**Acknowledgements**

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- Alcan Primary Metal and their representative Justus Benckhuysen for managing the contract and being the representative for the Recovery Team.
- The Department of Fisheries and Oceans, and their representatives George Cronkrite and Henry Enzenhofer for conducting the DIDSON surveys.
- Ministry of Water Land and Air Protection (Ministry of Environment) and their representative Cory Williamson for providing access to data collected by their telemetry base stations and for providing telemetry advice.
- The Carrier Sekani Tribal Council and their representative Sharolise Baker for providing egg mats.
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- Steve McAdams (MOE) and Justus Benckhuysen (Alcan) for providing comments on the draft report.

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# 1 Introduction

The Nechako River population of white sturgeon (*Acipenser transmontanus*) is a red-listed species in British Columbia (BC Conservation Data Centre 2005) and is classified as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC - November 2003). Genetic analysis indicates that the Nechako River population is distinct from that of the Fraser River suggesting that there is no or limited inter-breeding between the populations (Smith *et al*. 2002). In addition, research suggests that the Nechako population is experiencing recruitment failure with the population dominated by larger and older fish with few juveniles (Nechako White Sturgeon Recovery Initiative (NWSRI) 2004). At present the reasons for the recruitment failure is unknown, though substrate changes are implicated (McAdam *et al*. 2005).

A summary of the current status of the Nechako white sturgeon population can be found in the "Recovery Plan for the Nechako White Sturgeon" (NWSRI 2004), and an overview of the timing, habitat, and behaviour regarding white sturgeon spawning is provided in the "Adult White Sturgeon Monitoring – Nechako River 2004" report (Triton Environmental Consultants Ltd. 2004). The primary goal of the project completed by Triton in 2004 was to track the movements of radio-tagged adult fish in order to identify spawning locations. Additionally, if spawning was observed then an assessment of the habitat occupied at the egg and larval stages was also to be completed. That project was successful in confirming the use of the shallow riffle habitat immediately upstream of the Vanderhoof bridge for sturgeon spawning with the observation of a congregation (22-36 individuals) on May 18$^{th}$, 2004. The mean daily water temperature at the time of the congregation was 13.9°C with a river discharge of 131 m/s$^3$, occurring on a declining hydrograph.

A detailed analysis of the habitat conditions in and around the spawning area was undertaken, and it was determined that while gravel and fine substrates dominated the area, the majority of the fish were observed in an area where cobble substrates prevailed. Sampling for eggs and larvae yielded a total of 4 eggs and 1 yolk sack larvae. These results confirmed that the Nechako River white sturgeon are producing viable eggs and that at least a portion of the eggs are surviving to develop into larvae.

The work completed by Triton in 2004 formed the basis for the monitoring and sampling plan for 2005. In particular, that study identified a spawning area, which was the focus for the work in 2005. In addition, the physical conditions in the river around the time of the congregation in 2004 (*i.e.* water temperature and discharge) were to identify the critical monitoring period for 2005.

Using the information on timing and location of the 2004 congregation, the 2005 Nechko white sturgeon spawning and early life-phase assessment project was initiated in order to monitor Nechako River white sturgeon during the expected period of spawning activity (mid-May to mid-June) and to complete field surveys should a congregation of sturgeon be observed (Alan Primary Metal 2005).

# 2 Considerations for the 2005 program

The success of the 2004 adult white sturgeon monitoring program (Triton Environmental Consultants Ltd. 2004) was largely due to:

1. Clear water conditions which allowed for the identification and observation of the congregation from the air. Spawning behavior (including gamete release) was observed and geo-referenced, which allowed for the accurate deployment of egg and larval sampling gear.
2. Shallow water depth associated with typical spring flows (approximately 140 $m^3$/sec at the Vanderhoof bridge) allowed the entire water column and channel bottom of all but the deepest runs to be viewed from the air. Additionally, the shallow water depth allowed for the easy installation of sampling gear by wading out from the shore. Smaller side-channels could easily be waded across and there was an abundance of margin habitat available for kick-netting and pole seining by wading.
3. Active radio tags on numerous adult sturgeon allowed for the documentation of their migration out of overwintering areas and increased movement which culminated in the observed congregation.

Factors critical to the success of the 2004 program could not be relied upon for the 2005 field program. Based on the 2005 spring water level of the Nechako Reservoir and predicted inflow, it was known that forced spilling would be necessary during the course of the project. Such forced spilling would result in flow conditions significantly different then those observed in the spring of 2004. It was determined that river elevation would increase by a minimum of 0.95 m at the Vanderhoof bridge compared to 2004 levels (Water Survey of Canada 1999). Under wetter than average conditions in the region, forced spilling from the Nechako Reservoir would be increased to predicted flow levels of 435 $m^3$/sec at Vanderhoof (an increase in water elevation of 1.75 meters compared to the egg and larval sampling period in 2004).

Additionally, information regarding radio tagged sturgeon collected by the MWLAP (now referred to as the Ministry of Environment) was passed onto Triton by the Alcan Project Manager during the preparation of the proposal. Indications were that many of the radio tags on adult sturgeon (particularly tags on the 149.700 frequency) were no longer transmitting. This was confirmed during a telemetry flight conducted by Triton on April 21st, 2005 as part of the proposal preparation.

As a result of the anticipated changes to the physical conditions of the river (*e.g.* deeper water, potentially increased turbidity), and the lack of radio-tagged adult fish, Triton investigated alternate technologies that could be used to identify congregating sturgeon. Side scanning sonar and dual frequency identification sonar (DIDSON) were determined to be viable solutions for the 2005 sampling program.

Side scanning sonar is a technology that has just recently become available in a reasonably priced field portable unit, and has the ability to capture a 'picture-like' image of features within the water column (*e.g.* fish) as well as features on the bottom of rivers and lakes (*e.g.* submerged wood, rock). Examples of side scanning images can be found at: http://www.humminbird.com/generic2.asp?ID=514. The unit projects a beam 180° to each side of the boat up to a distance of 73 m, and to a depth of up to 30 m. This side scanning sonar is sensitive enough to separate targets that are within 6 cm of each other, and can allow a distinction to be made between large and small fish. The transducer of the side scanning sonar can be mounted to the transom of a boat, and the unit has an optimal cruising speed of 3 – 10 km/hr.

DIDSON is ideal for working in turbid river conditions or during periods of low light, and produces near video quality images. The DIDSON unit is very portable, but is best suited for installation at a stationary location (*e.g.* river bank as opposed to a moving boat). The DIDSON system uses multiple sound beams focused by a movable lens to produce images of underwater targets. The standard DIDSON system (used on this project) has a field of view of 29° horizontal and 12° vertical and operates at two frequencies, 1.1 and 1.8 MHz (Cronkite 2005). The low frequency mode uses 48 beams and is able to detect targets up to 40 m from the transducer, however the resolution is not high enough for positive identification, regardless of the distance of the target from the transducer. In contrast, the high frequency mode of the standard DIDSON system uses 96 beams to collect information on the size, shape and movement of a target with sufficiently high resolution to allow target identification up to 15 m from the transducer (Cronkite 2005).

# 3 Methods

## 3.1 TEMPERATURE, FLOW AND TURBIDITY MONITORING

Monitoring of the Water Survey of Canada (WSC) station at the Vanderhoof bridge (station 08JC001) was initiated upon award of the contract and continued until completion of the field program. The station provides real-time data on water temperature, primary water level and discharge. Additionally, three Onset StowAway® TidbiT™ temperature loggers were installed in the vicinity of where the congregation was identified in 2004 in order to determine if there was any temperature difference between the WSC station and the upstream spawning grounds.

Water samples were collected over the course of the study to document changes in turbidity, and were analysed with a LaMotte 2020 portable turbidity meter.

## 3.2 RADIO TELEMETRY

Two Lotek receivers (SRX_400-W7) were borrowed for the study, one from University of Northern British Columbia and the other from the Department of Fisheries and Oceans in Prince George. One receiver was used for the aerial and boat surveys, while the other was used for aerial surveys and also installed as a base station, located just downstream from the Vanderhoof bridge. The receivers used were programmed to only scan for the frequencies used on the tagged sturgeon, thereby reducing scanning time and minimizing the possibility of missing signals.

To determine the presence or absence and movement patterns of tagged fish within the study area a telemetry overflight was conducted between the Stuart and Nautley rivers on May 11$^{th}$, 2005 (Figure 1). The flight originated from the Vanderhoof airport and was flown over the Nechako River from Vanderhoof downstream to the Stuart River confluence, then from the Stuart River confluence upstream to the confluence of the Nautley River, and finally back downstream to Vanderhoof. This flight pattern resulted in two complete passes of the study area. Both passes of the telemetry flights were flown at a height of between 180 – 240 m above the river.

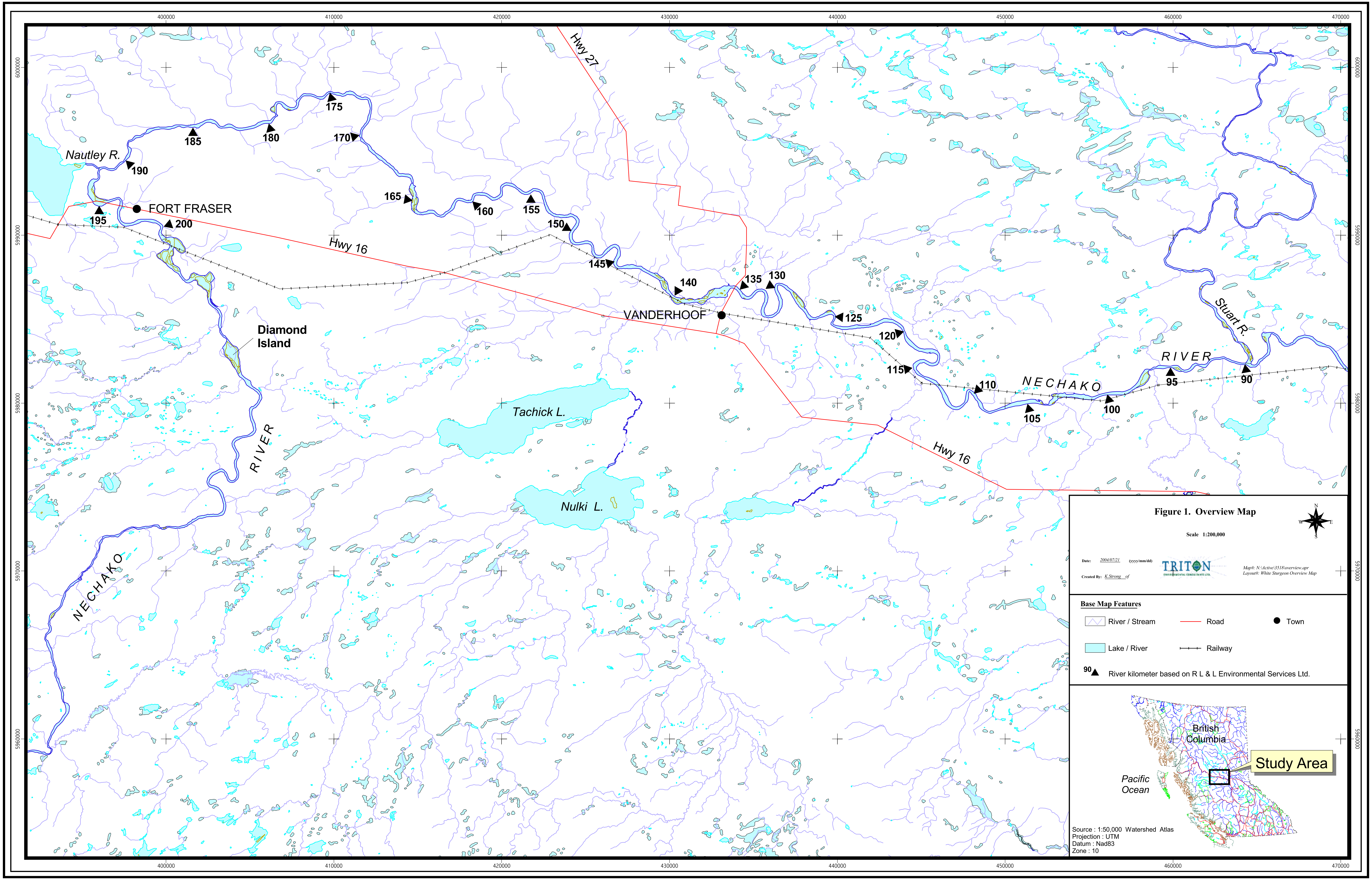

Figure 1. Overview Map
Scale 1:200,000
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S
Date: 2004/07/21 (yyyy/mm/dd)
Created By: K.Strong of
TRITON
Map#: N:\Active\3518\overview.apr
Layout#: White Sturgeon Overview Map
Base Map Features
River / Stream
Road
Town
Lake / River
Railway
90
River kilometer based on R L & L Environmental Services Ltd.
British Columbia
Study Area
Pacific Ocean
Source : 1:50,000 Watershed Atlas
Projection : UTM
Datum : Nad83
Zone : 10
Hwy 27
Hwy 16
Hwy 16
Nautley R.
FORT FRASER
VANDERHOOF
Diamond Island
Tachick L.
Nulki L.
Stuart R.
NECHAKO RIVER
NECHAKO RIVER
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Based on the results from the initial telemetry flight, it was suggested, by Cory Williamson of the Ministry of Water, Land and Air Protection, that the flight area be extended from the Nautley River downstream to the Isle Pierre Rapids. On May 13th, 2005, an extended telemetry flight was completed, once again originating for the Vanderhoof Airport and following the same flight pattern with the exception of the downstream end of the study area being extended to include the Isle Pierre Rapids.

A fixed-wing plane (Cessna 172) wired for telemetry work was used to complete the aerial surveys. "H" antennae were mounted with vertical orientation set at an angle slightly forward of 45° down, on both wings of the aircraft. For both flights, two Lotek receivers (SRX_400-W7), one per antenna, were used during the overflights. To reduce the risk of missing a tag during scan time, the active eight frequencies (149.800, 149.700, 149.480, 149.320, 148.420, 148.400, 148.320, 148.380) were split between the two receivers and were continually scanned during the flight at a rate of 7 seconds per frequency.

As each signal was received the frequency, code, river kilometre and time were recorded on data collection sheets. At the same time a UTM of where the signal was received was taken using a Garmin 12XL handheld GPS unit. Effort was not spent circling the plane to try and identify the exact location of each fish, as the goal of the telemetry data was to document general movement trends and timing. In the event that a tag was located but a code was not received or if there was more than one signal received for a given frequency at one time, the receiver was paused on that frequency to enable codes to be generated for the signals being received. Additionally, during these events the aircraft circled the area in question until all codes were received.

##### *3.2.1.1 Telemetry Base stations*

A telemetry base station was established by Triton Environmental downstream of the Vanderhoof bridge on May 13th, 2005, to detect fish passage close to the location where the congregation of sturgeon was located in 2004 (Triton Environmental Consultants Ltd. 2004). Ms. Deirdre Goodwin, a homeowner just downstream of the Vanderhoof bridge, provided access to her property to establish the base station.

#### 3.2.1.2 Telemetry Boat Surveys

Telemetry boat surveys were completed in conjunction with the sonar surveys (see section 3.3). The surveys began at the Highway 27 bridge and finished just downstream of km 116 on the Nechako River. During the boat surveys the Lotek receiver from the Vanderhoof bridge base station was used with a three element Yagi antenna and scanned through the eight active frequencies at a rate of a rate of seven seconds per frequency. Boat surveys were conducted at 5 – 10 km/hour.

Similar to telemetry overflights, as each signal was received the frequency, code, and river kilometre were recorded. Additionally, in the event that a tag was located but a code was not received or if there was more than one signal received for a given frequency at one time, the receiver was paused on that frequency to enable codes to be generated for the signals being received. Furthermore, during these events the boat crew boated back upstream, just past the received codes, and turned off the boats engine, allowing them to float downstream back over the tagged fish with no interference from the engine. This process was repeated until the codes in question were retrieved.

## 3.3 SIDE SCANNING SONAR

A Humminbird 981C SI side scanning sonar was used for the surveys, with the transducer mounted to the transom of a 16’ aluminium river boat. Sonar surveys were completed between the Highway 27 bridge and km 116 on the Nechako River. The sonar was typically set to a range of 20 –40 m to either side of the transducer. When a target of interest was observed the display was changed to only show the side of the boat that the target was on, which doubled the size of the object on the screen. The frequency setting of 455 kHz was used most of the time as it provided greater resolution without much of a decrease in the beam width (160° compared to 180° at the lower resolution frequency of 262 kHz).

Boat surveys were conducted at 5 – 10 km/hour generally down the center of the channel, with one crewmember carefully observing the screen at all times (as there is no recording or play-back option with the unit). A specific transect through the islands where the sturgeon congregation was observed in 2004 was established in order to familiarize the crew with substrate type and submerged objects in the area. The transect passed through the areas where the greatest density of sturgeon were observed in 2004, and was completed with the boat motor off so as to limit the potential for scattering any sturgeon present in the relatively shallow water.

### 3.4 DIDSON SONAR

The DIDSON sonar was provided by the Applied Technologies section of the Department of Fisheries and Oceans and operated by George Cronkrite and Henry Enzenhofer, individuals responsible for the testing of the usefulness of DIDSON for stock enumeration in 2004. The transducer mount was attached to the gunwale of a 16' aluminium river boat, which allowed the operator to rotate and change the angle and depth of the transducer. The DIDSON unit was almost always set on the high frequency mode as it provided sufficient resolution to collect information on the size, shape and movement of a target up to 15 m from the transducer. One of the DIDSON operators was responsible for the transducer positioning, which included ensuring that turbulence around the transducer was minimal, and raising the transducer in shallow water. The second DIDSON operator controlled the settings (*e.g.* range and focus) of the unit, observed the display on a laptop computer, and recorded the output when targets of interest were observed.

### 3.5 LOW LEVEL OVERFLIGHTS

As water temperature approached conditions similar to those observed during the 2004 spawning congregation, low level observation flights were conducted. Observations were made through the photo hole in the floor of a Cessna 182, flown by Eric Steir of Guardian Aerospace based out of the Vanderhoof airport. Flights were conducted approximately 500' above ground from the Highway 27 Bridge to approximately 1 km downstream of the Vanderhoof bridge. Flights were generally 0.5 hours in length which allowed 8-10 passes through the 2004 spawning grounds.

## 3.6 SAMPLING FOR EGGS

Egg mats provide an artificial surface to which the adhesive sturgeon eggs can adhere, and have been used successfully in numerous sturgeon studies (*e.g.* McCabe and Beckman 1990; Parsley and Beckman 1994; and Paragamian *et al*. 2001). Egg mats were constructed from polyurethane industrial filter fabric sandwiched between an angle iron frame with cross supports following the procedure outlined in McCabe and Beckman (1990). Mats were generally deployed in sets of two with one buoy line attached to the upstream mat which allowed for retrieval of the gear. As there was substantial boat traffic in the area, fluorescent buoys were used as they were clearly visible even in low light conditions. Separate anchors were not required as the two angle iron frames had a low profile and were heavy enough to remain stationary. Mats were checked and cleaned at 2 – 5 day intervals.

Additionally, Triton fabricated ten egg tubes to increase the sampling intensity for eggs. Egg tubes were constructed of 0.75 m long 0.15 m diameter PVC pipe wrapped with furnace filter material as described in Firehammer and Scarnecchia (2005). A railway angle bar was attached to each tube as an anchor, and the tube was then attached to an egg mat to further anchor the tube and to reduce the number of buoys that were required for the egg sampling gear. Egg tubes were checked at 2 – 5 day intervals in conjunction with checking the egg mats.

## 3.7 NOTIFICATION OF LOCAL RESIDENTS

A component of the monitoring program was to utilize the public as observers. Signs were posted at key locations, and provided contact information should a congregation of sturgeon be sighted. Locations where signs were posted included:

- Vanderhoof bridge boat launch and walking trails;
- Vanderhoof airport; and
- Vanderhoof mall.

# 4 Results

## 4.1 TEMPERATURE, FLOW AND TURBIDITY MONITORING

River discharge at the Vanderhoof bridge during the monitoring period ranged from 91 $m^3/s$ in early April, peaked at 407 $m^3/s$ in mid-May with a second peak of 382 $m^3/s$ at the end of May. Flows generally declined through the early part of June to a low of 208 $m^3/s$ on June 12, with increasing flows to the end of the study period (Figure 2).

Mean daily water temperature at the Vanderhoof bridge during the monitoring period ranged from 3.6°C on April 2 to a high of 16.1°C on June 10 and 19th. Daily mean water temperatures first approached conditions observed during the 2004 spawning congregation (13-15°C) during the last few days of May (Figure 2). Detailed flow and temperature data can be found in Appendix 1.

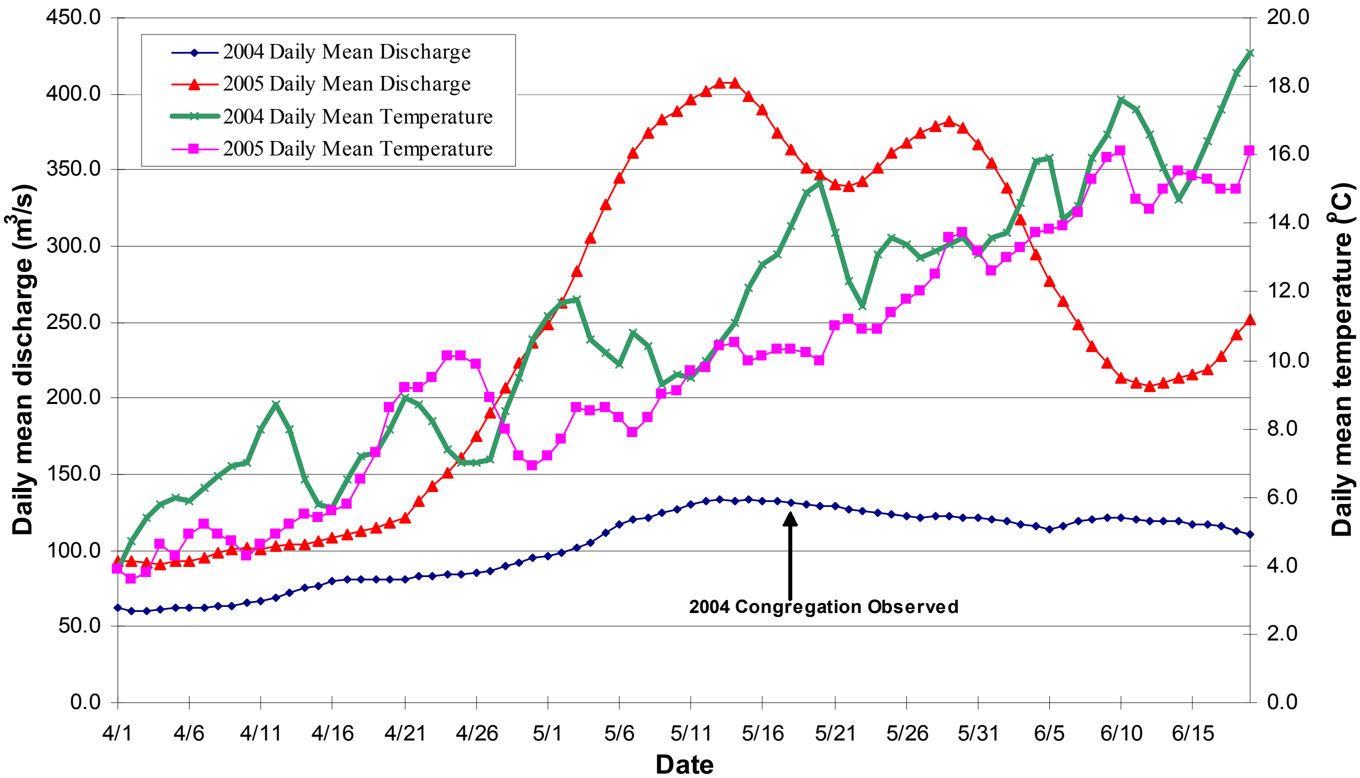



**Figure 2.** Daily mean discharge (primary X axis), and daily mean temperature (secondary X axis) at the Vanderhoof bridge (Water Survey of Canada station 08JC001) from April 1 to mid-June 2004 and 2005.

Turbidity at the Vanderhoof bridge during the monitoring period was low and relatively stable, ranging from a high of 6.1 NTUs on June 9 to a low of 3.6 on May 16 and May 25 (Table 1).

**Table 1.** Water turbidity (NTUs) at the Vanderhoof bridge, 2005.

| Date | NTU |
|---|---|
| 13-May | 4.3 |
| 16-May | 3.6 |
| 18-May | 5.1 |
| 23-May | 5.6 |
| 25-May | 3.6 |
| 27-May | 4.9 |
| 04-Jun | 5.9 |
| 06-Jun | 5.3 |
| 09-Jun | 6.1 |

The three Optic Stowaway® TidbiT™ temperature loggers that were installed within the 2004 spawning area recorded hourly temperature readings between 12:00 pm on May 13$^{th}$ and 3:00 pm June 16$^{th}$, 2005. The hourly data from the three loggers were always within 1.0°C of each other, and generally differed by less than 0.5°C. The data from the three loggers was averaged and the daily minimum, maximum and mean temperatures are presented in Appendix 1. The minimum average hourly temperature recorded during the study period was 8.94°C while the maximum average hourly temperature was 17.96°C. The daily mean temperatures based on the temperature logger data ranged from a low of 9.96°C on May 15$^{th}$, to a high of 16.56°C on June 10$^{th}$.

Appendix 1 also displays the daily mean temperature as recorded by the Water Survey of Canada (WSC) station at the Vanderhoof bridge (08JC001), as well as the difference between the two measurements of daily mean temperature. With the exception of May 13$^{th}$, the difference between the mean daily temperature based on the temperature logger data and the WSC data was never greater then 0.5°C. On May 13$^{th}$, the difference was 0.62°C, however, since the loggers were not installed until noon on that day, the daily average based on the logger data is considered to be artificially high since the cooler morning water temperatures are not included.

## 4.2 RADIO TELEMETRY

There were two telemetry flights conducted during the sturgeon monitoring program for 2005, one on May 11th and one on May 13th. On May 11th the codes from two tagged fish were recorded (148.380 code 2 and 149.480 Code 54), and on May 13th, an additional tagged fish was recorded (148.400 Code 9). Of the tags captured one was believed to be a shed tag, as it was noted in the exact same location during 5 flights conducted by Triton in 2004, and the other two tags were that of juvenile sturgeon tagged in September of 2004 (Appendix 2).

There were 16 boat telemetry surveys completed between May 13th and June 12th, 2005 in conjunction with sonar trips. On average, the number of active tags recorded during each trip was 1.5, with the highest number of tags (3) being recorded during the boat surveys conducted on May 18th and June 12th. All of the fish located during the tracking from the boat were recorded between km 116 and km 125 of the Nechako River (Appendix 2).

The base station at the Vanderhoof bridge was downloaded every second day in conjunction with other field activities. Although it was in operation for 31 days no tags were recorded by the base station during this study.

### 4.2.1 DETAILED TELEMETRY EVENTS FOR EACH FISH OBSERVED DURING THE 2005 STURGEON MONITORING PROGRAM.

*148.380-1*
Fish 148.380-1 is a ripe female that was captured, tagged and released on September 7th, 2004 in Stuart Lake. She was not recorded again until June 10th, 2005, when she was found at km 116 on the Nechako River. She was still present in the area of km 116 when the study ended on June 12th, 2005.

*148.380-2*
148.380-2 is a juvenile fish that was captured, tagged and released on September 23rd, 2004 in the Nechako River. On May 11th, 2005 it was recorded at km 111 during an overflight. Code 148.380-2 was then found again on May 13th, 4 kilometers upstream at km 115, where it remained until May 29th, when its signal was received 6 km upstream at

km 121. Fish 148.380-2 remained at km 121 until the final day of the study, when it was recorded downstream at km 117.

*148.380-3*
This male was captured and tagged at km 22.81 on the Nechako River on September 28, 2002. Pervious data provided by the Ministry of Water, Land and Air Protection shows that the first time he was seen after being tagged was July 8$^{th}$, 2004 at km 104.2 of the Stuart River. He was also recorded later that month (July 19$^{th}$, 21$^{st}$, 22$^{nd}$) between km 89.7 and km 116 of the Nechako River. Triton first observed fish 148.380-3, at km 124.5 during the May 16$^{th}$ boat survey. This fish underwent very few movements throughout the study period, remaining relatively stationary around km 125, only moving twice, to km 115 and km 116 where he was recorded on the 18$^{th}$ of May and 12$^{th}$ of June, respectively.

*148.400-9*
Fish 148.400-9 is a juvenile that was captured and tagged on September 23$^{rd}$, 2004 in the Nechako River. This fish was only recorded twice during the study period, once on May 13$^{th}$ at km 131 and again on May 18$^{th}$, 13 km downstream at km 118.

## 4.3 SIDE SCANNING SONAR

The side scanning sonar was used for a total of 18 surveys between May 10 and June 12. The focus of the surveys was the location of the 2004 spawning congregation. Logs and other features along the established transect through the spawning area were almost non-existent, and the channel bed was comprised of uniform cobble/gravel substrates.

Following is a description of objects typically observed during the surveys:

- Submerged logs, boulders, and riprap shoreline were observed. The trunk, branch structure, and a fuzzy blur from the needles were observed on a newly fallen tree hung up on a gravel bar.
- A 40 cm diameter irrigation pipe extending into the water was observable.
- A person swimming through the water was observable as a white oval with a shadow behind where the side scanning sonar was blocked.

- Images under the boat showed up in the water column of the display. By turning the motor off and floating over the km 125 and 116 holes, large white returns were observed several times within the water column. For example, a long cylindrical return was observed at the km 125 hole, at the same time the tag for the 148.380 Code 3 was picked up by the Lotek telemetry receiver. No return was observed while floating over the hole again along the same transect.

## 4.4 DIDSON

The DIDSON unit and crew were made available to the project for three field days (May 31 to June 2). Several orientations of the transducer were tried during the course of the field work, including directly vertical, but the most common orientation was having the transducer directed downward at a 45° angle.

The DIDSON was able to detect two sturgeon that were at km 125, one approximately 1.35 m long and the other 1.65 m long. No fish were identified in the vicinity of the 2004 spawning grounds. During the DISON surveys, visual observations of 3 juvenile sturgeon were made at km 125.

Attachment 1 contains video footage captured by the DIDSON on the Nechako River. Files include:

- 135cm sturgeon.avi - a brief look at sturgeon observed at km 125.
- 165cm sturgeon.avi - a brief look at sturgeon observed at km 125. Shows the range being adjusted to try and maintain the fish in the beam.
- 30cm fish.avi - shows a 30 cm long fish for comparison.
- fish habitat by chevrolet.avi – shows the area around km 135 where they have used old cars for bank stabilization. A fish can be observed swimming out of one of the car windows. A car steering wheel and other car parts can also be seen.
- grass and 27cm fish at dropoff.avi - shows a smaller fish and some associated habitat.
- rip rap.avi - a view of some rip rap associated with the railway using the DIDSON in a downlooking orientation (near vertical aim). The set up covers a smaller area but gives a very good 3-D perspective to objects.

## 4.5 LOW LEVEL OVERFLIGHTS

A total of 13 low level overflights were completed between May 29 and June 13. Average viewing conditions were such that deployed egg mats in 2.0 - 2.2 m of water could be seen from the air. Ducks and pieces of wood were easily observable, as were the bottom substrates across most of the side-channels. The bottom of the channel upstream of the islands was not visible (it was also not visible in 2004), as were portions of the two main channels that extend through the islands. Approximately 80% of the bottom substrates could be seen between the Vanderhoof Bridge and the upstream end of the 2004 spawning location.

Four juvenile sturgeon (1 – 1.5 m in length) were observed on the morning of June 8 at the 2004 spawning site. The individuals were spread out over a 1.5 km section of river. No pairing was observed. No fish were observed that evening (though viewing condition were not ideal), or the following morning under good viewing conditions.

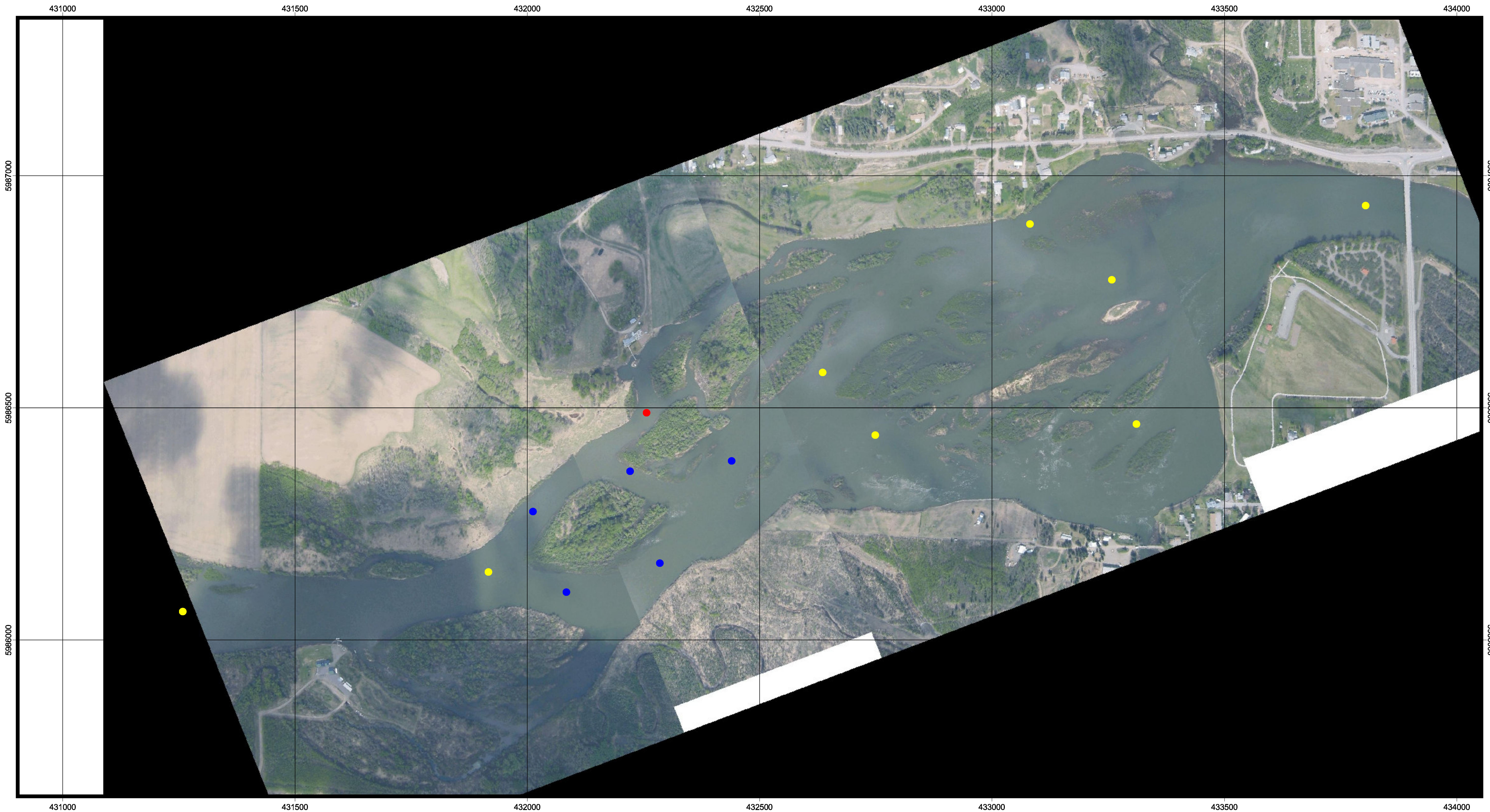
## 4.6 SAMPLING FOR EGGS

#### *4.6.1.1 Substrate (Egg) mats*

As many as 54 egg mats (37.3 $m^2$) were deployed at any one time from May 18 to June 17, at depths ranging from 0.6 to 2.7 m, and velocities ranging from 0.1 to 1.38 m/s (Appendix 3). Mats were set for a combined total of 31,847 hours. No sturgeon eggs were captured, but eggs mats did capture a total of seven sucker eggs (0.0003 eggs/hour/$m^2$). Egg mat locations are shown in Figure 3.

#### *4.6.1.2 Egg tubes*

As many as 10 egg tubes (3 $m^2$) were deployed at any one time from May 23 to June 17, at depths ranging from 0.6 to 2.7 m, and velocities ranging from 0.1 to 1.38 m/s (Appendix 3). Egg tubes were set for a combined total of 5,836 hours. No sturgeon eggs were captured, but eggs tubes did capture one sucker egg (0.0006 eggs/hour/$m^2$). Egg tube locations are shown in Figure 3.




**LEGEND**

- 2 egg mats (red)
- 4 egg mats (yellow)
- 4 egg mats, 2 egg tubes (blue)

| NO. | DATE (yyyy/mm/dd) | REVISION | BY |
|---|---|---|---|
| 1 | 2005/10/07 | Initail Draft | HDW |

**NECHAKO RIVER STURGEON PROJECT 2005**

## Figure 3. Egg Sampling Sites

N / W / E / S

Scale: 100 0 100 200 300 400 Meters — Scale: 1:8,000

Basemap Source: Air Photos by Ryan Liebe - May 11, 2005

Map Datum: UTM Zone 10. NAD 83

Project No: 3620

File No: Map#: 3620\apr\Egg Sampling Sites.apr Layout#: Figure 3

Date: 2005/10/07

TRITON ENVIRONMENTAL CONSULTANTS LTD.

# 5 Discussion

The 2005 program outlines the difficulty in detecting a congregation of sturgeon in the absence of transmitting radio tags, and when flows are such that visual observations of fish are unlikely. Although no congregation was detected, the project was able to document flow and discharge, collect a minor amount of sturgeon movement data through telemetry, and assess the usefulness of two sonar technologies as well as new egg sampling gear.

## 5.1 TEMPERATURE, FLOW AND TURBIDITY MONITORING

The delayed increase in mean daily water temperature compared to 2004 was largely due to cooler weather, but the larger volume of water associated with forced spilling from the Nechako Reservoir may also have been a factor. Temperatures similar to the May 18 congregation of 2004, did not occur until the last few days of May in 2005. Besides increased flow levels and a delayed increase in mean daily temperatures compared to 2004, forced spilling from the reservoir resulted in a bimodal hydrograph with the second peak occurring as daily mean water temperatures approached those observed during the 2004 congregation. It is unknown as to what the effect, if any, the fluctuating hydrograph and a delayed increase in daily mean temperature had on spawning cues for white sturgeon.

Turbidity measurements in 2005 were slightly higher than during the 2004 project (range of 3.6 – 6.1 NTU versus 1.6 – 4.5 in 2004). Such a small difference (*e.g.* 4.5 versus 6.1 NTU) would not be discernable to the naked eye in a water sample vial, but may have reduced the depth of the water column that could be observed from the air.

The installation of Onset StowAway® TidbiT™ temperature loggers in addition to monitoring the WSC station was completed to determine if there was any temperature difference between the WSC station and the upstream spawning grounds. Based on the similarities between the two independent measures of daily mean temperature, it is thought that installing separate temperature loggers within the spawning area immediately upstream of the Vanderhoof bridge is not necessary for future projects.

## 5.2 RADIO TELEMETRY

Two survey methodologies using radio telemetry were conducted during the 2005 sturgeon monitoring program, aerial surveys and boat surveys. Aerial surveys are a more efficient means of recording tags over a large area, as a greater distance can be covered in less time. However, boat surveys seemed to acquire the same number of tags along a given section of river, and completing the telemetry surveys from the boat in conjunction with sonar surveys was very cost effective.

At the suggestion of Cory Williamson (MWLAP), frequencies were split between two Lotek receivers during the aerial surveys (see section 3.1) in order to decrease the time it took to cycle through the frequency list. This was beneficial because if all 8 frequencies were located on a single receiver, and the plane traveled at 31m/s (70 mph) with each frequencies scanned for 7 seconds, there would be a minimum of 1,736 m between each time a frequency was scanned. However, by splitting the frequencies between the two receivers, the distance covered between frequencies was reduced in half, which decreased the chance of a tagged fish being missed.

As an increase in the number of different tag frequencies decreases the efficiency of telemetry surveys, it is recommended that future tagging programs try and acquire coded tags on the same frequencies already present within the Nechako River system. This is feasible even if many more fish are tagged, as the coded tags being used within the Nechako River can house up to 212 different codes per frequency (Pers. Comm. Henry Tam).

Telemetry surveys completed in 2005 demonstrated that almost all of the tags on adult sturgeon recorded in 2004 are no longer transmitting. Increasing the number of transmitting sturgeon tags within the Nechako River will enable the monitoring of sturgeon from overwintering areas towards possible spawning grounds. Additional tags will allow for continued documentation of sturgeon movements (juvenile and adult), not only to and from the known spawning grounds above the Vanderhoof bridge, but also to and from additional spawning grounds that may be present in the Nechako River or Stuart River watersheds.

## 5.3 SONAR

Although a congregation was not detected, the 2005 program allowed for the use and assessment of two different sonar technologies.

### 5.3.1 SIDE SCANNING SONAR

Although it was not possible to confirm that individual sturgeon were targeted by the side scanning sonar surveys, there were numerous instances when sturgeon-like returns were viewed on the display (see section 4.3). The clarity of the side image is typically such that fin detail would not be expected, rather just the general shape of the object. Similar to the DIDSON (see section 5.3.2), locating fish that occur at low densities along a 30 km section of river that is often greater than 100 m wide was a difficult task for the equipment. It would be easy to miss a sturgeon while floating long sections of river, especially where abundant LWD or other sturgeon-shaped targets are present. A target is only displayed once on the screen as the transducer passes over it, so targets of interest have to be resurveyed in order to determine if they have moved. It becomes very time consuming to make several passes over every torpedo shaped object.

Another difficulty with the side scanning sonar that was encountered was that the clarity of the image is reduced during windy/wavy conditions, as the boat rocks in the waves and spins side to side with the wind. Standing waves or rough water that could be encountered on other rivers or different sections of the Nechako River would likely result in a blurred image that would provide little useful information besides water depth and the general shape of the channel bottom.

The detection of sturgeon with the side scanning sonar was not as obvious as was hoped, but it is felt that the technology would be effective at detecting a congregation at the 2004 spawning site as there are no other objects in the area that could be misidentified and any return different from the uniform substrate would be noticed. However, due to the efficiency of low level overflights (see section 5.4) and visual confirmation that the flights can provide, the use of the side scanning sonar to detect congregating sturgeon should only be considered when water depth or turbidity are such that the low level flights are not useful.

#### 5.3.2 DIDSON

The DIDSON provides a high quality image that can be used to confirm the identification of sturgeon. However, the unit has a relative small field of view (especially at the high resolution setting) compared to the side scanning sonar, which makes it inefficient at covering long and wide sections of river. While floating down the Nechako the field of view was typically about 30 - 40 $m^2$ (a cone focused 8 – 10 m away and 4 -5 m wide at the channel bottom). Trying to locate a species of fish that occurs at low densities along a 30 km section of river that is often greater than 100 m was a difficult task for the equipment. By targeting known holes (*e.g.* km 125 and 116) where sturgeon were likely to occur, the DIDSON was able to detect and capture footage of two sturgeon.

A valuable application of DIDSON technology for sturgeon on the Nechako River would be to document spawning behaviour (*e.g.* pairing, movement of males in relation to females, gamete release) once a congregation has been detected by another means. The DIDSON could also be used to take accurate length measurements of fish within the congregation. The unit could be used from shore and panned through areas of congregating sturgeon. For this application of DIDSON to be successful a unit would have to be available to rent/borrow on short notice (*e.g.* ship as soon as a congregation is detected) or project funds would have to be sufficient or arrangements would have to be made to rent/borrow the unit for a longer period of time (*e.g.* rent for a three week period that covers the expected spawning period).

#### 5.3.3 SIDE SCANNING SONAR VERSUS DIDSON SONAR

Table 2 provides of summary comparison of side scanning sonar versus DIDSON.

**Table 2.** Summary of the effectiveness of DIDSON versus side scanning sonar.

| Parameter | DIDSON | Side Scanning |
|---|---|---|
| Detail | Very detailed – gravel substrates and 20 cm long fish can be observed. | 40 cm diameter irrigation pipe visible. A 1 m, 20 cm diameter object would likely be lost on the side image, but would show up if suspended in the water column below the boat. |
| View | Limited – cone shaped image typically looking 8 – 10 m away, 4 – 5 m wide cone | Typically set to look 20 - 40 m to each side of the boat. |
| Stationary use | Can be stationary (*e.g.* image constantly refreshes). | Must be moving (image scrolls down, with area beneath boat at top of screen). |
| Measuring capability | Can accurately measure fish/object on screen with the cursor. | Must use an object (*e.g.* bridge piers) to standardize lengths on screen. The faster you go the shorter objects become as it takes less time for the transducer to pass over them. |
| Cost | Expensive ($4,500/week to rent). | $2,500 to purchase. |

## 5.4 LOW LEVEL OVERFLIGHTS

Low level overflights were again successful at identifying sturgeon in the shallow water habitat upstream of the Vanderhoof bridge (four juvenile sturgeon were observed on June 8 from the photo hole of a Cessna 182). The low level flights are an efficient, cost-effective way to confirm the presence of white sturgeon in shallow water habitats. A 0.5 hour flight from the Vanderhoof airport can be completed for approximately $180 plus professional fees.

## 5.5 SAMPLING FOR EGGS

Although no sturgeon eggs were captured, the 2005 sampling program allowed for the assessment of egg tubes as an alternative or additional sampling technique to egg mats. Both types of gear captured sucker eggs, with the egg tubes having a higher CPUE (0.0006 eggs/hour/$m^2$ versus 0.0003 eggs/hour/$m^2$). These results are preliminary as the sample size was small (only one egg was captured on one of the egg tubes). The potential for a difference in the capture efficiency of the gear seems reasonable as egg mats lay flat on the channel bottom (essentially the same height as the substrate), while a portion of the egg tubes are elevated above the channel bottom.

However, an individual egg mat covers a greater surface area than two egg tubes. Egg mats are easier and more efficient to deploy, retrieve and check (*e.g.* do not require anchors in the Nechako River flow), are more durable, and are readily available locally (numerous mats are owned by the Carrier Sekani Tribal Council, Golder Associates Ltd., and Triton Environmental Consultants Ltd.). For these reasons, and their documented effectiveness at capturing sturgeon eggs, egg mats will likely remain the primary method for sampling for sturgeon eggs in the Nechako River.

## 5.6 OCCURRENCE OF A SPAWNING EVENT - 2005

Although no spawning congregation was identified in 2005, the question remains as to whether one occurred. Potential scenarios include:

1) Spawning occurred at the 2004 spawning site but was not detected.
2) Spawning occurred but not at the spawning location documented in 2004 (which was the focus of the 2005 study).
3) Spawning occurred prior to the initiation of the 2005 monitoring program or subsequent to the completion of the program.
4) Spawning did not occur within the Nechako River in 2005.

<u>Scenario 1.</u>

During the 2004 sampling program (Triton Environmental Consultants Ltd. 2004), 14 egg mats were deployed for a total set time of 399 hours. In 2004, egg mats were deployed at the tail end or even subsequent to the spawning event, as only a few smaller individuals (likely males) remained on the spawning grounds the morning that the egg mats were placed. Even with this relatively low effort and less than ideal timing, one of the egg mats captured a single sturgeon egg that likely had been dislodged from the river substrate. From mid-May to mid-June of 2005, up to 54 egg mats and 10 egg tubes were deployed at any one time within the spawning area, a large increase in effort (both duration and surface area) compared to 2004. Egg mats were located throughout the documented spawning area, were placed ahead of the environmental conditions thought to be requisite for spawning, and were monitored for weeks after the environmental conditions favorable for spawning had been observed.

Additional to sampling for eggs, side scanning sonar surveys and low level overflights were conducted on a regular basis (every day or every second day as the environmental conditions thought to be requisite for spawning occurred). It is the opinion of the authors that both the side scanning sonar (see section 5.3.1) and the low level overflights (see sections 4.5 and 5.4) would have been capable of detecting a congregation of sturgeon at the 2004 spawning location. Considering the diversity (egg mats, sonar and overflights) and level of effort employed, it is the opinion of the authors that a congregation of sturgeon did not occur at the 2004 spawning location.

<u>Scenario 2.</u>

The second scenario is that spawning occurred at a different location within the Nechako watershed during 2005. There has been substantial effort in previous years (*e.g.* RL&L Environmental Services Ltd. 2000) to document sturgeon migration using radio telemetry and to identify spawning locations using egg mats. Reviewing historical telemetry data in light of the identification of spawning grounds in 2004, confirms similar migrations to river km 130 – 140 followed by a downstream migration in previous years during the expected spawning window. Although possible, historical radio telemetry data does not suggest large scale migrations during the expected spawning window to specific river sections apart from km 130 - 140 and the Isle Pierre Rapids. Extensive sampling using egg mats at the Isle Pierre Rapids in previous years (RL&L Environmental Services Ltd. 2000) has not resulted in the capture of sturgeon eggs, which reduces the likelihood that the downstream migration to the rapids is spawning related.

<u>Scenario 3.</u>

The third scenario is that spawning occurred prior to the initiation of the 2005 monitoring program or subsequent to the completion of the program. It has been suggested that sturgeon spawn in response to environmental cues such as an increase in water temperature and changes in water discharge (Paragamian and Kruse 2001; Paragamian *et* *al*. 2001; Parsley *et al.* 1993). In 2004, the documented spawning event occurred around May 18 when the mean daily temperature was between 13-15.2 °C on the declining limb of the hydrograph. In 2005, the mean daily temperature did not reach 13°C until May 29$^{th}$, three weeks into the program. A declining hydrograph was observed on two occasions, the second of which occurred when water temperatures were similar to those observed during the 2004 congregation. Therefore, as environmental conditions thought to be favorable for spawning did not occur until several weeks into the program, and the program continued for a couple weeks beyond the first observation of favorable conditions, it is unlikely that the spawning occurred outside of the timeframe of the project.

Scenario 4.

The final scenario for discussion is that no sturgeon spawned within the Nechako River in 2005, due to a lack of appropriate spawning cues, poor in-river conditions during the previous year, or a lack of ripe females. Although the environmental cues documented during the 2004 spawning event which are thought to be requisite for spawning (*e.g.* temperatures greater than 13-15°C, a declining hydrograph) occurred in 2005, there were noticeable differences. The most obvious difference was the volume of water compared between the two years. As temperature approached 14°C, discharge in 2005 was more than double of that in 2004. However, discharge in 2005 is well within discharges observed at freshet before regulation of the river, and is therefore not thought to be a factor. The second difference was the bi-modal hydrograph due to forced spills, which resulted in sharply increasing flows after a declining limb of the hydrograph at the same time temperatures conditions were approaching those thought to be favorable for spawning. Whether the fluctuations in environmental cues were beyond those observed historically (*e.g.* rate of increase in flows) is unknown, as are the potential effects of such fluctuations.

Other mechanisms for having no spawning in 2005 include poor in-river conditions during the fall and winter of 2004/2005 (*e.g.* low sockeye salmon returns) that may have resulted in insufficient gonadal development (an idea presented by Steve McAdam in an email dated June14). Alternatively, due to the small population size of Nechako River white sturgeon, successful spawning in 2004 by a proportion of the population, and the length of time between spawning events for individual fish (as infrequent as 4 to 10 years; Nechako White Sturgeon Recovery Initiative 2005), there may not have been any ripe females in 2005 to broadcast eggs. In this scenario, males may have migrated to and from the spawning grounds in a somewhat uncoordinated and rapid fashion, never resulting in a larger prolonged congregation that would be more easily detectable.

Summary.

To summarize, no spawning congregation was identified as part of the 2005 program, for which there are several potential explanations. Based on the intensity and diversity of the sampling methods employed during the 2005 program, it is the opinion of the authors that a spawning congregation of sturgeon (*e.g.* 10+ fish including larger females, over a duration of a couple of days) did not occur at the 2004 spawning location. It does not seem likely that the program timing was inadequate (either in the initiation or duration), such that spawning occurred before or after the project. The occurrence of a spawning congregation at another distinct location is possible, but not suggested by historical tracking or sampling information. Therefore, it seems unlikely that a spawning congregation occurred in the Nechako River in 2005.

Even in the absence of a spawning congregation, the potential exists that limited (due to poor in-river conditions or lack of ripe females), "uncoordinated" spawning (compared to 2004) occurred and was not detected. Due to the number and distribution of egg mats, it seems unlikely that such spawning would have occurred within the 2004 spawning area. Alternatively, absolutely no spawning occurred in the Nechako River, a scenario that is possible but intuitively seems unlikely even with a small population of fish.

**Report reviewed and approved by:**

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# 6 References

Alcan Primary Metals. 2005. Request for proposals. Re: Nechako white sturgeon spawning and early life-phase assessment 2005. Dated April 11, 2005.

BC Species and Ecosystems Explorer. 2003. Victoria, British Columbia, Canada. Available: http://srmapps.gov.bc.ca/apps/eswp/ (March 8, 2004).

BC Conservation Data Centre. 2005. BC Species and Ecosystems Explorer. BC Ministry of Sustainable Resource Management. Victoria, British Columbia, Canada. Available: http://srmapps.gov.bc.ca/apps/eswp/ (October 5, 2005).

COSEWIC. 2003. Status report web site: http://www.cosewic.gc.ca

Cronkite, G. 2005. Memo to Troy Erin (LGL). RE: Fraser river sturgeon - DIDSON feasibility testing. Dated March 1, 2005.

Firehammer, J.A., and D.L. Scarnecchia. 2005. Detection of paddlefish spawning along the lower Yellowstone River through the modification of an egg sampling technique. Current submission to the North American Journal of Fisheries Management.

McAdam, S. O., C. J. Walters, and C. Nistor. 2005. Linkages between white sturgeon recruitment and altered bed substrates in the Nechako River, Canada. Transactions of the American Fisheries Society. 134:1448-1456.

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

Nechako White Sturgeon Recovery Initiative. 2004. Recovery Plan for Nechako White Sturgeon. Prepared by Golder Associates Ltd. 82 pp.

Nechako White Sturgeon Recovery Initiative. 2005. Biology. <online> http://www.nechakowhitesturgeon.org/sturgeon/about/biology/index.php.

Paragamian, V. L., G. Kruse. 2001. Kootenai River white sturgeon spawning migration behavior and a predictive model: North American Journal of Fisheries Management. 21:1:10-21.

Paragamian, V. L., G. Kruse, and V. Wakkinen. 2001. Spawning habitat of Kootenai River white sturgeon, post-Libby Dam: North American Journal of Fisheries. 21:1:22-33.

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

Parsley. M.J., L.G. Beckman and G.T. McCabe Jr. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream of the McNary Dam. Transactions of the American Fisheries Society 122: 217-227.

RL&L Environmental Services Ltd. 2000. Fraser River white sturgeon monitoring program – comprehensive report (1995-1999). Final report prepared for BC Fisheries. RL&L Report No. 815F: 85 p + app.

Smith, C.T., R.J. Nelson, S. Pollard, E. Rubidge, S.J. McKay, J. Rodzen, B. May and B. Koop. 2002. Population genetic analysis of white sturgeon (*Acipenser transmontanus*) in the Fraser River. J. Appl. Ichthyol. 18:307-312.

Triton Environmental Consultants Ltd. 2004. Adult white sturgeon monitoring – Nechako River 2004. Prepared for Alcan Primary Metal. Prepared by Liebe, R.L., B. Rublee, G. Sykes, and R. Manson.

Water Survey of Canada. Nechako River at Vanderhoof. Station No. 08JC001. Stage-Discharge Table No 31. June 10, 1999.

**Personal Communication**

Henry Tam. Senior Account Manager. Lotek Wireless Inc.

# Appendix 1

# Water Temperature and Discharge Data

**Table 3.** Daily mean discharge, and daily mean temperature at the Vanderhoof bridge (Water Survey of Canada station 08JC001) from April 1 to June 19, 2005.

| Date | Mean Daily Temperature (°C) | Mean Daily Discharge ($m^3$/sec) |
|---|---|---|
| 4/1 | 3.9 | 92.9 |
| 4/2 | 3.6 | 93.2 |
| 4/3 | 3.8 | 91.9 |
| 4/4 | 4.6 | 91.2 |
| 4/5 | 4.3 | 92.9 |
| 4/6 | 4.9 | 93.0 |
| 4/7 | 5.2 | 95.4 |
| 4/8 | 4.9 | 99.0 |
| 4/9 | 4.7 | 101.0 |
| 4/10 | 4.3 | 102.0 |
| 4/11 | 4.6 | 101.0 |
| 4/12 | 4.9 | 103.0 |
| 4/13 | 5.2 | 104.0 |
| 4/14 | 5.5 | 104.0 |
| 4/15 | 5.4 | 106.0 |
| 4/16 | 5.6 | 108.0 |
| 4/17 | 5.8 | 111.0 |
| 4/18 | 6.5 | 113.0 |
| 4/19 | 7.3 | 115.0 |
| 4/20 | 8.6 | 118.0 |
| 4/21 | 9.2 | 122.0 |
| 4/22 | 9.2 | 132.0 |
| 4/23 | 9.5 | 142.0 |
| 4/24 | 10.1 | 151.0 |
| 4/25 | 10.1 | 161.0 |
| 4/26 | 9.9 | 175.0 |
| 4/27 | 8.9 | 191.0 |
| 4/28 | 8.0 | 207.0 |
| 4/29 | 7.2 | 223.0 |
| 4/30 | 6.9 | 236.0 |
| 5/1 | 7.2 | 249.0 |
| 5/2 | 7.7 | 263.0 |
| 5/3 | 8.6 | 284.0 |
| 5/4 | 8.5 | 306.0 |
| 5/5 | 8.6 | 327.0 |
| 5/6 | 8.3 | 345.0 |
| 5/7 | 7.9 | 361.0 |
| 5/8 | 8.3 | 374.0 |
| 5/9 | 9.0 | 383.0 |
| 5/10 | 9.1 | 389.0 |

| Date | Mean Daily Temperature (°C) | Mean Daily Discharge ($m^3$/sec) |
|---|---|---|
| 5/11 | 9.7 | 396.0 |
| 5/12 | 9.8 | 402.0 |
| 5/13 | 10.4 | 407.0 |
| 5/14 | 10.5 | 407.0 |
| 5/15 | 10.0 | 399.0 |
| 5/16 | 10.1 | 390.0 |
| 5/17 | 10.3 | 375.0 |
| 5/18 | 10.3 | 363.0 |
| 5/19 | 10.2 | 352.0 |
| 5/20 | 10.0 | 347.0 |
| 5/21 | 11.0 | 340.0 |
| 5/22 | 11.2 | 339.0 |
| 5/23 | 10.9 | 343.0 |
| 5/24 | 10.9 | 351.0 |
| 5/25 | 11.4 | 361.0 |
| 5/26 | 11.8 | 368.0 |
| 5/27 | 12.0 | 374.0 |
| 5/28 | 12.5 | 379.0 |
| 5/29 | 13.6 | 382.0 |
| 5/30 | 13.7 | 378.0 |
| 5/31 | 13.2 | 367.0 |
| 6/1 | 12.6 | 355.0 |
| 6/2 | 13.0 | 338.0 |
| 6/3 | 13.3 | 317.0 |
| 6/4 | 13.7 | 295.0 |
| 6/5 | 13.8 | 277.0 |
| 6/6 | 13.9 | 264.0 |
| 6/7 | 14.3 | 249.0 |
| 6/8 | 15.3 | 234.0 |
| 6/9 | 15.9 | 223.0 |
| 6/10 | 16.1 | 214.0 |
| 6/11 | 14.7 | 210.0 |
| 6/12 | 14.4 | 208.0 |
| 6/13 | 15.0 | 210.0 |
| 6/14 | 15.5 | 213.0 |
| 6/15 | 15.4 | 216.0 |
| 6/16 | 15.3 | 219.0 |
| 6/17 | 15.0 | 228.0 |
| 6/18 | 15.0 | 242.0 |
| 6/19 | 16.1 | 252.0 |

**Table 4.** Comparison of daily mean temperature between Optic StowAway® TidbiT™ temperature loggers installed at the 2004 white sturgeon spawning grounds, and the Water Survey of Canada station 08JC001 a the Vanderhoof bridge, from May 13 to June 16, 2005.

| | Optic StowAway® TidbiT™ Temperature Loggers | | | Water Survey Of Canada (WSC) | |
|---|---|---|---|---|---|
| **Date** | **Daily Min. Temp. (°C)** | **Daily Max. Temp. (°C)** | **Daily Mean Temp. (°C)** | **Daily Mean Temp. (°C)** | **Difference between the loggers and WSC daily mean temp** |
| 13-May | 10.39 | 11.42 | 11.02 | 10.4 | 0.62 |
| 14-May | 9.97 | 10.80 | 10.39 | 10.5 | -0.11 |
| 15-May | 9.61 | 10.49 | 9.96 | 10.0 | -0.04 |
| 16-May | 9.66 | 10.75 | 10.08 | 10.1 | -0.02 |
| 17-May | 9.66 | 10.80 | 10.26 | 10.3 | -0.04 |
| 18-May | 9.71 | 10.80 | 10.28 | 10.3 | -0.02 |
| 19-May | 9.56 | 10.59 | 10.15 | 10.2 | -0.05 |
| 20-May | 8.94 | 10.85 | 10.00 | 10.0 | 0.00 |
| 21-May | 10.34 | 11.73 | 10.98 | 11.0 | -0.02 |
| 22-May | 10.90 | 11.88 | 11.26 | 11.2 | 0.06 |
| 23-May | 10.39 | 11.63 | 10.85 | 10.9 | -0.05 |
| 24-May | 9.92 | 11.89 | 10.90 | 10.9 | 0.00 |
| 25-May | 10.70 | 12.29 | 11.47 | 11.4 | 0.07 |
| 26-May | 11.16 | 12.71 | 11.92 | 11.8 | 0.12 |
| 27-May | 11.37 | 12.87 | 12.12 | 12.0 | 0.12 |
| 28-May | 11.83 | 13.59 | 12.66 | 12.5 | 0.16 |
| 29-May | 12.92 | 14.83 | 13.86 | 13.6 | 0.26 |
| 30-May | 13.39 | 14.57 | 13.87 | 13.7 | 0.17 |
| 31-May | 13.08 | 13.85 | 13.44 | 13.2 | 0.24 |
| 1-Jun | 12.61 | 13.23 | 12.80 | 12.6 | 0.20 |
| 2-Jun | 12.61 | 13.79 | 13.13 | 13.0 | 0.13 |
| 3-Jun | 13.13 | 14.47 | 13.60 | 13.3 | 0.30 |
| 4-Jun | 13.39 | 14.73 | 13.98 | 13.7 | 0.28 |
| 5-Jun | 13.44 | 15.05 | 14.08 | 13.8 | 0.28 |
| 6-Jun | 13.44 | 15.25 | 14.15 | 13.9 | 0.25 |
| 7-Jun | 13.74 | 15.84 | 14.71 | 14.3 | 0.41 |
| 8-Jun | 14.10 | 17.58 | 15.66 | 15.3 | 0.36 |
| 9-Jun | 15.36 | 17.74 | 16.36 | 15.9 | 0.46 |
| 10-Jun | 15.68 | 17.96 | 16.56 | 16.1 | 0.46 |
| 11-Jun | 14.47 | 15.73 | 15.09 | 14.7 | 0.39 |
| 12-Jun | 13.64 | 16.10 | 14.64 | 14.4 | 0.24 |
| 13-Jun | 14.41 | 16.89 | 15.44 | 15.0 | 0.44 |
| 14-Jun | 14.57 | 17.53 | 15.93 | 15.5 | 0.43 |
| 15-Jun | 14.26 | 17.42 | 15.82 | 15.4 | 0.42 |
| 16-Jun | 14.68 | 17.00 | 15.75 | 15.3 | 0.45 |

# Appendix 2

# Telemetry Data

**Table 5.** Detailed telemetry data, by frequency and code.

| Frequency | Code | Date First Recorded | Date Last Recorded | Method Recorded (plane, boat) | River Km |
|---|---|---|---|---|---|
| 148.380 | 1 | 10-June-05 | 7-Sept-04[1] | boat | 116 |
| 148.380 | 1 | 12-June-05 | 10-June-05 | boat | 116 |
| | | | | | |
| 148.380 | 2 | 11-May-05 | 23-Sept-04[1] | plane | 111 |
| 148.380 | 2 | 13-May-05 | 11-May-05 | plane | 115 |
| 148.380 | 2 | 27-May-05 | 13-May-05 | boat | 115 |
| 148.380 | 2 | 29-May-05 | 27-May-05 | boat | 121 |
| 148.380 | 2 | 31-May-05 | 29-May-05 | boat | 121 |
| 148.380 | 2 | 04-June-05 | 31-May-05 | boat | 121 |
| 148.380 | 2 | 08-June-05 | 04-June-05 | boat | 121 |
| 148.380 | 2 | 10-June-05 | 08-June-05 | boat | 121 |
| 148.380 | 2 | 12-June-05 | 10-June-05 | boat | 117 |
| | | | | | |
| 148.380 | 3 | 16-May-05 | 28-Sept-04 [1] | boat | 124.5 |
| 148.380 | 3 | 18-May-05 | 16-May-05 | boat | 115 |
| 148.380 | 3 | 20-May-05 | 18-May-05 | boat | 125 |
| 148.380 | 3 | 23-May-05 | 20-May-05 | boat | 125 |
| 148.380 | 3 | 27-May-05 | 23-May-05 | boat | 125 |
| 148.380 | 3 | 29-May-05 | 27-May-05 | boat | 125 |
| 148.380 | 3 | 31-May-05 | 29-May-05 | boat | 121 |
| 148.380 | 3 | 12-June-05 | 31-May-05 | boat | 116 |
| | | | | | |
| 148.400 | 9 | 13-May-05 | 22-July-04[2] | plane | 131 |
| 148.400 | 9 | 18-May-05 | 13-May-05 | boat | 118 |
| | | | | | |

[1] - Indicates when the fish was first captured, tagged and released.
[2] - MWLAP data.

# Appendix 3

# Field Survey Data

**Table 6.** Egg sampling gear (egg mats and egg tubes) specifications.

| Site/ Group | Date Set | Set Time | Date Retrieved | Retrieve Time | Length of Set (hours) | Group Description (#/Type) | Total Egg Mat Time (hours) | Total Egg Tube Time (hours) | Total Area Sample ($m^2$) | Depth (m) | Near bed velocity (m/s) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 18-May | 1100 | 20-May | 1410 | 51.2 | 2 EM* | 102.3 | 0.0 | 1.38 | 1.8 | 1.09 | |
| B | 18-May | 1110 | 20-May | 1420 | 51.2 | 4 EM | 204.7 | 0.0 | 2.76 | 1.8 | 0.55 | |
| C | 18-May | 1115 | 20-May | 1430 | 51.3 | 2 EM | 102.5 | 0.0 | 1.38 | 1.7 | 0.57 | |
| D | 18-May | 1130 | 20-May | 1440 | 51.2 | 2 EM | 102.3 | 0.0 | 1.38 | 2.0 | 0.61 | |
| | | | | | | | | | | | | |
| A | 20-May | 1415 | 23-May | 1600 | 73.8 | 4 EM | 295.0 | 0.0 | 2.76 | 1.8 | 1.09 | |
| B | 20-May | 1425 | 23-May | 1610 | 73.8 | 4 EM | 295.0 | 0.0 | 2.76 | 1.8 | 0.55 | |
| C | 20-May | 1435 | 23-May | 1620 | 73.8 | 4 EM | 295.0 | 0.0 | 2.76 | 1.7 | 0.57 | |
| D | 20-May | 1445 | 23-May | 1630 | 73.8 | 4 EM | 295.0 | 0.0 | 2.76 | 2.0 | 0.61 | |
| | | | | | | | | | | | | |
| A | 23-May | 1605 | 27-May | 1440 | 94.6 | 4 EM, 2 ET** | 378.3 | 189.2 | 3.36 | 1.8 | 1.09 | 1 sucker egg on egg mat. |
| B | 23-May | 1615 | 27-May | 1455 | 94.7 | 4 EM, 2 ET | 378.7 | 189.3 | 3.36 | 1.8 | 0.55 | 3 sucker eggs on egg mats. |
| C | 23-May | 1625 | 27-May | 1510 | 94.8 | 4 EM, 2 ET | 379.0 | 189.5 | 3.36 | 1.7 | 0.57 | |
| D | 23-May | 1640 | 27-May | 1445 | 94.1 | 4 EM, 2 ET | 376.3 | 188.2 | 3.36 | 2.0 | 0.61 | 1 sucker egg on egg tube. |
| E | 25-May | 1530 | 27-May | 1405 | 46.6 | 4 EM | 186.3 | 0.0 | 2.76 | 2.4 | 0.46 | |
| F | 25-May | 1540 | 27-May | 1355 | 46.3 | 4 EM | 185.0 | 0.0 | 2.76 | 2.2 | 0.55 | |
| G | 25-May | 1600 | 27-May | 1435 | 46.6 | 4 EM, 2 ET | 186.3 | 93.2 | 2.76 | 2.3 | 0.98 | |
| H | 25-May | 1610 | 27-May | 1550 | 47.7 | 4 EM | 190.7 | 0.0 | 2.76 | 1.7 | 0.79 | |
| I | 25-May | 1615 | 27-May | 1520 | 47.1 | 4 EM | 188.3 | 0.0 | 2.76 | 2.2 | 0.37 | |
| J | 25-May | 1450 | 27-May | 1605 | 49.3 | 4 EM | 197.0 | 0.0 | 2.76 | 1.9 | 0.55 | |
| K | 25-May | 1445 | 27-May | 1615 | 49.5 | 4 EM | 198.0 | 0.0 | 2.76 | 1.8 | 0.38 | 1 sucker egg on egg mat. |
| L | 25-May | 1505 | 27-May | 1625 | 49.3 | 4 EM | 197.3 | 0.0 | 2.76 | 1.9 | 0.10 | |
| M | 25-May | 1430 | 27-May | 1550 | 49.3 | 4 EM | 197.3 | 0.0 | 2.76 | 2.5 | 0.69 | |
| | | | | | | | | | | | | |
| A | 27-May | 1425 | 29-May | 1358 | 47.6 | 4 EM, 2 ET | 190.2 | 95.1 | 3.36 | 2.1 | 1.35 | |
| B | 27-May | 1500 | 29-May | 1330 | 46.5 | 4 EM, 2 ET | 186.0 | 93.0 | 3.36 | 2.2 | 0.81 | |

| Site/ Group | Date Set | Set Time | Date Retrieved | Retrieve Time | Length of Set (hours) | Group Description (#/Type) | Total Egg Mat Time (hours) | Total Egg Tube Time (hours) | Total Area Sample ($m^2$) | Depth (m) | Near bed velocity (m/s) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | 27-May | 1510 | 29-May | 1348 | 46.6 | 4 EM, 2 ET | 186.5 | 93.3 | 3.36 | 0.9 | 1.19 | 2 sucker eggs on egg mat. |
| D | 27-May | 1450 | 29-May | 1420 | 47.5 | 4 EM, 2 ET | 190.0 | 95.0 | 3.36 | 2.1 | 0.45 | |
| E | 27-May | 1410 | 29-May | 1322 | 47.2 | 4 EM | 188.8 | 0.0 | 2.76 | 2.3 | 1.05 | |
| F | 27-May | 1400 | 29-May | 1310 | 47.2 | 4 EM | 188.7 | 0.0 | 2.76 | 2.3 | 0.85 | |
| G | 27-May | 1440 | 29-May | 1413 | 47.6 | 4 EM, 2 ET | 190.2 | 95.1 | 3.36 | 2.7 | 0.56 | |
| H | 27-May | 1555 | 29-May | 1429 | 46.6 | 4 EM | 186.3 | 0.0 | 2.76 | 1.9 | 0.79 | |
| I | 27-May | 1520 | 29-May | 1436 | 47.3 | 4 EM | 189.1 | 0.0 | 2.76 | 2.5 | 0.65 | |
| J | 27-May | 1610 | 29-May | 1457 | 46.8 | 4 EM | 187.1 | 0.0 | 2.76 | 2.1 | 0.51 | |
| K | 27-May | 1620 | 29-May | 1450 | 46.5 | 4 EM | 186.0 | 0.0 | 2.76 | 2.2 | 0.47 | |
| L | 27-May | 1630 | 29-May | 1443 | 46.2 | 4 EM | 184.9 | 0.0 | 2.76 | 2.0 | 0.41 | |
| M | 27-May | 1535 | 29-May | 1504 | 47.5 | 4 EM | 189.9 | 0.0 | 2.76 | 2.6 | 0.57 | |
| N | 27-May | 1540 | 29-May | 1343 | 46.1 | 2 EM | 92.1 | 0.0 | 1.38 | 1.9 | 0.49 | |
| | | | | | | | | | | | | |
| A | 29-May | 1402 | 2-Jun | 1712 | 99.2 | 4 EM, 2 ET | 396.7 | 198.3 | 3.36 | 2.1 | 1.35 | |
| B | 29-May | 1334 | 2-Jun | 1642 | 99.1 | 4 EM, 2 ET | 396.5 | 198.3 | 3.36 | 2.2 | 0.81 | |
| C | 29-May | 1352 | 2-Jun | 1650 | 99.0 | 4 EM, 2 ET | 395.9 | 197.9 | 3.36 | 0.9 | 1.19 | |
| D | 29-May | 1424 | 2-Jun | 1728 | 99.1 | 4 EM, 2 ET | 396.3 | 198.1 | 3.36 | 2.1 | 0.45 | |
| E | 29-May | 1326 | 2-Jun | 1635 | 99.2 | 4 EM | 396.6 | 0.0 | 2.76 | 2.3 | 1.05 | |
| F | 29-May | 1314 | 2-Jun | 1630 | 99.3 | 4 EM | 397.1 | 0.0 | 2.76 | 2.3 | 0.85 | |
| G | 29-May | 1417 | 2-Jun | 1722 | 99.1 | 4 EM, 2 ET | 396.3 | 198.2 | 3.36 | 2.7 | 0.56 | |
| H | 29-May | 1433 | 2-Jun | 1735 | 99.0 | 4 EM | 396.1 | 0.0 | 2.76 | 1.9 | 0.79 | |
| I | 29-May | 1440 | 2-Jun | 1748 | 99.1 | 4 EM | 396.5 | 0.0 | 2.76 | 2.5 | 0.65 | |
| J | 29-May | 1501 | 2-Jun | 1800 | 99.0 | 4 EM | 395.9 | 0.0 | 2.76 | 2.1 | 0.51 | |
| K | 29-May | 1454 | 2-Jun | 1810 | 99.3 | 4 EM | 397.1 | 0.0 | 2.76 | 2.2 | 0.47 | |
| L | 29-May | 1447 | 2-Jun | 1815 | 99.5 | 4 EM | 397.9 | 0.0 | 2.76 | 2.0 | 0.41 | |
| M | 29-May | 1508 | 2-Jun | 1754 | 98.8 | 4 EM | 395.1 | 0.0 | 2.76 | 2.6 | 0.57 | |
| N | 29-May | 1347 | 2-Jun | 1653 | 98.9 | 2 EM | 197.9 | 0.0 | 1.38 | 1.9 | 0.49 | |
| | | | | | | | | | | | | |

| Site/ Group | Date Set | Set Time | Date Retrieved | Retrieve Time | Length of Set (hours) | Group Description (#/Type) | Total Egg Mat Time (hours) | Total Egg Tube Time (hours) | Total Area Sample ($m^2$) | Depth (m) | Near bed velocity (m/s) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2-Jun | 1717 | 6-Jun | 1112 | 89.9 | 4 EM, 2 ET | 359.7 | 179.8 | 3.36 | 1.3 | 1.32 | |
| B | 2-Jun | 1647 | 6-Jun | 1035 | 89.8 | 4 EM, 2 ET | 359.2 | 179.6 | 3.36 | 1.4 | 1.18 | |
| C | 2-Jun | 1655 | 6-Jun | 1048 | 89.9 | 4 EM, 2 ET | 359.5 | 179.8 | 3.36 | 1.3 | 1.02 | |
| D | 2-Jun | 1733 | 6-Jun | 1124 | 89.9 | 4 EM, 2 ET | 359.4 | 179.7 | 3.36 | 1.4 | 0.96 | |
| E | 2-Jun | 1637 | 6-Jun | 1024 | 89.8 | 4 EM | 359.1 | 0.0 | 2.76 | 1.8 | 1.26 | |
| F | 2-Jun | 1633 | 6-Jun | 1012 | 89.7 | 4 EM | 358.6 | 0.0 | 2.76 | 1.6 | 1.11 | |
| G | 2-Jun | 1727 | 6-Jun | 1056 | 89.5 | 4 EM, 2 ET | 357.8 | 178.9 | 3.36 | 1.5 | 1.02 | |
| H | 2-Jun | 1740 | 6-Jun | 1136 | 89.9 | 4 EM | 359.7 | 0.0 | 2.76 | 1.3 | 0.85 | |
| I | 2-Jun | 1753 | 6-Jun | 1147 | 89.9 | 4 EM | 359.6 | 0.0 | 2.76 | 1.3 | 0.98 | |
| J | 2-Jun | 1805 | 6-Jun | 1217 | 90.2 | 4 EM | 360.8 | 0.0 | 2.76 | 1.2 | 0.56 | |
| K | 2-Jun | 1813 | 6-Jun | 1206 | 89.9 | 4 EM | 359.5 | 0.0 | 2.76 | 0.9 | 0.67 | |
| L | 2-Jun | 1820 | 6-Jun | 1155 | 89.6 | 4 EM | 358.3 | 0.0 | 2.76 | 1.2 | 0.42 | |
| M | 2-Jun | 1759 | 6-Jun | 1229 | 89.5 | 4 EM | 358.0 | 0.0 | 2.76 | 1.8 | 0.79 | |
| N | 2-Jun | 1658 | 6-Jun | 1043 | 89.8 | 2 EM | 179.5 | 0.0 | 1.38 | 1.4 | 0.55 | |
| | | | | | | | | | | | | |
| A | 6-Jun | 1116 | 9-Jun | 1243 | 73.5 | 4 EM, 2 ET | 293.8 | 146.9 | 3.36 | 1.2 | 1.38 | |
| B | 6-Jun | 1039 | 9-Jun | 1223 | 73.7 | 4 EM, 2 ET | 294.9 | 147.5 | 3.36 | 1.3 | 1.21 | |
| C | 6-Jun | 1052 | 9-Jun | 1226 | 73.6 | 4 EM, 2 ET | 294.3 | 147.1 | 3.36 | 1.0 | 1.34 | |
| D | 6-Jun | 1128 | 9-Jun | 1252 | 73.4 | 4 EM, 2 ET | 293.6 | 146.8 | 3.36 | 1.1 | 0.93 | |
| E | 6-Jun | 1028 | 9-Jun | 1202 | 73.6 | 4 EM | 294.3 | 0.0 | 2.76 | 1.6 | 0.98 | |
| F | 6-Jun | 1016 | 9-Jun | 1152 | 73.6 | 4 EM | 294.4 | 0.0 | 2.76 | 1.6 | 0.79 | |
| G | 6-Jun | 1100 | 9-Jun | 1235 | 73.6 | 4 EM, 2 ET | 294.3 | 147.2 | 3.36 | 1.2 | 0.93 | |
| H | 6-Jun | 1140 | 9-Jun | 1301 | 73.4 | 4 EM | 293.4 | 0.0 | 2.76 | 1.0 | 0.93 | |
| I | 6-Jun | 1151 | 9-Jun | 1308 | 73.3 | 4 EM | 293.1 | 0.0 | 2.76 | 1.2 | 0.81 | |
| J | 6-Jun | 1221 | 9-Jun | 1333 | 73.2 | 4 EM | 292.8 | 0.0 | 2.76 | 1.0 | 0.67 | |
| K | 6-Jun | 1210 | 9-Jun | 1324 | 73.2 | 4 EM | 292.9 | 0.0 | 2.76 | 0.8 | 0.74 | |
| L | 6-Jun | 1159 | 9-Jun | 1316 | 73.3 | 4 EM | 293.1 | 0.0 | 2.76 | 0.8 | 0.72 | |
| M | 6-Jun | 1233 | 9-Jun | 1343 | 73.2 | 4 EM | 292.7 | 0.0 | 2.76 | 1.4 | 0.80 | |

| Site/ Group | Date Set | Set Time | Date Retrieved | Retrieve Time | Length of Set (hours) | Group Description (#/Type) | Total Egg Mat Time (hours) | Total Egg Tube Time (hours) | Total Area Sample ($m^2$) | Depth (m) | Near bed velocity (m/s) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 6-Jun | 1047 | 9-Jun | 1218 | 73.5 | 2 EM | 147.0 | 0.0 | 1.38 | 1.2 | 0.85 | |
| | | | | | | | | | | | | |
| A | 9-Jun | 1248 | 12-Jun | 1448 | 74.0 | 4 EM, 2 ET | 296.0 | 148.0 | 3.36 | 1.7 | 0.94 | |
| B | 9-Jun | 1225 | 12-Jun | 1415 | 73.8 | 4 EM, 2 ET | 295.3 | 147.7 | 3.36 | 1.9 | 1.34 | |
| C | 9-Jun | 1231 | 12-Jun | 1425 | 73.9 | 4 EM, 2 ET | 295.6 | 147.8 | 3.36 | 1.2 | 1.05 | |
| D | 9-Jun | 1257 | 12-Jun | 1500 | 74.1 | 4 EM, 2 ET | 296.2 | 148.1 | 3.36 | 1.2 | 0.83 | |
| E | 9-Jun | 1207 | 12-Jun | 1407 | 74.0 | 4 EM | 296.0 | 0.0 | 2.76 | 1.0 | 1.10 | |
| F | 9-Jun | 1157 | 12-Jun | 1354 | 74.0 | 4 EM | 295.8 | 0.0 | 2.76 | 1.4 | 1.05 | |
| G | 9-Jun | 1240 | 12-Jun | 1445 | 74.1 | 4 EM, 2 ET | 296.3 | 148.2 | 3.36 | 1.1 | 1.18 | |
| H | 9-Jun | 1306 | 12-Jun | 1508 | 74.0 | 4 EM | 296.1 | 0.0 | 2.76 | 1.5 | 1.05 | |
| I | 9-Jun | 1313 | 12-Jun | 1518 | 74.1 | 4 EM | 296.3 | 0.0 | 2.76 | 1.1 | 1.07 | |
| J | 9-Jun | 1338 | 12-Jun | 1547 | 74.2 | 4 EM | 296.6 | 0.0 | 2.76 | 1.3 | 0.83 | |
| K | 9-Jun | 1329 | 12-Jun | 1537 | 74.1 | 4 EM | 296.5 | 0.0 | 2.76 | 0.8 | 0.60 | |
| L | 9-Jun | 1321 | 12-Jun | 1527 | 74.1 | 4 EM | 296.4 | 0.0 | 2.76 | 0.6 | 0.63 | |
| M | 9-Jun | 1347 | 12-Jun | 1557 | 74.2 | 4 EM | 296.7 | 0.0 | 2.76 | 0.9 | 0.64 | |
| N | 9-Jun | 1222 | 12-Jun | 1420 | 74.0 | 2 EM | 147.9 | 0.0 | 1.38 | 1.4 | 0.85 | |
| | | | | | | | | | | | | |
| A | 12-Jun | 1452 | 17-Jun | 930 | 114.6 | 4 EM, 2 ET | 458.5 | 229.3 | 3.4 | 1.7 | 0.94 | |
| B | 12-Jun | 1419 | 17-Jun | 935 | 115.3 | 4 EM, 2 ET | 461.1 | 230.5 | 3.4 | 1.9 | 1.34 | |
| C | 12-Jun | 1429 | 17-Jun | 940 | 115.2 | 4 EM, 2 ET | 460.7 | 230.4 | 3.4 | 1.2 | 1.05 | |
| D | 12-Jun | 1505 | 17-Jun | 1010 | 115.1 | 4 EM, 2 ET | 460.3 | 230.2 | 3.4 | 1.2 | 0.83 | |
| E | 12-Jun | 1412 | 17-Jun | 1407 | 114.9 | 4 EM | 459.7 | 0.0 | 2.8 | 1.0 | 1.10 | |
| F | 12-Jun | 1358 | 17-Jun | 925 | 115.5 | 4 EM | 461.8 | 0.0 | 2.8 | 1.4 | 1.05 | |
| G | 12-Jun | 1447 | 17-Jun | 1005 | 115.3 | 4 EM, 2 ET | 461.2 | 230.6 | 3.4 | 1.1 | 1.18 | |
| H | 12-Jun | 1512 | 17-Jun | 1015 | 115.0 | 4 EM | 460.1 | 0.0 | 2.8 | 1.5 | 1.05 | |
| I | 12-Jun | 1522 | 17-Jun | 1020 | 115.0 | 4 EM | 459.9 | 0.0 | 2.8 | 1.1 | 1.07 | |
| J | 12-Jun | 1551 | 17-Jun | 1110 | 115.3 | 4 EM | 461.3 | 0.0 | 2.8 | 1.3 | 0.83 | |
| K | 12-Jun | 1541 | 17-Jun | 1100 | 115.3 | 4 EM | 461.3 | 0.0 | 2.8 | 0.8 | 0.60 | |

| Site/ Group | Date Set | Set Time | Date Retrieved | Retrieve Time | Length of Set (hours) | Group Description (#/Type) | Total Egg Mat Time (hours) | Total Egg Tube Time (hours) | Total Area Sample ($m^2$) | Depth (m) | Near bed velocity (m/s) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L | 12-Jun | 1531 | 17-Jun | 1025 | 114.9 | 4 EM | 459.6 | 0.0 | 2.8 | 0.6 | 0.63 | |
| M | 12-Jun | 1601 | 17-Jun | 1120 | 115.3 | 4 EM | 461.3 | 0.0 | 2.8 | 0.9 | 0.64 | |
| N | 12-Jun | 1423 | 17-Jun | 945 | 115.4 | 2 EM | 230.7 | 0.0 | 1.4 | 1.4 | 0.85 | |
| | | | | | | | | | | | | |
| **Totals** | | | | | | | **31,847** | **5,836** | | | | |

Notes: * EM = egg mat (surface area of 0.7 $m^2$)

** ET = egg tube (exposed surface area of 0.3 $m^2$).

# Appendix 4

# Photograph Plates

**Plate:** 1 **Date:** May 11, 2005
**Comment:** Showing the 2004 white sturgeon spawning location (km 136-138) at a river discharge of approximately 400 $m^3$/second.

**Plate:** 2 **Date:** April 28, 2004
**Comment:** Showing the 2004 white sturgeon spawning location (km 136-138) at a river discharge of approximately 90 $m^3$/second.

**Plate:** 3 **Date:** June 17, 2005
**Comment:** Demobilizing egg mats and egg tubes at the end of the project.


**Plate:** 4 **Date:** June 17, 2004
**Comment:** Checking egg mats.