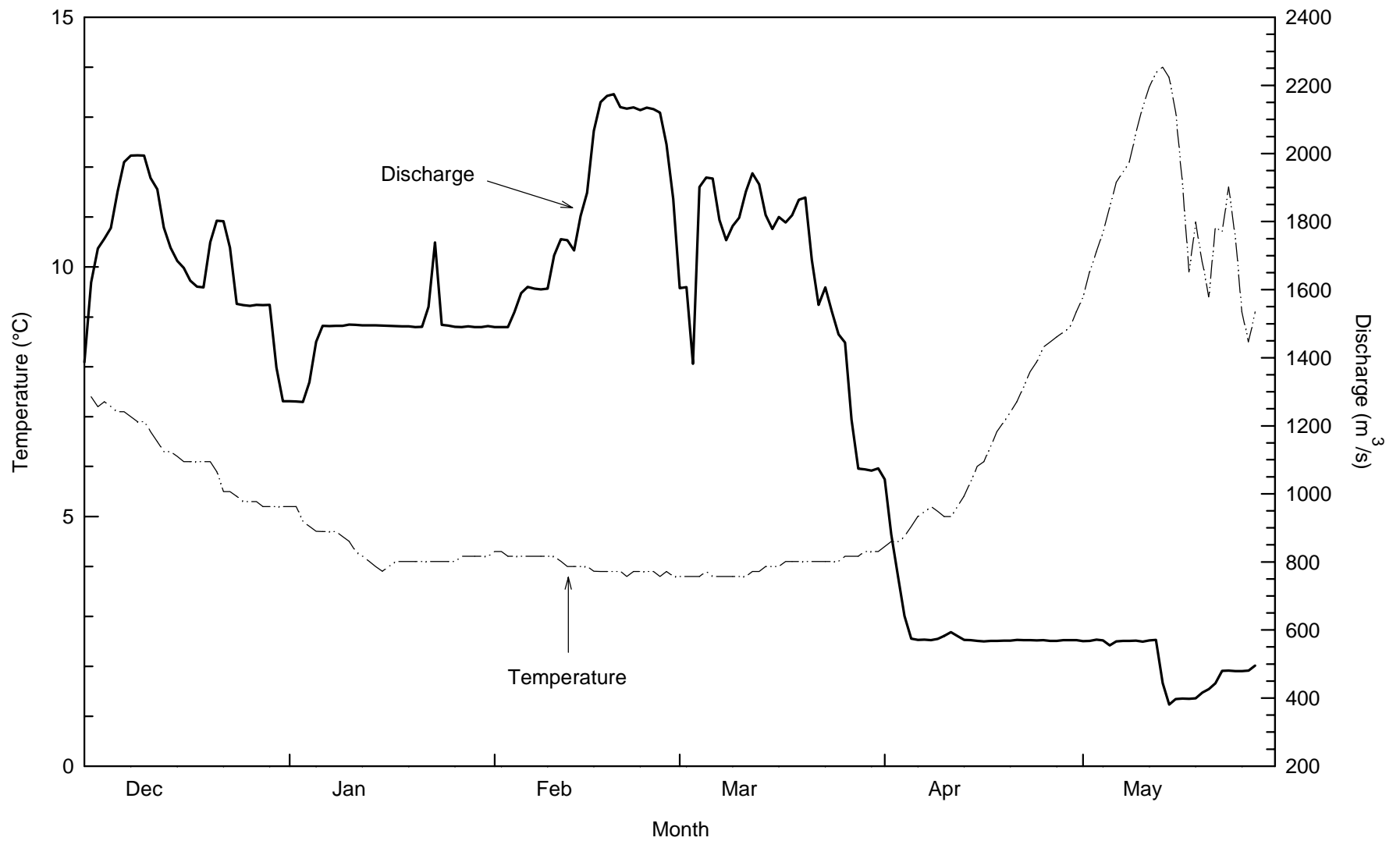


Figure A1 Mean daily water temperature of the Columbia River at the rock groin below Hugh L. Keenleyside Dam, and mean daily discharge at Hugh L. Keenleyside Dam (BC Hydro), 1997-1998 (Unpublished data).

APPENDIX B

CAPTURE DATA

Table B1 Summary of catch and catch-rate (CPUE=no. caught/100 hook-hours) for white sturgeon captured by set line in the upper Columbia River study area, 1997-1998.

Water Body	Survey Session	Station (km) ^a	Set		Pulled		Duration (h)	No. Hooks	Hook Hours	Catch	CPUE
			Date	Time	Date	Time					
Columbia R.	Winter	0.1M	15-Dec	11:22	16-Dec	9:20	22.0	30	659.0	7	1.1
		1.2R	15-Dec	11:48	16-Dec	14:24	26.6	8	212.8	2	0.9
		5.7R	15-Dec	12:20	16-Dec	13:45	25.4	8	203.3	0	0.0
		5.7L	16-Dec	16:00	17-Dec	9:46	17.8	8	142.1	0	0.0
		0.1M	17-Dec	11:14	18-Dec	9:00	21.8	30	653.0	2	0.3
		1.2R	17-Dec	11:00	18-Dec	9:52	22.9	8	182.9	2	1.1
		16.9R	18-Dec	13:43	19-Dec	14:05	24.4	8	194.9	0	0.0
Columbia R. Subtotal							160.7	100	2248.1	13	0.6
Kootenay R.	Winter	0.2L	18-Dec	12:50	19-Dec	10:29	21.7	30	649.5	5	0.8
		2.0R	18-Dec	13:10	19-Dec	13:20	24.2	8	193.3	0	0.0
Kootenay R. Subtotal							45.8	38	842.8	5	0.6
Winter Subtotal							206.6	138	3091.0	18	0.6
Columbia R.	Spring	0.1M	13-Apr	13:55	14-Apr	10:40	20.8	30	622.5	2	0.3
		1.2R	13-Apr	14:10	14-Apr	13:45	23.6	8	188.7	2	1.1
		2.2R	13-Apr	14:30	14-Apr	13:22	22.9	8	182.9	0	0.0
		0.1M	14-Apr	12:04	15-Apr	10:34	22.5	30	675.0	5	0.7
		1.0R	14-Apr	15:34	15-Apr	14:22	22.8	8	182.4	1	0.5
		1.2R	14-Apr	15:22	15-Apr	15:28	24.1	8	192.8	2	1.0
		1.2R	15-Apr	16:49	16-Apr	13:15	20.4	8	163.5	2	1.2
		0.1M	15-Apr	14:11	16-Apr	10:21	20.2	30	605.0	2	0.3
		2.2R	15-Apr	15:08	16-Apr	14:36	23.5	8	187.7	0	0.0
		0.1M	16-Apr	15:20	17-Apr	10:42	19.4	30	581.0	1	0.2
		1.2R	16-Apr	14:30	17-Apr	12:56	22.4	8	179.5	2	1.1
		0.1M	20-Apr	11:42	21-Apr	10:30	22.8	29	661.2	8	1.2
		1.2R	20-Apr	11:05	21-Apr	16:30	29.4	8	235.3	3	1.3
		2.0R	20-Apr	12:25	21-Apr	13:42	25.3	8	202.3	5	2.5
		0.1M	21-Apr	13:37	22-Apr	10:08	20.5	30	615.5	5	0.8
1.2R	21-Apr	17:23	22-Apr	13:45	20.4	8	162.9	1	0.6		
0.1M	22-Apr	13:37	23-Apr	9:55	20.3	30	609.0	1	0.2		
Columbia R. Subtotal							381.1	289	6247.2	42	0.7
Kootenay R.	Spring	0.2L	16-Apr	16:00	17-Apr	15:09	23.2	30	694.5	3	0.4
		2.1R	22-Apr	15:40	23-Apr	13:41	22.0	8	176.1	0	0.0
		0.2L	22-Apr	15:15	23-Apr	12:45	21.5	30	645.0	1	0.2
Kootenay R. Subtotal							66.7	68	1515.6	4	0.3
Spring Subtotal							447.8	357	7762.8	46	0.6
Grand Total							654.4	495	10853.8	64	0.6

^a For location of sampling sites, see Figure 1.1; L and R refer to left and right banks viewed facing upstream, M refers to mid-channel.

APPENDIX C

LIFE HISTORY DATA

Table C1 Summary of life history information for white sturgeon captured by set line in the Columbia and Kootenay river study area, 1997-1998.

Date	Site (km) ^a	Length		Snout Length (cm)	Girth (cm)	Weight (kg)	Sex ^b	Depth (m)	Aging Method ^c	Floy Tag		PIT Tag No.	Capture Code ^e	Sonic tag	Comments
		Fork (cm)	Total (cm)							C ^d	No.				
16-Dec-97	0.1M	171.0	187.5	42.0	72.0	49.0	02	14.2	47	O ₂	30784	41585D2632	2		surgery
16-Dec-97	0.1M	136.5	152.5	34.0	51.5	20.0	97	13.3	35	O	30785	41586C5912	0		
16-Dec-97	0.1M	114.0	127.0	28.5	45.0	14.1	98	12.3	33	O	30786	41597C5839	0		
16-Dec-97	0.1M	158.5	176.5	39.5	59.5	29.5	97	10.5	N	P	21791	7F7D4C717E	2		very flaccid, floy scar abscessed, no surgery
16-Dec-97	0.1M	134.5	151.0	32.5	50.0	21.8	97	14.5	N	O	1801	7F7D217C3E	2		
16-Dec-97	0.1M	130.0	149.5	31.5	50.0	19.1	98	17.8	N	P	25788	7F7D501C4B	2		skinny
16-Dec-97	0.1M	157.0	178.0	37.5	64.0	37.3	13	18.1	N	O	30783	4158502936	0	2-2-3-7	both fins gnarled, surgery, egg sample
16-Dec-97	1.2R	168.5	188.0	40.5	65.0	41.8	02	13.7	N	O ₂	30782	7F7D205919	2		surgery
16-Dec-97	1.2R	129.0	145.0	31.5	48.5	16.4	98	9.2	27	O	1664	4158592307	2		floy tag on right side, no pit tag at capture, flaccid
18-Dec-97	0.1M	145.0	164.0	38.5	58.5	28.2	97	13.9	N	P	23786	7F7D491B2C	2		no surgery scar
18-Dec-97	0.1M	137.5	156.0	34.5	50.0	20.9	97	16.6	35	O	30781	415864572D	0		
18-Dec-97	1.2R	171.5	193.0	41.0	70.0	48.2	17	13.2	N	O ₂	30780	7F7D200C50	2		no fin ray scar visible, surgery
18-Dec-97	1.2R	199.0	222.0	49.5	75.5	65.5	13	6.8	N	O	1902	4158696408	2		no pit on capture, surgery
19-Dec-97	0.2L-K	186.5	208.5	46.0	72.0	51.9	03	8.0	N	O ₂	30778	7F7A003763	2		gnarled fins, scarred operculum, surgery
19-Dec-97	0.2L-K	183.5	206.0	47.5	73.0	43.2	97	8.2	N	O	30779	415849236B	0		l. pect fin previously broken @ tip
19-Dec-97	0.2L-K	157.5	175.5	39.0	66.5	40.9	97	9.1	N	O	30777	4158590013	? ^f		
19-Dec-97	0.2L-K	120.5	136.5	30.5	45.5	16.8	98	12.3	N	P	21310	7F7D216D26	2		sharp scutes
19-Dec-97	0.2L-K	152.5	168.5	39.0	59.0	30.5	97	14.8	N	P	28409	7F7D217003	2		very little mucus layer
14-Apr-98	0.1M	175.0	192.0	41.5	74.0	52.7	03	10.9	FR	O	30924	41584C4404	2		surgery
14-Apr-98	0.1M	152.0	167.0	38.0	60.5	29.1	97	15.5	N	P	21312	7F7D216A28	2		possible previous right fin clip
14-Apr-98	1.2R	207.0	228.0	52.0	76.0	66.4	97	12.1	N	O	30775	4158652113	0		both fins previously broken
14-Apr-98	1.2R	280.0	315.0	69.0	109.0		13	12.1	N	O	30773	4158555B1E	0	2-3-4-5	knobby pectoral fins, surgery, egg sample
15-Apr-98	0.1M	156.0	174.5	37.0	61.0	30.0	97	15.8	N	O	30772	7F7D4D3372	2		nodule on lower lobe of caudal, new PIT tag
15-Apr-98	0.1M	143.5	159.5	36.0	57.0	22.3	02	15.6	N	P	21889	7F7D4D1647	2		previous surgery scar, surgery
15-Apr-98	0.1M	136.0	154.5	35.0	53.0	20.0	97	15.9	FR	O	30771	4158445F7C	0		right first fin ray bent

Continued...

^a For location of sampling sites, see Figure 1.1; L and R refer to left and right banks viewed facing upstream, M refers to mid-channel, and K refers to Kootenay River.

^b For a description of the sexual maturity codes, see Appendix D, Table D1.

^c FR indicates a fin ray sample was taken from the pectoral fin to be used in ageing; N indicates a sample was not taken.

^d Denotes colour of tag; O=orange, P=pink. Subscript indicates original external tag was missing at recapture, a second floy tag was applied during processing.

^e Capture code: 0=first capture, 2=recapture.

^f Possible previous surgery scar and left fin clip at capture, no floy tag, no PIT tag, possible recapture.

Table C1 Continued.

Date	Site (km) ^a	Length		Snout Length (cm)	Girth (cm)	Weight (kg)	Sex ^b	Depth (m)	Aging Method ^c	Floy Tag		PIT Tag No.	Capture Code ^e	Sonic tag	Comments
		Fork (cm)	Total (cm)							C ^d	No.				
15-Apr-98	0.1M	175.5	194.0	44.5	74.0	52.7	02	16.2	N	P	21894	7F7D502651	2		plump fish, previous surgery scar, surgery
15-Apr-98	0.1M	144.0	162.5	35.5	54.5	24.5	97	16.2	FR	O	30770	41584E6A08	0		
15-Apr-98	1.0R	144.5	161.0	37.5	55.5	21.4	97	10.1	FR	O	30769	4159671E26	0		thin fish
15-Apr-98	1.2R	173.5	194.5	44.0	73.0	45.9	02	12.4	FR	O	30768	4158683122	0		surgery
15-Apr-98	1.2R	158.0	173.5	40.5	63.5	31.4	97	12.0	N	O	32056	4158626953	2		sharp scutes
16-Apr-98	1.2R	162.0	181.0	39.0	57.5	29.1	13	13.0	FR	O	30765	4159531D46	0		surgery
16-Apr-98	1.2R	194.0	217.0	46.0	76.0	64.1	97	12.3	N	O	1902	4158696408	2		
16-Apr-98	0.1M	154.5	181.0	39.0	58.0	32.3	13	8.5	FR	O	30767	41585B557E	0	2-5-2-5	surgery, egg sample
16-Apr-98	0.1M	146.0	164.5	34.0	52.0	23.2	97	14.4	FR	O	30766	41586A5525	0		
17-Apr-98	0.2L-K	153.0	171.0	37.0	60.5	29.5	97	6.8	FR	O	30761	4158570E47	0		
17-Apr-98	0.2L-K	144.0	165.0	34.5	51.0	20.9	97	8.3	FR	O	30760	41584B097D	0		badly torn dorsal fin
17-Apr-98	0.2L-K	95.0	107.5	24.5	39.0	7.7	98	10.5	FR	O	30758	41595DOF30	0		
17-Apr-98	0.1M	153.5	175.0	36.5	56.5	27.3	11	17.0	FR	O	30764	4158681418	0		surgery
17-Apr-98	1.2R	175.5	194.0	40.0	76.0	55.5	15	13.2	FR	O	30762	4158562501	0	4-4-5	fishing line in vent, surgery, egg sample, radio tag 41.021
17-Apr-98	1.2R	126.0	144.5	28.0	48.5	15.9	98	13.9	FR	O	30763	4158604D2D	0		
21-Apr-98	0.1M	130.0	146.0	29.5	46.0	15.9	98	9.4	N	O	30753	7F7D187F2E	2		
21-Apr-98	0.1M	110.5	126.0	25.0	42.0	10.9	98	10.1	N	O	32076	4159653F61	2		previous sonic tag 2-3-9
21-Apr-98	0.1M	148.5	166.0	35.0	50.0	24.5	97	9.9	FR	O	30755	7F7D435878	0		
21-Apr-98	0.1M	167.5	187.0	43.0	65.5	36.8	03?	9.5	N	P	21278	7F7D1C237E	2		surgery, biopsy sample taken
21-Apr-98	0.1M	144.0	161.0	34.5	49.0	20.0	97	9.8	N	O	30754	7F7B03226D	2		dorsal damaged from previous floy tag
21-Apr-98	0.1M	136.0	153.5	36.5	53.5	20.0	97	11.4	FR	O	30756	7F7D343852	0		
21-Apr-98	0.1M	117.0	132.0	28.5	43.0	12.3	98	15.7	N	O	30757	7F7D4D1C68	2		no floy tag scar
21-Apr-98	0.1M	150.5	168.5	34.0	54.0	25.5	97	15.3	N	P	23735	7F7D4F626F	2		dorsal scute torn off
21-Apr-98	1.2R	153.5	171.5	38.5	57.0	27.3	97	10.7	N	O	30997	7F7D381619	0		gnarled fins, no fin clip taken
21-Apr-98	1.2R	160.5	181.5	41.0	63.0	34.1	97	7.3	N	P	25770	7F7D1D0347	2		pit tag on right side

Continued...

^a For location of sampling sites, see Figure 1.1; L and R refer to left and right banks viewed facing upstream, M refers to mid-channel, and K refers to Kootenay River.

^b For a description of the sexual maturity codes, see Appendix D, Table D1.

^c FR indicates a fin ray sample was taken from the pectoral fin to be used in ageing; N indicates a sample was not taken.

^d Denotes colour of tag; O=orange, P=pink. Subscript indicates original external tag was missing at recapture, a second floy tag was applied during processing.

^e Capture code: 0=first capture, 2=recapture.

^f Possible previous surgery scar and left fin clip at capture, no floy tag, no PIT tag, possible recapture.

Table C1 Concluded.

Date	Site (km) ^a	Length		Snout Length (cm)	Girth (cm)	Weight (kg)	Sex ^b	Depth (m)	Aging Method ^c	Floy Tag		PIT Tag No.	Capture Code ^e	Sonic tag	Comments
		Fork (cm)	Total (cm)							C ^d	No.				
21-Apr-98	1.2R	130.5	145.5	32.0	49.0	17.7	98	7.3	N	O	30998	7F7D191025	2		
21-Apr-98	2.0R	142.0	160.0	35.0	55.0	23.2	97	15.7	FR	O	30752	7F7D492B09	2		
21-Apr-98	2.0R	142.5	158.0	36.0	55.0	22.3	97	15.7	N	O	32065	7F7D315168	2		pit tag scar, tag not functioning, new tag applied
21-Apr-98	2.0R	144.0	159.5	36.5	55.0	22.3	97	15.7	N	O	30751	7F7D1C593C	2		
21-Apr-98	2.0R	174.0	199.0	45.5	72.0	50.5	14	15.7	FR	O	31000	7F7D266702	0	2-3-6	surgery, egg sample taken
21-Apr-98	2.0R	139.0	156.5	33.0	52.5	21.4	97	15.7	FR	O	30999	7F7D32157C	0		flaccid
22-Apr-98	0.1M	164.0	182.0	41.0	58.0	31.4	02	13.3	N	O	30996	7F7D4F725F	2		surgery, large stomach
22-Apr-98	0.1M	160.0	182.0	40.0	58.0	32.3	97	16.5	N	O	30995	7F7D1C282B	0		fishing line coming out vent
22-Apr-98	0.1M	173.0	194.0	44.0	70.0	47.8	03	17.9	FR	O	30994	7F7D372747	0		surgery
22-Apr-98	0.1M	119.5	138.0	28.0	45.5	14.5	98	14.4	FR	O	30993	4159211167	0		
22-Apr-98	0.1M	178.0	198.5	49.5	68.0	42.3	97	17.4	N	O	1813	7F7D1C477C	2		surgery scar
22-Apr-98	1.2R	146.5	164.0	36.5	55.5	21.8	97	12.7	N	P	25752	7F7D4F6677	2		
23-Apr-98	0.2L-K	149.5	167.0	35.0	57.5	25.9	97	11.4	FR	O	30991	415862216C	0		
23-Apr-98	0.1M	138.5	155.0	34.5	55.5	21.8	97	11.8	N	O	30992	7F7D1C5A66	2		removed old floy tag P 21295

^a For location of sampling sites, see Figure 1.1; L and R refer to left and right banks viewed facing upstream, M refers to mid-channel, and K refers to Kootenay River.

^b For a description of the sexual maturity codes, see Appendix D, Table D1.

^c FR indicates a fin ray sample was taken from the pectoral fin to be used in ageing; N indicates a sample was not taken.

^d Denotes colour of tag; O=orange, P=pink. Subscript indicates original external tag was missing at recapture, a second floy tag was applied during processing.

^e Capture code: 0=first capture, 2=recapture.

^f Possible previous surgery scar and left fin clip at capture, no floy tag, no PIT tag, possible recapture.

APPENDIX D

SEX AND MATURITY DATA

Table D1 Sexual developmental stages of white sturgeon sampled in the Columbia River study area, 1997-1998. Data for fish captured multiple times during the sampling period are excluded.

Sex	Code	Development State Description ^a	Number Sampled (%)		
			Winter	Spring	All Seasons
Male	01	Non-reproductive, testes appear as thin strips with no pigmentation	0 (0.0)	0 (0.0)	0 (0.0)
	02	Maturing; small testes; some folding may be apparent; translucent, smoky pigmentation	2 (11.1)	4 (8.9)	6 (9.6)
	03	Early reproductive; large testes, folds beginning to form lobes; some pigmentation still present; testes more white than cream coloured	1 (5.6)	3 (6.7)	4 (6.3)
	04	Late reproductive; testes large, often filling posterior of body cavity; white with little or no pigmentation	0 (0.0)	0 (0.0)	0 (0.0)
	05	Ripe; milt flowing; large white lobular testes; no pigmentation	0 (0.0)	0 (0.0)	0 (0.0)
	06	Spent; testes pinkish-white, flaccid, and strongly lobed	0 (0.0)	0 (0.0)	0 (0.0)
	10	General unknown maturity	0 (0.0)	0 (0.0)	0 (0.0)
Male Subtotal			3 (16.7)	7 (15.6)	10 (15.9)
Female	11	Non-reproductive; ovaries small, folded with no visible oocytes; tissue colour white to yellowish	0 (0.0)	1 (2.2)	1 (1.6)
	12	Pre-vitellogenic, moderate size ovary with small eggs present (0.2 to 0.5 mm diameter); may have "salt and pepper" appearance	0 (0.0)	0 (0.0)	0 (0.0)
	13	Early vitellogenic; large ovary varying in colour from white to yellowish-cream to light grey; eggs 0.6 to 2.1 mm in diameter	2 (11.1)	3 (6.7)	5 (7.9)
	14	Late vitellogenic; ovaries large with pigmented oocytes still attached to ovarian tissue; eggs 2.2 to 2.9 mm in diameter; sometimes with salt and pepper appearance	0 (0.0)	1 (2.2)	1 (1.6)
	15	Ripe; eggs fully pigmented and easily detached from ovarian tissue; eggs 3.0 to 3.4 mm in diameter	0 (0.0)	1 (2.2)	1 (1.6)
	16	Spent; ovaries are flaccid with some residual fully developed eggs	0 (0.0)	0 (0.0)	0 (0.0)
	17	Pre-vitellogenic with atretic oocytes; small eggs (<0.5 mm diameter) present; dark pigmented tissue present that may be reabsorbed eggs.	1 (5.6)	0 (0.0)	1 (1.6)
	20	General unknown maturity	0 (0.0)	0 (0.0)	0 (0.0)
Female Subtotal			3 (16.7)	6 (13.3)	9 (14.3)
Unknown ^b	97	Gonad undifferentiated or not visible; adult based on size	8 (44.4)	25 (55.6)	33 (52.4)
	98	Gonad undifferentiated or not visible; juvenile based on size	4 (22.2)	7 (15.5)	11 (17.4)
Unknown Subtotal			12 (66.6)	32 (71.1)	44 (69.8)
Grand Total			18 (100.0)	45 (100.0)	63 (100.0)

^a Descriptions of maturity state classifications adapted from Conte et al. (1988).

^b All fish categorized as "Unknown" sexual stage were not examined surgically during this program.

APPENDIX E

MARK-RECAPTURE AND RADIO TELEMETRY DATA

Table E1 Summary of life history information for white sturgeon recaptured in the Columbia River, 1997-1998.

Original Capture Data									Recapture Data									Summary	
Dart or Floy Tag		PIT Tag	Length (cm)		Weight (kg)	S ^b	Site (km)	Capture Date	Dart or Floy Tag		PIT Tag	Length (cm)		Weight (kg)	S ^b	Site (km)	Date of 2nd Capture	Days at Large	Movement (km) ^c
C ^a	No.		Fork	Total					C ^a	No.		Fork	Total						
O	30924		167.5	184.5	45.5	1	0.1K	20-Aug-96	O	30924	41584C4404	175.0	192.0	52.7	03	0.1	14-Apr-98	602	10.4
P	21312	7F7D216A28	129.5		15.0	98	6.4	9-Nov-92	P	21312	7F7D216A28	152.0	167.0	29.1	97	0.1	14-Apr-98	1982	6.3
P	21894	7F7D502651	160.5		38.2	3	2.2	22-Jul-93	P	21894	7F7D502651	175.5	194.0	52.7	02	0.1	15-Apr-98	1728	2.1
P	21889	7F7D4D1647	135.5		19.5	98	0.1	21-Jul-93	P	21889	7F7D4D1647	137.0		20.0	98	2.2	10-Jun-94	324	-2.1
P	21889	7F7D4D1647	137.0		20.0	98	2.2	10-Jun-94	P	21889	7F7D4D1647	137.0		18.2	98	0.1	15-Aug-94	66	2.1
P	21889	7F7D4D1647	137.0		18.2	98	0.1	15-Aug-94	P	21889	7F7D4D1647	143.5	159.5	22.3	02	0.1	15-Apr-98	1339	0.0
O	32056	4158626953	155.0	173.5	34.1	97	5.7	25-Sep-96	O	32056	4158626953	158.0	173.5	31.4	97	1.2	15-Apr-98	567	4.5
O	1902		185.0		59.1	97	0.1	26-Jun-92	O	1902	4158696408	199.0	222.0	65.5	13	1.2	18-Dec-97	2001	-1.1
O	1902	4158696408	199.0	222.0	65.5	13	1.2	18-Dec-97	O	1902	4158696408	194.0	217.0	64.1	97	1.2	16-Apr-98	119	0.0
P	21281	7F7D187F2E	109.0		9.5	98	0.1	7-Nov-92	O ₂	30753	7F7D187F2E	130.0	146.0	15.9	98	0.1	21-Apr-98	1991	0.0
O	32076	4159653F61	105.5	121.5	11.8	2	5.7	3-Dec-96	O	32076	4159653F61	110.5	126.0	10.9	98	0.1	21-Apr-98	504	5.6
P	21278	7F7D1C237E	141.5		21.4	98	0.1	7-Nov-92	P	21278	7F7D1C237E	167.5	187.0	36.8	03	0.1	21-Apr-98	1991	0.0
P	25706	7F7D4D1C68	102.0		7.3	97	0.3	7-Oct-94	O ₂	30757	7F7D4D1C68	117.0	132.0	12.3	98	0.1	21-Apr-98	1292	0.2
P	23735	7F7D4F626F	138.0		18.6	98	0.1	21-Nov-93	P	23735	7F7D4F626F	150.5	168.5	25.5	97	0.1	21-Apr-98	1612	0.0
P	25770	7F7D1D0347	158.0		33.6	2	4.5	1-Nov-94	P	25770	7F7D1D0347	160.5	181.5	34.1	97	1.2	21-Apr-98	1267	3.3

Continued...

^a Denotes colour of tag; O=orange, P=pink. Subscript indicates original external tag was missing at recapture, a second floy tag was applied during processing.

^b S=sexual maturity stage. For a description of the sexual maturity codes, see Appendix D, Table D1.

^c Negative number indicates downstream movement.

Table E1 Continued.

Original Capture Data									Recapture Data									Summary	
Dart or Floy Tag		PIT Tag	Length (cm)		Weight (kg)	S ^b	Site (km)	Capture Date	Dart or Floy Tag		PIT Tag	Length (cm)		Weight (kg)	S ^b	Site (km)	Date of 2nd Capture	Days at Large	Movement (km) ^c
C ^a	No.		Fork	Total					C ^a	No.		Fork	Total						
P	21254	7F7D191025	116.5		11.8	98	0.1	5-Nov-92	O ₂	30998	7F7D191025	130.5	145.5	17.7	98	1.2	21-Apr-98	1993	-1.1
P	23775	7F7D492B09	129.0		17.7	98	2.2	26-Mar-94	O ₂	30752	7F7D492B09	142.0	160.0	23.2	97	2.0	21-Apr-98	1487	0.2
O	32065	415861366C	140.0	158.0	21.4	97	2.2	3-Oct-96	O	32065	7F7D315168	142.5	158.0	22.3	97	2.0	21-Apr-98	565	0.2
P	21270	7F7D1C593C	141.0		20.0	98	2.2	6-Nov-92	O ₂	30751	7F7D1C593C	144.0	159.5	22.3	97	2.0	21-Apr-98	1992	0.2
P	21870	7F7D4F725F	154.0		30.4	3	0.1	4-Jul-93	O ₂	30996	7F7D4F725F	164.0	182.0	31.4	02	0.1	22-Apr-98	1753	0.0
P	21259	7F7D1C282B	142.5		22.7	98	0.1	5-Nov-92	P	21959	7F7D1C282B	146.5		24.1	98	0.1	15-Aug-94	648	0.0
P	21959	7F7D1C282B	146.5		24.1	98	0.1	15-Aug-94	O ₂	30995	7F7D1C282B	160.0	182.0	32.3	97	0.1	22-Apr-98	1346	0.0
O	1813	7F7D1C477C	160.0		31.4	97	0.1	7-Jul-92	O	1813	7F7D1C477C	163.0		31.4	97	0.1	27-May-93	324	0.0
O	1813	7F7D1C477C	163.0		31.4	97	0.1	27-May-93	O	1813	7F7D1C477C	166.0		35.0	02	5.7	18-Oct-94	509	-5.6
O	1813	7F7D1C477C	166.0		35.0	2	5.7	18-Oct-94	O	1813	7F7D1C477C	178.0	198.5	42.3	97	0.1	22-Apr-98	1282	5.6
P	25752	7F7D4F6677	134.5		19.1	98	0.1	17-Oct-94	P	25752	7F7D4F6677	146.5	164.0	21.8	97	1.2	22-Apr-98	1283	-1.1
P	21295	7F7D1C5A66	137.0		19.1	98	0.1	8-Nov-92	O ₂	30992	7F7D1C5A66	138.5	155.0	21.8	97	0.1	23-Apr-98	1992	0.0
P	21791	7F7D336458	146.5		21.8	98	0.1	27-May-93	P	21791	7F7D336458	147.5	162.0	25.0	98	2.2	26-Jul-95	790	-2.1
P	21791	7F7D336458	147.5	162.0	25.0	98	2.2	26-Jul-95	P	21791	7F7D4C717E	158.5	176.5	29.5	97	0.1	16-Dec-97	874	2.1
O	1801	7F7D217C3E	122.0		16.8	98	6.4	11-Jun-92	O	1801	7F7D217C3E	125.0		17.3	98	6.2	6-Jun-93	360	0.2
O	1801	7F7D217C3E	125.0		17.3	98	6.2	6-Jun-93	O	1801	7F7D217C3E	131.5	146.5	19.5	98	1	5-Dec-96	1278	5.2
O	1801	7F7D217C3E	131.5	146.5	19.5	98	1	5-Dec-96	O	1801	7F7D217C3E	134.5	151.0	21.8	97	0.1	16-Dec-97	376	0.9

Continued...

^a Denotes colour of tag; O=orange, P=pink. Subscript indicates original external tag was missing at recapture, a second floy tag was applied during processing.

^b S=sexual maturity stage. For a description of the sexual maturity codes, see Appendix D, Table D1.

^c Negative number indicates downstream movement.

Table E1 Concluded.

Original Capture Data									Recapture Data									Summary	
Dart or Floy Tag		PIT Tag	Length (cm)		Weight (kg)	S ^b	Site (km)	Capture Date	Dart or Floy Tag		PIT Tag	Length (cm)		Weight (kg)	S ^b	Site (km)	Date of 2nd Capture	Days at Large	Movement (km) ^c
C ^a	No.		Fork	Total					C ^a	No.		Fork	Total						
O	1812	7F7D205919	139.0		22.3	97	0.1	7-Jul-92	P	21912	7F7D205919	143.0		20.4	03	2.2	18-Aug-93	407	-2.1
P	21912	7F7D205919	143.0		20.4	3	2.2	18-Aug-93	P	21912	7F7D205919	159.0	178.5	33.9	97	0.8	3-Oct-96	1142	1.4
P	21912	7F7D205919	159.0	178.5	33.9	97	0.8	3-Oct-96	O ₂	30782	7F7D205919	168.5	188.0	41.8	02	1.2	16-Dec-97	439	-0.4
P	23786	7F7D491B2C	131.5		23.6		52.3	30-Mar-94	P	23786	7F7D491B2C	136.0		24.1	98	55.8	4-Nov-94	219	-3.5
P	23786	7F7D491B2C	136.0		24.1	98	55.8	4-Nov-94	P	23786	7F7D491B2C	145.0	164.0	28.2	97	0.1	18-Dec-97	1140	55.7
P	20035	7F7D200C50	152.0		32.7	11	0.1	15-Jul-92	O ₂	30780	7F7D200C50	171.5	193.0	48.2	17	1.2	18-Dec-97	1982	-1.1
O	1902		185.0		59.1	97	0.1	26-Jun-92	O	1902	4158696408	199.0	222.0	65.5	13	1.2	18-Dec-97	2001	-1.1
O	1902	4158696408	199.0	222.0	65.5	13	1.2	18-Dec-97	O	1902	4158696408	194.0	217.0	64.1	97	1.2	16-Apr-98	119	0.0
P	21310	7F7D216D26	103.0		9.5	98	6.4	9-Nov-92	P	21310	7F7D216D26	120.5	136.5	16.8	98	0.2	19-Dec-97	1866	6.2
P	28409	7F7D217003	151.0		32.7		0.1K	28-Nov-95	P	28409	7F7D217003	152.5	168.5	30.5	97	0.2K	19-Dec-97	752	0.1
P	23717	7F7D4D3375	137.0		27.3	12	0.1	17-Nov-93	P	23717	7F7D4D3375	149.5	166.0	32.7	03	0.1	6-Dec-96	1115	0.0
P	23717	7F7D4D3375	149.5	166.0	32.7	3	0.1	6-Dec-96	O ₂	30772	7F7D4D3375	156.0	174.5	30.0	97	0.1	15-Apr-98	495	0.0
P	28423	7F7D03226D	138.0	154.0	18.6	98	0.1	14-Nov-95	O ₂	30754	7F7D03226D	144.0	161.0	20.0	97	0.1	21-Apr-98	889	0.0
P	25788	7F7D501C48	127.5		17.3	98	0.1	1-Feb-95	P	25788	7F7D501C4B	130.0	149.5	19.1	98	0.1	16-Dec-97	1049	0.0
P	21932	7F7D003763	179.0		48.2	97	0.1K	11-Jun-94	O ₂	30778	7F7D003763	186.5	208.5	51.9	03	0.2K	19-Dec-97	1287	0.1

^a Denotes colour of tag; O=orange, P=pink. Subscript indicates original external tag was missing at recapture, a second floy tag was applied during processing.

^b S=sexual maturity stage. For a description of the sexual maturity codes, see Appendix D, Table D1.

^c Negative number indicates downstream movement.

Table E2 Tracking record of white sturgeon with active sonic and radio transmitters in the Columbia and lower Kootenay rivers, 1997-1998.

Sonic/Radio Tag Frequency	Sex Code ^a	Fork Length (cm)	Floy Tag		Release Date	Location Released (km)	Location At Each Tracking Date							Maximum Movement (+/-) ^c		
			C ^b	Number			17-Dec-97 (boat)	21-Jan-98 (boat)	27-Apr-98 (shore)	1-May-98 (boat)	4-May-98 (boat)	11-May-98 (shore)	22-May-98 (boat)		27-May-98 (boat)	
4-5-5	02	126.5	-	-	4-Oct-96	5.7	0.7									5.0/0.0
3-6-5	02	124.0	O	32068	4-Oct-96	6.4	2.4				2.2		4.3			4.2/-2.1
2-3-9	02	105.5	O	32076	3-Dec-96	5.7							0.2			5.5/0.0
3-4-7	98	105.5	O	30921	20-Aug-96	Koot 0.1	4.3	4.0					4.0			6.4/0.0
4-8-2	02	102.0	P	5415	25-Sep-96	5.7		2.0								3.7/0.0
2-2-3-7	13	157.0	O	30783	16-Dec-97	0.1	0.2	0.1	0.8	0.8	0.4		0.1			0.0/-0.7
2-3-4-5	13	280.0	O	30773	14-Apr-98	1.2			1.2	0.2	0.2		0.3			1.0/0.0
2-5-2-5	13	154.5	O	30767	16-Apr-98	0.1			0.2	1.2			3.1			0.0/-3.0
4-4-5/41.021	15	175.5	O	30762	17-Apr-98	1.2				3.9	3.9	3.9	3.7	0.3		0.9/-2.7
2-3-6	14	174.0	O	31000	21-Apr-98	2.0			0.2	0.2	0.1		0.5			1.9/0.0

Note: Shaded area under tracking dates indicates tags were not applied until after these dates.

^a For a description of sexual maturity codes, see Appendix D, Table D1.

^b Denotes colour of tag; O=orange, P=pink.

^c Maximum movement is the maximum distance moved either upstream (+) or downstream (-) from the location released.