Investigation of Lake Sturgeon Spawning Activities at Xxxxxxxxxxxxx on the St. Lawrence River in 2008

Final Report

Modified to remove location reference

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1 INTRODUCTION

1.1 Background

Lake sturgeon (*Acipenser fulvescens*) is listed as a threatened species in New York State and is considered a priority species for recovery (Carlson, 2000). Although the specific causes of lake sturgeon population decline across its entire range are not known, several factors have been identified including over exploitation of stocks, construction of dams that inhibited migration and altered spawning habitat and habitat deterioration due to pollution and channelization. The largest remnant population of lake sturgeon in New York State is thought to occur in the St. Lawrence River below the St. Lawrence–FDR Power Project near Massena, NY (Werner and Hayes, 2005).

The New York Power Authority's (NYPA) St. Lawrence-FDR Power Project (Project) is licensed by the Federal Energy Regulatory Commission (FERC). NYPA was issued a license to operate the Project on October 23, 2003. As part of its application for the new license, NYPA signed a Settlement Agreement with state and federal resource agencies, local governments, non-governmental organizations, and other stakeholders. Portions of this Settlement Agreement were included in the new License. License Article 409 requires that NYPA develop a habitat improvement project (HIP) for lake sturgeon.

In 2004, NYPA developed a Habitat Improvement Implementation Plan that was approved by the FERC in its Order of November 18, 2004. The Plan specified that the objective of the lake sturgeon HIP was to provide spawning habitat to increase production.

In October 2007, NYPA installed two sturgeon spawning beds in the vicinity of Xxxxxxxxxxxxx near Waddington, NY. Xxxxxxxxxxxxx is a water control dam that consists of 32 gated structures. Generally, the gates are in the full open position resulting in full continuous flows, although they may be lowered at certain times of the year for specific purposes, such as ice formation or to reduce potential for downstream flooding. One spawning bed was installed just upstream of the dam and one was installed just downstream of the dam. Each bed is approximately 30 m wide and 30 m long and consists of Number 3 and 4 clean gravel (5-10 cm). In addition, 10 large boulders were placed on the downstream end of each spawning bed to act as velocity breaks for staging sturgeon. The depth of water at each location varies from 9 to 12 m and current velocities range from 0.80 to 1.5 m/s.

In order to determine if the spawning beds are used by lake sturgeon, Environnement Illimité inc. (EI) was retained by NYPA to monitor lake sturgeon spawning activity. The following report details the methodology and the results of the initial post-construction monitoring, which was conducted in the spring of 2008.

1.2 Objectives

The specific objectives of this study were:

1. to confirm the presence of spawning lake sturgeon on the newly constructed spawning beds;
2. to document lake sturgeon egg deposition on the spawning beds;
3. to document lake sturgeon fry emergence (larval drift).

1.3 Study Area

The study area was located in Lake St. Lawrence near Xxxxxxxxxxxxx on the St. Lawrence River in the Town of Waddington, NY (Map 1).

MAP 1 — Study Area

2 METHODS

Post-construction monitoring of the spawning beds consisted mainly of three activities:

1. confirm the presence of spawners using an underwater video camera;
2. if video monitoring demonstrated sturgeon on the beds, verify the presence of egg deposition using egg traps; and
3. if egg traps demonstrated spawning on the beds, monitor larval drift using plankton nets to confirm the successful development of eggs in the spawning beds.

2.1 Spawner Observations through Video Monitoring

Video equipment was used to confirm the presence of lake sturgeon prior to and during the spawning period in the spawning bed areas. The underwater video camera (Aquavu Scout SRT) was weighted and had fins to provide proper orientation relative to the current. The camera was positioned in the horizontal plane and was oriented so it looked ahead and down as the boat drifted downstream over the spawning beds. The analog output from the video camera was converted to a digital format and recorded on a digital video camera (Sony, DCR-SR80). Camera locations were determined using a global positioning system (GPS; Garmin, GPS-76) and a GPS-Video overlay (Geostamp from Intuitive Circuits LLC) to provide geo-referenced recorded images. The GPS was connected to an on-board laptop computer and the real-time National Marine Electronics Association (NMEA) output (two-second intervals) was used to position the boat relative to the spawning beds with the assistance of hydrographic software (HYPACK V6.1).

A series of transects parallel to the flow, spaced every 10 meters, were positioned over the beds in order to obtain systematic coverage. Video observations began at the upstream end of each transect presented on Map 2. Video recordings were later viewed at the laboratory on a desktop computer and the number of lake sturgeon within the view of the camera was noted. The estimated number of lake sturgeon was standardized as the number of individuals observed in the video recording per 50 meters of transect, which permitted the comparison of the number of lake sturgeon observed both spatially and temporally for each transect.

Observations with the underwater camera were also made on one occasion (May 9, 2008) near the Canadian shore near Xxxxxxxxxxxxx where sturgeon had been observed and netted in previous studies (Environnement Illimité inc., 2005a and 2005b). Additionally, the gravel bed water intake structure at a power plant near Chimney Point in Ogdensburg was inspected once, on June 13, 2008, since sturgeon have been documented spawning there in recent years (Johnson et al. 2006).

MAP 2 — Underwater Video Transects to Observe Lake Sturgeon–Xxxxxxxxxxxxx–2008

2.2 Characterization of the Spawning Beds

Although detailed characterization of the spawning bed installation sites was done in 2004 (Environnement Illimité inc., 2005a and 2005b), observations of the substrate and measurements of depth and current velocity were collected again in order to adequately characterize the recently constructed beds. Methods used to measure depth and current velocity, as well as to describe substrate, are described in the following sections.

2.2.1 Depth and Current

Current velocity, direction of the current and depth were collected on both spawning beds and the immediate area surrounding the beds using an Acoustic Doppler Current Profiler (ADCP). Data were recorded on June 17, 2008 at 2,852 locations on the downstream site and at 2,588 locations on the upstream site (Map 3).

The ADCP instrument (RD Instruments' *Rio Grande* 1200 kHz) has a maximum range of 25 m and was configured with a blanking distance under the instrument of 0.25 m and a cell size of 0.25 m. The magnetic declination of the site was entered in the ADCP software in order to obtain location corrected flow directions.

The location of the flow measurement profiles was obtained using a GPS (Garmin 76). GPS position data containing the required NMEA message (GGA) were transferred to the on-board computer and merged with the flow measurement information by the ADCP software (WinRiver V1.06). The position data were updated at a frequency of 1 Hz.

Results from the ADCP were integrated in a geographical information system (GIS) and interpolations were calculated for both the mean current velocity of the water column and the current velocity at 1 m from the bottom for each bed. The location of the egg traps were plotted over the interpolation results. Using a 2.5 m buffer around each egg trap point location, values (minimum, maximum and mean) of mean current velocity of the water column, current velocity at 1 m from the bottom, and depth, were assigned to each egg trap location.

2.2.2 Underwater Video-Camera Observation of Substrate

Underwater imagery collected from the video transects described in Section 2.1 was also used to visually characterize the spawning bed substrate that had been installed in October 2007. This imagery documented post-construction conditions after the first winter.

MAP 3 — Current Velocity Measurement Locations–Xxxxxxxxxxxxx–2008

Additionally the beds were reinspected late in summer, August 27, 2008, to further provide documentation of the substrate condition after the summer. In particular the observations were used to document whether the spawning bed substrates had collected sediment or been colonized by filamentous algae (*Cladophora*) or zebra mussels.

Video recordings, with their GPS location stamp, were also used to establish the as-built limits of the spawning beds. The GPS coordinates embedded into the video imagery for each transect were used to record the limits of the installed substrate. These coordinates were then used to draw the edges of the installed beds in GIS.

2.3 Egg Trapping in the Spawning

Egg traps were deployed along transects (Map 4) to verify the presence of eggs on the spawning beds. Egg traps were made from concrete blocks (38.7 cm in length x 19.1 cm in width x 14 cm in height) wrapped with a latex-covered, horsehair fiber material usually used for air filtration (Photo 1; distributor: FiltrationLAB; model: Bestair). This type of gear was used in similar studies on the St. Lawrence River (La Haye et al., 2003; Hayes, 2000) and on other rivers (Environnement Illimité inc., 2003) and was found to perform well.

In Lake St. Lawrence, the lake sturgeon spawning period generally occurs when water temperature reaches 10°C (Environnement Illimité inc., 1987; LaPan et al., 1996; La Haye et al., 2003; Environnement Illimité inc., 2005a). In this study, water temperature was measured on each field sampling day. Egg traps were deployed when the water temperature reached 10.5 °C (May 13, 2008). Egg traps were set along five transects on the upstream bed and four transects on the downstream bed, and were marked by buoys (Photos 2 and 3). Transects were spaced approximately 10 m apart, with each containing five egg traps spaced out at approximately 7.5 meter intervals. A total of 45 egg traps were placed over the two spawning beds (25 upstream and 20 downstream) (Map 4). During field sampling, it became apparent that transect line #4 in the downstream bed was located too far offshore from the spawning bed to effectively catch eggs. Therefore, on May 28th, egg traps along this transect were repositioned to a new transect line (#10) for the remainder of the study period.

Egg traps were deployed for a period of two to seven days before they were recovered, reset and then redeployed in approximately the same place. Egg trap positions were recorded with a GPS (Garmin GPS76) each time they were redeployed. When traps were recovered, the mesh fabric was removed and stored in the boat in an individual, labeled container for further inspection. To reset the traps, a clean mesh fabric was attached to the block and then the trap was redeployed. Mesh fabrics that had been removed were taken to a temporary lab area on shore where they were visually inspected. All eggs were removed and preserved in ethanol (90%). Identification and counting occurred later in the office laboratory utilizing dissecting microscopes and Wang et al. (1985) and Auer (1982) as reference for identification.

MAP 4 — Monitoring Locations for Lake Sturgeon Eggs and Larvae–Xxxxxxxxxxxxx–2008

2.4 Larval Drift Netting

Sampling approach

Three one-meter diameter, circular-mouth, drift nets were set on the downstream edge of each bed where eggs had been collected (Map 4). Nets were placed approximately 20 m downstream of the lower edge of each bed. The anchoring system was located upstream from the bed and was comprised of an approximately 15 kg grapnel, followed by a 15 m line with an approximately 70 kg rock-filled bag at the end (Figure 1). The anchoring system was fitted with a line to a surface marker buoy. The drift net was attached to the anchoring system by an approximately 35-40 m long line that trailed down across the bed to hold the net close to the downstream edge of the bed. A third anchor, an approximately 15 kg rock-filled bag, was used to hold the end of the line over the bottom edge of the spawning bed. Finally, a line fitted with a buoy was attached to the drift net to position the net approximately one-meter above the bottom, help mark its location, and allow for recovery.

Lake sturgeon larval drift is known to be minimal during daylight and peak during darkness (21:00 – 03:00) (D'amours et al., 2001; Johnson. et al., 2006). Therefore, drift net sampling was conducted three days per week, from approximately 9:00 p.m. to 3:00 a.m. with at least one day between each sampling event. Drift nets were set for three 2-hour sampling periods, for a total of six sampling hours each night. Nets were raised using a portable winch attached to the boat (Photo 4). Once at the surface, the net was cleaned, and reset for a 2-hour fishing period.

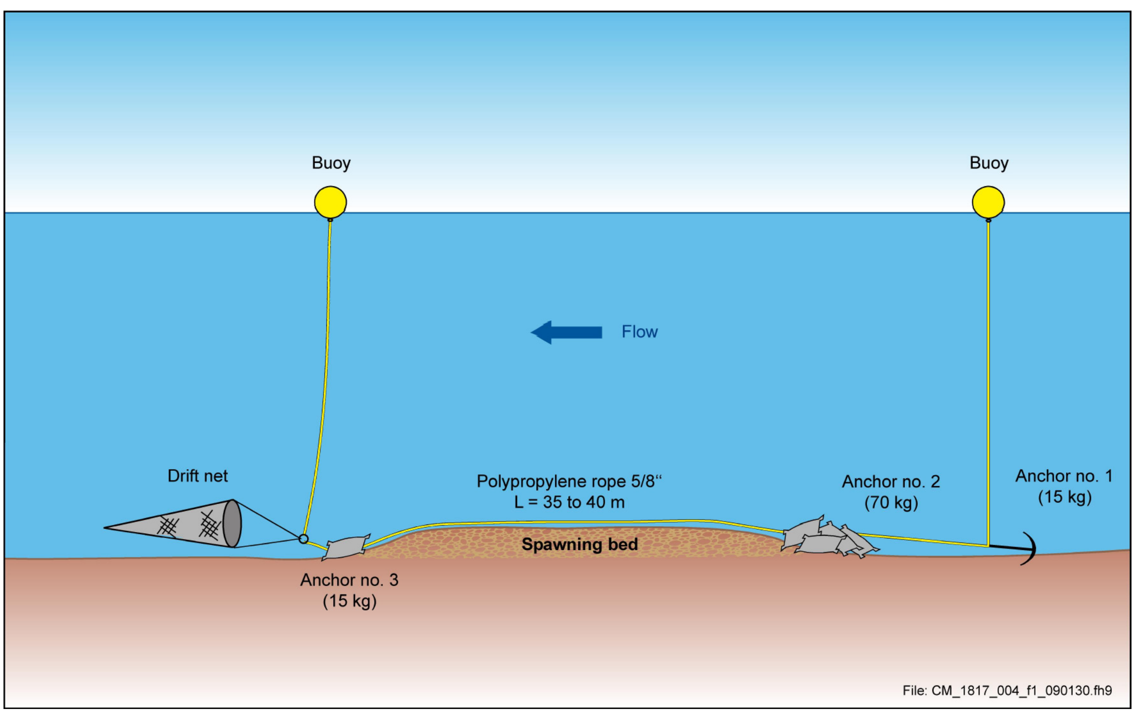

FIGURE 1 — Schematic of System Used to Sample Drifting Lake Sturgeon Larvae

Larval fish samples from each net were preserved in 90% ethanol for later identification at the office laboratory. Identification and counting of lake sturgeon larvae was completed for every sampling period utilizing microscopes and Auer (1982) as a reference for identification. Identification of the different specimens was not completed for species other than lake sturgeon.

Data analysis

Catch data were expressed as catch per unit effort (CPUE) for each 2-hour sample period ($_i$) $CPUE_i$ (number of larvae/100 m^3 water filtered) were estimated for each net at each sampling period as in D'amours et al. (2001):

$$CPUE_i = \frac{N_i}{V_i \times S_i \times T_i}$$

Where N_i is the number of larvae captured in the net; V_i is the water velocity (m/s) at 1 meter from the bottom at the net site. Water velocity values measured with the ADCP current profiler (measured once during the study: see section 2.3.1) were initially used to produce interpolated current velocity matrices corresponding to different depths (e.g.: 1, 2, 3 and 4 m from the bottom). The current velocity values obtained for the different depths were then projected on a vertical depth-velocity profile corresponding to the net site. The depth of the net (1 m from bottom) was used to extract the velocity from the depth-velocity profile. This current velocity was later corrected to take into account the resistance of the net by multiplying by a factor of 0.7. (Environnement Illimité inc., 2008 and in prep; Garceau and Bilodeau, 2003). Finally, S_i is the area (m^2) of the mouth of the net *i*, and T_i is time of sampling (s) of net *i*.

An estimate of the total number of larvae produced by the spawning beds was calculated from the CPUE results obtained from drift nets and from the flow (m^3/s) on a section corresponding to the 30 m width of the spawning bed and at a height of 2 m from the bottom.

Flow crossing the spawning beds was partitioned into three subsections that were sampled by individual drift nets. Using the Doppler data, flows in each subsection were calculated from the bottom, up to a 2-meter depth as noted above. Because drift nets were positioned immediately downstream from the installed spawning beds, it was assumed that emerging larvae can not go higher than 2 m in the water column before reaching the driftnets due to high current velocities. As reported by D'amours et al. (2001), larval drift of sturgeon occurs principally between 6 a.m. and 6 p.m.; therefore, the total number of larvae produced was estimated over a 12-hour period (6:00 p.m. to 6:00 a.m.).

The total number of larvae per night in each subsection was calculated using the mean $CPUE_i$ for the corresponding night obtained for each net and the volume of water flowing through the subsection in a 12-hour period.

$$\text{Number of drifting larvae/sub-section} = \frac{(\text{average CPUE } x \text{ Volume filtered in the subsection})}{100}$$

The total number of larvae emerging from the spawning bed in one day is the sum of larvae calculated for each of the subsections. Because sampling was conducted every other day, the total number of larvae on non-sampling days was interpolated from the values obtained for the days prior to and after the sampling. The total number of larvae that drifted over the spawning beds during the monitoring period was calculated by summing the observed and interpolated daily counts for each bed.

Finally, the numbers of drifting larvae caught during each of the three 2-hour sampling periods (11:00 p.m., 01:00 a.m., and 03:00 a.m.) were compared to determine if the catch rate differed from one period to the next. Statistical analysis of variation (ANOVA analysis using SPSS software) was performed on the number of larvae caught during each sample period.

3 RESULTS

3.1 Spawner Observations through Video Monitoring

Video observations were carried out between May 9 and June 12, 2008. During this period, the water temperature ranged from 9.1 to 15.8 °C. Video observations were conducted along 16 transects, nine at the upstream spawning bed and seven at the downstream spawning bed.

For the upstream spawning bed, the number of spawning sturgeon from May 9 to June 3 was relatively consistent between transects, with ratios ranging from zero to seven spawners per 50 m (Figure 2a). The number of spawning sturgeon started to increase considerably around June 4, peaking on approximately June 10th for all transects (Figure 2a and Photos 5 and 6). The highest observation occurred on Transect #5, with 36 sturgeon per 50 m on June 10th. After that time, the number of spawning fish rapidly decreased for each transect, with the exception of Transects #6 and #7 when a slight increase was observed on the June 11th. In general, few sturgeon were observed along Transects #8 and #9, located further offshore (Figure 2a).

Although slightly greater numbers of spawning sturgeon were observed in the upstream spawning beds, results from the downstream transects, especially the timing and duration of the peak numbers of spawning sturgeon, were similar and consistent with the upstream transects (Figure 2b). An early peak of spawners was observed in the downstream beds on May 28th for Transects #3 and #4. The downstream beds began to show an increasing number of spawning fish on June 4th, with a maximum observation reached on June 10th (Transect #3; 24 sturgeon per 50 m). Transect #2 also showed a relatively high number of sturgeon around June 8th, with 13 sturgeon observed per 50 m. During the field observations, the number of spawning sturgeon on downstream Transects #5 and #6 remained fairly low and stable (between 0 and 5 spawners per 50 m), while no sturgeon were observed on downstream Transect #7 (Figure 2b). Several downstream transects shown in Figure 2b have disconnected lines, which correspond to dates where video observations could not be performed in the field due to technical or logistic problems.

Besides sturgeon several other species were observed at both upstream and downstream locations including walleye (*Sander vitreus*), sucker (most likely *Catostomus commersoni*, *Catostomus catostomus* and *Moxostoma valenciennesi*) and carp (*Cyprinus carpio*).

Detailed results from each video transect, including GPS coordinates, number of sturgeon per observation transect, duration of transect, etc., are presented in Appendix 1.

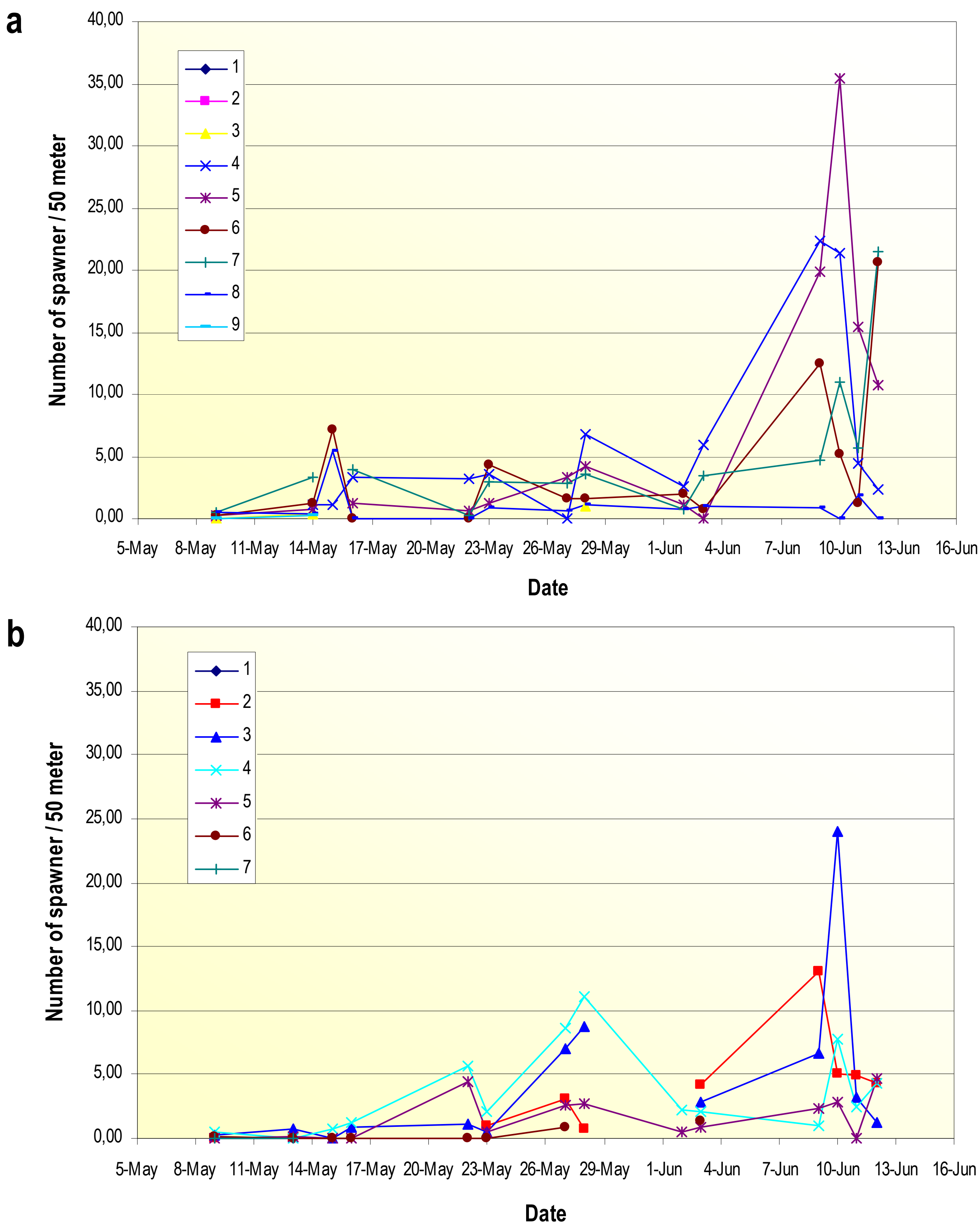

FIGURE 2 — Observation through Video Monitoring of Lake Sturgeon Spawner (Number per 50 Meters) over the Spawning Beds (a: Upstream Site; b: Downstream Site) – Iroquois Control Dam – Lake St. Lawrence

3.1.1 Underwater Video Observations at the Canadian-Side of Xxxxxxxxxxxxx and Ogdensburg

Sturgeon were not observed during the limited inspections on the Canadian side of Xxxxxxxxxxxxx. This sector was only inspected at the beginning of the campaign (May 9, 2008). This area was inspected because ripe male Sturgeon were caught during the previous studies (Environnement Illimité inc. 2005a and 2005b). This area appears to have very low potential as sturgeon spawning habitat as the upstream area is mainly covered with sand and the downstream area, where the sturgeon were caught in the previous studies, is mainly bedrock.

Sturgeon were not observed at the Ogdensburg site. The region was inspected towards the end of the expected spawning period (June 13, 2008), thus sturgeon could have been there earlier and then left. Most of the substrate appeared to be covered with sediment and algae, however there were a few scattered open, uncovered areas.

3.2 Characterization of the Spawning Beds

Current velocities, depth measurements and substrate observations were conducted at each site in order to characterize the surrounding habitat at the egg trap locations on the spawning beds. The results are presented in the following section. During the study period, May 9 to June 30, average river discharge for the St. Lawrence River was 8242 m^3/s and varied from 7775 m^3/s to 8577m^3/s (variation < 10%).

3.2.1 Depth and Current

3.2.1.1 Spawning Bed Upstream from the Xxxxxxxxxxxxx

The overall average of mean water column velocities at the upstream spawning bed was 1.06 m/s and the average depth was 10.30 m (Appendix 2A). Map 5 shows velocities measured from across the study area, at 1 m from the bottom and for the entire water column. A maximum current velocity (water column) of 1.18 m/s was measured at egg trap location L8P5, while a minimum velocity of 0.84 m/s was measured at egg trap location L5P1 (Appendix 2A). Current velocities measured at 1 meter from the bottom were slightly less, with an overall mean velocity of 0.83 m/s (Appendix 2A). At a 1 m depth, a maximum current velocity of 1.14 m/s was measured at egg trap L6P4 and a minimum velocity of 0.54 was measured at egg trap L5P5.

3.2.1.2 Spawning Bed Downstream from the Xxxxxxxxxxxxx

The overall average of mean water column velocities at the downstream spawning bed was 1.24 m/s and the average depth was of 12.5 m (Appendix 2B). A maximum current velocity of

MAP 5 — Current Velocity (m/s; 1 m from the Bottom and Mean for the Water Column) Measured in the Vicinity of the Upstream and Downstream Spawning Beds–Xxxxxxxxxxxxx–Lake St. Lawrence–2008

1.43 m/s (water column) was measured at egg trap L1P5 while a minimum current velocity of 1.05 m/s (water column) was measured at egg trap L2P2. Current velocities measured at 1 m from the bottom were slightly less, with an average of 0.96 m/s. At a 1 m depth, a maximum current velocity of 1.38 m/s (1 m from the bottom) was measured at egg traps L1P3 and a minimum current velocity of 0.58 m/s (1 m from the bottom) was measured at egg trap L2P2.

3.2.2 Underwater Video-Camera Observation of Substrate

As noted in Section 2.3.2, video transects of the nine upstream and seven downstream transects were also used to determine the state of the spawning bed (Map 2). Data from the spring 2008 survey, conducted from May 9 to June 12, 2008, indicated that both upstream and downstream beds showed no sign of sediment fouling or colonization by the filamentous algae (*Cladophora*) or zebra mussels. Surveys on August 27th indicated that the spawning beds were still clean, with no notable siltation or algal buildup (Photos 9 and 10).

3.2.3 Egg Trapping over the Spawning Beds

Sampling efforts to trap sturgeon eggs began on May 13th for the downstream spawning bed and on May 14th for the upstream spawning bed. At that time water temperatures were approximately 10°C.

Daily data from traps along each transect were summed and are presented in Figure 3. In the upstream spawning bed, eggs were first observed in the traps on June 10th (Photos 7 and 8). Peak egg counts occurred during June 11-12, with 598 eggs caught on transect line #8 in a two–day period, or a catch rate of 299 eggs per day (Figure 3a). The other egg trap transects peaked during the same period of time, but substantially fewer eggs were trapped. For example, peak egg counts on June 12th for the other transects were 104 (line #5), 87 (line #7), and 38 (line #6), which corresponds to a catch rate of 52 eggs per day, 43 eggs per day and 19 eggs per day, respectively (Figure 3a). Transect line #9, located furthest offshore, showed the lowest yields and eggs were only trapped in the last two egg traps of this transect (Map 6).

In the downstream transects, eggs were observed seven days before the upstream transects, with peak capture rates in the downstream bed occurring a day before the upstream bed. During the peak egg-capture period (June 10-11), 702 eggs were collected in a two-day period from Transect line #10 and 402 eggs from line #1, corresponding to a catch rate of 351 eggs per day and 201 eggs per day, respectively (Figure 3b). At the end of the sampling period (June 15th), Transects #10 and #1 had a catch rate of 0.3 eggs per day and 4 eggs per day, respectively (Figure 3a). Finally, the two first egg traps of both line #1 and #10 (L1P1, L1P2 and L10P1, L10P2) had the highest number of eggs for the downstream spawning beds, indicating that this was the most heavily used portion of the spawning bed (Map 6).

A detailed compilation of the egg trapping data is presented in Appendix 3.

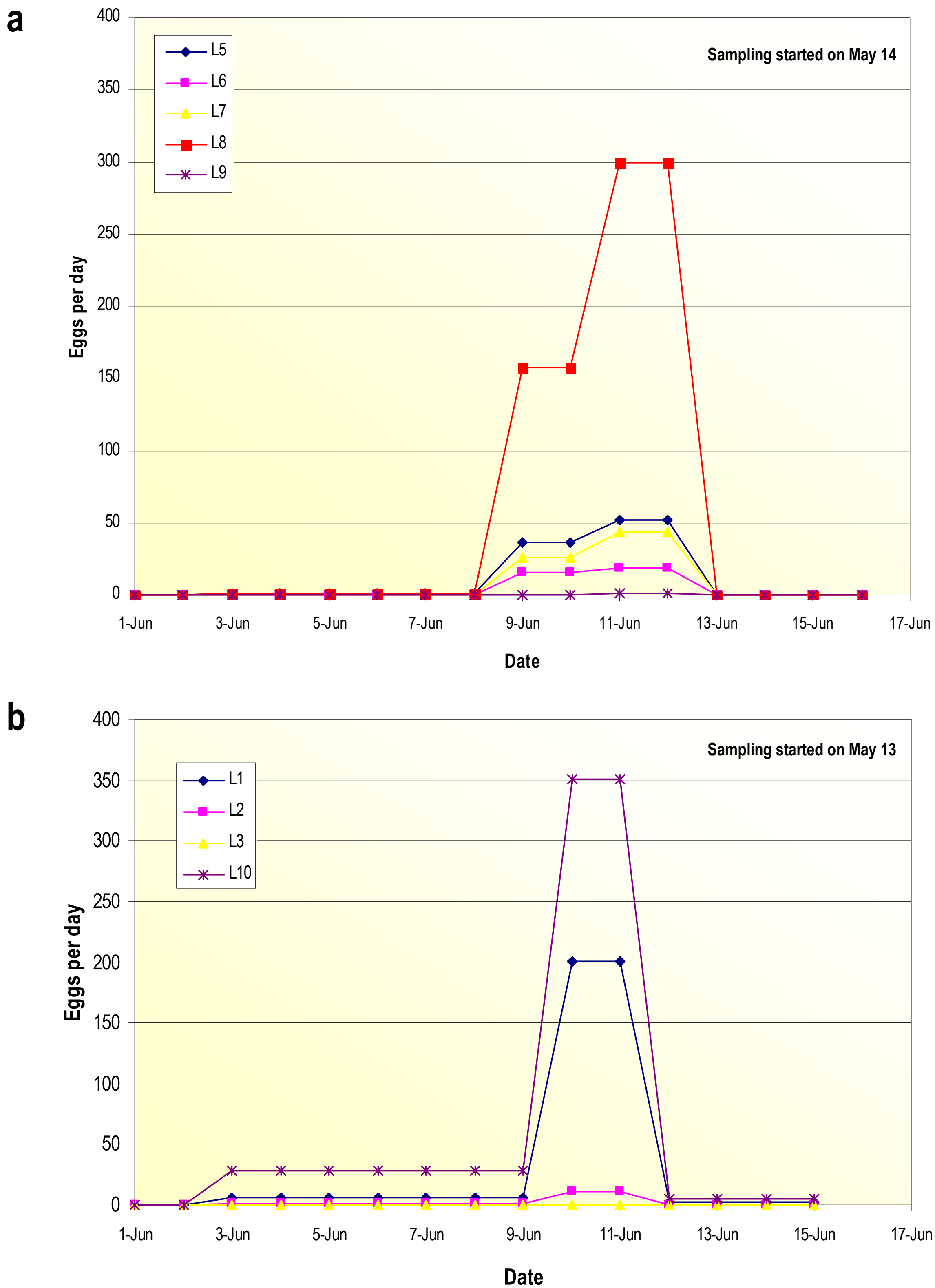

FIGURE 3 — Catch Rate of Lake Sturgeon Eggs (Number per Day) Collected with Egg Traps along each Transect (5 Egg Traps per Transect) Installed in the Spawning Beds (a: Upstream Site; b: Downstream Site)

MAP 6 — Lake Sturgeon Eggs Collected from Egg Traps Installed in the Spawning Beds Xxxxxxxxxxxxx–Lake St. Lawrence

3.3 Larval Drift Netting

Larval drift sampling was conducted from June 18 to June 30, 2008 at the three upstream and three downstream locations shown on Map 4. During this period, water temperatures ranged from 16.9 °C to 19.4 °C. Due to severe thunderstorms, the first sampling series on June 26 (9h00 pm to 11h00 pm) was not conducted. Larval lake sturgeon from the sampling effort are shown in Photos 11 and 12.

Generally, capture rates for lake sturgeon larvae were similar between upstream and downstream spawning beds. Few larvae were caught on the first days of sampling at either spawning bed (Figures 4a and 4b). After June 20th, the number of larvae started to increase rapidly at both upstream and downstream locations, reaching a peak number on June 24th, and a peak CPUE on June 26th (Figures 4a and 4b). The maximum number of larvae caught would probably have been observed on June 26th if field crews had been able to sample during the first sample series of the day (9h00 pm to 11h00 pm). After the June 26th peak, CPUE ratios started to decrease in all nets and the larval drift appeared to end by June 30th (Figures 4a and 4b).

The most productive drift nets at both beds were those closest to the shore. For example, upstream net U1 and downstream net D1 collected the most larvae at each spawning bed, with a total of 188 and 232 larvae caught in each net during the sampling season; these values correspond to mean CPUE values of 0.51 and 0.72, respectively. The least number of larvae were caught in upstream net U3 and downstream net D3, with 33 and 12 larvae caught in each net during the season; these values correspond to mean CPUE values of 0.1 and 0.02, respectively. Finally, 71 larvae were collected at upstream net U2 and 160 were collected from downstream net D2 during the season; CPUE values for these sites are 0.15 and 0.27, respectively. Details of the field and laboratory data from the larval drift netting sampling effort are presented in Appendix 4.

Comparison of data between the upstream and downstream spawning beds shows that more larvae were caught at the downstream bed (404) compared to the upstream bed (291) during the sampling period. In addition, an ANOVA analysis of the data from the three daily net-recovery times (11:00 p.m., 01:00 a.m., and 03:00 a.m.) showed that there was no significant difference in capture rates between the periods.

Although the screening and species identification focused on lake sturgeon, larvae of other fish species were recovered. Identification of the different specimens was not completed for species other than lake sturgeon (Appendix 4) but numerous larvae from the *Catostomidae* family and some larvae from the *Cyprinidae* family were caught as well. Adult and juvenile of white sucker (*Catostomus commersoni*), pumpkinseed (*Lepomis gibbosus*), Johnny darter (*Etheostoma nigrum*) round goby (*Neogobius melanostomus*), logperch (*Percina caprodes*) and some cyprinids were also caught (Appendix 4).

The total number of lake sturgeon larvae that drifted from the spawning beds during the monitoring period was estimated. The total number of larvae produced for the upstream spawning bed was estimated at 85,911 larvae, and the total number for the downstream spawning bed was estimated at 126,091 larvae (Figure 5).

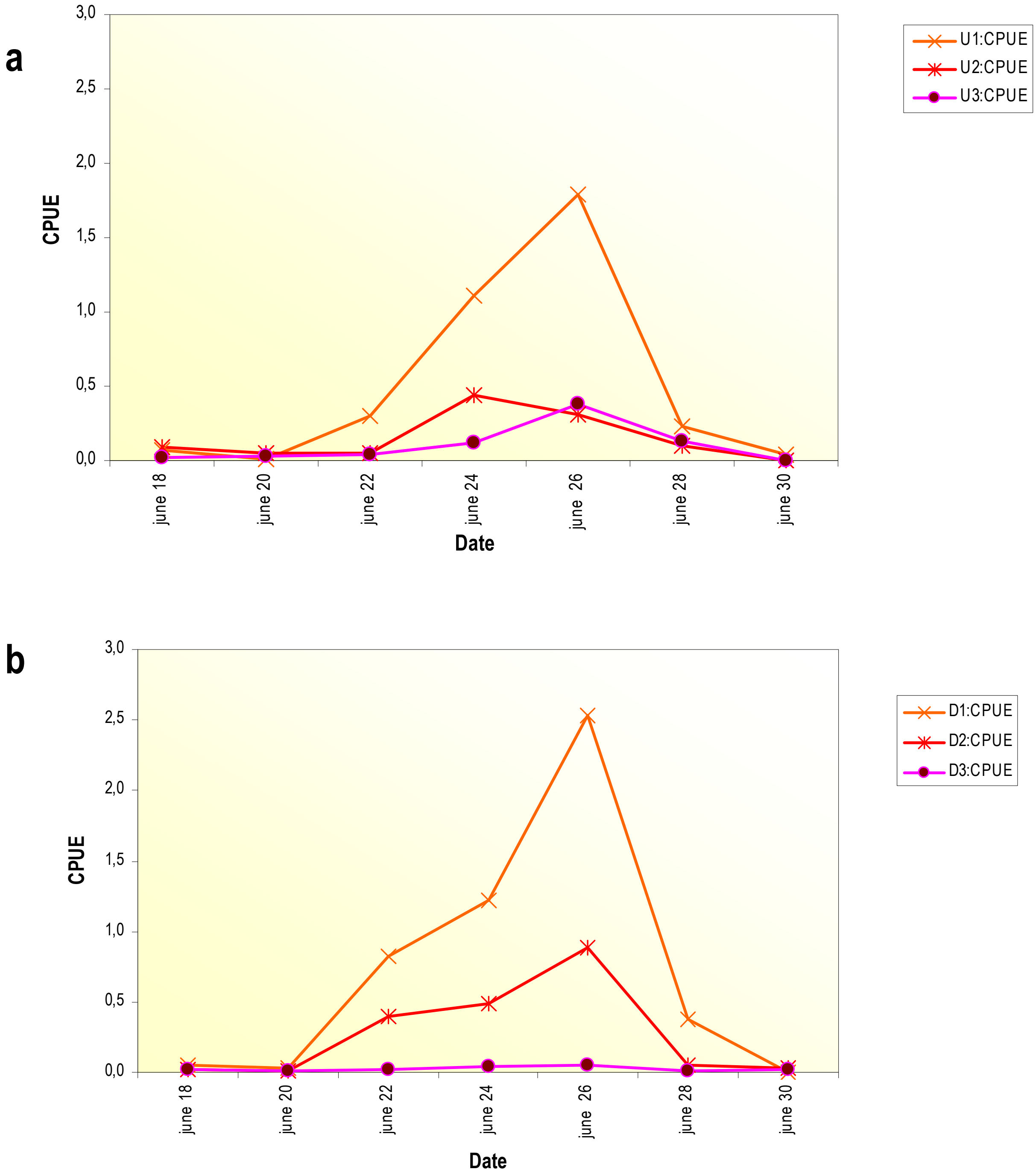

FIGURE 4 — Daily CPUE (number of larvae/100 m^3 water filtered) for Lake Sturgeon Larvae Collected in 1.0 m Drift Nets installed below the Spawning Beds (a: Upstream Site; b: Downstream Site)

Note: The fishing effort was different for June 26. The 9h00 pm to 11h00 pm sampling was not done due to a thunderstorm.

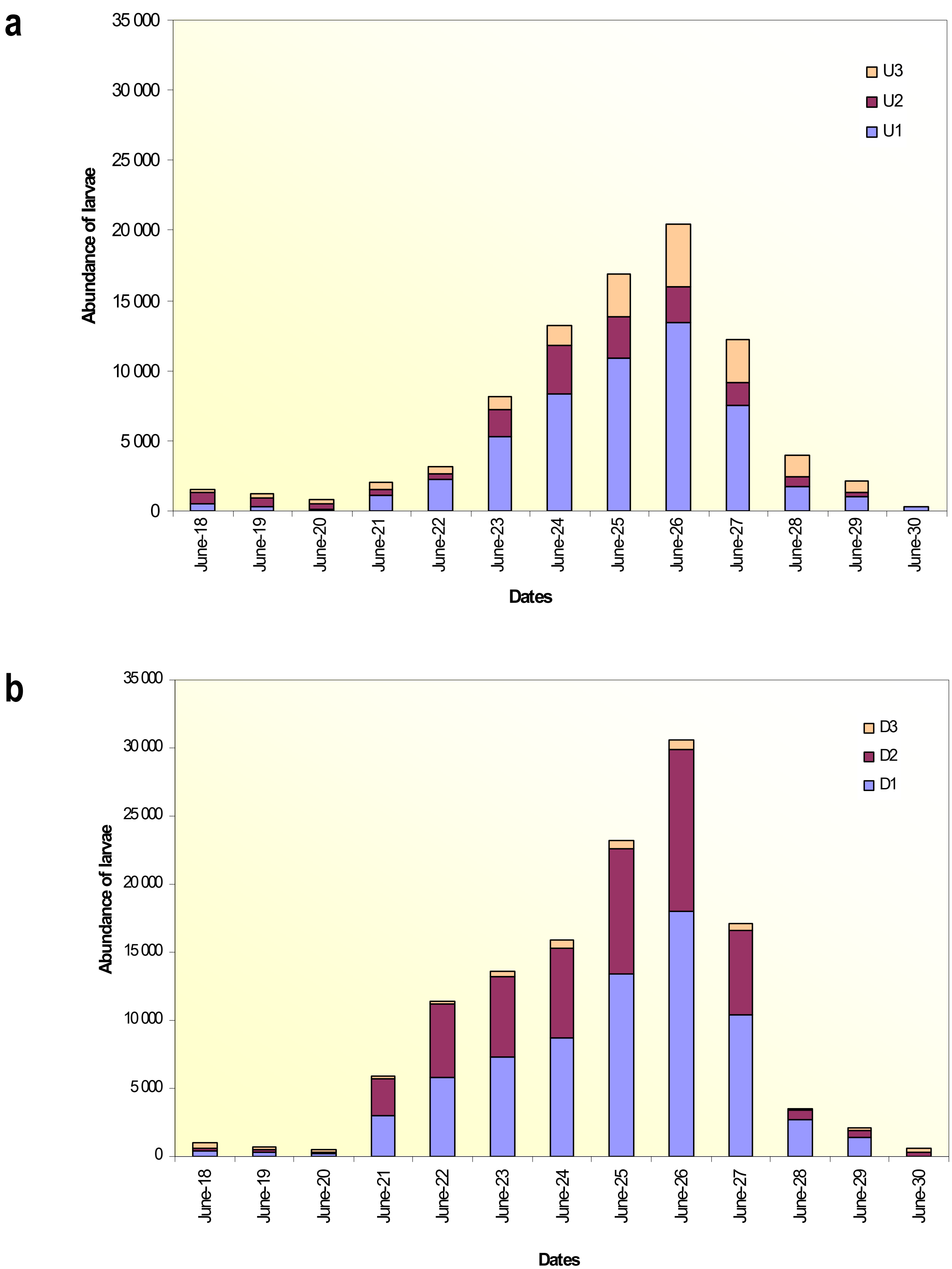

FIGURE 5 — Estimate of the Abundance of Lake Sturgeon Larvae Produced at the Spawning Beds Installed at Xxxxxxxxxxxxx – Estimates for the Spring 2008 (a: Upstream Site ; b: Downstream Site)

4 DISCUSSION

Post-construction field surveys conducted in spring 2008 have confirmed the use of the two spawning beds by lake sturgeon and several species of suckers (*Catostomidae*).

In the spring 2004 and 2005, prior to the installation of the spawning beds, the general areas of the spawning bed sites were characterized (bottom substrate, depths and water velocities), a comprehensive egg sampling program was conducted, gillnetting for adult sturgeon was performed, and video monitoring was conducted (Environnement Illimité inc. 2005a and 2005b). Gillnetting in the general vicinity of Xxxxxxxxxxxxx resulted in only 11 sturgeon (7 ripe males and 4 undetermined) caught in 2004 and three in 2005 (1 ripe male and 2 undetermined). These fish were mainly caught on the Canadian side of the St. Lawrence River. During the 2005 monitoring, between May 26 and June 15, 100 egg traps were deployed in the vicinity of the two recently installed beds. No lake sturgeon eggs were collected. Finally, observations made during the spring of 2004 and 2005 with an underwater video camera showed no concentration of spawning lake sturgeon in these areas. Consequently, data from the first post-construction monitoring period (spring 2008) indicate that installation of spawning beds upstream and downstream from the Xxxxxxxxxxxxx has resulted in significant use of these two sites by spawning lake sturgeon.

Comparison of the main results of this study (spawning chronology, habitat characteristics and productivity) to similar studies, conducted mainly in Lake St. Lawrence, is presented in the following sections.

4.1 Spawning and Larval Drift Chronology

In the St. Lawrence River, the lake sturgeon spawning period generally starts when water temperature reaches 10°C (La Haye et al, 2003) and peaks when temperature is around 15°C (LaPan et al., 1996). Based on observations in this study, the prime temperature range for lake sturgeon spawning in 2008 was between 13ºC to 18ºC, with an apparent peak around 15ºC.

The presence of spawning sturgeon was first observed on May 9, 2008, when the water temperature was approximately 10ºC (Figure 6). Water temperatures increased slowly and sturgeon eggs were not collected until the water temperature was 12.5ºC. Eggs were then collected when water temperatures ranged between 12.5ºC and 16.5ºC, between June 3rd and June 12th. The spawning period ended on June 13th, when water temperature was 16.5ºC (Figure 6).

Larval drift monitoring began on June 18th, about 15 days after the beginning of the spawn, when the water had reached 16.9ºC. The initial sampling resulted in low numbers of larvae. The number of larvae collected showed a distinct peak when the water temperatures was about 19.5ºC and sampling ended on June 30th when water temperature was approximately 20°C. The pattern indicates that the emergence of larvae occurred approximately 14-15 days after the spawning period based on the time elapsed between the peak egg collection and peak larval drift periods. This time period is somewhat longer than that reported by Johnson et al. (2006) for spawning sturgeon several kilometers upstream in Ogdensburg, NY, in which the authors observed a 7 day egg development period (first observation of fry in the gravel) and larvae were collected in the drift net 4 days after the first observation of sturgeon fry in the gravel.

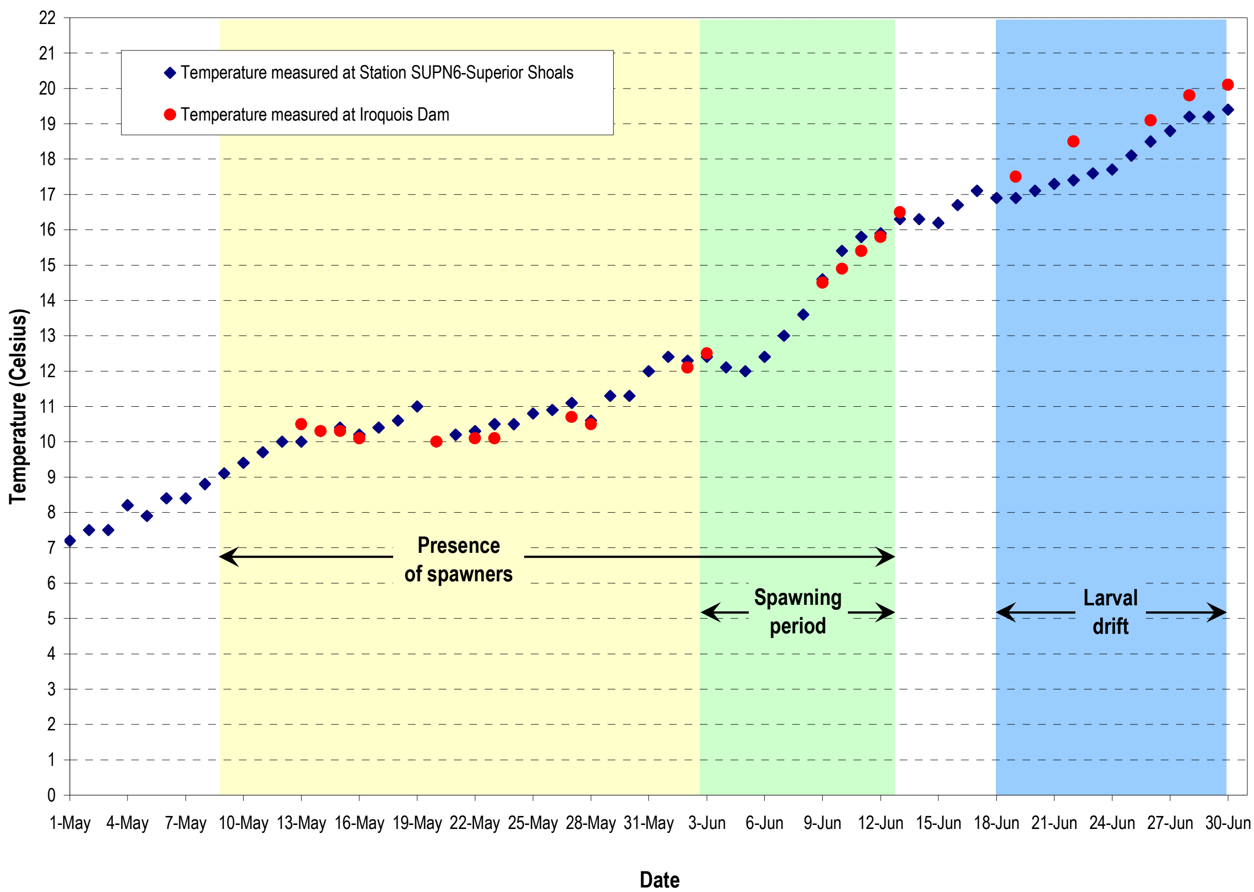

FIGURE 6 — Water Temperature (Xxxxxxxxxxxxx and Station SUPN6-Superior Shoals from the National Data Buoy Center , NOAA) During the 2008 Investigation of Lake Sturgeon Spawning Activities – Lake St. Lawrence.

Temperature ranges observed in this study are typical for spawning sturgeon, as shown in similar studies. For example, a second study conducted in Ogdensburg, NY recorded sturgeon spawning water temperatures ranging from 13.8° to 17°C (Table 1; La Pan et al., 1998; Environnement Illimité inc., 2005a). Another study conducted on the St. Lawrence River near the Lachine Rapids also showed that sturgeon started to spawn at 11.8ºC (La Haye et al., 2004).

TABLE 1 — Lake Sturgeon Spawning Habitat Literature Review – St. Lawrence River and Great Lakes

Source (chronological order)	Observations or suggested criteria or habitat model	Number of spawning grounds	Depth (m)	Velocity (m/s)	Substrate (original terms, units if mentioned)	Temperature (°C)	Period	Location	Natural or artificial substrate	Important factor or notes
Environnement Illimité inc. (1987)	Observations	1	1.5 to 2	0.25 to 1.5	Boulders (> 25 cm) and bedrock	13 to 15	May 31 to June 4	St Lawrence River, at the foot of Pointe-du-Buisson dam, Québec	Natural	Current and swirl
Environnement Illimité inc. (1994)	Suggested criteria (general for *Acipenseridae*) (1)	—	0.5 to 2.0	0.6 to 1.2	Heterogeneous, rock (65 to 225 cm) and gravel (17 to 65 cm)	—	—	—	Artificial	Current shelter: boulders (> 1 m³), submerged islets or groins disposed all along the facilities with gravel beds (2 x 6 m) downstream of those structures; long shape, parallel to current with slow slope; laminar flow; 3000 m²; observation of fish gathering near the site.
LaPan et al. (1996)	Observations	1	4.3	0.07 to 0.4	Number two limestone	15 (first spawning) 17 (second spawning)	June 17 (first spawning) June 28 (second spawning)	St. Lawrence River, Ogdensburg, New-York	Artificial	—
LaPan et al. (1997)	Suggested criteria	—	—	—	—	—	—	—	Artificial substrate	Current velocity, substrate particle size, depth of substrate, and maintenance of sediment-free interstitial spaces are important considerations in planning future habitat enhancement projects.
LaPan et al. (1998)	Observations	1	—	—	—	—	—	St. Lawrence River, Ogdensburg, New-York	Artificial	In 1997 and 1998, the artificial substrate was covered with *Cladophora* and silt, no lake sturgeon spawning was observed. Additional placement of stone is suggested.
Hayes (2000)	Observations	1	6.5 to 7.0	0.5 to 1.2	—	—	—	St. Lawrence River, Massena, New-York	Natural	—
Caswell et al. (2002)	Observations	1	5 to 6	0.4	Cinders (1 to 4 cm) and gravel (2 to 8 cm)	14	May 8	Detroit River, Zug Island, Michigan-Ontario	Artificial	Secchi disk depth (2.4 m)
Manny and Kennedy (2002)	Observations	1	12.2	1	Cobble (10 to 30 cm), coarse gravel (3 to 8 cm)	13	June 8	Channel between lakes Huron and Erie, Port Huron, Michigan-Ontario	Natural	Percentage of light reaching the bottom (8.7 %), Secchi disk depth (6.5 m)
Manny and Kennedy (2002)	Observations	1	9.1	0.5	Cinders (0.5 to 12 cm)	13	June 8	Channel between lakes Huron and Erie, Algonac, Michigan-Ontario	Artificial	Percentage of light reaching the bottom (5.0 %), Secchi disk depth (2.6 m)
Manny and Kennedy (2002)	Observations	1	10.4	0.3	Coarse gravel (2 to 8 cm; natural) and cinder (1 to 4 cm; artificial)	13	May 9	Channel between lakes Huron and Erie, Zug Island, Michigan-Ontario	Natural and artificial	Percentage of light reaching the bottom (0.05 %), Secchi disk depth (2.5 m)
La Haye et al. (2003)	Observations	1	1.4 to 3.0	1.0 to 1.9	Boulders, rocks and gravels (20 to 150 cm)	10.8 to 12.8	May 28th to June 3rd	St. Lawrence River, Lachine rapids, Québec	Natural	Great depth and transparent water
Environnement Illimité inc. (2005a)	Observations	1	4.6 to 4.9	0.6 to 0.7	Pebble (4.0 to 7.9 cm)	13.8	June 4	St. Lawrence River, Ogdensburg, New-York	Artificial	Vegetation and silt free

Artificial substrate

(1) Based on the work of Khoroshko and Vlasenko (1970) in former USSR, Folz and Meyers (1985) in Wisconsin and La Haye et al. (1992) in Québec.

The time of the year which spawning occurred, namely from June 3rd to June 18th, is also similar to other studies conducted on the St. Lawrence River at Ogdensburg, Pointe du Buisson and in the Lachine Rapids. In these locations, the start of the spawning period have been observed respectively from June 17th to June 28th, from May 31st to June 4th, and from May 31st to June 4th, (Table 1).

Finally, water temperature data from an anchored buoy maintained by the National Data Buoy Center (National Oceanic and Atmospheric Administration; Station SUPCN6 http://seaboard.ndbc.noaa.gov/station_page.php?station=supn6) located upstream from the Xxxxxxxxxxxxx are also shown on Figure 6. Although this permanent buoy is located approximately 60 kilometers upstream from the study area, the data obtained are almost identical to those measured in the study area (Figure 6). Thus, temperature data recorded from this buoy may be helpful in the future to predict the spawning period at Xxxxxxxxxxxxx.

4.2 Habitat Characteristics

Current velocity (1 m from the bottom) varied between 0.65 m/s and 1.03 m/s at the upstream spawning bed while velocities measured at the downstream spawning bed were significantly faster by 20% (One way ANOVA; $p<0.001$), with values ranging from 0.71 m/s to 1.29 m/s. On both sites, spawning as shown by the number of eggs seemed to be concentrated along the middle to shoreward sides of the beds but current velocities are not significantly different among stations where eggs are present or absent (Two way ANOVA; downstream/upstream factor, $p <0.001$; presence/absence of eggs factor, $p > 0.05$; interaction term, $p > 0.05$). Generally, lake sturgeon spawning beds surveyed in the St. Lawrence River and in the Great Lakes have current velocities ranging from 0.07 m/s to 1.9 m/s (Table 1). Current velocities measured at the two installed spawning beds are within these ranges for the St. Lawrence River and the Great Lakes.

Average depths of the spawning beds were 10.3 m (upstream) and 12.5 m (downstream). The spawning beds installed on the Xxxxxxxxxxxxx are amongst the deepest observed in similar studies in the channel between Lake Huron and Erie, which report depths between 9 to 12 m (Manny and Kennedy, 2002; Table 1). Other spawning beds have generally been observed in shallower depths, namely from 1 to 7 m deep (Table 1).

4.3 Productivity of Spawning Beds

Sampling carried out with egg traps caught 1,792 eggs at the upstream spawning bed and 1,401 eggs at the downstream bed, with a mean of 56 eggs per trap upstream and 72 eggs per trap downstream. Comparative productivity data for the St. Lawrence River are limited. Results from the most similar survey are from a natural spawning bed at the Lachine Rapids area, where La Haye et al. (2003) reported a total catch of 163 eggs for 44 egg traps, with a mean of four eggs per trap. However this direct comparison needs to be considered cautiously because

La Haye et al. (2004) reported that their egg traps may have been placed beside the spawning bed rather than on it.

Productivity in terms of sturgeon larvae CPUE for the six driftnets can be compared with results from other studies; although, such comparisons are best viewed qualitatively because differences in deployment techniques of sampling gear likely result in different capture efficiencies. The mean CPUE for the upstream spawning bed is 0.25 larvae/100 m^3, while the CPUE for the downstream spawning bed is 0.34 larvae/100 m^3. In a lake sturgeon study conducted on des Prairies River near Montreal by D'Amours et al. (2001) the mean CPUE was 1.30 larvae/100 m^3 from a transect located approximately 3 km downstream from the spawning bed. Other sturgeon studies have used similar approaches and have obtained CPUE mean values of 0.10 larvae/100 m^3 (Eastmain River; 600 m downstream from the spawning bed), and 0.11 larvae/100 m^3 (Opinaca River; 650 m downstream from the spawning bed) (Environnement Illimité inc., 2008 and in prep). The mean CPUE obtained from the recently installed spawning beds at Xxxxxxxxxxxxx are less than those from des Prairies River, even though the sampling for that site was carried out several kilometers downstream from the spawning bed as opposed to the present study, where nets were located directly (< 20 meters) downstream from the spawning beds. The spawning bed at des Prairies River is one of the most important lotic spawning habitats in this portion of the St. Lawrence system (D'Amours et al.2001), consequently the number of sturgeon that use this spawning bed is very high, further explaining the higher CPUE for this location. The CPUE from the James Bay Rivers (Eastmain, Opinaca and Rupert) are of the same order of magnitude or slightly less than those for the two Xxxxxxxxxxxxx spawning beds. However, the nets used to catch larvae in these Rivers were placed further downstream from the spawning beds than in the present study. Given the greater distance between the spawning bed and the sampling gear in the James Bay Rivers studies than in our study at Xxxxxxxxxxxxx, larval production on the James Bay Rivers may have been greater than what occurred in our study.

It is estimated that a total of 85,911 larvae emerged from the upstream spawning bed and 126,091 larvae emerged from the downstream spawning bed. Caution should be used when comparing these estimates with estimates or conclusions on sturgeon production obtained from other studies due to differences in collection methodologies. For example, few studies have estimated the total number of lake sturgeon larvae immediately downstream of a spawning bed; since in most other comparable studies the larval drift nets were placed a few kilometers downstream from a spawning bed, which makes it difficult to make direct comparisons between those studies and the results from this effort. However, comparison may be made between baseline (pre-construction) and post-construction conditions at the study sites and these data indicate a substantial increase in the number of successfully spawning sturgeon within a single spawning season since project construction.

5 PHOTOGRAPHIC INDEX

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APPENDIX 1

Spawner observation through video monitoring - Field data

APPENDIX 2

Summary of Lake Sturgeon Egg Trapping Data and habitat characteristic of the spawning beds

APPENDIX 2A — Summary of Lake Sturgeon Egg Trapping Data from the Upstream Spawning Bed–Iroquois Control Dam–Lake St. Lawrence–2008

Upstream site	Current velocity (m/s) 1 m from the bottom*			Mean current velocity (m/s) for the water column*			Depth (m)	Lake sturgeon eggs Total
Egg traps	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**		
L5P1	0.77	0.88	0.80	0.84	0.98	0.91	10.15	4
L5P2	0.69	0.76	0.73	0.86	0.99	0.93	10.62	28
L5P3	0.78	0.87	0.82	0.92	1.03	0.96	10.77	79
L5P4	0.89	1.11	1.00	1.01	1.14	1.07	10.73	253
L5P5	0.54	0.77	0.65	1.01	1.06	1.04	10.96	99
L6P1	0.67	0.94	0.79	0.98	1.08	1.02	10.49	91
L6P2	0.70	0.75	0.72	0.99	1.02	1.01	10.67	193
L6P3	0.75	0.86	0.79	1.04	1.08	1.05	10.52	6
L6P4	0.95	1.14	1.03	1.11	1.16	1.13	10.04	5
L6P5	0.72	1.02	0.88	1.05	1.14	1.10	10.40	5
L7P1	0.76	0.82	0.79	1.05	1.07	1.06	10.53	3
L7P2	0.76	0.85	0.80	1.06	1.07	1.07	10.20	4
L7P3	0.86	1.01	0.94	1.10	1.17	1.13	9.61	36
L7P4	1.03	1.10	1.06	1.17	1.19	1.18	9.39	29
L7P5	0.70	0.98	0.83	1.08	1.19	1.13	10.04	42
L8P1	0.69	0.73	0.71	1.00	1.04	1.02	10.67	97
L8P2	0.71	0.84	0.78	1.04	1.08	1.06	10.34	288
L8P3	0.89	0.95	0.92	1.08	1.11	1.10	9.86	401
L8P4	0.83	0.94	0.89	1.10	1.13	1.11	9.68	83
L8P5	0.87	0.95	0.91	1.13	1.18	1.15	9.77	44
L9P1	0.70	0.74	0.72	0.96	1.04	1.01	10.41	0
L9P2	0.67	0.87	0.76	1.06	1.10	1.09	10.19	0
L9P3	0.68	0.78	0.74	1.05	1.08	1.06	10.26	0
L9P4	0.80	0.83	0.81	1.08	1.10	1.09	10.47	1
L9P5	0.77	0.87	0.81	1.05	1.10	1.07	10.80	1
	Mean		**0.83**	**Mean**		**1.06**	**10.30**	**1,792**

* Extracted from a 2.5 m radius around each egg trap

APPENDIX 2B — Summary of Lake Sturgeon Egg Trapping Data from the Downstream Spawning Bed –Iroquois Control Dam–Lake St. Lawrence–2008

Downstream site	Current velocity (m/s) 1 m from the bottom*			Mean current velocity (m/s) for the water column*			Depth (m)	Lake sturgeon eggs Total
Egg traps	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**		
L1P1	0.83	1.01	0.90	1.18	1.24	1.21	12.76	79
L1P2	0.98	1.26	1.12	1.27	1.34	1.31	12.19	177
L1P3	1.19	1.38	1.29	1.34	1.40	1.38	11.86	63
L1P4	0.73	1.01	0.90	1.23	1.32	1.27	12.17	91
L1P5	0.88	1.09	0.99	1.29	1.43	1.34	12.36	42
L2P1	0.75	0.89	0.84	1.06	1.14	1.11	13.37	1
L2P2	0.58	0.78	0.68	1.05	1.15	1.10	13.02	0
L2P3	0.91	1.18	1.06	1.18	1.29	1.24	12.21	3
L2P4	0.94	1.19	1.05	1.16	1.29	1.22	11.83	16
L2P5	0.82	0.95	0.87	1.16	1.25	1.20	12.03	11
L3P1	0.90	1.02	0.97	1.11	1.20	1.14	13.15	0
L3P2	0.95	1.04	0.99	1.15	1.32	1.23	12.47	0
L3P3	1.02	1.11	1.07	1.24	1.33	1.29	12.32	0
L3P4	0.90	1.01	0.95	1.20	1.34	1.28	12.23	0
L3P5	0.97	1.18	1.08	1.28	1.42	1.35	11.90	0
L4P1	0.79	0.87	0.83	1.16	1.20	1.18	13.39	0
L4P2	0.86	0.94	0.89	1.19	1.25	1.22	12.98	0
L4P3	0.80	0.95	0.87	1.16	1.20	1.18	12.79	0
L4P4	0.81	0.97	0.90	1.23	1.31	1.26	12.68	0
L4P5	0.93	1.14	1.04	1.31	1.42	1.35	12.27	0
L10P1	0.91	0.99	0.95	1.11	1.17	1.14	12.35	677
L10P2	1.13	1.30	1.22	1.19	1.30	1.26	12.02	112
L10P3	0.89	1.10	1.00	1.23	1.32	1.29	12.32	60
L10P4	0.72	0.90	0.79	1.18	1.21	1.20	13.15	45
L10P5	0.67	0.74	0.71	1.14	1.19	1.16	12.72	24
	Mean		**0.96**	**Mean**		**1.24**	**12.50**	**1,401**

* Extracted from a 2.5 m radius around each egg trap

APPENDIX 3

Egg trapping effort over the spawning beds – Field data

APPENDIX 4

Larval drift netting – Field data