WHITE STURGEON SPAWNING AT WANETA

2005 INVESTIGATIONS

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Prepared for

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and
BC Hydro

by

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C**over photo:** The Waneta white sturgeon spawning and egg deposition area as viewed from station SM56C4, July 2005.

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1.0 INTRODUCTION

1.1 BACKGROUND

The section of the Columbia River, from Hugh L. Keenleyside Dam (HLK) downstream to Lake Roosevelt, supports a small population of white sturgeon *(Acipenser transmontanus)* that experiences frequent recruitment failures[9,10,11]. Previous studies of this white sturgeon population since 1990 have indicted that even though spawning has been detected in all years examined, juvenile age-classes (under ten years of age) from wild-spawned eggs are lacking within this population.

To protect the remaining white sturgeon in the Columbia River between the Canada-US border and HLK dam, this population was listed in 1990 as "vulnerable" (blue-listed) under the Canadian Endangered Species Listing (COSEWIC). This status was changed to "imperilled" (S2, red-listed) in 1994 and then upgraded to "critically imperilled (S1 red-listed) in 1996 by the BC Conservation Data Centre. This species is currently under review for listing as a Schedule 1 species (endangered) under the Species at Risk Act (SARA).

The Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) has identified monitoring of white sturgeon spawning at Waneta as a priority research program. Since 1993, white sturgeon spawning at Waneta has been monitored annually with funding provided by BC Hydro, Teck Cominco, Columbia Power Corporation, and the BC Ministry of Environment [3,4,5,7,9,10,11,12,13,14].

In May 2005, the peak runoff prediction for the Pend d'Oreille River basin at Box Canyon Dam was 62% of the 30-year average [16,23]. Based on this prediction, there was a reasonable probability that during the 2005 June to July white sturgeon spawning period, the mean daily Pend d'Oreille River flows would be below 708 m^3/s for a substantial portion of the spawning period. This would trigger implementation of the White Sturgeon Flow Augmentation Program (WSFAP), a commitment of the Project Approval Certificate (PAC; E97-01) for the Waneta Upgrade Project. Under the conditions of the WSFAP, when mean daily Pend d'Oreille flows are below 708 m^3/s, Waneta Dam provides minimum discharges of 283 m^3/s during the day (0600h to 2400h) in an effort to attain the minimum white sturgeon spawning velocity target of 0.8 m/s or greater (mean column velocity) in the upper portion of the spawning area. The WSFAP also requires the release of a minimum flow of 142 m^3/s during the night (2400h to 0600h) to help discourage predation on incubating sturgeon eggs. This flow supplementation program was developed in 1996 to meet obligations under the Fisheries Act as part of the Mitigation and Compensation Plan associated with the Waneta Upgrade Project. As part of these obligations, Teck Cominco committed to conducting five years of monitoring to assess the effects of the WSFAP on sturgeon spawning. Some of the monitored years were to be conducted during low water years when the WSFAP would be implemented for a substantial portion of the spawning period. Based on the May 2005 flow forecast, DFO and the BC MWLAP agreed that 2005 would be selected as for monitoring and would represent the third year of the five year monitoring program.

The purpose of the 2005 white sturgeon spawn monitoring study was to collect additional data on spawning frequency during a low discharge year and to assess the effect of WSFAP flows on the relative abundance and distribution of potential egg predators in the Waneta tailrace area. During the study, additional information was also to be obtained from *in situ* incubation of wild spawned white sturgeon eggs in order to assist in the development of *in situ* incubation techniques. Larval sturgeon hatched through this method were preserved and archived for potential future genetic analysis.

The spawn monitoring program was conducted concurrently with the UCWSRI 2005 white sturgeon brood stock collection program and transboundary white sturgeon radio telemetry program. The 2005 white sturgeon spawn monitoring program was also conducted concurrently with white sturgeon larvae monitoring and predator assessment studies conducted in the US portion of the upper Columbia River by the Washington Department of Fish and Wildlife (WDFW). Upon detection of each spawning event in the Waneta area, WDFW personnel were notified (by email or phone) so they could deploy larval sampling gear in downstream sections of the Columbia River during the predicted hatch period.

1.2 OBJECTIVES

The specific objectives of the 2005 program were as follows:

- to collect an additional year of white sturgeon spawning data during a low water year;
- to identify the frequency of and intensity of spawning events using egg collection mats to recover spawned eggs;
- to collect continuous temperature data in the forebay of Waneta Dam and in the tailrace area at the incubation arrays; and
- to incubate eggs *in situ* and preserve the larvae for genetic analysis.

The relative abundance of potential egg predators in the white sturgeon spawning area during WSFAP minimum flows was also assessed. This involved night time boat electrofishing during period of constant 708 m^3/s and 142 m^3/s minimum WSFAP flows. The specific objectives of this component were:

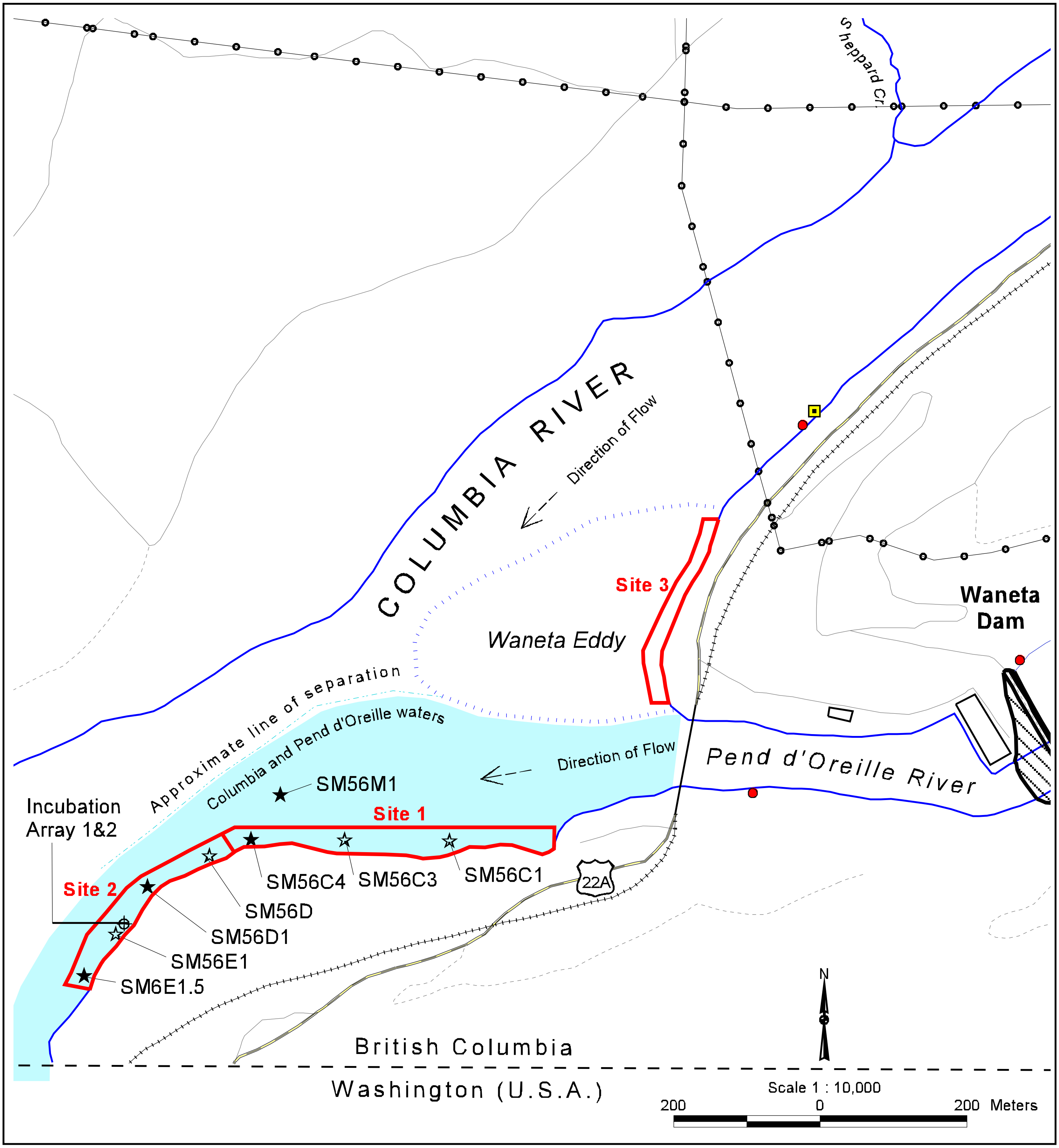
- to conduct two boat electrofishing sample sessions under WSFAP flow conditions and following confirmation of a white sturgeon spawning event;
- to record life history data and preserve the stomach contents of captured fish;
- determine the relative abundance of potential egg predators within the white sturgeon spawn area during WSFAP minimum flows; and
- to examine stomach contents of potential egg predators for the presence of white sturgeon eggs and larvae.

1.3 STUDY AREA

The 2005 study area consisted of the Columbia and Pend d'Oreille river confluence area, located approximately 100 m upstream of the Canada-U.S. border (Figure 1.1). Egg collection mats were deployed at previously designated stations within a general area known as the Waneta spawning area, where the majority of white sturgeon eggs have been captured in previous studies. One *in situ* incubation array (see Section 2.3) was deployed near station SM56E1.

1.4 STUDY PERIOD

The spawning study was conducted from 1 June to 29 July 2005. Sampling was initially conducted twice per week (generally Tuesday and Friday) until newly spawned white sturgeon eggs were initially captured; thereafter, sampling was conducted three times per week during the peak spawning period from late June to early July. Based on the decline in the number of eggs recovered later in the spawning season, sampling reverted back to the twice-weekly schedule. This sampling plan was used to maximize the number of eggs captured for use in the *in situ* incubation study and to maximize the possibility that all spawning events were detected.



LEGEND

- Non-Index Mat Locations
- Index Mat Locations
- Thermograph Locations
- Cominco Water Station
- Incubation Arrays
- Waneta Spawning Area
- Electroshocking Sites
- River
- Bridge
- Paved Road
- Paved Road 1 Lane
- Rough Road
- Railway
- Transmission Line

REFERENCE

Digital Data Sets 082F.002
Protection, 1997. Datum: NAD 83 Projection: UTM Zone 11

PROJECT

White Sturgeon Spawning at Waneta, 2005 Investigations

TITLE

Waneta White Sturgeon Spawning Area Egg Collection Mat, Incubation Array and Electrofishing Site Locations, 2005

Golder Associates
Castlegar, British Columbia

PROJECT No. 05-1480-030			SCALE AS SHOWN	REV. 0
DESIGN	EL	09 Dec. 2005	**FIGURE 1.1**	
GIS	EL	09 Dec. 2005		
CHECK	PG	09 Dec. 2005		
REVIEW	LH	09 Dec. 2005		

2.0 METHODOLOGY

2.1 PHYSICAL PARAMETERS

2.1.1 Temperature

Daily surface water temperatures in the Waneta spawning area were obtained using lab grade (±0.1°C accuracy) hand-held thermometer. In addition, water temperature loggers (Onset StowAway Tidbits™; ±0.2°C accuracy), set to measure temperature at hourly intervals, were deployed in the Pend d'Oreille River at the forebay and tailrace of Waneta Dam and in the Columbia River at the Teck Cominco water station (Figure 1.1). At the incubation array, located between stations SM56E1 and SM56E1.5, a Tidbit™ temperature logger was placed on the each of the inshore and offshore concrete weights used to anchor the array.

2.1.2 Discharge

Hourly average discharge data for the Pend d'Oreille River and the Columbia River were used in the analysis of the spawning data. Pend d'Oreille River discharge during the study period was provided by the operators of Waneta Dam (Fortis BC Ltd.) in the form of hourly spill and generation plant discharges from Waneta Dam. Hourly Pend d'Oreille River discharge data for the remainder of the year was obtained from Seven Mile Dam (BC Hydro), which is located approximately 9.1 km upstream of Waneta Dam. There are no major tributaries entering the Waneta headpond between Seven Mile and Waneta Dams so the Seven Mile data is considered a good approximation of Waneta Dam releases. All discharge data for the Columbia River was provided by BC Hydro, who obtained the data from the Water Survey of Canada Birchbank gauge station.

2.2 CAPTURE TECHNIQUES

2.2.1 Egg Collection Mats

The spawn monitoring component of the 2005 study involved the deployment of egg collection mats to capture white sturgeon eggs spawned in the Waneta area. Out of the various egg collection methods that have been tested in the past to capture white sturgeon eggs (e.g., D-rings, Serber samplers), egg collection mats have proven to be the most effective and cost-efficient method of collecting eggs from white sturgeon whose reproductive life history is characterized by broadcast spawning and which exhibit a protracted spawning period [3,4,5,7,9,10,11,12,13,14]. During the 2005 spawning study, the type of equipment deployed and the method of deployment and retrieval were essentially unchanged from the 2004 protocol (i.e., paired egg collection mats retrieved from the river bottom and inspected in metal trays filled with water)[7]. In 2005, an electrical water pump was used in combination with the trays to continuously inundate the egg collection mats with fresh river water during inspection to reduce desiccation and thermal shock of the eggs.

As in previous studies, high Pend d'Oreille River discharge at the start of the 2005 monitoring period prevented the deployment of mid-channel egg mat sets. By 21 June, discharge levels had decreased sufficiently to allow deployment of the mid-set.

2.3 EGG INCUBATION TECHNIQUES

To assess the various factors that may influence egg survival within the spawning and incubation area, the majority of captured white sturgeon eggs were incubated *in situ* on an incubation array located near station SM56E1. White sturgeon eggs were carefully removed (using forceps) from the mats and placed in shallow water-filled trays where healthy, viable eggs were separated from dead or damaged eggs (often identifiable by the presence of fungal mycelium). The healthy, viable eggs were placed in incubation trays and returned to the river near where they were captured, and allowed to incubate *in situ* until hatch. This was done to obtain sufficient cellular material for economical DNA analysis that would allow determination of the genetic make-up of the eggs captured.

During the 2004 study, white sturgeon eggs were incubated using two different methods; incubation cassettes and incubation trays. Based on hatch success, incubation trays were the more effective egg incubators and therefore, were the only *in situ* incubation method used during the 2005 study[7]. The incubation trays consisted of a 18 cm long by 9 cm wide piece of 6 mm thick plexiglass middle sheet with 50 perforations (6 mm wide) distributed in a rectangular grid pattern. Two 3 mm thick sheets of similarly sized and perforated plexiglass, with 1 mm plastic screen glued to one side, were paced on either side of the middle sheet to seal the eggs within the incubator. The bottom and middle plates of the incubator were placed in a shallow tray of fresh river water and a single white sturgeon egg was placed in each of the 50 perforations. The top sheet was then placed over the other two sheets and the entire unit was sealed by bolting all three sheets together.

The incubation trays were deployed in crab bait cages (two incubators per cage) at depths between 2 m and 4 m, attached to a weighted rope (the incubation line or array). The incubation line consists of a 25 m length of rope with concrete anchors attached to each end of the rope to help stabilize the array on the river bottom. The upstream end of the array was tethered to shore. A buoy attached to the downstream anchor served as a backup method of retrieval in case the shoreline tether failed. To reduce sediment accumulation within the incubator, up to six incubators in three pairs of two were suspended in the water column by attaching the bait cages (containing the incubators) to a loop on a 0.5 m tether equipped with a small float. For additional ballast and stabilization, the end of the tether was attached to metal weight which was in turn attached to the incubation line with a carabineer (Plates A and B).

Depending on the numbers of eggs recovered, one to two arrays (three sets of paired incubators per array) were deployed at any one time. The arrays were left undisturbed until a sufficient amount of time elapsed for the eggs to hatch. Array retrieval was determined based on the developmental stage of the eggs at capture (determined using a hand lens), accumulated thermal units (ATUs), and rates of embryonic development provided in the literature [1,15]. Water temperatures were recorded hourly to accurately determine temperatures during egg incubation. The larvae from eggs that successfully hatch were preserved in 99% anhydrous ethanol and sent to the BC Ministry of Environment to be archived for future DNA analysis.

2.4 EGG PRESERVATION AND STAGING

In the present study, a random sample of eggs captured (i.e., every fifth egg collected from a mat) was preserved in 10% formalin. These eggs were used to assess egg developmental stages and allow back calculation to determine the timing of spawning (i.e., fertilization) based on known rates of white sturgeon egg development [1,15]. All preserved eggs were staged in the laboratory to determine the number and timing of spawning events over the spawning season.

In the assessment of spawning events in 2005, a minimum time separation of 18 hours between spawn time estimates was used as a guideline to delineate spawning events based on egg developmental differences recorded among eggs from a single egg capture event. This value was selected based on a lab incubation study of white sturgeon eggs conducted in 2004[6]. This study indicated that after 100 hours of incubation, developmental stages of eggs fertilized at the same time differed substantially. Applying time-based egg developmental stages for white sturgeon provided in the literature to this group of same-aged eggs resulted in estimates as to the time of fertilization that differed by up to 35 hours. All eggs examined during the lab study were underdeveloped (i.e., developed more slowly) relative to the published development rates of white sturgeon eggs at similar temperatures (i.e., between 10ºC and 18ºC) and all the eggs in the experiment were eventually were colonized by fungus and died prior to hatch [1,15]. Based on the 2004 lab study and under the assumption that wild spawned eggs incubate under more natural conditions and would be less susceptible to fungal infection than the eggs in the lab study, differences in development rate of up to 18 hours were assumed for early stage eggs (e.g., from post-fertilization to late cleavage) from a single spawning event.

Overall, the most reliable indicator of a spawning event was when eggs at very early developmental stages were captured after a period of time without egg capture. Early developmental eggs were also the easiest to accurately stage. During consecutive days of egg capture, when eggs at many different developmental stages were captured, greater weight was placed on early rather than later stage eggs in the identification of additional spawning events (Appendix A, Table A3). Due to differences in developmental rate among early stage eggs, eggs more that 18 hours apart in development were assumed to be from separate spawning events. Once spawning events were delineated, determination of spawn time was generally based on the egg stage with the greatest number of eggs. This criterion for determining spawn time was not applied if the egg stage with the greatest number of eggs was determined to have been spawned within 18 hours from the previous event. In this case, the most mature eggs were used to estimate the spawning time of the latter event (e.g., 7 July, Appendix A, Table A3).

2.5 EGG PREDATOR ASSESSMENT

Following consultation with Colin Spence and Steve McAdam of the BC Ministry of Environment, Golder Associates Ltd. (Golder) was granted permission to conduct multiple-pass sampling with a boat electroshocker in order to assess the species composition and relative abundance of potential egg predators within the Waneta white sturgeon spawning and egg deposition/incubation area. The authorization to proceed was granted with the stipulation that all sampling would cease if white sturgeon were observed.

To assess the effect of the WSFAP flows on the relative abundance of egg predators in the Waneta tailrace, sampling was conducted between an hour after dusk to an hour before dawn during a period when continuous night time flows of 708 m^3/s were maintained, and when night time flows of 142 m^3/s commenced. White sturgeon spawning events were determined by the egg collection program under each of these flow regimes. In each case, sampling was initiated one hour after dusk during heavy load hour (HLH) flows (ideally not in excess of 800 m^3/s) and about 1 hour before dawn during light load hour (LLH) flows. Sampling was conducted on 8 July (sampling at HLH and LLH flows when both were at least 708 m^3/s) and on 16 July (sampling at HLH at flows of at least 708 m^3/s and sampling at LLH flows of at least 142 m^3/s).

Three boat electrofishing surveys were conducted in the Waneta spawning area and Waneta Eddy on 8 July. The south shore of the Waneta spawning area was divided into upper and lower sites, designated as site 1 and site 2, respectively (Figure1.1). Site 1 was approximately 425 m long, with the upstream boundary at the large eddy located 100 m upstream of SM56C1 and the downstream boundary located at station SM56D. Site 2 was approximately 340 m long with the upstream boundary at station SM56D and the downstream boundary near the Canada-U.S. border. During initial sampling in site 2, a single adult white sturgeon was observed and sampling within the spawning area was terminated. As a result, sampling was conducted along the east bank of Waneta Eddy to assess the density of egg predators in the eddy. This site, designated as site 3, was approximately 215 m long. During sampling on 16 July, white sturgeon were not observed and four boat electrofishing surveys were conducted in the Waneta spawning area, with site 1 and site 2 sampled twice at HLH and LLH flows.

Sampling was conducted in a downstream direction using a Smith-Root 18E electrofishing boat with a three person crew (two netters and a boat operator). Fish captured in each site were kept in an aerated live well and were processed on the west bank of the Columbia River once sampling of the site was complete. During sampling, netters also estimated and reported the numbers of each species observed that avoided capture relative to the location of each egg collection station (i.e., SM56C1 to SM56E1.5). Fish processing consisted of recording species, length (FL to the nearest mm), and weight (to the nearest gm). Gastric lavage with river water was used to evacuate the stomach contents of captured salmonids that were released unharmed; non-sportfish species (e.g., sucker, northern pikeminnow, etc.) were killed and the stomach and gastrointestinal (GI) tract preserved in 10% formalin for subsequent examination in the lab. During sampling on 8 July, time delays required the preservation of the entire fish (by freezing) to reduce processing time. During sampling on 16 July, refinement of the dissection technique and elimination of measured weights improved overall processing efficiency. Prior to analysis of the preserved stomach samples, all samples were first transferred from 10% formalin to 10% Carosafe solution. The samples were inspected with a dissection scope to determine the dominant food items and to identify the presence and numbers of white sturgeon eggs and larvae.

3.0 RESULTS

3.1 BACKGROUND PHYSICAL CONDITIONS

3.1.1 Pend d'Oreille River

The Pend d'Oreille River originates from Lake Pend d'Oreille in northern Idaho, which receives the combined flows of the Clark Fork and Flathead rivers, which in turn receive drainage from watersheds in northern Montana. From Pend d'Oreille Lake, the Pend d'Oreille River flows northwest through Idaho and Washington for approximately 156 km until it crosses the Canada-US border near Nelway, B.C. North of the border, the Pend d'Oreille River then turns west and flows through the southern part of British Columbia near the U.S. border for approximately 15 km and eventually joins the Columbia River near Waneta, B.C. The Pend d'Oreille River has a total drainage area of about 66,600 km^2, with 65,300 km^2 located in the United States. [17]

The hydroelectric facilities on Pend d'Oreille River in Canada and the United States are operated as run-of-the-river facilities and are characterized by small reservoirs with limited storage capacity and rapid volume turnover. The annual spring freshet discharge pattern of the Pend d'Oreille River is produced by runoff from snowmelt events. With the increase in discharge during the spring freshet, water released from an upstream dam cannot be retained by the dams immediately downstream and must be released through either power generation or spill. Consequently, although the Pend d'Oreille is a regulated river for the majority of the year, the discharge regime of Pend d'Oreille River at Waneta during high flow periods exhibits a relatively natural freshet pattern in terms of timing, although the magnitude of peak flows are likely lower compared to historical levels. Freshet discharge from the Pend d'Oreille River typically reaches a maximum between mid-May and mid-June, during which time flows in excess of the current Waneta Dam plant generation capacity (868 m^3/s) are released via spillways.

In warm years with low precipitation, water temperatures in the Pend d'Oreille River can approach 24ºC. These high water temperatures likely are due in part to surface heating of Lake Pend d'Oreille and drainage from low elevation watersheds. In addition, the impoundments formed by the dams on the lower Pend d'Oreille River have reduced flow and increased surface area, which likely has resulted in additional surface heating. Consequently, the maximum summer temperature of the Pend d'Oreille River typically is 3ºC to 4ºC warmer and on occasion up to 6ºC warmer than the Columbia River.

3.1.2 Columbia River

Upstream of the Pend d'Oreille-Columbia confluence, the Columbia River has a drainage area of 88,100 km^2. The hydraulic characteristics of the Columbia River are dependent on discharge from Kootenay Lake and Arrow Lakes Reservoir. Discharge from Kootenay Lake flows into the Kootenay River and joins the Columbia River approximately 45 km upstream of the Waneta area. Due to the small reservoir capacity of the dams on the lower Kootenay River, discharge from this system is similar to the Pend d'Oreille River in that peak flows typically occur in early spring and decline rapidly by early August. The Columbia River discharge is regulated by Hugh L. Keenleyside Dam (HLK) and the Arrow Lakes Generating Station (ALGS), located approximately 56 km upstream of the Waneta area. The impoundment created by HLK formed the Arrow Lakes Reservoir out of what was originally the Upper and Lower Arrow lakes. During the spring freshet, Arrow Lakes Reservoir stores up to 7.1 million acre-feet of water for later release downstream after flows from the Kootenay and Pend d'Oreille rivers decline in late July. Consequently, the Columbia River downstream of HLK does not exhibit a natural spring freshet pattern and water levels below HLK during the summer remain higher for a longer period of time than they otherwise would if the Columbia River was unregulated. Due to the depth and size of both Arrow Reservoir and Kootenay Lake, Columbia River summer maximum water temperature typically does not exceed 20ºC in most years.

3.1.3 Waneta Area

Previous studies have been conducted to describe the physical conditions of the white sturgeon spawning habitat located at the confluence of Columbia and Pend d'Oreille rivers [18, 19,20,21]. The two main physical features of the confluence area are Waneta Eddy and the Waneta Dam tailrace area. Both of these features provide important habitat for white sturgeon during the spawning season.

Waneta Eddy is a large eddy on the east bank of the Columbia River formed by the hydraulic interaction of the Columbia and Pend d'Oreille rivers and by the presence of a large cobble bar, located on the north edge of the eddy, that extends from the shore into the center of the channel. For adult white sturgeon, Waneta Eddy represents an important holding and staging area during the spawning season. Based on velocity and depth data obtained with an Acoustic Doppler Current Profiler (ADCP), a 3-dimensional numerical model of the eddy was developed by ASL Environmental Sciences Inc.[18]. From this model, it was determined that the Waneta Eddy is composed of two smaller hydraulic circulations known as gyral features or gyres. In the northern section of the eddy, a counter-clockwise gyre that forms is related to the Columbia River flows. To the south, a clockwise gyre that forms is related to the Pend d'Oreille River discharge.

The size and strength of these two gyres are determined by the relative discharges of the Columbia and Pend d'Oreille rivers; under most combinations of river discharges, both gyres are present. During the white sturgeon spawning when Pend d'Oreille flows are high, the Columbia gyre component of the eddy is dominant and the majority of the eddy circulates counter-clockwise direction. At lower Pend d'Oreille River flow conditions later in the spawning season and, during the periods of load shaping at Waneta Dam (i.e., when Pend d'Oreille River flow is reduced to 142 m^3/s during overnight light load hours) the Pend d'Oreille gyre component of the eddy is dominant and the majority of the eddy circulates in a clockwise direction [18].

During the freshet period, habitat conditions in the confluence area downstream from the highway bridge are dominated by the powerful hydraulic jet of the Waneta Dam tailrace. During moderate to high flow conditions, water flowing over the irregular bedrock features located near the highway bridge produces a train of large standing waves that extends into the Columbia River. This jet plume represents the main white sturgeon spawning and egg deposition/incubation area. The actual location of spawning (i.e., point of egg release) is unknown but suspected to occur in area located 50 m to 150 m downstream of the highway bridge, with the actual location likely dependent on discharge of the Pend d'Oreille River (L. Hildebrand, Golder Associates, Castlegar, pers. comm., 2004). Based on past observations, a series of small eddies located along the south bank and parallel to the jet, are also likely used by white sturgeon, possibly as temporary holding and staging areas during spawning [7]. During periods of reduced flows at Waneta Dam, water temperatures in the spawning and egg deposition zone can decrease by up to 4ºC due to the influx of cooler Columbia River water into the egg deposition/incubation area.

3.2 PHYSICAL PARAMETERS

3.2.1 Pend d'Oreille and Columbia River Discharge

From 1 January to 20 November 2005, the mean daily discharge of the Pend d'Oreille River ranged between 20 m^3/s on 18 September and 2346 m^3/s on 10 June (Figure 3.1). Daily average discharge during the 2005 white sturgeon spawning period (1 June to 29 July) averaged 1031 m^3/s and ranged between 331 m^3/s on 22 July and 2346 m^3/s on 10 June. Hourly average discharge data from Waneta Dam over the spawning period ranged between 191 m^3/s on 26 July (at 0500 hrs) and 2424 m^3/s on 10 June (at 0800 hrs). The peak average daily discharge from Waneta Dam over the spawning period was 2032 m^3/s on 10 June. The discrepancy between peak daily average discharge data reported for 10 June at Seven Mile Dam (2346 m^3/s) and Waneta Dam (2032 m^3/s) was likely due to difficulties in calculating spill discharge at Waneta Dam. For the purpose of this report, records from Waneta Dam were used for all hourly discharge data and Seven Mile Dam records were used for daily average discharge data.

Between 1 January and 10 November, the minimum and maximum daily average discharges of the Columbia River at the Birchbank Gauge Station were 1089 m^3/s on 15 April and 3279 m^3/s on 11 July, respectively. During the white sturgeon spawning period, daily average Columbia River discharge averaged 2921 m^3/s and ranged between 2399 m^3/s on 1 June and 3279 m^3/s on 11 July (Figure 3.1).

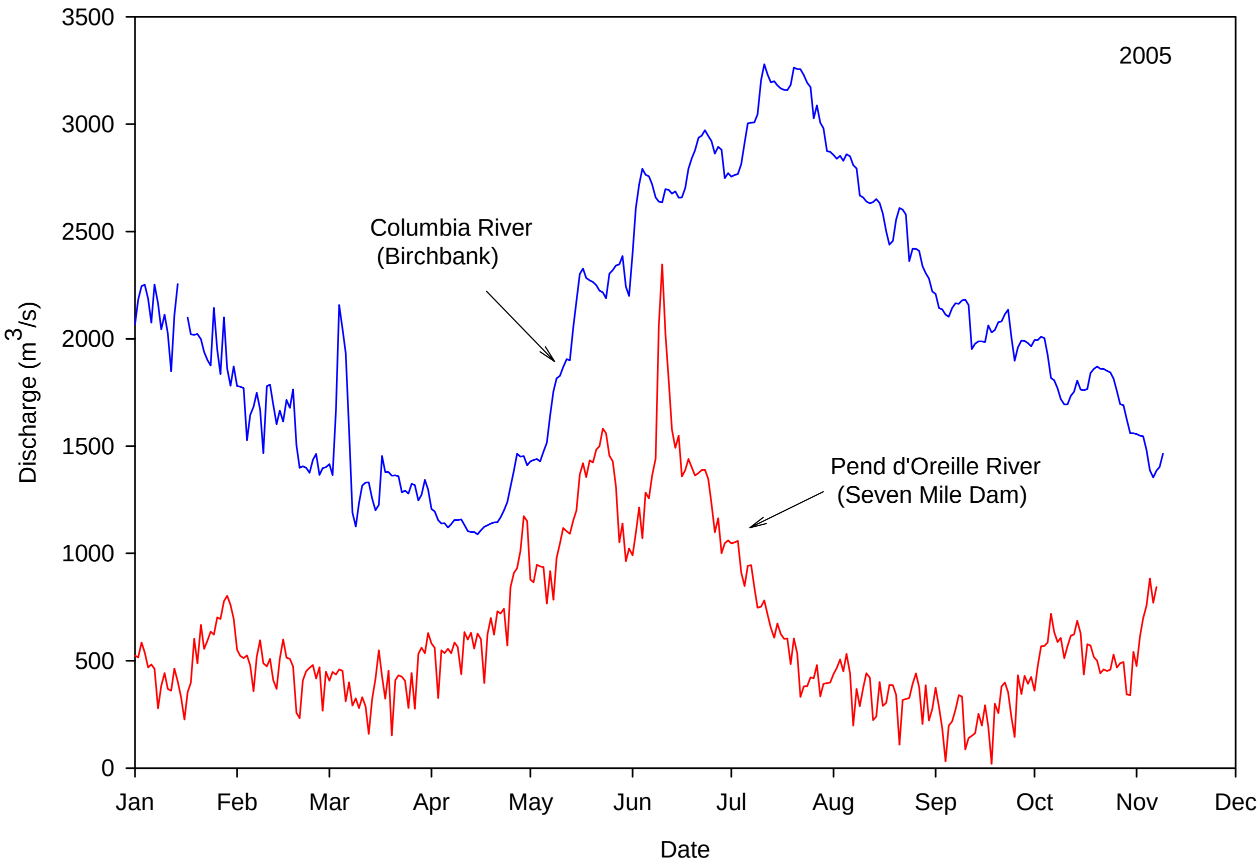


Figure 3.1 Mean daily discharge of the Pend d'Oreille River at Seven Mile Dam and of the Columbia River at Birchbank, 1 January to 20 November 2005.

3.2.2 Pend d'Oreille River and Columbia River Temperatures

Hourly water temperatures in the Pend d'Oreille River, as measured in the Waneta Dam forebay between 1 January and 22 November, ranged between 0ºC on several days in mid-January and 23.4ºC on 21 August (Figure 3.2). Over the spawning survey period the hourly water temperature of the Pend d'Oreille River averaged 17.4ºC and ranged between 14.0ºC during several days in mid-June and 22.4ºC on 28 July.

Columbia River water temperatures between 5 January and 22 November, as measured at the Teck Cominco Water Station, ranged between 2.2ºC on 24 February and 19.5°C on 9, 10 and 12 August (Figure 3.2). During the spawning survey period, Columbia River water temperature averaged 14.3ºC, and ranged between 10.9ºC on 7 June and 18.0ºC on 26 July. Additional temperature data was also obtained from temperature loggers attached to the incubation array located near station SM56E1. Temperatures at this location during periods of high Pend d'Oreille discharge closely approximated Pend d'Oreille River water temperature. With the decline in Pend d'Oreille discharge levels by mid-July and a corresponding increase in Columbia River discharge (Figure 3.1), a greater amount of mixing occurred between the two flows and water temperature at the array location represented a mixture of both Columbia River and Pend d'Oreille River water. Rapid daily decreases in water temperature at the array station corresponds to the onset of daily load shaping operations at Waneta Dam when flows were reduced during light load hours to the WSFAP minimum flow of 142 m^3/s (Figure 3.2).

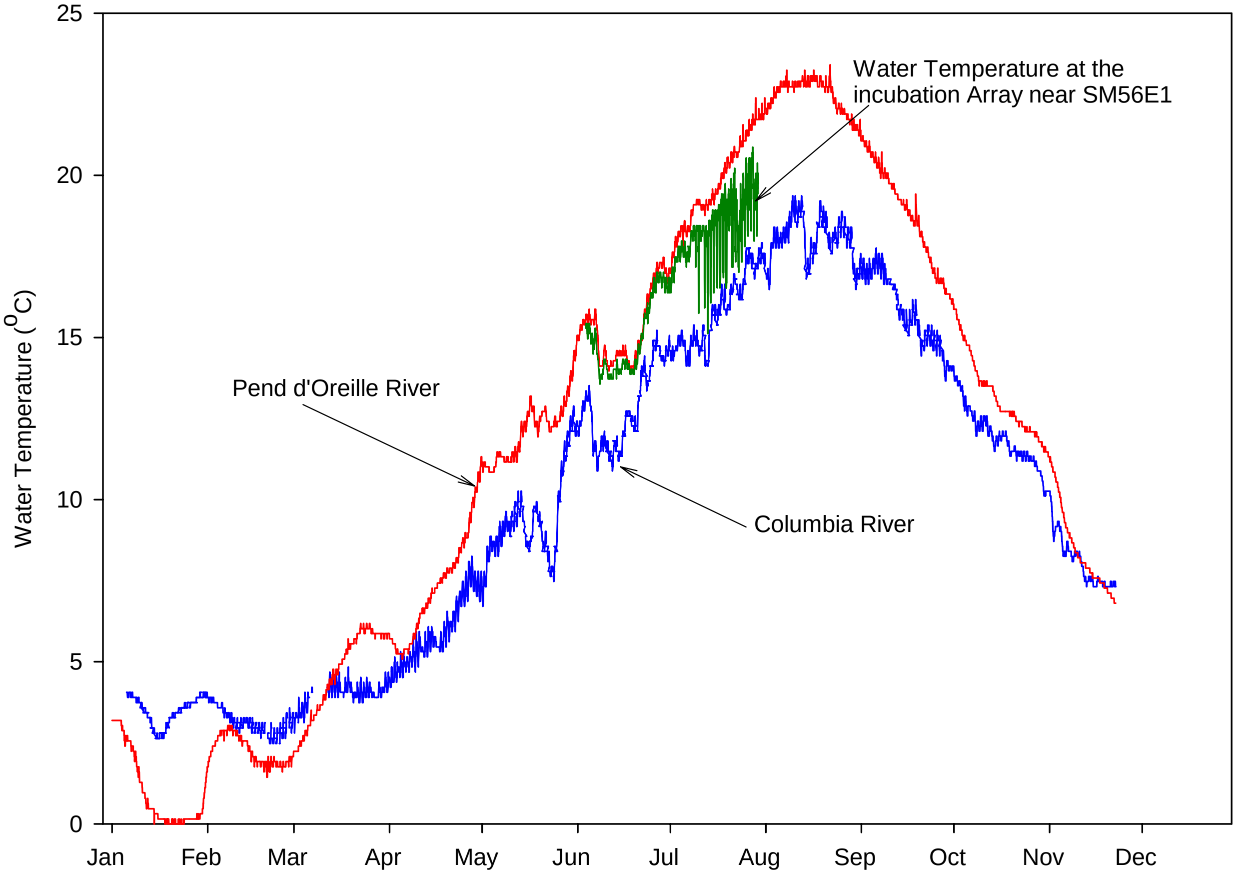


Figure 3.2 Hourly average water temperature recorded for the Pend d'Oreille River in the forebay of Waneta Dam and for the Columbia River at the Teck Cominco Water Station, 1 January to 22 November 2005. Hourly water temperature at the incubation array, located near station SM56E1, was monitored from 3 June to 29 July 2005

3.3 WHITE STURGEON SPAWNING ASSESSMENT

3.3.1 Egg and Larvae Collections

Over the 1 June to 29 July survey period, 4815 white sturgeon eggs and 5 white sturgeon larvae were captured using eight sets of paired egg collection mats (total combined sampling effort of over 21,200 mat-hours; Appendix A, Table A1). White sturgeon eggs were first captured on 23 June at station SM56C4. The last day that live eggs were captured was 19 July. The largest catch recovered from a single set was 905 eggs on 2 July at SM56C4; this catch represented 19% of the total egg catch for the entire study. The next largest single set capture was 579 eggs on 24 June, also at SM56C4.

In terms of the total combined catch from individual stations, the greatest proportion (51%) of eggs was captured at set location SM56C4 (n=2459 eggs). The remaining eggs were captured at SM56D (*n*=1079 eggs), SM56D1 (*n*=436 eggs), SM56M1 (*n*=365 eggs), SM56E1 (*n*=255 eggs), SM56E1.5 (*n*=154), SM56C1 (*n*=35 eggs), and SM56C3 (*n*=32 eggs). The highest one-day catch-rate (CPUE) recorded during the study was 321 eggs/24 mat-hours at station SM56C4. Over the entire study, station SM56C4 also had the highest overall average CPUE (21.3 eggs/24 mat-hours over a deployment duration of 2770 mat-hours; Appendix A, Table A2).

3.2.2 Egg Developmental Stage and Spawning Events

An estimated minimum of twelve discrete spawning events occurred during the 2005 study period (Figure 3.3). This was based on the distribution of captured eggs an examination of egg developmental stages and data on average hourly water temperature recorded at the incubation array prior to the capture event.

In total, 525 eggs were recovered on 23 June from stations SM56C4 (*n*=284 eggs), SM56D (*n*=137 eggs), SM56D1 (*n*=65 eggs), SM56M1 (*n*=8 eggs), and SM56E1.5 (*n*=3 eggs) combined. The development stage of the eggs collected ranged between post-fertilization and late cleavage. Average hourly water temperatures in the egg deposition area (based on temperatures at the incubation array) between 23 June and the previous inspection of the mats on 21 June was 15.4ºC. Average hourly discharge from the Pend d'Oreille River over the same time period was 1328 m^3/s. Based on available data on white sturgeon egg development rates, two spawning events were identified. The first spawning event was based on late cleavage eggs which were estimated to have been collected at 19 hours post-fertilization. The second spawning event was based on eggs estimated to be less that 1 hour post-fertilization. Back calculating from the time of capture, these spawning events likely occurred on 22 June at approximately 1800 hrs and 23 June at 1300 hrs.

On 24 June, 1219 eggs were recovered from stations SM56C4 (*n*=579 eggs), SM56M1 (*n*=243 eggs), SM56D (*n*=204 eggs), SM56E1 (*n*=86 eggs), SM56D1 (*n*=58 eggs), and SM56E1.5 (*n*=49 eggs) combined. Between 23 and 24 June, the average hourly water temperature in the egg deposition area was 15.9°C and average Pend d'Oreille River discharge was 1341 m^3/s. Developmental stages of the eggs recovered ranged between post-fertilization and early neurulation. Based on the water temperature, the age of the post-fertilized eggs was estimated at less than 1 hour old and the spawning event associated with these eggs likely occurred on 24 June at approximately 1200 hrs. All older white sturgeon eggs recovered were considered to be from previous spawning events.

A total of 559 eggs were recovered on 27 June from stations SM56C4 (*n*=380 eggs), SM56D (*n*=91 eggs), SM56E1 (*n*=32 eggs), SM56D1 (*n*=26 eggs), SM56E1.5 (*n*=18 eggs), SM56M1 (*n*=9 eggs), SM56C1 (*n*=2 eggs), and SM56C3 (*n*=1 egg) combined. The development stages of the eggs collected ranged between post-fertilization and heart formation. Between 24 June and 27 June, average hourly water temperature in the egg deposition area was 16.6ºC. Average hourly discharge from the Pend d'Oreille River over the same time period was 1145 m^3/s. Two spawning events were identified. The first vent was based on early yolk plug eggs estimated to be approximately 30 hours old. The second event was based on post-fertilized eggs estimated to be less that 1 hour old. Back calculating from the time of capture, these spawning events likely occurred on 26 June at approximately 0400 hrs and 27 June at 1300 hrs.

On 29 June, 176 eggs were recovered from stations SM56C4 (*n*=61 eggs), SM56D (*n*=52 eggs), SM56M1 (*n*=20 eggs), SM56D1 (*n*=18 eggs), SM56E1 (*n*=11 eggs), SM56C3 (*n*=7 eggs), SM56E1.5 (*n*=5 eggs), and SM56C1 (*n*=2 eggs) combined. Between 27 and 29 June, the average hourly water temperature in the egg deposition area was 16.8°C and average Pend d'Oreille River discharge was 1029 m^3/s. The developmental stage of the eggs recovered ranged between early cleavage and the heart formation. The spawning event was based on late epithelial eggs that were estimated to be 20 hours old. The spawning event associated with these eggs likely occurred on 28 June at approximately 1700 hrs. All older stage eggs recovered on this date were considered to be from previous spawning events. Eggs at early developmental stages were assumed to be from the same event, but were developing at a slower rate.

On 2 July, 1616 eggs were captured from station SM56C4. (*n*=905 eggs), SM56D (*n*=317 eggs), SM56D1 (*n*=224 eggs), SM56E1 (*n*=55 eggs), SM56E1.5 (*n*=49 eggs), SM56M1 (*n*=33 eggs), SM56C3 (*n*=17 eggs), and SM56C1 (*n*=16 eggs) combined. Between 29 June and 2 July, the average hourly water temperature in the egg deposition area was 16.8°C and average Pend d'Oreille River discharge was 1046 m^3/s. The developmental stages of the eggs recovered ranged between late cleavage and the heart formation although most eggs were between early yolk plug and late neurulation stages. Due to this clumped distribution, definitive identification of multiple spawning events was not possible and only a single event was identified based on the late neurulation eggs. These eggs were estimated to be 36 hours old, which indicated spawning likely occurred on 1 July at approximately 0100 hrs. Eggs at early developmental stages were assumed to be from the 1 July event that developed at a slower rate.

On 7 July, 388 eggs were recovered from stations SM56C4 (*n*=198 eggs), SM56D (*n*=100 eggs), SM56M1 (*n*=46 eggs), SM56D1 (*n*=14 eggs), SM56E1 (*n*=10 eggs), SM56C1 (*n*=10 eggs), SM56E1.5 (*n*=5 eggs) and SM56C3 (*n*=5 eggs) combined. Between 7 July and the previous inspection of the mats on 6 July, the average hourly water temperature in the egg deposition area was 17.7°C and average Pend d'Oreille River discharge was 911 m^3/s. The developmental stages of the eggs recovered ranged between post-fertilization and the early neurulation. Two spawning events were identified. The first event was based on a single early neurulation egg estimated to be 29 hours old. The second event was based on post-fertilized eggs estimated to be less that 1 hour old. Back calculating from the time of capture, these spawning events likely occurred on 6 July at approximately 1100 hrs and 7 July at 1500 hrs.

On 13 July, 5 eggs were recovered from stations SM56E1 (*n*=3 eggs), SM56D (*n*=1 egg), and SM56E1.5 (*n*=1 egg) combined. Between 11 and 13 July, the average hourly water temperature in the egg deposition area was 17.8°C and average Pend d'Oreille River discharge was 669 m^3/s. Three of the eggs were early cleavage, late cleavage, and pre-hatch. The spawning event was based on the one late cleavage egg estimated to be 11 hours old. The spawning event associated with this egg likely occurred on 13 July at approximately 0300 hrs. All older white sturgeon eggs recovered were considered to be from previous spawning events. Eggs at early developmental stages were assumed to be from the 13 July event that developed at a slower rate.

On 15 July, 53 eggs were recovered from stations SM56D (*n*=44 eggs), SM56E1 (*n*=3 eggs), SM56E1.5 (*n*=3 eggs), SM56D1 (*n*=2 eggs), and SM56M1 (*n*=1 egg) combined. Between 13 and 15 July, the average hourly water temperature in the egg deposition area was 18.1°C and average Pend d'Oreille River discharge was 630 m^3/s. The developmental stage of the eggs ranged between early cleavage and early gastrulation. The spawning event was based on early gastrulation eggs estimated to be 19 hours old. The spawning event likely occurred on 14 July at approximately 1700 hrs. Eggs at early developmental stages were assumed to be from the 14 July event, but were developing at a slower rate.

The last spawning event in 2005 was detected on 19 July when a total of 141 eggs were recovered from stations SM56D (*n*=106 eggs), SM56D1 (*n*=12 eggs), SM56E1.5 (*n*=8 eggs), SM56E1 (*n*=6 eggs), SM56C1 (*n*=5 eggs), and SM56M1 (*n*=4 eggs) combined. Between 15 and 19 July, the average hourly water temperature in the egg deposition area was 18.3°C and average Pend d'Oreille River discharge was 587 m^3/s. The developmental stages of the eggs recovered were either at heart formation or the pre-hatch stage. The spawning event was based on pre-hatch eggs that were estimated to be 87 hours old. The spawning event associated with these eggs likely occurred on 15 July at approximately 2200 hrs. Eggs at early developmental stages were assumed to be from the 15 July event, but were developing at a slower rate.

3.4 *IN SITU* EGG INCUBATION EXPERIMENT

In 2005, over 1400 eggs were incubated *in situ* in incubation trays (ITs). Of the eggs incubated, a large proportion of the eggs (approximately 50%) were in early developmental stages that ranged late cleavage to late epithelial. The remainder of the eggs were in middle developmental stages between early gastrulation and late yolk plug. Developmental stages that were "late yolk plug" and older only made up 21% of the eggs sampled. Average hourly water temperature during the incubation study ranged between 16.6 C and 18.5ºC. Even though the deployment method kept the incubators off the river bottom, some sediment accumulation within the ITs was observed during the study. Turbidity levels in the Pend d'Oreille River, as measured in the eddy upstream of SM56C1, averaged 1.02 NTU over the study and ranged between at maximum of 3.00 NTU on 10 June and a minimum of 0.52 NTU on 27 July. Secchi depth readings tracked with changes in the turbidity readings.

Hatch success rates of the eggs in the ITs ranged from 38.0% to 74.0% with an overall hatch success of 61.8% among all ITs (Table 3.1). Of the eggs that successfully hatched, larval survival ranged from 84.6% to 97.8% and averaged 94.7% among all ITs. The low hatch success (38.0%) in incubation group 4 (IG4) appeared to be due to sediment accumulation in the ITs.

Table 3.1 Hatch and survival data for white sturgeon eggs in incubation trays (ITs) within each incubation group (IG) in the Pend d'Oreille River downstream of Waneta Dam, June to July 2005. Temperatures are based on hourly water temperature data from temperature loggers located at the incubation site.

Incubation Group No. (Number of trays)	No. Eggs	Incubation Period	Predominant Egg Developmental Stage[a]	Average Water Temp. (°C)	Contents of Incubators at Pull				Hatch Success[b] (%)	Larval Survival[b] (%)
					Larvae		Eggs			
					Live	Dead	Live	Dead[c]		
IG1 (6)	300	23 Jun to 2 Jul	Late cleavage	16.6	176	8	0	116	61.3	95.6
IG2 (6)	300	24 Jun to 2 Jul	Late epithelial	16.7	170	5	0	125	58.3	96.6
IG3 (6)	300	27 Jun to 2 Jul	Late cleavage/Early yolk plug	16.8	204	14	0	82	72.7	93.4
IG4 (2)	100	29 Jun to 6 Jul	Early yolk plug	17.2	34	4	0	62	38.0	91.3
IG5 (6)	300	2 Jul to 6 Jul	Late yolk plug	17.6	168	4	0	128	57.3	97.8
IG6 (2)	100	7 Jul to 13 Jul	Late epithelial	18.0	66	8	0	26	74.0	88.7
IG7 (1)	36	15 Jul to 23 Jul	Early gastrulation	18.5	22	4	0	10	72.2	84.6
Total	1436				840	47	0	549	61.8	94.7

[a] Developmental stage of the majority of eggs at the start of the incubation periods. Developmental stage category from Beer (1981).
[b] Hatch success=the number of larvae (living plus dead) divided by the number of total eggs minus live eggs x 100. Larval survival=the number of live larvae divided by the total number of larvae (live plus dead) x 100.
[c] Includes both unfertilized and fungus infected eggs.

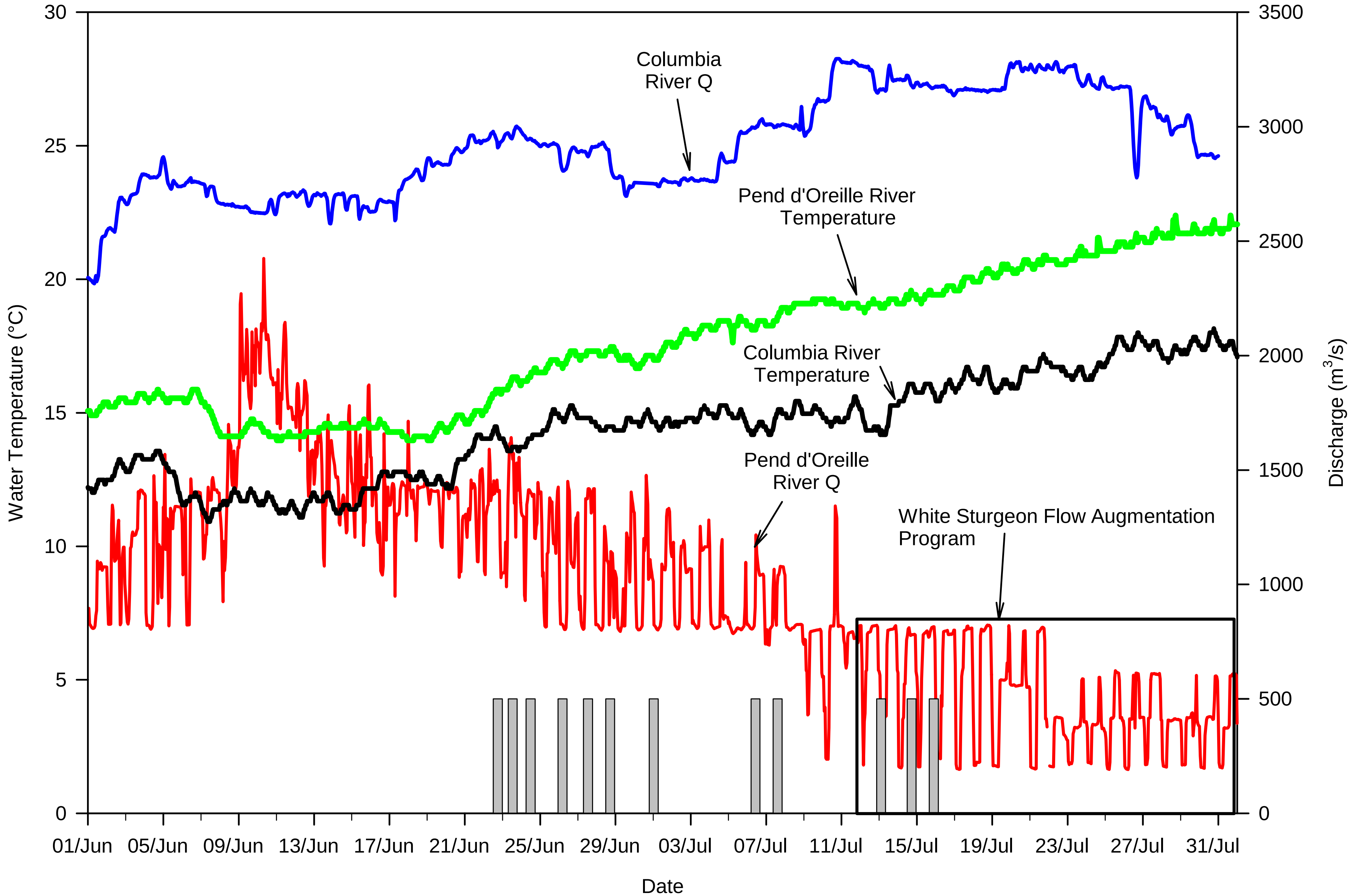


Figure 3.3 Hourly average water temperature and discharge (Q) of the Columbia River (measured at Birchbank) and Pend d'Oreille rivers (measured at Waneta Dam) over the duration of the white sturgeon spawning period from early June to late July 2005. Vertical bars denote discrete spawning events.

3.5 EGG PREDATOR ASSESSMENT

Boat electrofishing was conducted in the Waneta spawning area on 8 and 16 July 2005 to assess the species composition and relative density of potential white sturgeon egg predators in the main area of egg deposition area along the south bank that parallels the main discharge plume of the Pend d'Oreille River. Sampling was conducted on these dates based on the collection of eggs which indicated white sturgeon spawning had occurred on 7 and 15 July. Discharge from Waneta Dam during this period also was representative of WSFAP flows.

Three sites were sampled during Session 1 on 8 July (Figure 1.1; Table 3.2). Discharge from Waneta Dam during this session was between 750 m^3/s and 758 m^3/s, which was slightly higher than the 708 m^3/s discharge required under the WSFAP during this period (Table 3.3). Flows in the Columbia River remained between 3000 and 3050 m^3/s during this session. In estimating Columbia River discharge, a 3 hour lag time was assumed for water to travel from Birchbank to the International border. Water temperature of the Columbia and Pend d'Oreille River was constant during all sampling sessions at 15.0ºC and 19.1ºC, respectively. Temperature within the Waneta spawning area, as measured at the incubation array located near SM56E1, ranged from 18.1ºC to 18.3ºC. In site 1, 640 seconds of electrofishing effort were applied during one downstream pass. In site 2, an adult white sturgeon was rolled near SM56E1 after only 98 seconds of electrofishing effort. Under the terms of the fish collection permit, this event required the immediately termination of electrofishing in the main spawning area. As an alternative, a third site (site 3) located along the east bank of Waneta Eddy was sampled to assess the density of potential egg predators holding within nearshore areas of the eddy. Sampling effort in site 3 consisted of single pass and a total electrofishing time of 597 seconds. Poor weather and visibility reduced overall sampling efficiency and increased time required to travel between sites.

Table 3.2 Boat electrofishing sampling effort by session during the egg predator studies on 8 and 16 July 2005.

Session No. (Date)	Site	Electrofishing Effort (s)	Start Time	End Time
1 (8 July)	1	640	22:45	22:55
	2	98	1:45	1:46
	3	597	2:16	2:25
2 (16 July)	1	577	22:30	22:39
	2	337	0:55	1:00
3 (16 July)	1	580	2:41	2:46
	2	881	3:00	3:14

Sampling sessions 2 and 3 were conducted during the 16 July survey (Table 3.2); Site 1 and site 2 were sampled at HLH and LLH flows that approximated the 708 m^3/s day time (HLH) and the 142 m^3/s night time (LLH) minimum flows required under the WSFAP (Table 3.3). Columbia River discharge remained relatively constant during all sampling sessions at approximately 3140 m^3/s. Water temperature of the Columbia and Pend d'Oreille River were constant during all sampling sessions at 15.9ºC and 19.6ºC, respectively. During session 2 (HLH flows) water temperatures within the spawning area ranged between 19.1ºC and 18.8ºC. During session 3 (LLH flows) water temperatures within the spawning area were reduced to 16.5ºC (Table 3.3). Sampling effort in site 1 consisted of 577 seconds during session 2 and 580 seconds during session 3. Sampling effort in site 2 consisted of 337 seconds during session 2 and 881 seconds during session 3. The increase in sampling effort during session 3 in site 2 was due to reduced water velocity during LLH flows.

Table 3.3 Hourly discharge and temperature of the Columbia and Pend d'Oreille rivers, and water temperature at the incubation array near station SM56E1 during the egg predator study on 8 an 16 July 2005.

Session (Date)	Site	Columbia River Discharge (m^3/s)	Pend d'Oreille River Discharge (m^3/s)	Pend d'Oreille River Temp (ºC)	Array Temp (ºC)	Columbia River Temp (ºC)
1 (8 July)	1	3041	750.	19.1	18.1	15.0
	2	3002	758	19.1	18.3	15.0
	3	3002	758	19.1	18.3	15.0
2 (16 July)	1	3150	800	19.7	19.1	15.9
	2	3138	646	19.6	18.8	15.9
3 (16 July)	1	3138	196	19.6	16.5	15.9
	2	3138	196	19.6	16.5	15.9

3.5.1 Egg Predator Survey Results: Session 1 (8 July 2005)

In total, 81 fish were captured from all sites during session 1 (Table 3.4). The species captured and the percent composition of each species of the total catch consisted of largescale sucker (*Catostomus macrocheilus*; 39.5%), walleye (*Stizostedion vitreum*; 19.8%), prickly sculpin (*Cottus asper*; 9.9%), northern pikeminnow (*Ptychocheilus oregonensis*; 6.2%), rainbow trout (*Oncorhynchus mykiss*; 6.2%), and smallmouth bass (*Micropterus dolomieui*; 6.2%). Other species present in lower numbers (i.e., 1-2% of the total catch) were bridgelip sucker (*Catostomus columbianus*), burbot (*Lota lota*), torrent sculpin (*Cottus rhotheus*), kokanee (*Oncorhynchus nerka*), longnose sucker (*Catostomus catostomus*), lake whitefish (*Coregonus clupeaformis*), and redside shiner (*Richardsonius balteatus*).

At site 1, fish captured and observed consisted of sucker spp (*n*=71), walleye (*n*=11), northern pikeminnow (*n*=5), smallmouth bass (*n*=4), mountain whitefish (*n*=4), and rainbow trout (*n*=2). One burbot and one lake whitefish were also captured. The majority of fish were captured/observed between stations SM56C3 and SM56C4.

At site 2, the catch consisted of sucker spp (*n*=64), followed by sculpin spp (*n*=10), walleye (*n*=8), and rainbow trout (*n*=8), mountain whitefish (*n*=1), and northern pikeminnow (n=1). The majority of fish were captured/observed between stations SM56D and SM56D1. One white sturgeon was also observed near station SM56E1.

Within site 3 (Waneta Eddy), the catch consisted of sculpin spp (*n*=59), walleye (*n*=11), sucker spp (*n*=7), northern pikeminnow (*n*=2), rainbow trout (*n*=3), and kokanee (*n*=1), mountain whitefish (*n*=1), smallmouth bass (*n*=1), and redside shiner (*n*=1)

Table 3.4 Fish species composition recorded during Session 1 of the egg predator assessment at the Waneta white sturgeon spawning area, 8 July 2005.

Species	Session 1								
	Site 1			Site 2			Site 3		
	No. Captured	No. Observed	Total	No. Captured	No. Observed	Total	No. Captured	No. Observed	Total
Sucker spp.	30	41	71	4	60	64	3	4	7
Walleye	7	4	11	3	5	8	6	5	11
Smallmouth bass	4	0	4	0	0	0	1	0	1
Northern pikeminnow	3	2	5	0	1	1	2	0	2
Rainbow trout	2	0	2	2	6	8	1	2	3
Burbot	1	0	1	0	0	0	0	0	0
Lake whitefish	1	0	1	0	0	0	0	0	0
Mountain whitefish	0	4	4	0	1	1	0	1	1
Sculpin spp.	0	0	0	0	10	10	9	50	59
Kokanee	0	0	0	0	0	0	1	0	1
Redside shiner	0	0	0	0	0	0	1	0	1

To obtain a relative measure of fish density among the three sites, catch-per-unit-effort (CPUE: no. fish/km) was calculated for the most abundant fish species within each site based on combined catch and observed data. Due to the presence of the adult white sturgeon in site 2, only the upper portion of this site between SM56D and SM56E1 was sampled. Based on sampling of the entire length of site 2 during session 2 on 16 July (under similar flow conditions), the majority of fish in site 2 were recorded in the vicinity of these egg mat stations. Consequently, the fish capture results during the brief period of sampling of site 2 on 8 July were considered representative of fish distribution and density throughout the site. Therefore, to provide a between-session comparison of CPUE for site 2 the sampling effort and site length from session 2 was applied to the session 1 catch results in the calculation of CPUE.

At site 1, catch-rate of sucker spp. was 167 fish/km, followed by walleye at 26 fish/km and northern pikeminnow at 12 fish/km (Figure 3.4). At site 2, the catch rate of suckers was 188 fish/km, followed by sculpin spp. (29 fish/km) and walleye (24 fish/km). The substantially higher catch-rates of sucker spp. from site 2 were due to the large numbers of suckers that were observed by the netters. In site 3, the fish species assemblage differed from sites 1 and 2 due to lower water velocities and large angular riprap habitat throughout the site. Sculpin (CPUE=274 fish/km) were the most abundant species recorded followed by walleye (51 fish/km) and sucker spp. (33 fish/km). Similar to site 2 CPUE's results, large numbers of observed fish (in this case sculpin) contributed to the high CPUE's in site 3.

3.5.2 Egg Predator Survey Results: Sessions 2 and 3 (16 July 2005)

In total, 102 fish were captured over all sites during sessions 2 and 3 conducted on 16 July (Table 3.5). The species captured and their percent composition of the total catch consisted of largescale sucker (*Catostomus macrocheilus*; 28.4%), smallmouth bass (*Micropterus dolomieui*; 16.7%), prickly sculpin (*Cottus asper*; 13.7%), walleye (*Stizostedion vitreum*; 11.8%), rainbow trout (*Oncorhynchus mykiss*; 7.8%), northern pikeminnow (*Ptychocheilus oregonensis*; 6.9%), and bridgelip sucker (*Catostomus columbianus*; 5.9%). Other species present in lower numbers (i.e., 2% or less) were mottled sculpin (*Cottus bairdi*), torrent sculpin (*Cottus rhotheus*), peamouth (*Mylocheilus caurinus*) and longnose sucker (*Catostomus catostomus*).

During session 2 at site 1, sucker spp (*n*=43) were most abundant in the catch followed by mountain whitefish (*n*=11), sculpin spp (*n*=10), walleye (*n*=9), northern pikeminnow (*n*=6), smallmouth bass (*n*=5), rainbow trout (*n*=1), and peamouth (*n*=1). Fish in site 1 were relatively evenly distributed between stations SM56C1 and SM56C4.

The catch during session 2 at site 2 consisted of sucker spp (*n*=26), smallmouth bass (*n*=10), rainbow trout (*n*=6), sculpin spp (*n*=4), mountain whitefish (*n*=1), and walleye (*n*=1). The majority of fish were captured/observed between stations SM56D and SM56E1.

During session 3 at site 1, the catch consisted mainly of sculpin spp (*n*=132), followed by sucker spp (*n*=8), rainbow trout (*n*=4), walleye (*n*=3), peamouth (*n*=1), and northern pikeminnow (*n*=1). The majority of fish were captured or observed between stations SM56C3 and SM56C4.

The catch during session 3 at site 2 consisted of sculpin spp. (*n*=19), smallmouth bass (*n*=10), sucker spp. (*n*=9), walleye (*n*=3), northern pikeminnow (*n*=1), and rainbow trout (*n*=1). The majority of fish were captured/observed near station SM56D1.

Table 3.5 Fish species composition recorded during sessions 2 and 3 of the egg predator assessment at the Waneta white sturgeon spawning area, 16 July 2005.

Species	Session 2						Session 3					
	Site 1			Site 2			Site 1			Site 2		
	No. Captured	No. Observed	Total	No. Captured	No. Observed	Total	No. Captured	No. Observed	Total	No. Captured	No. Observed	Total
Sucker spp.	19	24	43	7	19	26	5	3	8	5	4	9
Walleye	5	4	9	1	0	1	3	0	3	3	0	3
Smallmouth bass	5	0	5	6	4	10	0	0	0	6	4	10
Northern pikeminnow	5	1	6	0	0	0	1	0	1	1	0	1
Rainbow trout	1	0	1	4	2	6	2	2	4	1	0	1
Peamouth	1	0	1	0	0	0	1	0	1	0	0	0
Mountain whitefish	0	11	11	0	1	1	0	0	0	0	0	0
Sculpin spp.	5	5	10	1	3	4	11	121	132	3	16	19

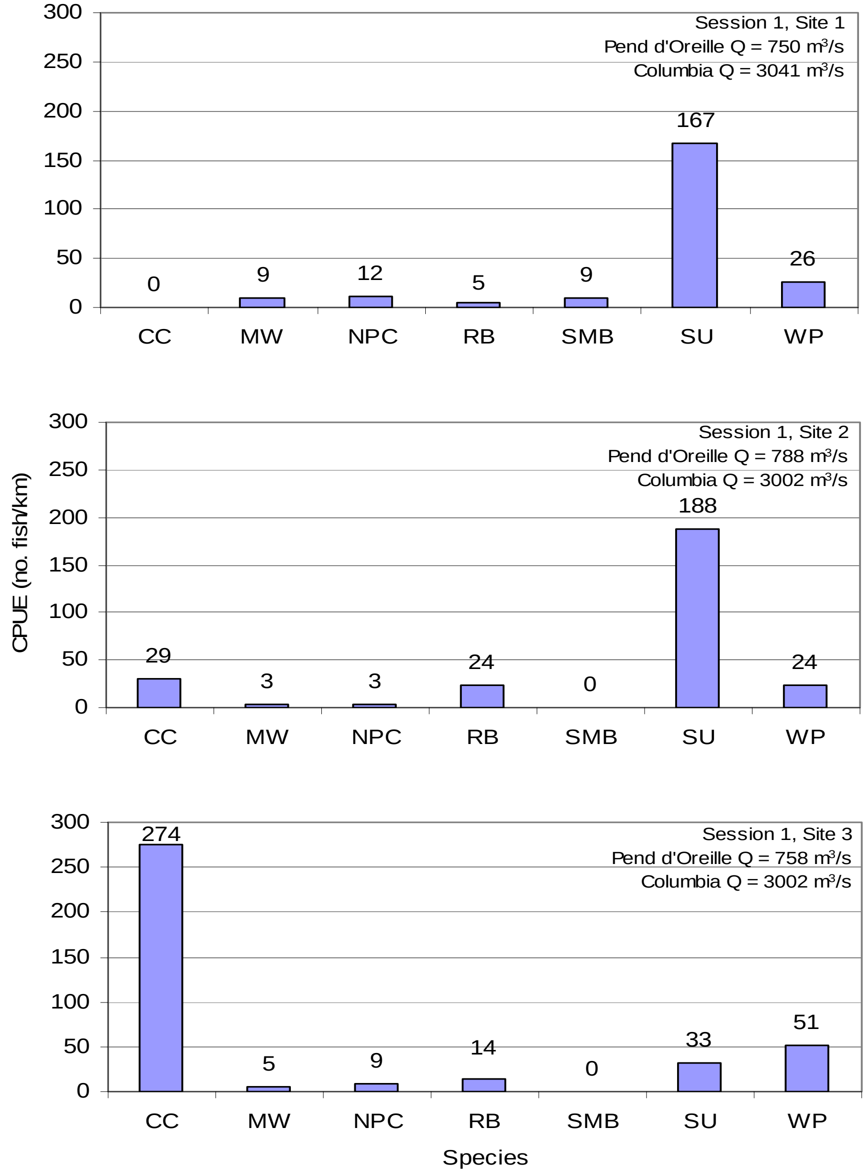


Figure 3.4 Sessional boat electrofishing catch rates (no. fish captured and observed/km) for sculpin spp. (CC), mountain whitefish (MW), northern pikeminnow (NPC), rainbow trout (RB), smallmouth bass (SMB), sucker spp. (SU), and walleye (WP) recorded in the Waneta white sturgeon spawning area, 8 July 2005

During session 2, sucker spp. numbers were the most abundant of any taxa at site 1 and site 2 (Figure 3.5). In site 1, sucker spp. abundance was 101 fish/km, followed by mountain whitefish (26 fish/km), sculpin spp. (24 fish/km), and walleye (21 fish/km). In site 2, the sucker spp. abundance was 76 fish/km, followed by smallmouth bass (29 fish/km), rainbow trout (18 fish/km) and sculpin spp. (12 fish/km).

Fish species composition and relative abundance in sites 1 and 2 changed noticeably between session 2 (conducted at the higher Waneta discharges) and session 3 (conducted at lower discharge; Figure 3.5). Combined observation and catch-rates of sculpin spp. were higher at both sites in session 3 compared to session 2, while the combined observation and catch-rates of other fish species were lower. The high numbers of sculpin at site 1 during session 3 was due to the large numbers of fish that were observed.

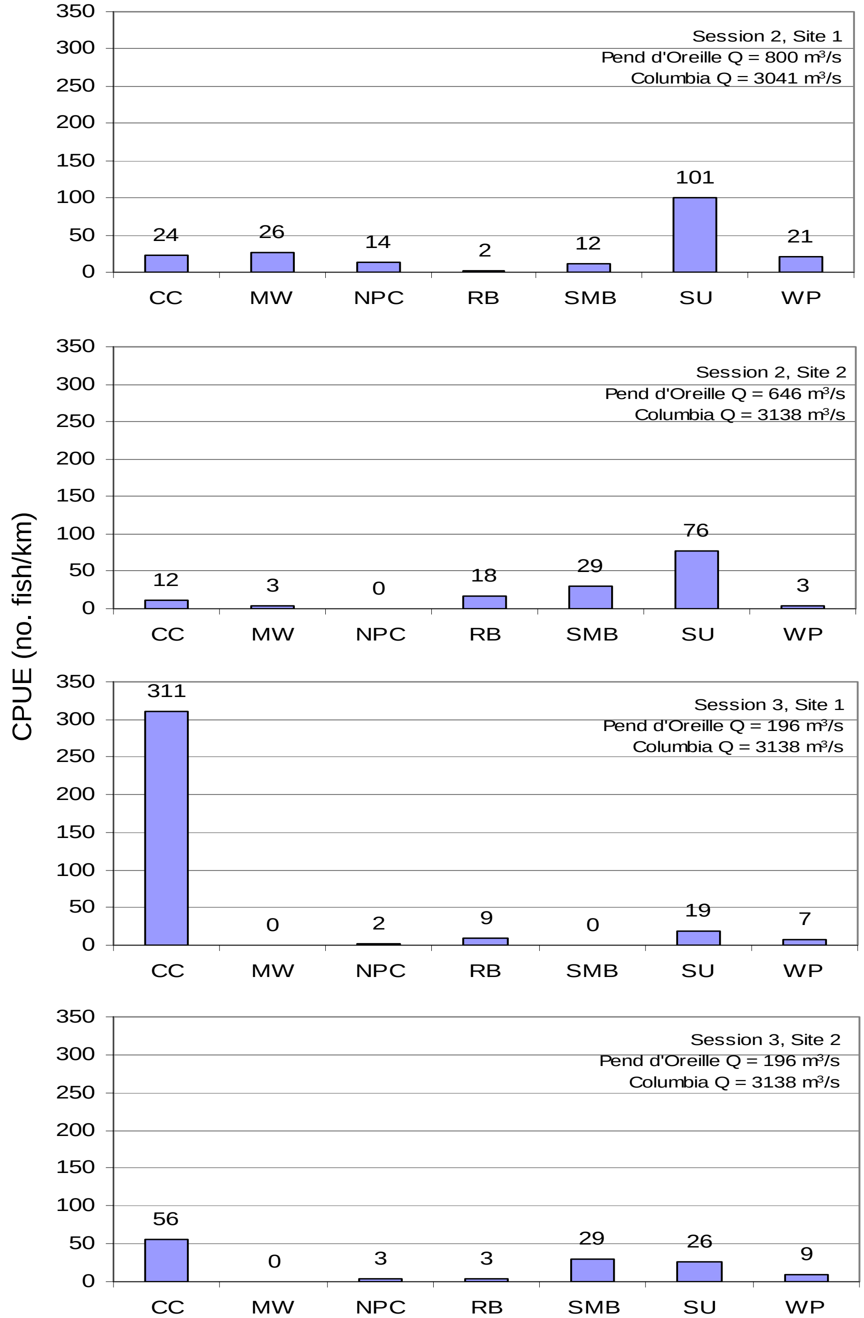


Figure 3.5 Sessional boat electrofishing catch rates (no. fish captured and observed/km) for sculpin spp. (CC), mountain whitefish (MW), northern pikeminnow (NPC), rainbow trout (RB), smallmouth bass (SMB), sucker spp. (SU), and walleye (WP) recorded in the Waneta white sturgeon spawning area, 16 July 2005.

3.5.3 Stomach Contents Analysis

The stomach contents of 165 fish sampled during the 8 and 16 July sessions were examined for white sturgeon eggs and larvae. Of this total, the stomach content of 27 fish, consisting primarily rainbow trout and smallmouth bass, were inspected in the field using gastric lavage. After the stomach contents were extracted, these fish were released alive. The remaining fish captured were sacrificed and the stomach contents obtained through either 1) removal and preservation of the foregut or 2) through preservation of the entire fish by freezing. The later method was used only during the 8 July session in order to reduce processing and handling time. During the 16 July sessions, better weather, exclusion of weight measurements, and refinement of the stomach extraction technique increased overall processing efficiency and allowed removal and preservation of the foreguts of all fish sacrificed.

Inspection of the contents within the preserved stomachs was conducted in the lab. In general, the stomach contents of non-piscivores consisted of a mixture of unidentifiable organic material, caddis, snails, and fine sediments. For walleye, predation on sculpin was evident due to the presence of fish bones and, in some instances, the presence of whole, identifiable fish.

Out of the 165 fish examined, identifiable white sturgeon eggs were found in only two largescale suckers captured on 8 July in site 1 during session 1. The stomach from the largest largescale sucker (580 mm FL and 2383 g) contained three white sturgeon eggs. The stomach contents of the second sucker (381 mm FL and 720 g) contained one white sturgeon egg.

4.0 DISCUSSION

4.1 DISCHARGE AND TEMPERATURE

Discharge levels of Pend d'Oreille River during the 2005 white sturgeon spawn monitoring period exhibited a typical freshet pattern. Compared to the 2004 hydrograph, the descending limb of the 2005 Pend d'Oreille hydrograph was steeper and total river discharge decreased more rapidly after the peak of the freshet. Overall, the pattern of Pend d'Oreille River discharge observed during the white sturgeon spawning period was very similar to the 2003 hydrograph in terms of average and maximum discharge levels recorded. In both 2003 and 2005, Pend d'Oreille River discharge increased gradually throughout early May, followed by a decrease in mid-May due to cool weather which delayed peak freshet flows until early June. The daily average Pend d'Oreille River temperature, as measured in the Waneta Dam forebay, exceeded the 18ºC upper limit for successful white sturgeon egg incubation on 3 July.

The fluctuations in water temperature recorded at the incubation array in July resulted from load shaping operations at power generation facilities upstream of Waneta Dam that reduce total discharge from Waneta Dam during periods of low power demand (e.g., typically from 0000 hrs to 0600 hrs). With the decline in mean daily Pend d'Oreille River discharge by mid-July, WSFAP flows were implemented on 12 July to provide minimum day (283 m^3/s) and night (142 m^3/s) flows until the end of the white sturgeon spawning season in late July. During periods of lowest night time flow from 12 to 31 July, minimum night time discharge levels were maintained near 200 m^3/s.

4.2 SPAWNING

The number of eggs captured (*n*=4815 eggs) and the number of spawning events identified (*n*=12) in the 2005 white sturgeon spawning study surpassed or equalled these results from all previous spawning studies (Table 4.1). Six of the 12 spawning events occurred in the last week of June; the remaining six events occurred by mid-July. Of the six events in July, the last three occurred under WSFAP flow conditions. Late July spawning events were not recorded in 2005.

Since 2001, a white sturgeon broodstock collection program has been conducted on the Columbia River as part of the conservation aquaculture component of the UCWSRI. The brood stock collection program conducted in 2005 removed eight pre-spawning female white sturgeon from the Columbia River. Under the assumption that the eight fish sent to the hatchery would have spawned at the Waneta area, the potential total number of spawning events in 2005 could have been as high as 20 events.

Two additional pre-spawning female white sturgeon were captured and brought to the hatchery as potential replacement brood stock. These extra females were surplus to the needs of the 2005 hatchery program and were returned and released into the Columbia River at Beaver Creek on 6 July. Furthermore, during the capture component the 2005 brood stock program, two other ripe female white sturgeon were captured and surgically examined, but were deemed too large for transport to the hatchery. These fish were returned to the river immediately after processing (B. Chapman, Golder

Associates, Castlegar, pers. comm., 2005). In the 2004 analysis of the effect of WSFAP flows on spawn timing, the brood stock collection program was identified as an anthropogenic variable that likely affects the identification of annual spawn timing and intensity[6]. For example, holding two of the four pre-spawn females until 6 July effectively prevented them from spawning earlier had they volitionally chosen to do so.

Table 4.1 Estimated dates of white sturgeon spawning events in the Waneta area from 1993 to 1996, 1998, and from 2000 to 2005.

Spawning Event	Year										
	1993	1994	1995	1996[a]	1998	2000	2001	2002	2003	2004	2005
1	7 Jun	16 Jun	17 Jun	24 Jun	18 Jun	25 Jun	29 Jun	25 Jun	13 Jun	20 Jun	22 Jun
2	14 Jun	19 Jun	20 Jun	25 Jun	25 Jun	4 Jul	2 Jul	27 Jun	14 Jun	23 Jun	23 Jun
3	23 Jun	28 Jun	21 Jun	26 Jun	2 Jul	6 Jul	5 Jul	28 Jun	19 Jun	25 Jun	24 Jun
4	5 Jul	12 Jul	23 Jun	27 Jun	10 Jul	10 Jul	8 Jul	30 Jun	20Jun	28 Jun	26 Jun
5	9 Jul		26 Jun	04 Jul	18 Jul	24 Jul	9 Jul	4 Jul	21Jun	29 Jun	27 Jun
6			4 Jul	07 Jul			11 Jul	12 Jul	23 Jun	7 Jul	28 Jun
7			5 Jul	08 Jul			21 Jul	14 Jul	10 Jul	8 Jul	01 Jul
8			9 Jul	11 Jul				21 Jul	11 Jul	9 Jul	06 Jul
9			25 Jul	12 Jul				24 Jul	12 Jul	11 Jul	7 Jul
10				15 Jul							13 Jul
11				20 Jul							14 Jul
12				22 Jul							15 Jul

[a] Previously reported spawning data for 1996 were changed after reanalysis of the 1996 staging data as part of the 2004 analysis of WSFAP flows and their effect on white sturgeon spawning [6].

Insufficient information regarding aspects of white sturgeon spawning behaviour and egg maturation rates reduced the effectiveness of egg developmental staging as a method to delineate spawning events and estimate time of spawning. In this study and previous studies, estimates of the number of spawning events were based on the following assumptions:

1) each event represents spawning by one female white sturgeon (i.e., multiple females are not involved);
2) each female spawns only once and releases her entire egg mass within a 24 hour period;
3) all spawned eggs are simultaneously fertilized;
4) available published data on egg development rates in relation to water temperature are accurate and eggs simultaneously fertilized subsequently develop at a similar rate;
5) all spawning occurs downstream the highway bridge within the direct influence of Pend d'Oreille River flows and every spawning event is detected through the interception of drifting eggs by one or more egg collection mats; and
6) once newly spawned and fertilized eggs settle, they adhere to the substrate and remain attached until hatching.

Due to the physical environment within the Waneta white sturgeon spawning area (i.e. deep, fast-moving, turbulent flow), obtaining visual observations of white sturgeon spawning behaviour to corroborate some of the above assumptions has not been possible. Consequently, for each of the above assumptions that may be incorrect, the ability to accurately determine the number and timing of spawning events based on back-calculation from egg developmental stages would be reduced and would limit the effectiveness of any analysis to identify environmental variables that may affect spawn timing. A qualitative assessment, based on available evidence in support or against the above assumptions, and the potential problems that violation of these assumptions may have on the interpretation of egg capture data, is provided below:

Assumption 1: female white sturgeon spawn alone at different times from other females.

The degree of temporal separation of spawning among ripe females is not known; however, given that eggs are captured over most of the known two month spawning period, at least some temporal separation of spawning events must exist. In the event that temporal separation is occasionally low or negligible, either where the spawning of one female triggers one or more other females to spawn concurrently or where by chance alone, two or more females begin spawning at roughly the same time, the eggs captured would likely be at a similar stage of development and only a single event would be identified based on egg development staging. The only way to confirm the identification of separate or simultaneous spawning events would be through an analysis of the mitochondrial (maternal) DNA of the eggs captured.

Assumption 2 :each female spawns only once and discharges her entire egg mass within a 24 hour period

The manner of release of the egg mass from a single female white sturgeon, as either a single release of the entire egg mass during one spawning event or as multiple releases over a certain period, is unknown. This assumption is based on movement data obtained from pre-spawning females equipped with radio tags and information on the ovarian maturation and ovulation process. Telemetry studies have shown that females detected in the Waneta spawning area on the same day freshly fertilized eggs were collected, did not remain in the spawning area for extended periods of time[9]. Typically, within 10 to 24 hours following their detection in the spawning area, these females had moved downstream. Information from cultured females and observations during the artificial inducement of spawning indicate that ovulation does not occur simultaneously throughout the ovary but takes place over several hours and progresses from the posterior to the anterior of the ovary. This is the basis for the premise that one female likely spawns more than once but the entire spawning act occurs within one day. Violations of this assumption, however, based solely on egg capture data, would be difficult to distinguish from violations of other assumptions (e.g., assumptions 3, 4, and 6).

In this and previous spawning studies, the collection of very few newly spawned eggs at only one egg collection station may also support the possibility that multiple spawning events occur and that some of these may represent low intensity events where only a relatively few eggs are released and fertilized (e.g., early or late in the ovulation cycle) [3,14]. For example, during the present study, a single post-fertilized egg was captured at the most downstream station (SM56E1.5) on 6 July. To verify whether a spawning event occurred, mats at stations SM56C4 and D were re-pulled that same day but additional eggs were not recovered. The following day however, large numbers of eggs were recovered from all mats. This suggested that the single egg capture on 6 July may have been associated with a smaller release of eggs on 6 July followed by the main spawning event on 7 July. Based on these findings, the egg captured on 6 July was not treated as a separate spawning event. In the absence of this type of information, however, current analysis of egg capture data assumes that the actual number of eggs captured during a single event is independent and essentially random. Consequently, these low intensity spawning events would be given equal weighting with events associated with large number of captured eggs and would result in an overestimate of the number female white sturgeon that spawn in a given year. In addition, this would further confound the ability to correlate spawning to environmental variables, such as discharge or temperature.

Assumption 3: all spawned eggs are simultaneously fertilized.

Based on the life history of other broadcast spawning fish species (including other sturgeon species), males typically are in close physical proximity to the female and release sperm simultaneously with eggs. Due to rapid displacement and dilution of reproductive products, eggs that do not encounter sperm immediately upon release likely do not get fertilized. Upon contact with the egg, the actual time of syngamy (fusion of genetic material) will typically take 3 to 4 four hours in fish and lower vertebrates [22]. Among eggs, variation in the various boundary layers and the ability of the sperm to penetrate these layers may result in a slight variation in syngamy and the onset of cell division (1 to 2 hours). Overall, simultaneous fertilization is likely a valid assumption for each spawning event. However, the possibility that a female may spawn several times over the course of a day confounds the identification of environmental parameters associated with spawning of an individual female.

Assumption 4: published data on egg development rates in relation to water temperature are accurate and eggs simultaneously fertilized subsequently develop at a similar rate.

To date, the best estimated of white sturgeon egg development rate in relation to temperature are interpolated development time estimates based on relationships developed by Wang et. al. (1985)[15] and egg and larval development time described by Beer (1981)[1] (M. Parsely, US Geological Survey, Cook WA, pers. comm., 2002). The primary short-coming of the relationship developed was a lack of an error term to describe the variance associated with the developmental times estimated for each of the identified egg and pre-hatch larval stages. Results of a recent lab incubation experiment that examined temperature effects on white sturgeon egg development, indicated substantial variation in developmental rates among eggs simultaneously fertilized incubated at constant temperatures of either 8.7ºC or 14.3ºC [6]. The largest differences in development time were recorded during incubation experiments conduct at 14.3ºC, where after approximately 100 hrs of incubation, the difference in developmental time between the earliest (late epithelial) and latest stage (early neurulation) was estimated to be 35 hours based on available development rates. Had these eggs been recovered as part of the Waneta spawn monitoring program, two spawning events instead of one would have been estimated. In this and previous studies, eggs at development stages earlier than late epithelial were assumed to be more accurate indicators of spawning events from which relatively accurate estimates of spawn time could be back calculated [3,4,5,7,11,12,13,14].

Assumption 5: all spawning occurs downstream the highway bridge within the direct influence of Pend d'Oreille River flows and every spawning event is detected through the interception of drifting eggs by one or more egg collection mats.

Consistent throughout all previous studies, every spawning event identified was represented by the capture of eggs at station SM56D[3,4,5,7,11,12,13,14]. The eggs captured during spawning events during higher flow in June typically were distributed over all mats, with the majority of eggs captured at SM56C4 and SM56D. Although it is likely that most spawning occurs immediately downstream of the highway bridge, in years with very high and very low flows, changes in actual location of egg release and shoreline hydraulics could result in eggs from one or more spawning events missing all the egg collection mats and consequently, a spawning event going undetected.

Assumption 6: once newly spawned and fertilized eggs settle, they adhere to the substrate and remain attached until hatching

White sturgeon eggs are very negatively buoyant and when spawned, quickly sink to the river bottom and strongly adhere to surface of the coarse substrates. Under constant or reducing discharge conditions, as is typically the case during the descending limb of the freshet when spawning at Waneta occurs, the majority of eggs are assumed to remain attached to the substrate until hatch. However, there is a possibility that some eggs may become dislodged for reasons unknown and drift downstream. In turn, a certain percentage of these eggs will be intercepted by the egg collection mats. Consequently, when inspected at regular interval, the egg collection mats will continue to accumulate eggs associated with the initial spawning event. These eggs can potentially be interpreted as a second spawning event.

In summary, the absolute number and timing of white sturgeon spawning events observed in a given year likely relates to several environment and biological factors that interact to varying degrees with white sturgeon life history. Accurate assessment of the number and timing of white sturgeon spawning events in a giving year is likely confounded by flow fluctuations in both the Pend d'Oreille and Columbia rivers, the brood stock capture program, and a generally lack of knowledge on basic white sturgeon spawning behaviour and egg maturation and development. The only two consistent patterns shared with all previous studies was that the onset of spawning in 2005 occurred during the descending limb of the Pend d'Oreille River hydrograph and at water temperatures between 14ºC and 16ºC.

4.3 EGG AND LARVAE CATCH

The amount of sampling effort during the 2005 study was approximately 21,000 mat-hours and was comparable to sample efforts in previous years. In terms of flow, Pend d'Oreille River peak freshet daily average discharge in 2005 was very similar to levels recorded in 2003. Similarly, the total number of eggs captured in 2005 (n=4815) was comparable to the total catch in 2003 (n=3829). A summary of selected physical attributes of the Pend d'Oreille River along with egg catches recorded in the present study and in previous years is provided in Table 4.2.

Table 4.2 Summary of daily average water temperature and discharge in the Pend d'Oreille River during the start and end of recorded white sturgeon spawning activity and the numbers of white sturgeon eggs and larvae captured in the Waneta area.

Year	First Recorded Spawning Event			Last Recorded Spawning Event			Total Catch		Peak Freshet Discharge	
	Date	Water Temp.[a] (°C)	Discharge[a] (m^3/s)	Date	Water Temp.[a] (°C)	Discharge[a] (m^3/s)	Eggs	Larvae	Date	Discharge[a] (m^3/s)
1993[b]	7 Jun	16.2	1000	13 Jul	17.0	1200	61	4	17 May	1760
1994[b]	16 Jun	14.5	1190	14 Jul	19.0	450	33	0	5 Jun	1480
1995	17 Jun	15.2	1657	27 Jul	21.0	442	762	4	10 Jun	1920
1996	21 Jun	14.0	1920	21 Jul	21.0	798	1680	13	14 Jun	2788
1998	18 Jun	16.8	1432	19 Jul	21.5	853	1621	2	2 Jun	2038
2000	25 Jun	16.3	1247	24 Jul	21.5	454	474	1	6 May	1710
2001	29 Jun	17.3	719	21 Jul	21.4	272	620	1	14 May	1053
2002	25 Jun	15.5	2108	24 Jul	20.2	680	2058	15	10 Jun	2921
2003	13 Jun	16.2	1333	12 Jul	20.4	507	3829	1	5 Jun	2108
2004	20 Jun	14.7	1089	11 Jul	19.6	794	2038	0	28 May	1449
2005	22 Jun	15.6	1388	15 Jul	19.4	674	4815	5	10 Jun	2346

[a] Daily average temperature and discharge for the Pend d'Oreille River were measured at Waneta Dam and Seven Mile Dam, respectively.
[b] Studies in 1993 and 1994 were conducted at a reconnaissance level of effort.

Of the 4815 eggs captured in 2005, 2459 eggs (51%) were captured at set location SM56C4 (see Figure 1.1) which is located on a lateral cobble bar extending out into the main channel. Due to the high water velocity at SM56C4, the egg collection mats typically settle near shore at a depth between 2 and 3 m. Given the white sturgeon eggs are negatively buoyant, the large number of eggs caught suggests that at least one or two spawning events may have occurred in close proximity to the SM56C4 sampling location., However, even though more eggs were captured in 2005, a substantial reduction in the number of eggs captured at SM56C3 was recorded in 2005 (n=32 or 0.7% of total catch) compared to 2004 egg capture results (n=150 or 7.4% of total catch). These data suggest spawning and egg deposition is highly aggregated and, as a result, egg CPUE values can vary by orders of magnitude due to small changes in spawning location, both vertically and horizontally, relative to the egg collection mats.

During the present study and in past studies, white sturgeon were observed breaching and rolling on the surface near the right upstream bank in the vicinity of the station SM56C3 (Golder 2003) and near SM56C1 (2004). In 2005, similar activity was observed near station SM56C1 on 10 and 29 June and near the mid-channel station SM56M1 on 21 and 23 June. This type of activity is thought to be a component of white sturgeon spawning behaviour.

A comparison of peak Pend d'Oreille River discharges with the total number of eggs collected in each year during the 1993 to 2005 spawning periods have suggested a possible relationship between discharge and the numbers of white sturgeon eggs collected (Figure 4.1). This relationship was initially thought to represent a positive correlation of discharge with sturgeon spawning periodicity, frequency, and intensity (Hildebrand et al. 1999). Subsequently, however, an equally valid hypothesis has been suggested (i.e., that egg distribution and dispersal is either greater or more uniform during high discharge periods or eggs are more frequently displaced and therefore at higher risk of capture by egg mats during high flow volumes). The 2005 data appears to not support the hypothesis that greater numbers of eggs are captured in high discharge years.

Another possible hypothesis is that since most of the eggs are captured at SM56C4 and SM56D, factors that affect either the degree to which Pend d'Oreille River discharge is confined to the south bank and diverted over the cobble bar where SM56C4 is located or the physical location of spawning in the discharge plume, may alter the capture efficiency at SM56C4 and consequently, the total number of eggs captured in a given water year.

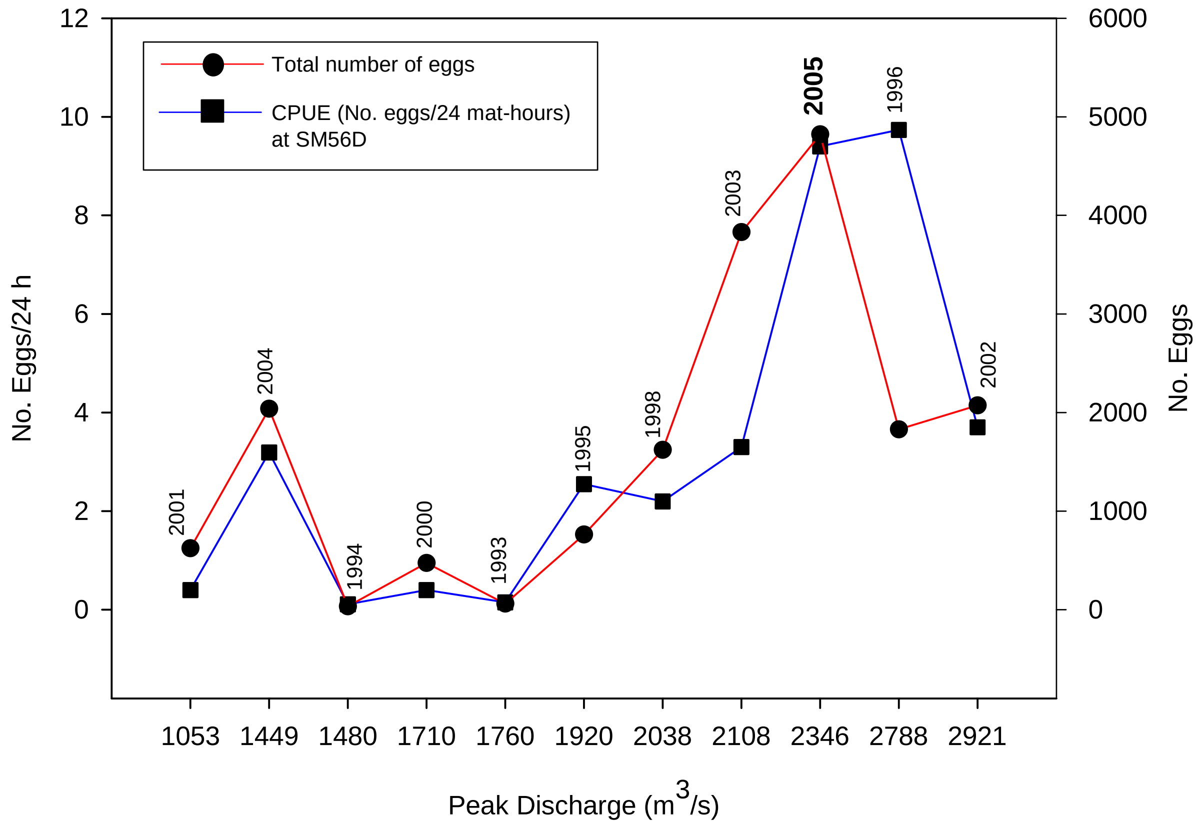


Figure 4.1 Comparisons between annual peak daily average discharge of the Pend d'Oreille River and white sturgeon egg collections (catch-rates at index site SM56D and total number of eggs collected over 24 mat-hours) for spawning periods in 1993 to 1996, 1998, and 2000 to 2005.

4.4 *IN SITU* EGG INCUBATION EXPERIMENT

The results of the 2005 *in situ* egg incubation experiment confirmed that white sturgeon eggs can be successfully hatched in the modified egg incubation trays. The trays were effective in isolating individual eggs and likely reduced mortality associated with the spread of fungal contamination among incubating eggs. Sediment accumulation within individual cells was suspected as the primary cause of mortality during the 2005 incubation experiment. During low flow periods at Waneta Dam as a result of daily load shaping operations at Waneta Dam, water temperature at the incubation array fluctuated by approximately 2.5ºC due to incursion of cooler water from the Columbia River. The primary effect of these daily temperature fluctuations was likely a reduction in the developmental rate of incubating white sturgeon eggs. The effect of these fluctuations on egg mortality rate was unknown but was assumed to be negligible or even slightly beneficial when water temperature of the Pend d'Oreille River exceeded the optimum rearing temperature of white sturgeon eggs (i.e., 18ºC)[15]. In future egg collection studies, the incubation of captured eggs in *in situ* incubation trays would be an effective method to obtain large quantities of genetic material for the purpose of identifying family lineages and population structure.

4.5 EGG PREDATOR ASSESSMENT

The 2005 egg predator assessment at Waneta documented the species composition and relative densities of potential egg predators in the vicinity of the white sturgeon spawning area and Waneta Eddy at Pend d'Oreille River discharges representative of WSFAP flows of 708 m^3/s and 142 m^3/s. The consumption of white sturgeon eggs, based on the recovery of a total of 4 eggs from the stomachs of two largescale suckers, was also confirmed during the assessment. In addition to largescale suckers, other potential egg predators in the Waneta area included walleye, sculpin, smallmouth bass, rainbow trout, and northern pikeminnow.

Estimates of egg predator densities in the Waneta spawning area during WSFAP flows conditions were either based on single or paired samples. To assess the effect of WSFAP flows on egg predators based on CPUE, catch results and effort were pooled based on discharge during each sampling session. At WSFAP flows near 708 m^3/s during session 1 on 8 July and session 2 on 16 July, the catch-rate of suckers was highest (133 fish/km), followed by sculpin spp. (22 fish/km), walleye (18 fish/km), smallmouth bass (17 fish/km), rainbow trout (12 fish/km), and northern pikeminnow (10 fish/km). At the WSFAP flow near 142 m^3/s during session 3 on 16 July, catch-rate of sculpin spp. was highest (183 fish/km), followed by smallmouth bass (29 fish/km), sucker spp. (17 fish/km), rainbow (16 fish/km), walleye (9 fish/km), and northern pikeminnow (3 fish/km) (Figure 4.2). The apparent decrease in catch-rate for suckers, during a period of decreased flow was contrary to the intuitive expectation that higher flows would deter egg predator from using the area and that egg predator densities would increase during periods of lower water velocity at lower discharge levels. The observed reduction in sucker catch-rate may be due in part to an erroneous assumption that the intervening period (approximately 3 hours) between sampling sessions at high and low flows on 16 July was sufficient to allow fish to re-establish after the first sampling pass. Therefore, the reductions in fish densities recorded may simply reflect depletion due to the previous sampling pass.

A second possible cause is that, during low Pend d'Oreille flows, cooler Columbia River water (approximately 2.5ºC colder that the Pend d'Oreille River) inundates the spawning area and may discourage fish use. The large increase in sculpin recorded during low flows was more likely due to an increase in sampling efficiency, in that sculpin were easier to see and catch at lower discharge levels, rather than evidence that sculpin were moving into the area during low flows.

Regardless of the cause, however, the data indicate that there is not a large influx of potential egg predators into the egg deposition area from adjacent areas of the Columbia River during periods of low flow from Waneta Dam. This would support a hypothesis that the potential egg predators that are present in the area consist of locally resident fish that may occasionally feed on sturgeon eggs.

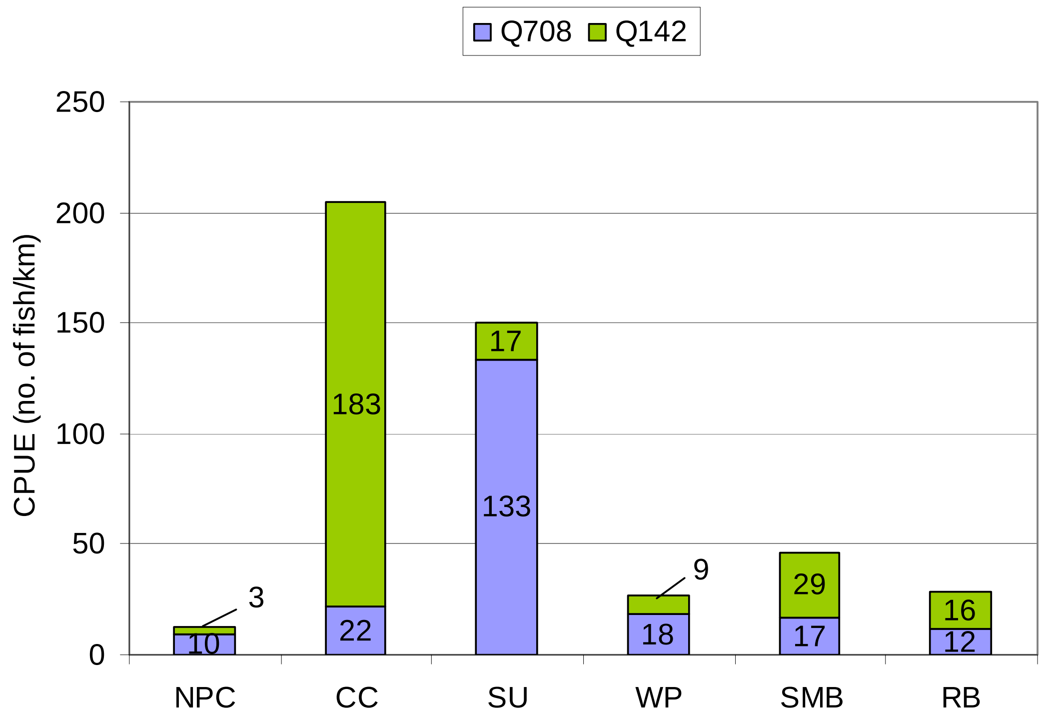


Figure 4.2 The catch-rate of northern pikeminnow (NPC), sculpin spp. (CC), suckers (SU), walleye (WP), smallmouth bass (SMB), and rainbow trout (RB) at WSFAP flows (Q) near 708 m^3/s and 142 m^3/s during the egg predator assessment at Waneta, 8 and 16 July 2005.

Although the 2005 egg predator assessment achieved its basic objectives, an estimate of the effect of egg predation on overall white sturgeon egg mortality rates at the population level could not be determined due to the small number of samples from which predator densities were estimated, and uncertainties regarding the total number of white sturgeon spawning events and the total number of eggs released. Given the relatively unique condition under which sampling could occur (i.e., during WSFAP flow of 708m^3/s or 142 m^3/s and in conjunction with a white sturgeon spawning event), opportunities for additional sampling, even with an unlimited budget, would have been infrequent. In 2001, a single pass boat electrofishing survey of the spawning and egg deposition area (i.e., habitat between the bridge crossing and the international border) was conducted in late August during low flow conditions. During the 2001 survey, the fish species assemblage recorded was similar to the assemblage recorded in the present study with the exception of low numbers of smallmouth bass, burbot, kokanee, lake whitefish, and white sturgeon that were recorded in 2005. In terms of relative catch-rates, the total catch in 2001 consisted primarily of sucker spp. (60 fish/km), followed by walleye (56 fish/km), rainbow trout (28 fish/km), and sculpin spp. (18 fish/km). In comparison, the density suckers spp. and sculpin spp. in 2001 were lower that in the present study while the density of both walleye and rainbow trout were higher. Overall, however, fish capture results from both 2001 and 2005 suggest that suckers spp. are the dominant potential egg predator in the Waneta area [24].

Generally, the results indicated that potential egg predators use the spawning area for feeding and that white sturgeon eggs were consumed, albeit in low numbers. There is a possibility that preservation techniques used in session 1 did not immediately stop the digestion process. A cursory review of published literature did not reveal information on the digestion and stomach evacuation rates of sucker spp. Information was found for brown trout, and for this species [and likely most fish in general], the primary factors that affected digestion rates were ambient water temperature, meal size, and food type[25]. In general, fish also tend to move into areas of warmer water after feeding to facilitate digestion. During sampling, water temperatures in the Waneta tailrace were approximately 20ºC. As a food type, the outer layers of white sturgeon eggs consist mainly of phosolipids and protein, are relatively prone to damage, and are likely readily digested. Therefore, assuming that the digestion process in sucker spp. is similar to brown trout, and given the high ambient water temperature in the Waneta tailrace, white sturgeon eggs would likely be digested to an unrecognisable state within 2 hours after ingestion. Consequently, the actual number of egg consumed may have been higher than the number recorded. Regardless, the fact that suckers and sculpin likely opportunistically eat white sturgeon eggs, and have historically done so, would not be disputed.

5.0 SUMMARY

In total, 4815 eggs and 5 larvae were captured during the 2005 white sturgeon spawning investigations at Waneta. The 12 spawning events recorded equalled the largest number of spawning events ever recorded since spawning studies were initiated in 1993. Similar to other years, spawning occurred during the descending limb of the Pend d'Oreille River freshet and commenced after mean daily water temperatures in that system exceeded 14°C. The last three spawning events occurred during periods when the WSFAP was implemented.

Approximately 1400 eggs were incubated *in situ* using incubation trays, of which, 61% were successfully hatched. As in previous incubation experiments, sediment accumulation within the incubator was identified as a possible cause of egg mortality. Approximately 20% of the total eggs captured were preserved and were examined to determine their developmental stage. On the basis of substantial differences in the time of egg capture, large developmental difference among eggs captured on a single day, and the presence of very recently spawned eggs, at total of 12 spawning events were identified during the 2005 study. The accuracy of the total number and timing of spawning events estimated was examined in context with the validity of assumptions regarding aspects of white sturgeon spawning behaviour and egg development. The need for additional research into white sturgeon egg developmental rates in relation to water temperature was identified as necessary step in order to obtain estimates of variance associated with egg development rates.

The assessment of egg predator use of the Waneta area in association with white sturgeon spawning events in the Waneta area identified suckers and possibly sculpin as the predominant potential egg predators in the area. Predation by sucker spp. on white sturgeon eggs was confirmed. Based on the 2005 survey results, due to the limited number of sampling sessions and uncertainty regarding the actual density of egg predators in the area, the number of eggs consumed, and the absolute numbers of white sturgeon eggs spawned, the study was unable to assess what effect egg predation might have on the total white sturgeon egg survival. In future assessments of egg predation in the Waneta spawning area, the use of two crews, where one crew solely processes fish captured by the other crew, is recommended to allow immediate, post-capture preservation of stomach contents. Potential egg predators that reside in the Waneta spawning area likely opportunistically feed on white sturgeon eggs as an alternate food source. Given limited availability and the relative small numbers of white sturgeon eggs spawned annually relative to other, much larger food sources (e.g., invertebrates) in the Columbia River, a mass long-distance migration of potential egg predators to the Waneta area for sole purpose of exploiting spawned white sturgeon eggs is considered unlikely and is not supported either from an energetics perspective or from the data obtained in the present study.

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PLATES

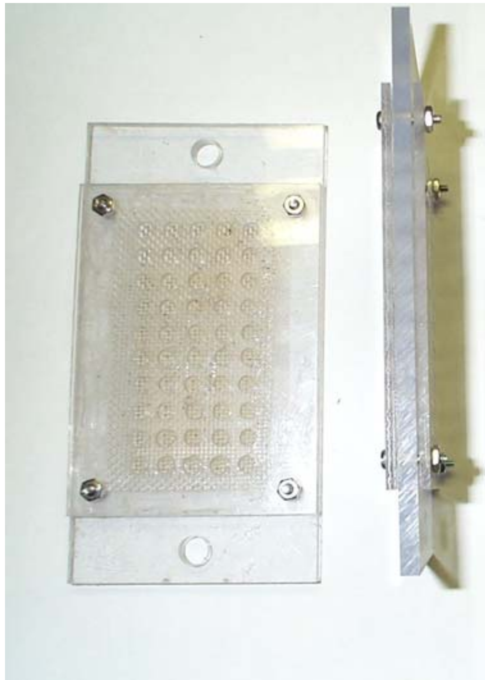

Plate A An example of the a Plexiglas incubation tray used in the 2005 white sturgeon egg *in situ* incubation experiments.

APPENDIX A

2005 WHITE STURGEON EGG COLLECTION DATA

Table A1 Summary of white sturgeon eggs and larvae captured by egg mats deployed in the Waneta area, 1 June to 29 July 2005.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C1	1-Jun-05 11:07	3-Jun-05 12:25	49.3	14.0	15.0	11.5	0.5	1.0	4.0	3.0	0	0	0	0	0	98.6	*0.0*
SM56C3	1-Jun-05 11:17	3-Jun-05 12:41	49.4	14.0	15.0	8.4	0.5	1.0	4.0	3.0	0	0	0	0	0	98.8	*0.0*
SM56C4	1-Jun-05 11:26	3-Jun-05 12:57	49.5	14.0	15.0	2.3	0.5	1.0	4.0	3.0	0	0	0	0	0	99.0	*0.0*
SM56D	1-Jun-05 12:05	4-Jun-05 13:20	73.3	14.0	15.0	3.0	0.5	1.0	4.0	3.0	0	0	0	0	0	146.5	*0.0*
SM56D1	1-Jun-05 12:12	3-Jun-05 13:40	49.5	14.0	15.0	4.1	0.5	1.0	4.0	3.0	0	0	0	0	0	98.9	*0.0*
SM56E1	1-Jun-05 12:22	3-Jun-05 13:57	49.6	14.0	15.0	6.3	0.5	1.0	4.0	3.0	0	0	0	0	0	99.2	*0.0*
SM56E1.5	1-Jun-05 12:44	3-Jun-05 14:12	49.5	14.0	15.0	3.3	0.5	1.0	4.0	3.0	0	0	0	0	0	98.9	*0.0*
SM56C1	3-Jun-05 12:36	6-Jun-05 12:06	71.5	15.0	15.5	11.5	1.0	0.7	2.5	3.5	0	0	0	0	0	143.0	*0.0*
SM56C3	3-Jun-05 12:51	6-Jun-05 12:43	71.9	15.0	15.5	5.6	1.0	0.7	2.5	3.5	0	0	0	0	0	143.7	*0.0*
SM56C4	3-Jun-05 13:17	6-Jun-05 13:00	71.7	15.0	15.5	n/a[c]	1.0	0.7	2.5	3.5	0	0	0	0	0	143.4	*0.0*
SM56D	4-Jun-05 13:36	6-Jun-05 13:16	47.7	15.0	15.5	3.3	1.0	0.7	2.5	3.5	0	0	0	0	0	95.3	*0.0*
SM56D1	3-Jun-05 13:53	6-Jun-05 13:38	71.8	15.0	15.5	3.2	1.0	0.7	2.5	3.5	0	0	0	0	0	143.5	*0.0*
SM56E1	3-Jun-05 14:08	6-Jun-05 13:47	71.7	15.0	15.5	3.3	1.0	0.7	2.5	3.5	0	0	0	0	0	143.3	*0.0*
SM56E1.5	3-Jun-05 14:12	6-Jun-05 14:01	71.8	15.0	15.5	3.7	1.0	0.7	2.5	3.5	0	0	0	0	0	143.6	*0.0*
SM56C1	6-Jun-05 12:18	10-Jun-05 11:46	95.5	15.5	14.0	9.8	0.5	0.8	4.5	2.5	0	0	0	0	0	190.9	*0.0*
SM56C3	6-Jun-05 12:56	10-Jun-05 12:02	95.1	15.5	14.0	4.0	0.5	0.8	4.5	2.5	0	0	0	0	0	190.2	*0.0*
SM56C4	6-Jun-05 13:13	10-Jun-05 12:45	95.5	15.5	14.0	2.1	0.5	0.8	4.5	2.5	0	0	0	0	0	191.1	*0.0*
SM56D	6-Jun-05 13:27	10-Jun-05 13:00	95.5	15.5	14.0	2.9	0.5	0.8	4.5	2.5	0	0	0	0	0	191.1	*0.0*
SM56D1	6-Jun-05 13:44	10-Jun-05 13:13	95.5	15.5	14.0	3.1	0.5	0.8	4.5	2.5	0	0	0	0	0	191.0	*0.0*
SM56E1	6-Jun-05 13:58	10-Jun-05 13:30	95.5	15.5	14.0	5.1	0.5	0.8	4.5	2.5	0	0	0	0	0	191.1	*0.0*
SM56E1.5	6-Jun-05 14:11	10-Jun-05 13:46	95.6	15.5	14.0	3.8	0.5	0.8	4.5	2.5	0	0	0	0	0	191.2	*0.0*
SM56C1	10-Jun-05 11:57	14-Jun-05 11:17	95.3	14.0	14.0	n/a[c]	0.5	3.0	6.0	2.3	0	0	0	0	0	190.7	*0.0*
SM56C3	10-Jun-05 12:15	14-Jun-05 11:31	95.3	14.0	14.0	n/a[c]	0.5	3.0	6.0	2.3	0	0	0	0	0	190.5	*0.0*
SM56C4	10-Jun-05 12:58	14-Jun-05 11:44	94.8	14.0	14.0	n/a[c]	0.5	3.0	6.0	2.3	0	0	0	0	0	189.5	*0.0*
SM56D	10-Jun-05 13:10	14-Jun-05 12:24	95.2	14.0	14.0	n/a[c]	0.5	3.0	6.0	2.3	0	0	0	0	0	190.5	*0.0*
SM56D1	10-Jun-05 13:25	14-Jun-05 12:36	95.2	14.0	14.0	4.4	0.5	3.0	6.0	2.3	0	0	0	0	0	190.4	*0.0*
SM56E1	10-Jun-05 13:41	14-Jun-05 12:49	95.1	14.0	14.0	5.0	0.5	3.0	6.0	2.3	0	0	0	0	0	190.3	*0.0*
SM56E1.5	10-Jun-05 13:54	14-Jun-05 13:02	95.1	14.0	14.0	4.0	0.5	3.0	6.0	2.3	0	0	0	0	0	190.3	*0.0*

[a] See Figure 1.1 for sample locations.

Continued…

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Table A1 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C1	14-Jun-05 11:28	17-Jun-05 11:41	72.2	14.0	14.0	n/a	0.5	1.2	4.5	3.0	0	0	0	0	0	144.4	*0.0*
SM56C3	14-Jun-05 11:40	17-Jun-05 11:57	72.3	14.0	14.0	5.8	0.5	1.2	4.5	3.0	0	0	0	0	0	144.6	*0.0*
SM56C4	14-Jun-05 11:54	17-Jun-05 12:36	72.7	14.0	14.0	1.9	0.5	1.2	4.5	3.0	0	0	0	0	0	145.4	*0.0*
SM56D	14-Jun-05 12:33	17-Jun-05 12:51	72.3	14.0	14.0	2.6	0.5	1.2	4.5	3.0	0	0	0	0	0	144.6	*0.0*
SM56D1	14-Jun-05 12:45	17-Jun-05 13:06	72.3	14.0	14.0	4.9	0.5	1.2	4.5	3.0	0	0	0	0	0	144.7	*0.0*
SM56E1	14-Jun-05 12:59	17-Jun-05 13:20	72.3	14.0	14.0	3.1	0.5	1.2	4.5	3.0	0	0	0	0	0	144.7	*0.0*
SM56E1.5	14-Jun-05 13:13	17-Jun-05 13:36	72.4	14.0	14.0	4.4	0.5	1.2	4.5	3.0	0	0	0	0	0	144.8	*0.0*
SM56C1	17-Jun-05 11:53	21-Jun-05 13:23	97.5	14.0	14.9	8.9	0.6	1.0	3.5	2.8	0	0	0	0	0	195.0	*0.0*
SM56C3	17-Jun-05 12:05	21-Jun-05 13:35	97.5	14.0	14.9	5.9	0.6	1.0	3.5	2.8	0	0	0	0	0	195.0	*0.0*
SM56C4	17-Jun-05 12:48	21-Jun-05 13:46	97.0	14.0	14.9	1.7	0.6	1.0	3.5	2.8	0	0	0	0	0	193.9	*0.0*
SM56D	17-Jun-05 13:02	21-Jun-05 13:57	96.9	14.0	14.9	2.0	0.6	1.0	3.5	2.8	0	0	0	0	0	193.8	*0.0*
SM56D1	17-Jun-05 13:16	21-Jun-05 14:10	96.9	14.0	14.9	3.9	0.6	1.0	3.5	2.8	0	0	0	0	0	193.8	*0.0*
SM56E1	17-Jun-05 13:32	21-Jun-05 14:24	96.9	14.0	14.9	3.5	0.6	1.0	3.5	2.8	0	0	0	0	0	193.7	*0.0*
SM56E1.5	17-Jun-05 13:46	21-Jun-05 14:38	96.9	14.0	14.9	3.5	0.6	1.0	3.5	2.8	0	0	0	0	0	193.7	*0.0*
SM56C1	21-Jun-05 13:31	23-Jun-05 11:58	46.5	14.9	15.6	12.2	0.5	1.4	5.0	2.9	0	0	0	0	0	92.9	*0.0*
SM56C3	21-Jun-05 13:44	23-Jun-05 12:13	46.5	14.9	15.6	5.2	0.5	1.4	5.0	2.9	0	0	0	0	0	93.0	*0.0*
SM56C4	21-Jun-05 13:50	23-Jun-05 12:56	47.1	14.9	15.6	1.9	0.5	1.4	5.0	2.9	119	0	165	0	284	94.2	*72.4*
SM56D	21-Jun-05 14:07	23-Jun-05 14:15	48.1	14.9	15.6	2.7	0.5	1.4	5.0	2.9	30	0	107	0	137	96.3	*34.2*
SM56D1	21-Jun-05 14:18	23-Jun-05 15:03	48.8	14.9	15.6	3.4	0.5	1.4	5.0	2.9	59	0	6	0	65	97.5	*16.0*
SM56E1	21-Jun-05 14:35	23-Jun-05 15:42	49.1	14.9	15.6	5.6	0.5	1.4	5.0	2.9	9	0	19	0	28	98.2	*6.8*
SM56E1.5	21-Jun-05 14:48	23-Jun-05 16:06	49.3	14.9	15.6	3.6	0.5	1.4	5.0	2.9	1	0	2	0	3	98.6	*0.7*
SM56M1	21-Jun-05 12:55	23-Jun-05 16:34	51.7	14.9	15.6	10.3	0.5	1.4	5.0	2.9	4	0	4	0	8	103.3	*1.9*
SM56C1	23-Jun-05 12:10	24-Jun-05 11:18	23.1	15.6	16.0	10.7	0.5	1.2	4.6	3.0	0	0	0	0	0	46.3	*0.0*
SM56C3	23-Jun-05 12:23	24-Jun-05 11:36	23.2	15.6	16.0	3.8	0.5	1.2	4.6	3.0	0	0	0	0	0	46.4	*0.0*
SM56C4	23-Jun-05 14:13	24-Jun-05 11:50	21.6	15.6	16.0	1.7	0.5	1.2	4.6	3.0	173	0	406	0	579	43.2	*321.4*
SM56D	23-Jun-05 15:05	24-Jun-05 13:34	22.5	15.6	16.0	2.5	0.5	1.2	4.6	3.0	174	0	30	0	204	45.0	*108.9*
SM56D1	23-Jun-05 15:38	24-Jun-05 14:10	22.5	15.6	16.0	3.0	0.5	1.2	4.6	3.0	27	0	31	0	58	45.1	*30.9*
SM56E1	23-Jun-05 16:04	24-Jun-05 14:37	22.5	15.6	16.0	2.2	0.5	1.2	4.6	3.0	19	0	67	0	86	45.1	*45.8*

[a] See Figure 1.1 for sample locations.

Continued…

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Table A1 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56E1.5	23-Jun-05 16:22	24-Jun-05 15:10	22.8	15.6	16.0	4.3	0.5	1.2	4.6	3.0	17	0	32	0	49	45.6	*25.8*
SM56M1	23-Jun-05 17:39	24-Jun-05 15:43	22.1	15.6	16.0	10.5	0.5	1.2	4.6	3.0	101	0	142	0	243	44.1	*132.1*
SM56C1	24-Jun-05 11:34	27-Jun-05 09:58	70.4	16.0	16.6	12.3	0.6	1.2	3.5	2.8	0	0	2	0	2	140.8	*0.3*
SM56C3	24-Jun-05 11:46	27-Jun-05 10:15	70.5	16.0	16.6	2.6	0.6	1.2	3.5	2.8	0	0	1	0	1	141.0	*0.2*
SM56C4	24-Jun-05 13:00	27-Jun-05 10:29	69.5	16.0	16.6	2.3	0.6	1.2	3.5	2.8	132	0	248	0	380	139.0	*65.6*
SM56D	24-Jun-05 14:05	27-Jun-05 11:43	69.6	16.0	16.6	2.3	0.6	1.2	3.5	2.8	38	0	53	0	91	139.3	*15.7*
SM56D1	24-Jun-05 14:33	27-Jun-05 12:11	69.6	16.0	16.6	2.6	0.6	1.2	3.5	2.8	14	0	12	0	26	139.3	*4.5*
SM56E1	24-Jun-05 15:06	27-Jun-05 12:34	69.5	16.0	16.6	3.1	0.6	1.2	3.5	2.8	24	0	8	0	32	138.9	*5.5*
SM56E1.5	24-Jun-05 15:32	27-Jun-05 12:58	69.4	16.0	16.6	3.8	0.6	1.2	3.5	2.8	10	0	8	0	18	138.9	*3.1*
SM56M1	24-Jun-05 16:51	27-Jun-05 09:25	64.6	16.0	16.6	13.5	0.6	1.2	3.5	2.8	3	0	6	0	9	129.1	*1.7*
SM56C1	27-Jun-05 10:10	29-Jun-05 11:39	49.5	16.6	16.6	n/a[c]	0.6	1.0	4.0	3.0	1	0	1	0	2	99.0	*0.5*
SM56C3	27-Jun-05 10:26	29-Jun-05 11:57	49.5	16.6	16.6	4.4	0.6	1.0	4.0	3.0	1	0	6	0	7	99.0	*1.7*
SM56C4	27-Jun-05 11:16	29-Jun-05 12:45	49.5	16.6	16.6	1.5	0.6	1.0	4.0	3.0	41	0	20	0	61	99.0	*14.8*
SM56D	27-Jun-05 12:07	29-Jun-05 13:08	49.0	16.6	16.6	2.7	0.6	1.0	4.0	3.0	31	0	21	0	52	98.0	*12.7*
SM56D1	27-Jun-05 12:31	29-Jun-05 13:32	49.0	16.6	16.6	3.8	0.6	1.0	4.0	3.0	9	0	9	0	18	98.0	*4.4*
SM56E1	27-Jun-05 12:55	29-Jun-05 13:53	49.0	16.6	16.6	4.2	0.6	1.0	4.0	3.0	9	0	2	0	11	97.9	*2.7*
SM56E1.5	27-Jun-05 13:49	29-Jun-05 14:12	48.4	16.6	16.6	4.0	0.6	1.0	4.0	3.0	3	0	2	0	5	96.8	*1.2*
SM56M1	27-Jun-05 09:54	29-Jun-05 11:57	50.1	16.6	16.6	n/a[c]	0.6	1.0	4.0	3.0	9	0	11	0	20	100.1	*4.8*
SM56C1	29-Jun-05 11:53	2-Jul-05 11:25	71.5	16.6	17.4	12.5	0.6	1.0	5.5	3.5	5	0	11	0	16	143.1	*2.7*
SM56C3	29-Jun-05 12:11	2-Jul-05 11:49	71.6	16.6	17.4	8.1	0.6	1.0	5.5	3.5	5	0	12	0	17	143.3	*2.8*
SM56C4	29-Jun-05 13:04	2-Jul-05 12:36	71.5	16.6	17.4	2.1	0.6	1.0	5.5	3.5	85	0	820	0	905	143.1	*151.8*
SM56D	29-Jun-05 13:29	2-Jul-05 13:42	72.2	16.6	17.4	3.6	0.6	1.0	5.5	3.5	212	0	105	0	317	144.4	*52.7*
SM56D1	29-Jun-05 13:49	2-Jul-05 14:40	72.8	16.6	17.4	3.7	0.6	1.0	5.5	3.5	182	0	42	0	224	145.7	*36.9*
SM56E1	29-Jun-05 14:08	38535.6	72.8	16.6	17.4	3.3	0.6	1.0	5.5	3.5	18	0	37	0	55	145.5	*9.1*
SM56E1.5	29-Jun-05 14:45	2-Jul-05 15:20	72.6	16.6	17.4	4.2	0.6	1.0	5.5	3.5	18	0	31	0	49	145.2	*8.1*
SM56M1	29-Jun-05 11:34	2-Jul-05 10:56	71.4	16.6	17.4	9.1	0.6	1.0	5.5	3.5	16	0	17	0	33	142.7	*5.5*
SM56C1	2-Jul-05 11:44	4-Jul-05 11:51	48.1	17.4	17.7	9.3	0.4	0.9	4.3	2.8	0	0	0	0	0	96.2	*0.0*
SM56C3	2-Jul-05 12:04	4-Jul-05 12:03	48.0	17.4	17.7	5.2	0.4	0.9	4.3	2.8	1	0	1	0	2	96.0	*0.5*

[a] See Figure 1.1 for sample locations.

Continued…

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Table A1 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C4	2-Jul-05 13:38	4-Jul-05 12:54	47.3	17.4	17.7	1.7	0.4	0.9	4.3	2.8	7	0	0	0	7	94.5	*1.8*
SM56D	2-Jul-05 14:16	4-Jul-05 13:07	46.8	17.4	17.7	2.4	0.4	0.9	4.3	2.8	3	0	7	0	10	93.7	*2.6*
SM56D1	2-Jul-05 14:51	4-Jul-05 13:24	46.5	17.4	17.7	3.3	0.4	0.9	4.3	2.8	3	0	2	0	5	93.1	*1.3*
SM56E1	2-Jul-05 15:15	4-Jul-05 13:38	46.4	17.4	17.7	4.7	0.4	0.9	4.3	2.8	2	0	7	1	10	92.8	*2.6*
SM56E1.5	2-Jul-05 15:37	4-Jul-05 13:55	46.3	17.4	17.7	4.1	0.4	0.9	4.3	2.8	3	0	0	0	3	92.6	*0.8*
SM56M1	2-Jul-05 11:20	4-Jul-05 11:35	48.3	17.4	17.7	9.7	0.4	0.9	4.3	2.8	0	0	0	0	0	96.5	*0.0*
SM56C1	4-Jul-05 12:00	6-Jul-05 11:36	47.6	17.7	17.5	12.6	0.7	0.9	3.5	2.2	0	0	0	0	0	95.2	*0.0*
SM56C3	4-Jul-05 12:17	6-Jul-05 11:48	47.5	17.7	17.5	8.1	0.7	0.9	3.5	2.2	0	0	0	0	0	95.0	*0.0*
SM56C4	4-Jul-05 13:04	6-Jul-05 12:30	47.4	17.7	17.5	1.7	0.7	0.9	3.5	2.2	0	0	3	0	3	94.9	*0.8*
SM56D	4-Jul-05 13:20	6-Jul-05 12:44	47.4	17.7	17.5	2.6	0.7	0.9	3.5	2.2	0	0	0	1	1	94.8	*0.3*
SM56D1	4-Jul-05 13:34	6-Jul-05 12:57	47.4	17.7	17.5	3.5	0.7	0.9	3.5	2.2	0	0	3	0	3	94.8	*0.8*
SM56E1	4-Jul-05 13:51	6-Jul-05 13:11	47.3	17.7	17.5	3.3	0.7	0.9	3.5	2.2	0	0	3	0	3	94.7	*0.8*
SM56E1.5	4-Jul-05 14:08	6-Jul-05 13:23	47.3	17.7	17.5	3.8	0.7	0.9	3.5	2.2	1	0	4	1	6	94.5	*1.5*
SM56M1	4-Jul-05 11:47	6-Jul-05 11:21	47.6	17.7	17.5	10.9	0.7	0.9	3.5	2.2	0	0	0	0	0	95.1	*0.0*
SM56C1	6-Jul-05 11:45	7-Jul-05 12:43	25.0	17.5	17.8	12.5	0.6	1.1	5.0	3.0	7	0	3	0	10	49.9	*4.8*
SM56C3	6-Jul-05 11:58	7-Jul-05 13:05	25.1	17.5	17.8	8.3	0.6	1.1	5.0	3.0	3	0	2	0	5	50.2	*2.4*
SM56C4	6-Jul-05 12:40	7-Jul-05 13:52	25.2	17.5	17.8	2.2	0.6	1.1	5.0	3.0	76	0	122	0	198	50.4	*94.3*
SM56D	6-Jul-05 12:54	7-Jul-05 14:39	25.8	17.5	17.8	2.7	0.6	1.1	5.0	3.0	85	0	15	0	100	51.5	*46.6*
SM56D1	6-Jul-05 13:07	7-Jul-05 15:09	26.0	17.5	17.8	4.5	0.6	1.1	5.0	3.0	8	0	6	0	14	52.1	*6.5*
SM56E1	6-Jul-05 13:21	7-Jul-05 15:31	26.2	17.5	17.8	5.6	0.6	1.1	5.0	3.0	6	0	4	0	10	52.3	*4.6*
SM56E1.5	6-Jul-05 13:40	7-Jul-05 15:52	26.2	17.5	17.8	3.8	0.6	1.1	5.0	3.0	3	0	2	0	5	52.4	*2.3*
SM56M1	6-Jul-05 11:31	7-Jul-05 11:58	24.5	17.5	17.8	9.2	0.6	1.1	5.0	3.0	15	0	31	0	46	48.9	*22.6*
SM56C1	7-Jul-05 12:58	11-Jul-05 11:58	95.0	17.8	18.4	12.3	0.5	1.0	4.5	3.5	0	0	0	0	0	190.0	*0.0*
SM56C3	7-Jul-05 13:24	11-Jul-05 12:33	95.2	17.8	18.4	6.1	0.5	1.0	4.5	3.5	0	0	0	0	0	190.3	*0.0*
SM56C4	7-Jul-05 14:34	11-Jul-05 12:44	94.2	17.8	18.4	2.1	0.5	1.0	4.5	3.5	22	0	19	0	41	188.3	*5.2*
SM56D	7-Jul-05 15:04	11-Jul-05 13:05	94.0	17.8	18.4	2.5	0.5	1.0	4.5	3.5	14	1	3	0	18	188.0	*2.3*
SM56D1	7-Jul-05 15:26	11-Jul-05 13:24	94.0	17.8	18.4	3.7	0.5	1.0	4.5	3.5	3	0	6	0	9	187.9	*1.1*

[a] See Figure 1.1 for sample locations.

Continued…

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Table A1 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56E1	7-Jul-05 15:48	11-Jul-05 13:39	93.8	17.8	18.4	3.2	0.5	1.0	4.5	3.5	4	0	5	0	9	187.7	*1.2*
SM56E1.5	7-Jul-05 16:18	11-Jul-05 13:54	93.6	17.8	18.4	3.8	0.5	1.0	4.5	3.5	4	0	2	0	6	187.2	*0.8*
SM56M1	7-Jul-05 12:38	11-Jul-05 11:40	95.0	17.8	18.4	10.7	0.5	1.0	4.5	3.5	1	0	0	0	1	190.1	*0.1*
SM56C1	11-Jul-05 12:06	13-Jul-05 11:49	47.7	18.4	18.2	14.7	0.5	0.8	4.5	4.0	0	0	0	0	0	95.4	*0.0*
SM56C3	11-Jul-05 12:41	13-Jul-05 12:28	47.8	18.4	18.2	5.7	0.5	0.8	4.5	4.0	0	0	0	0	0	95.6	*0.0*
SM56C4	11-Jul-05 13:02	13-Jul-05 12:41	47.6	18.4	18.2	1.6	0.5	0.8	4.5	4.0	0	0	0	0	0	95.3	*0.0*
SM56D	11-Jul-05 13:21	13-Jul-05 12:52	47.5	18.4	18.2	2.2	0.5	0.8	4.5	4.0	0	0	1	0	1	95.0	*0.3*
SM56D1	11-Jul-05 13:35	13-Jul-05 13:10	47.6	18.4	18.2	3.6	0.5	0.8	4.5	4.0	0	0	0	0	0	95.2	*0.0*
SM56E1	11-Jul-05 13:51	13-Jul-05 13:24	47.6	18.4	18.2	5.1	0.5	0.8	4.5	4.0	0	0	3	0	3	95.1	*0.8*
SM56E1.5	11-Jul-05 14:15	13-Jul-05 13:44	47.5	18.4	18.2	4.1	0.5	0.8	4.5	4.0	0	0	1	0	1	95.0	*0.3*
SM56M1	11-Jul-05 11:53	13-Jul-05 11:33	47.7	18.4	18.2	11.2	0.5	0.8	4.5	4.0	0	0	0	0	0	95.3	*0.0*
SM56C1	13-Jul-05 11:59	15-Jul-05 11:17	47.3	18.2	18.6	13.4	0.5	0.7	4.5	5.0	0	0	0	0	0	94.6	*0.0*
SM56C3	13-Jul-05 12:38	15-Jul-05 11:32	46.9	18.2	18.6	6.4	0.5	0.7	4.5	5.0	0	0	0	0	0	93.8	*0.0*
SM56C4	13-Jul-05 12:50	15-Jul-05 12:08	47.3	18.2	18.6	1.2	0.5	0.7	4.5	5.0	0	0	0	0	0	94.6	*0.0*
SM56D	13-Jul-05 13:07	15-Jul-05 12:20	47.2	18.2	18.6	1.6	0.5	0.7	4.5	5.0	29	0	15	0	44	94.4	*11.2*
SM56D1	13-Jul-05 13:20	15-Jul-05 12:47	47.4	18.2	18.6	1.9	0.5	0.7	4.5	5.0	1	0	1	0	2	94.9	*0.5*
SM56E1	13-Jul-05 13:41	15-Jul-05 13:17	47.6	18.2	18.6	6.3	0.5	0.7	4.5	5.0	1	0	2	0	3	95.2	*0.8*
SM56E1.5	13-Jul-05 14:03	15-Jul-05 13:40	47.6	18.2	18.6	4.1	0.5	0.7	4.5	5.0	1	0	2	0	3	95.2	*0.8*
SM56M1	13-Jul-05 11:46	15-Jul-05 10:55	47.2	18.2	18.6	11.2	0.5	0.7	4.5	5.0	0	0	1	0	1	94.3	*0.3*
SM56C1	15-Jul-05 11:30	19-Jul-05 11:20	95.8	18.6	19.6	13.6	0.4	1.0	5.0	3.0	0	0	5	0	5	191.7	*0.6*
SM56C3	15-Jul-05 11:44	19-Jul-05 11:36	95.9	18.6	19.6	6.1	0.4	1.0	5.0	3.0	0	0	0	0	0	191.7	*0.0*
SM56C4	15-Jul-05 12:17	19-Jul-05 12:20	96.0	18.6	19.6	1.1	0.4	1.0	5.0	3.0	0	0	0	0	0	192.1	*0.0*
SM56D	15-Jul-05 12:44	19-Jul-05 12:34	95.8	18.6	19.6	2.7	0.4	1.0	5.0	3.0	6	0	100	0	106	191.7	*13.3*
SM56D1	15-Jul-05 13:09	19-Jul-05 13:11	96.0	18.6	19.6	3.2	0.4	1.0	5.0	3.0	11	0	1	0	12	192.1	*1.5*
SM56E1	15-Jul-05 13:38	19-Jul-05 13:38	96.0	18.6	19.6	2.5	0.4	1.0	5.0	3.0	1	0	5	0	6	192.0	*0.8*
SM56E1.5	15-Jul-05 14:03	19-Jul-05 13:54	95.9	18.6	19.6	3.6	0.4	1.0	5.0	3.0	5	1	2	0	8	191.7	*1.0*
SM56M1	15-Jul-05 11:14	19-Jul-05 10:59	95.8	18.6	19.6	8.5	0.4	1.0	5.0	3.0	1	0	3	0	4	191.5	*0.5*
SM56C1	19-Jul-05 11:31	23-Jul-05 12:01	96.5	19.6	19.7	7.5	0.4	0.6	4.3	3.7	0	0	0	0	0	193.0	*0.0*
SM56C3	19-Jul-05 11:46	23-Jul-05 12:37	96.8	19.6	19.7	4.8	0.4	0.6	4.3	3.7	0	0	0	0	0	193.7	*0.0*

[a] See Figure 1.1 for sample locations.

Continued…

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Table A1 Concluded.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C4	19-Jul-05 12:29	23-Jul-05 12:52	96.4	19.6	19.7	1.4	0.4	0.6	4.3	3.7	0	0	1	0	1	192.8	*0.1*
SM56D	19-Jul-05 13:06	23-Jul-05 13:02	95.9	19.6	19.7	1.6	0.4	0.6	4.3	3.7	0	0	0	0	0	191.9	*0.0*
SM56D1	19-Jul-05 13:33	23-Jul-05 13:22	95.8	19.6	19.7	1.7	0.4	0.6	4.3	3.7	0	0	0	0	0	191.6	*0.0*
SM56E1	19-Jul-05 13:51	23-Jul-05 13:34	95.7	19.6	19.7	4.8	0.4	0.6	4.3	3.7	0	0	0	0	0	191.4	*0.0*
SM56E1.5	19-Jul-05 14:09	23-Jul-05 13:50	95.7	19.6	19.7	2.9	0.4	0.6	4.3	3.7	0	0	0	0	0	191.4	*0.0*
SM56M1	19-Jul-05 11:15	23-Jul-05 11:43	96.5	19.6	19.7	9.6	0.4	0.6	4.3	3.7	0	0	0	0	0	192.9	*0.0*
SM56C1	23-Jul-05 12:10	27-Jul-05 12:07	96.0	19.7	20.7	9.8	0.4	0.7	6.0	4.0	0	0	0	0	0	191.9	*0.0*
SM56C3	23-Jul-05 12:48	27-Jul-05 12:53	96.1	19.7	20.7	7.3	0.4	0.7	6.0	4.0	0	0	0	0	0	192.2	*0.0*
SM56C4	23-Jul-05 13:00	27-Jul-05 13:08	96.1	19.7	20.7	0.8	0.4	0.7	6.0	4.0	0	0	0	0	0	192.3	*0.0*
SM56D	23-Jul-05 13:18	27-Jul-05 13:28	96.2	19.7	20.7	1.9	0.4	0.7	6.0	4.0	0	0	0	0	0	192.3	*0.0*
SM56D1	23-Jul-05 13:31	27-Jul-05 13:42	96.2	19.7	20.7	1.4	0.4	0.7	6.0	4.0	0	0	0	0	0	192.4	*0.0*
SM56E1	23-Jul-05 13:44	27-Jul-05 14:00	96.3	19.7	20.7	3.7	0.4	0.7	6.0	4.0	0	0	0	0	0	192.5	*0.0*
SM56E1.5	23-Jul-05 14:06	27-Jul-05 14:13	96.1	19.7	20.7	3.2	0.4	0.7	6.0	4.0	0	0	0	0	0	192.2	*0.0*
SM56M1	23-Jul-05 11:57	27-Jul-05 11:48	95.9	19.7	20.7	8.7	0.4	0.7	6.0	4.0	0	0	0	0	0	191.7	*0.0*
SM56C1	27-Jul-05 12:19	29-Jul-05 11:47	47.5	20.7	20.7	11.5	0.4	0.5	5.0	4.5	0	0	0	0	0	94.9	*0.0*
SM56C3	27-Jul-05 13:05	29-Jul-05 11:56	46.8	20.7	20.7	6.7	0.4	0.5	5.0	4.5	0	0	0	0	0	93.7	*0.0*
SM56C4	27-Jul-05 13:26	29-Jul-05 12:33	47.1	20.7	20.7	2.0	0.4	0.5	5.0	4.5	0	0	0	0	0	94.2	*0.0*
SM56D	27-Jul-05 13:38	29-Jul-05 12:54	47.3	20.7	20.7	1.8	0.4	0.5	5.0	4.5	0	0	0	0	0	94.5	*0.0*
SM56D1	27-Jul-05 13:57	29-Jul-05 13:04	47.1	20.7	20.7	0.9	0.4	0.5	5.0	4.5	0	0	0	0	0	94.2	*0.0*
SM56E1	27-Jul-05 14:10	29-Jul-05 13:38	47.5	20.7	20.7	3.1	0.4	0.5	5.0	4.5	0	0	0	0	0	94.9	*0.0*
SM56E1.5	27-Jul-05 14:23	29-Jul-05 13:47	47.4	20.7	20.7	4.2	0.4	0.5	5.0	4.5	0	0	0	0	0	94.8	*0.0*
SM56M1	27-Jul-05 12:04	29-Jul-05 11:36	47.5	20.7	20.7	10.2	0.4	0.5	5.0	4.5	0	0	0	0	0	95.1	*0.0*

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Concluded.

Table A2 Summary of white sturgeon eggs and larvae captured by egg mats at individual sample stations in the Waneta area, 28 May to 28 July 2003.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C1	1-Jun-05 11:07	3-Jun-05 12:25	49.3	14.0	15.0	11.5	0.5	1.0	4.0	3.0	0	0	0	0	0	98.6	*0.0*
	3-Jun-05 12:36	6-Jun-05 12:06	71.5	15.0	15.5	11.5	1.0	0.7	2.5	3.5	0	0	0	0	0	143.0	*0.0*
	6-Jun-05 12:18	10-Jun-05 11:46	95.5	15.5	14.0	9.8	0.5	0.8	4.5	2.5	0	0	0	0	0	190.9	*0.0*
	10-Jun-05 11:57	14-Jun-05 11:17	95.3	14.0	14.0	n/a	0.5	3.0	6.0	2.3	0	0	0	0	0	190.7	*0.0*
	14-Jun-05 11:28	17-Jun-05 11:41	72.2	14.0	14.0	n/a	0.5	1.2	4.5	3.0	0	0	0	0	0	144.4	*0.0*
	17-Jun-05 11:53	21-Jun-05 13:23	97.5	14.0	14.9	8.9	0.6	1.0	3.5	2.8	0	0	0	0	0	195.0	*0.0*
	21-Jun-05 13:31	23-Jun-05 11:58	46.5	14.9	15.6	12.2	0.5	1.4	5.0	2.9	0	0	0	0	0	92.9	*0.0*
	23-Jun-05 12:10	24-Jun-05 11:18	23.1	15.6	16.0	10.7	0.5	1.2	4.6	3.0	0	0	0	0	0	46.3	*0.0*
	24-Jun-05 11:34	27-Jun-05 09:58	70.4	16.0	16.6	12.3	0.6	1.2	3.5	2.8	0	0	2	0	2	140.8	*0.3*
	27-Jun-05 10:10	29-Jun-05 11:39	49.5	16.6	16.6	n/a	0.6	1.0	4.0	3.0	1	0	1	0	2	99.0	*0.5*
	29-Jun-05 11:53	2-Jul-05 11:25	71.5	16.6	17.4	12.5	0.6	1.0	5.5	3.5	5	0	11	0	16	143.1	*2.7*
	2-Jul-05 11:44	4-Jul-05 11:51	48.1	17.4	17.7	9.3	0.4	0.9	4.3	2.8	0	0	0	0	0	96.2	*0.0*
	4-Jul-05 12:00	6-Jul-05 11:36	47.6	17.7	17.5	12.6	0.7	0.9	3.5	2.2	0	0	0	0	0	95.2	*0.0*
	6-Jul-05 11:45	7-Jul-05 12:43	25.0	17.5	17.8	12.5	0.6	1.1	5.0	3.0	7	0	3	0	10	49.9	*4.8*
	7-Jul-05 12:58	11-Jul-05 11:58	95.0	17.8	18.4	12.3	0.5	1.0	4.5	3.5	0	0	0	0	0	190.0	*0.0*
	11-Jul-05 12:06	13-Jul-05 11:49	47.7	18.4	18.2	14.7	0.5	0.8	4.5	4.0	0	0	0	0	0	95.4	*0.0*
	13-Jul-05 11:59	15-Jul-05 11:17	47.3	18.2	18.6	13.4	0.5	0.7	4.5	5.0	0	0	0	0	0	94.6	*0.0*
	15-Jul-05 11:30	19-Jul-05 11:20	95.8	18.6	19.6	13.6	0.4	1.0	5.0	3.0	0	0	5	0	5	191.7	*0.6*
	19-Jul-05 11:31	23-Jul-05 12:01	96.5	19.6	19.7	7.5	0.4	0.6	4.3	3.7	0	0	0	0	0	193.0	*0.0*
	23-Jul-05 12:10	27-Jul-05 12:07	96.0	19.7	20.7	9.8	0.4	0.7	6.0	4.0	0	0	0	0	0	191.9	*0.0*
	27-Jul-05 12:19	29-Jul-05 11:47	47.5	20.7	20.7	11.5	0.4	0.5	5.0	4.5	0	0	0	0	0	94.9	*0.0*
Total SM56C1			**1388.8**								**13**	**0**	**22**	**0**	**35**	**2777.5**	***0.3***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Continued…

Table A2 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C3	1-Jun-05 11:17	3-Jun-05 12:41	49.4	14.0	15.0	8.4	0.5	1.0	4.0	3.0	0	0	0	0	0	98.8	*0.0*
	3-Jun-05 12:51	6-Jun-05 12:43	71.9	15.0	15.5	5.6	1.0	0.7	2.5	3.5	0	0	0	0	0	143.7	*0.0*
	6-Jun-05 12:56	10-Jun-05 12:02	95.1	15.5	14.0	4.0	0.5	0.8	4.5	2.5	0	0	0	0	0	190.2	*0.0*
	10-Jun-05 12:15	14-Jun-05 11:31	95.3	14.0	14.0	n/a	0.5	3.0	6.0	2.3	0	0	0	0	0	190.5	*0.0*
	14-Jun-05 11:40	17-Jun-05 11:57	72.3	14.0	14.0	5.8	0.5	1.2	4.5	3.0	0	0	0	0	0	144.6	*0.0*
	17-Jun-05 12:05	21-Jun-05 13:35	97.5	14.0	14.9	5.9	0.6	1.0	3.5	2.8	0	0	0	0	0	195.0	*0.0*
	21-Jun-05 13:44	23-Jun-05 12:13	46.5	14.9	15.6	5.2	0.5	1.4	5.0	2.9	0	0	0	0	0	93.0	*0.0*
	23-Jun-05 12:23	24-Jun-05 11:36	23.2	15.6	16.0	3.8	0.5	1.2	4.6	3.0	0	0	0	0	0	46.4	*0.0*
	24-Jun-05 11:46	27-Jun-05 10:15	70.5	16.0	16.6	2.6	0.6	1.2	3.5	2.8	0	0	1	0	1	141.0	*0.2*
	27-Jun-05 10:26	29-Jun-05 11:57	49.5	16.6	16.6	4.4	0.6	1.0	4.0	3.0	1	0	6	0	7	99.0	*1.7*
	29-Jun-05 12:11	2-Jul-05 11:49	71.6	16.6	17.4	8.1	0.6	1.0	5.5	3.5	5	0	12	0	17	143.3	*2.8*
	2-Jul-05 12:04	4-Jul-05 12:03	48.0	17.4	17.7	5.2	0.4	0.9	4.3	2.8	1	0	1	0	2	96.0	*0.5*
	4-Jul-05 12:17	6-Jul-05 11:48	47.5	17.7	17.5	8.1	0.7	0.9	3.5	2.2	0	0	0	0	0	95.0	*0.0*
	6-Jul-05 11:58	7-Jul-05 13:05	25.1	17.5	17.8	8.3	0.6	1.1	5.0	3.0	3	0	2	0	5	50.2	*2.4*
	7-Jul-05 13:24	11-Jul-05 12:33	95.2	17.8	18.4	6.1	0.5	1.0	4.5	3.5	0	0	0	0	0	190.3	*0.0*
	11-Jul-05 12:41	13-Jul-05 12:28	47.8	18.4	18.2	5.7	0.5	0.8	4.5	4.0	0	0	0	0	0	95.6	*0.0*
	13-Jul-05 12:38	15-Jul-05 11:32	46.9	18.2	18.6	6.4	0.5	0.7	4.5	5.0	0	0	0	0	0	93.8	*0.0*
	15-Jul-05 11:44	19-Jul-05 11:36	95.9	18.6	19.6	6.1	0.4	1.0	5.0	3.0	0	0	0	0	0	191.7	*0.0*
	19-Jul-05 11:46	23-Jul-05 12:37	96.8	19.6	19.7	4.8	0.4	0.6	4.3	3.7	0	0	0	0	0	193.7	*0.0*
	23-Jul-05 12:48	27-Jul-05 12:53	96.1	19.7	20.7	7.3	0.4	0.7	6.0	4.0	0	0	0	0	0	192.2	*0.0*
	27-Jul-05 13:05	29-Jul-05 11:56	46.8	20.7	20.7	6.7	0.4	0.5	5.0	4.5	0	0	0	0	0	93.7	*0.0*
Total SM56C3			**1388.8**								**10**	**0**	**22**	**0**	**32**	**2777.7**	***0.3***

[a] See Figure 1.1 for sample locations.

Continued…

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Table A2 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56C4	1-Jun-05 11:26	3-Jun-05 12:57	49.5	14.0	15.0	2.3	0.5	1.0	4.0	3.0	0	0	0	0	0	99.0	*0.0*
	3-Jun-05 13:17	6-Jun-05 13:00	71.7	15.0	15.5	n/a	1.0	0.7	2.5	3.5	0	0	0	0	0	143.4	*0.0*
	6-Jun-05 13:13	10-Jun-05 12:45	95.5	15.5	14.0	2.1	0.5	0.8	4.5	2.5	0	0	0	0	0	191.1	*0.0*
	10-Jun-05 12:58	14-Jun-05 11:44	94.8	14.0	14.0	n/a	0.5	3.0	6.0	2.3	0	0	0	0	0	189.5	*0.0*
	14-Jun-05 11:54	17-Jun-05 12:36	72.7	14.0	14.0	1.9	0.5	1.2	4.5	3.0	0	0	0	0	0	145.4	*0.0*
	17-Jun-05 12:48	21-Jun-05 13:46	97.0	14.0	14.9	1.7	0.6	1.0	3.5	2.8	0	0	0	0	0	193.9	*0.0*
	21-Jun-05 13:50	23-Jun-05 12:56	47.1	14.9	15.6	1.9	0.5	1.4	5.0	2.9	119	0	165	0	284	94.2	*72.4*
	23-Jun-05 14:13	24-Jun-05 11:50	21.6	15.6	16.0	1.7	0.5	1.2	4.6	3.0	173	0	406	0	579	43.2	*321.4*
	24-Jun-05 13:00	27-Jun-05 10:29	69.5	16.0	16.6	2.3	0.6	1.2	3.5	2.8	132	0	248	0	380	139.0	*65.6*
	27-Jun-05 11:16	29-Jun-05 12:45	49.5	16.6	16.6	1.5	0.6	1.0	4.0	3.0	41	0	20	0	61	99.0	*14.8*
	29-Jun-05 13:04	2-Jul-05 12:36	71.5	16.6	17.4	2.1	0.6	1.0	5.5	3.5	85	0	820	0	905	143.1	*151.8*
	2-Jul-05 13:38	4-Jul-05 12:54	47.3	17.4	17.7	1.7	0.4	0.9	4.3	2.8	7	0	0	0	7	94.5	*1.8*
	4-Jul-05 13:04	6-Jul-05 12:30	47.4	17.7	17.5	1.7	0.7	0.9	3.5	2.2	0	0	3	0	3	94.9	*0.8*
	6-Jul-05 12:40	7-Jul-05 13:52	25.2	17.5	17.8	2.2	0.6	1.1	5.0	3.0	76	0	122	0	198	50.4	*94.3*
	7-Jul-05 14:34	11-Jul-05 12:44	94.2	17.8	18.4	2.1	0.5	1.0	4.5	3.5	22	0	19	0	41	188.3	*5.2*
	11-Jul-05 13:02	13-Jul-05 12:41	47.6	18.4	18.2	1.6	0.5	0.8	4.5	4.0	0	0	0	0	0	95.3	*0.0*
	13-Jul-05 12:50	15-Jul-05 12:08	47.3	18.2	18.6	1.2	0.5	0.7	4.5	5.0	0	0	0	0	0	94.6	*0.0*
	15-Jul-05 12:17	19-Jul-05 12:20	96.0	18.6	19.6	1.1	0.4	1.0	5.0	3.0	0	0	0	0	0	192.1	*0.0*
	19-Jul-05 12:29	23-Jul-05 12:52	96.4	19.6	19.7	1.4	0.4	0.6	4.3	3.7	0	0	1	0	1	192.8	*0.1*
	23-Jul-05 13:00	27-Jul-05 13:08	96.1	19.7	20.7	0.8	0.4	0.7	6.0	4.0	0	0	0	0	0	192.3	*0.0*
	27-Jul-05 13:26	29-Jul-05 12:33	47.1	20.7	20.7	2.0	0.4	0.5	5.0	4.5	0	0	0	0	0	94.2	*0.0*
Total SM56C4			**1385.1**								**655**	**0**	**1804**	**0**	**2459**	**2770.2**	***21.3***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Continued…

Table A2 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56D	1-Jun-05 12:05	4-Jun-05 13:20	73.3	14.0	15.0	3.0	0.5	1.0	4.0	3.0	0	0	0	0	0	146.5	*0.0*
	4-Jun-05 13:36	6-Jun-05 13:16	47.7	15.0	15.5	3.3	1.0	0.7	2.5	3.5	0	0	0	0	0	95.3	*0.0*
	6-Jun-05 13:27	10-Jun-05 13:00	95.5	15.5	14.0	2.9	0.5	0.8	4.5	2.5	0	0	0	0	0	191.1	*0.0*
	10-Jun-05 13:10	14-Jun-05 12:24	95.2	14.0	14.0	n/a	0.5	3.0	6.0	2.3	0	0	0	0	0	190.5	*0.0*
	14-Jun-05 12:33	17-Jun-05 12:51	72.3	14.0	14.0	2.6	0.5	1.2	4.5	3.0	0	0	0	0	0	144.6	*0.0*
	17-Jun-05 13:02	21-Jun-05 13:57	96.9	14.0	14.9	2.0	0.6	1.0	3.5	2.8	0	0	0	0	0	193.8	*0.0*
	21-Jun-05 14:07	23-Jun-05 14:15	48.1	14.9	15.6	2.7	0.5	1.4	5.0	2.9	30	0	107	0	137	96.3	*34.2*
	23-Jun-05 15:05	24-Jun-05 13:34	22.5	15.6	16.0	2.5	0.5	1.2	4.6	3.0	174	0	30	0	204	45.0	*108.9*
	24-Jun-05 14:05	27-Jun-05 11:43	69.6	16.0	16.6	2.3	0.6	1.2	3.5	2.8	38	0	53	0	91	139.3	*15.7*
	27-Jun-05 12:07	29-Jun-05 13:08	49.0	16.6	16.6	2.7	0.6	1.0	4.0	3.0	31	0	21	0	52	98.0	*12.7*
	29-Jun-05 13:29	2-Jul-05 13:42	72.2	16.6	17.4	3.6	0.6	1.0	5.5	3.5	212	0	105	0	317	144.4	*52.7*
	2-Jul-05 14:16	4-Jul-05 13:07	46.8	17.4	17.7	2.4	0.4	0.9	4.3	2.8	3	0	7	0	10	93.7	*2.6*
	4-Jul-05 13:20	6-Jul-05 12:44	47.4	17.7	17.5	2.6	0.7	0.9	3.5	2.2	0	0	0	1	1	94.8	*0.3*
	6-Jul-05 12:54	7-Jul-05 14:39	25.8	17.5	17.8	2.7	0.6	1.1	5.0	3.0	85	0	15	0	100	51.5	*46.6*
	7-Jul-05 15:04	11-Jul-05 13:05	94.0	17.8	18.4	2.5	0.5	1.0	4.5	3.5	14	1	3	0	18	188.0	*2.3*
	11-Jul-05 13:21	13-Jul-05 12:52	47.5	18.4	18.2	2.2	0.5	0.8	4.5	4.0	0	0	1	0	1	95.0	*0.3*
	13-Jul-05 13:07	15-Jul-05 12:20	47.2	18.2	18.6	1.6	0.5	0.7	4.5	5.0	29	0	15	0	44	94.4	*11.2*
	15-Jul-05 12:44	19-Jul-05 12:34	95.8	18.6	19.6	2.7	0.4	1.0	5.0	3.0	6	0	100	0	106	191.7	*13.3*
	19-Jul-05 13:06	23-Jul-05 13:02	95.9	19.6	19.7	1.6	0.4	0.6	4.3	3.7	0	0	0	0	0	191.9	*0.0*
	23-Jul-05 13:18	27-Jul-05 13:28	96.2	19.7	20.7	1.9	0.4	0.7	6.0	4.0	0	0	0	0	0	192.3	*0.0*
	27-Jul-05 13:38	29-Jul-05 12:54	47.3	20.7	20.7	1.8	0.4	0.5	5.0	4.5	0	0	0	0	0	94.5	*0.0*
Total SM56D			**1386.4**								**622**	**1**	**457**	**1**	**1081**	**2772.7**	***9.4***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Continued…

Table A2 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56D1	1-Jun-05 12:12	3-Jun-05 13:40	49.5	14.0	15.0	4.1	0.5	1.0	4.0	3.0	0	0	0	0	0	98.9	*0.00*
	3-Jun-05 13:53	6-Jun-05 13:38	71.8	15.0	15.5	3.2	1.0	0.7	2.5	3.5	0	0	0	0	0	143.5	*0.00*
	6-Jun-05 13:44	10-Jun-05 13:13	95.5	15.5	14.0	3.1	0.5	0.8	4.5	2.5	0	0	0	0	0	191.0	*0.00*
	10-Jun-05 13:25	14-Jun-05 12:36	95.2	14.0	14.0	4.4	0.5	3.0	6.0	2.3	0	0	0	0	0	190.4	*0.00*
	14-Jun-05 12:45	17-Jun-05 13:06	72.3	14.0	14.0	4.9	0.5	1.2	4.5	3.0	0	0	0	0	0	144.7	*0.00*
	17-Jun-05 13:16	21-Jun-05 14:10	96.9	14.0	14.9	3.9	0.6	1.0	3.5	2.8	0	0	0	0	0	193.8	*0.00*
	21-Jun-05 14:18	23-Jun-05 15:03	48.8	14.9	15.6	3.4	0.5	1.4	5.0	2.9	59	0	6	0	65	97.5	*16.00*
	23-Jun-05 15:38	24-Jun-05 14:10	22.5	15.6	16.0	3.0	0.5	1.2	4.6	3.0	27	0	31	0	58	45.1	*30.89*
	24-Jun-05 14:33	27-Jun-05 12:11	69.6	16.0	16.6	2.6	0.6	1.2	3.5	2.8	14	0	12	0	26	139.3	*4.48*
	27-Jun-05 12:31	29-Jun-05 13:32	49.0	16.6	16.6	3.8	0.6	1.0	4.0	3.0	9	0	9	0	18	98.0	*4.41*
	29-Jun-05 13:49	2-Jul-05 14:40	72.8	16.6	17.4	3.7	0.6	1.0	5.5	3.5	182	0	42	0	224	145.7	*36.90*
	2-Jul-05 14:51	4-Jul-05 13:24	46.5	17.4	17.7	3.3	0.4	0.9	4.3	2.8	3	0	2	0	5	93.1	*1.29*
	4-Jul-05 13:34	6-Jul-05 12:57	47.4	17.7	17.5	3.5	0.7	0.9	3.5	2.2	0	0	3	0	3	94.8	*0.76*
	6-Jul-05 13:07	7-Jul-05 15:09	26.0	17.5	17.8	4.5	0.6	1.1	5.0	3.0	8	0	6	0	14	52.1	*6.45*
	7-Jul-05 15:26	11-Jul-05 13:24	94.0	17.8	18.4	3.7	0.5	1.0	4.5	3.5	3	0	6	0	9	187.9	*1.15*
	11-Jul-05 13:35	13-Jul-05 13:10	47.6	18.4	18.2	3.6	0.5	0.8	4.5	4.0	0	0	0	0	0	95.2	*0.00*
	13-Jul-05 13:20	15-Jul-05 12:47	47.4	18.2	18.6	1.9	0.5	0.7	4.5	5.0	1	0	1	0	2	94.9	*0.51*
	15-Jul-05 13:09	19-Jul-05 13:11	96.0	18.6	19.6	3.2	0.4	1.0	5.0	3.0	11	0	1	0	12	192.1	*1.50*
	19-Jul-05 13:33	23-Jul-05 13:22	95.8	19.6	19.7	1.7	0.4	0.6	4.3	3.7	0	0	0	0	0	191.6	*0.00*
	23-Jul-05 13:31	27-Jul-05 13:42	96.2	19.7	20.7	1.4	0.4	0.7	6.0	4.0	0	0	0	0	0	192.4	*0.00*
	27-Jul-05 13:57	29-Jul-05 13:04	47.1	20.7	20.7	0.9	0.4	0.5	5.0	4.5	0	0	0	0	0	94.2	*0.00*
Total SM56D1			**1388.0**								**317**	**0**	**119**	**0**	**436**	**2776.1**	***3.77***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Continued…

Table A2 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56E1	1-Jun-05 12:22	3-Jun-05 13:57	49.6	14.0	15.0	6.3	0.5	1.0	4.0	3.0	0	0	0	0	0	99.2	*0.0*
	3-Jun-05 14:08	6-Jun-05 13:47	71.7	15.0	15.5	3.3	1.0	0.7	2.5	3.5	0	0	0	0	0	143.3	*0.0*
	6-Jun-05 13:58	10-Jun-05 13:30	95.5	15.5	14.0	5.1	0.5	0.8	4.5	2.5	0	0	0	0	0	191.1	*0.0*
	10-Jun-05 13:41	14-Jun-05 12:49	95.1	14.0	14.0	5.0	0.5	3.0	6.0	2.3	0	0	0	0	0	190.3	*0.0*
	14-Jun-05 12:59	17-Jun-05 13:20	72.3	14.0	14.0	3.1	0.5	1.2	4.5	3.0	0	0	0	0	0	144.7	*0.0*
	17-Jun-05 13:32	21-Jun-05 14:24	96.9	14.0	14.9	3.5	0.6	1.0	3.5	2.8	0	0	0	0	0	193.7	*0.0*
	21-Jun-05 14:35	23-Jun-05 15:42	49.1	14.9	15.6	5.6	0.5	1.4	5.0	2.9	9	0	19	0	28	98.2	*6.8*
	23-Jun-05 16:04	24-Jun-05 14:37	22.5	15.6	16.0	2.2	0.5	1.2	4.6	3.0	19	0	67	0	86	45.1	*45.8*
	24-Jun-05 15:06	27-Jun-05 12:34	69.5	16.0	16.6	3.1	0.6	1.2	3.5	2.8	24	0	8	0	32	138.9	*5.5*
	27-Jun-05 12:55	29-Jun-05 13:53	49.0	16.6	16.6	4.2	0.6	1.0	4.0	3.0	9	0	2	0	11	97.9	*2.7*
	29-Jun-05 14:08	2-Jul-05 14:54	72.8	16.6	17.4	3.3	0.6	1.0	5.5	3.5	18	0	37	0	55	145.5	*9.1*
	2-Jul-05 15:15	4-Jul-05 13:38	46.4	17.4	17.7	4.7	0.4	0.9	4.3	2.8	2	0	7	1	10	92.8	*2.6*
	4-Jul-05 13:51	6-Jul-05 13:11	47.3	17.7	17.5	3.3	0.7	0.9	3.5	2.2	0	0	3	0	3	94.7	*0.8*
	6-Jul-05 13:21	7-Jul-05 15:31	26.2	17.5	17.8	5.6	0.6	1.1	5.0	3.0	6	0	4	0	10	52.3	*4.6*
	7-Jul-05 15:48	11-Jul-05 13:39	93.8	17.8	18.4	3.2	0.5	1.0	4.5	3.5	4	0	5	0	9	187.7	*1.2*
	11-Jul-05 13:51	13-Jul-05 13:24	47.6	18.4	18.2	5.1	0.5	0.8	4.5	4.0	0	0	3	0	3	95.1	*0.8*
	13-Jul-05 13:41	15-Jul-05 13:17	47.6	18.2	18.6	6.3	0.5	0.7	4.5	5.0	1	0	2	0	3	95.2	*0.8*
	15-Jul-05 13:38	19-Jul-05 13:38	96.0	18.6	19.6	2.5	0.4	1.0	5.0	3.0	1	0	5	0	6	192.0	*0.8*
	19-Jul-05 13:51	23-Jul-05 13:34	95.7	19.6	19.7	4.8	0.4	0.6	4.3	3.7	0	0	0	0	0	191.4	*0.0*
	23-Jul-05 13:44	27-Jul-05 14:00	96.3	19.7	20.7	3.7	0.4	0.7	6.0	4.0	0	0	0	0	0	192.5	*0.0*
	27-Jul-05 14:10	29-Jul-05 13:38	47.5	20.7	20.7	3.1	0.4	0.5	5.0	4.5	0	0	0	0	0	94.9	*0.0*
Total SM56E1			**1388.3**								**93**	**0**	**162**	**1**	**256**	**2776.6**	***2.2***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Continued…

Table A2 Continued.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56E1.5	1-Jun-05 12:44	3-Jun-05 14:12	49.5	14.0	15.0	3.3	0.5	1.0	4.0	3.0	0	0	0	0	0	98.9	*0.0*
	3-Jun-05 14:12	6-Jun-05 14:01	71.8	15.0	15.5	3.7	1.0	0.7	2.5	3.5	0	0	0	0	0	143.6	*0.0*
	6-Jun-05 14:11	10-Jun-05 13:46	95.6	15.5	14.0	3.8	0.5	0.8	4.5	2.5	0	0	0	0	0	191.2	*0.0*
	10-Jun-05 13:54	14-Jun-05 13:02	95.1	14.0	14.0	4.0	0.5	3.0	6.0	2.3	0	0	0	0	0	190.3	*0.0*
	14-Jun-05 13:13	17-Jun-05 13:36	72.4	14.0	14.0	4.4	0.5	1.2	4.5	3.0	0	0	0	0	0	144.8	*0.0*
	17-Jun-05 13:46	21-Jun-05 14:38	96.9	14.0	14.9	3.5	0.6	1.0	3.5	2.8	0	0	0	0	0	193.7	*0.0*
	21-Jun-05 14:48	23-Jun-05 16:06	49.3	14.9	15.6	3.6	0.5	1.4	5.0	2.9	1	0	2	0	3	98.6	*0.7*
	23-Jun-05 16:22	24-Jun-05 15:10	22.8	15.6	16.0	4.3	0.5	1.2	4.6	3.0	17	0	32	0	49	45.6	*25.8*
	24-Jun-05 15:32	27-Jun-05 12:58	69.4	16.0	16.6	3.8	0.6	1.2	3.5	2.8	10	0	8	0	18	138.9	*3.1*
	27-Jun-05 13:49	29-Jun-05 14:12	48.4	16.6	16.6	4.0	0.6	1.0	4.0	3.0	3	0	2	0	5	96.8	*1.2*
	29-Jun-05 14:45	2-Jul-05 15:20	72.6	16.6	17.4	4.2	0.6	1.0	5.5	3.5	18	0	31	0	49	145.2	*8.1*
	2-Jul-05 15:37	4-Jul-05 13:55	46.3	17.4	17.7	4.1	0.4	0.9	4.3	2.8	3	0	0	0	3	92.6	*0.8*
	4-Jul-05 14:08	6-Jul-05 13:23	47.3	17.7	17.5	3.8	0.7	0.9	3.5	2.2	1	0	4	1	6	94.5	*1.5*
	6-Jul-05 13:40	7-Jul-05 15:52	26.2	17.5	17.8	3.8	0.6	1.1	5.0	3.0	3	0	2	0	5	52.4	*2.3*
	7-Jul-05 16:18	11-Jul-05 13:54	93.6	17.8	18.4	3.8	0.5	1.0	4.5	3.5	4	0	2	0	6	187.2	*0.8*
	11-Jul-05 14:15	13-Jul-05 13:44	47.5	18.4	18.2	4.1	0.5	0.8	4.5	4.0	0	0	1	0	1	95.0	*0.3*
	13-Jul-05 14:03	15-Jul-05 13:40	47.6	18.2	18.6	4.1	0.5	0.7	4.5	5.0	1	0	2	0	3	95.2	*0.8*
	15-Jul-05 14:03	19-Jul-05 13:54	95.9	18.6	19.6	3.6	0.4	1.0	5.0	3.0	5	1	2	0	8	191.7	*1.0*
	19-Jul-05 14:09	23-Jul-05 13:50	95.7	19.6	19.7	2.9	0.4	0.6	4.3	3.7	0	0	0	0	0	191.4	*0.0*
	23-Jul-05 14:06	27-Jul-05 14:13	96.1	19.7	20.7	3.2	0.4	0.7	6.0	4.0	0	0	0	0	0	192.2	*0.0*
	27-Jul-05 14:23	29-Jul-05 13:47	47.4	20.7	20.7	4.2	0.4	0.5	5.0	4.5	0	0	0	0	0	94.8	*0.0*
Total SM56E1.5			**1387.3**								**66**	**1**	**88**	**1**	**156**	**2774.5**	***1.3***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Continued…

Table A2 Concluded.

Station[a]	Date and Time		Set Duration (h)	Water Temp.		Mat Depth (m)	Turbidity (NTU)		Secchi Depth (m)		Catch				Total Catch	Sampling Effort[b] (mat-hours)	CPUE Per Station (Total catch/ 24 mat-hours)
											Mat 1		Mat 2				
	Set	Pull		Set (°C)	Pull (°C)		Columbia River	Pend d'Oreille River	Columbia River	Pend d'Oreille River	No. Eggs	No. Larvae	No. Eggs	No. Larvae			
SM56M1	21-Jun-05 12:55	23-Jun-05 16:34	51.7	14.9	15.6	10.3	0.5	1.4	5.0	2.9	4	0	4	0	8	103.3	*1.9*
	23-Jun-05 17:39	24-Jun-05 15:43	22.1	15.6	16.0	10.5	0.5	1.2	4.6	3.0	101	0	142	0	243	44.1	*132.1*
	24-Jun-05 16:51	38530.4	64.6	16.0	16.6	13.5	0.6	1.2	3.5	2.8	3	0	6	0	9	129.1	1.7
	27-Jun-05 09:54	38532.5	50.1	16.6	16.6	n/a	0.6	1.0	4.0	3.0	9	0	11	0	20	100.1	4.8
	29-Jun-05 11:34	38535.5	71.4	16.6	17.4	9.1	0.6	1.0	5.5	3.5	16	0	17	0	33	142.7	5.5
	2-Jul-05 11:20	38537.5	48.3	17.4	17.7	9.7	0.4	0.9	4.3	2.8	0	0	0	0	0	96.5	0.0
	4-Jul-05 11:47	38539.5	47.6	17.7	17.5	10.9	0.7	0.9	3.5	2.2	0	0	0	0	0	95.1	0.0
	6-Jul-05 11:31	38540.5	24.5	17.5	17.8	9.2	0.6	1.1	5.0	3.0	15	0	31	0	46	48.9	22.6
	7-Jul-05 12:38	38544.5	95.0	17.8	18.4	10.7	0.5	1.0	4.5	3.5	1	0	0	0	1	190.1	0.1
	11-Jul-05 11:53	38546.5	47.7	18.4	18.2	11.2	0.5	0.8	4.5	4.0	0	0	0	0	0	95.3	0.0
	13-Jul-05 11:46	15-Jul-05 10:55	47.2	18.2	18.6	11.2	0.5	0.7	4.5	5.0	0	0	1	0	1	94.3	*0.3*
	15-Jul-05 11:14	19-Jul-05 10:59	95.8	18.6	19.6	8.5	0.4	1.0	5.0	3.0	1	0	3	0	4	191.5	*0.5*
	19-Jul-05 11:15	23-Jul-05 11:43	96.5	19.6	19.7	9.6	0.4	0.6	4.3	3.7	0	0	0	0	0	192.9	*0.0*
	23-Jul-05 11:57	27-Jul-05 11:48	95.9	19.7	20.7	8.7	0.4	0.7	6.0	4.0	0	0	0	0	0	191.7	*0.0*
	27-Jul-05 12:04	29-Jul-05 11:36	47.5	20.7	20.7	10.2	0.4	0.5	5.0	4.5	0	0	0	0	0	95.1	*0.0*
Total SM56M1			**905.4**								**150**	**0**	**215**	**0**	**365**	**1810.8**	***4.8***

[a] See Figure 1.1 for sample locations.

[b] Calculated by multiplying the number of mats set at each station (usually two) by the set duration.

[c] n/a indicates the data was unavailable.

Concluded.

Table A3 Developmental stages of white sturgeon eggs collected in the Waneta area, 28 May to 28 July 2004.

Date	Site[a]	Number of Eggs Preserved and Examined	Egg Developmental Category (Stage)[b]																
			Unfertilized or Fungused Eggs	Post Fert 12	Early Cleavage 13	Early Cleavage 14	Early Cleavage 15	Early Cleavage 16	Late Cleavage 17	Late Cleavage 18	Late Epithelial (19)	Early Gastrulation (20)	Early Yolk Plug (21)	Late Yolk Plug (22)	Early Neurulation (23)	Late Neurulation (24)	Late Neurulation (25)	Heart (26)	Pre-hatch (27)
23-Jun	C4	35		1		5	4	3	17	5									
23-Jun	D	27			2	6			13	6									
23-Jun	D1	14		1			2	2	4	5									
23-Jun	E1	6						1	2	2	1								
23-Jun	E1.5	2						1		1									
23-Jun	M1	4			1		3												
24-Jun	C4	75	1	3	1	3	5	10	8	20	15	4	5						
24-Jun	D	33		1		2			6	21			3						
24-Jun	D1	11		1	1	1					6		1	1					
24-Jun	E1	13				1				2	8		1		1				
24-Jun	E1.5	9			1		1			1	6								
24-Jun	M1	38		9						3	21	5							
27-Jun	C1	1															1		
27-Jun	C4	63	1					25	2	2		2	14		9	1	7		
27-Jun	D	21			2	1			3		2	3	1				4	5	
27-Jun	D1	7									5			1				1	
27-Jun	E1	6									1	1	2		1		1		
27-Jun	E1.5	4		1		1	1							1					
27-Jun	M1	3	1															2	
29-Jun	C1	2					1			1									
29-Jun	C3	3											1		2				
29-Jun	C4	13								1			10	1				1	
29-Jun	D	9									4		3	1	1				
29-Jun	D1	4								1	1	1		1					
29-Jun	E1	3									1				1			1	
29-Jun	E1.5	2												1	1				
29-Jun	M1	4												2	2				
2-Jul	C1	5												3	2				
2-Jul	C3	4												1	3				
2-Jul	C4	110	2							2	6	5	36	30	16	10	3		
2-Jul	D	57	2								11		9	11	10	13		1	
2-Jul	D1	46	6								4	1	2	8	3	22			
2-Jul	E1	12	1								5		1	1	1	3			
2-Jul	E1.5	13	1									2	1	4	1	2	2		
2-Jul	M1	8									2	1		2	2	1			
Total		**667**	**15**	**17**	**8**	**20**	**17**	**42**	**55**	**73**	**99**	**25**	**90**	**69**	**56**	**52**	**18**	**11**	**0**

[a] See Figure 1.1 for sample locations.

[b] See Beer (1981) for a description of developmental stages.

Continued...

Table A3 Concluded.

Date	Site[a]	Number of Eggs Preserved and Examined	Egg Developmental Category (Stage)[b]																
			Unfertilized or Fungused Eggs	Post Fert 12	Early Cleavage 13	Early Cleavage 14	Early Cleavage 15	Early Cleavage 16	Late Cleavage 17	Late Cleavage 18	Late Epithelial (19)	Early Gastrulation (20)	Early Yolk Plug (21)	Late Yolk Plug (22)	Early Neurulation (23)	Late Neurulation (24)	Late Neurulation (25)	Heart (26)	Pre-hatch (27)
4-Jul	C3	1																1	
4-Jul	D	4	2															2	
4-Jul	D1	1																1	
4-Jul	E1	6																6	
4-Jul	E1.5	2																2	
6-Jul	E1.5	1		1															
7-Jul	C1	3		1				1			1								
7-Jul	C3	2		1				1											
7-Jul	C4	43	4			1			3	4	31								
7-Jul	D	19		1		2			2		14								
7-Jul	D1	1									1								
7-Jul	E1	3									2			1					
7-Jul	E1.5	3		1							1		1						
7-Jul	M1	10	1	1			1	2	1		4								
11-Jul	C4	7																	7
11-Jul	D	1																	1
11-Jul	D1	1																1	
11-Jul	E1	2																	2
11-Jul	E1.5	2																1	1
11-Jul	M1	2																1	1
13-Jul	E1	2							1										1
13-Jul	E1.5	1			1														
15-Jul	D	9									4	5							
15-Jul	D1	1										1							
15-Jul	E1	2	1					1											
15-Jul	E1.5	2						1				1							
15-Jul	M1	1									1								
19-Jul	C1	1																	1
19-Jul	D	9																9	
19-Jul	D1	2																1	1
19-Jul	E1	1																1	
19-Jul	E1.5	2																	2
19-Jul	M1	2																	2
Total		**149**	**8**	**6**	**1**	**3**	**1**	**6**	**7**	**4**	**59**	**7**	**1**	**1**	**0**	**0**	**0**	**26**	**19**

[a] See Figure 1.1 for sample locations.

[b] See Beer (1981) for a description of developmental stages.

Concluded.