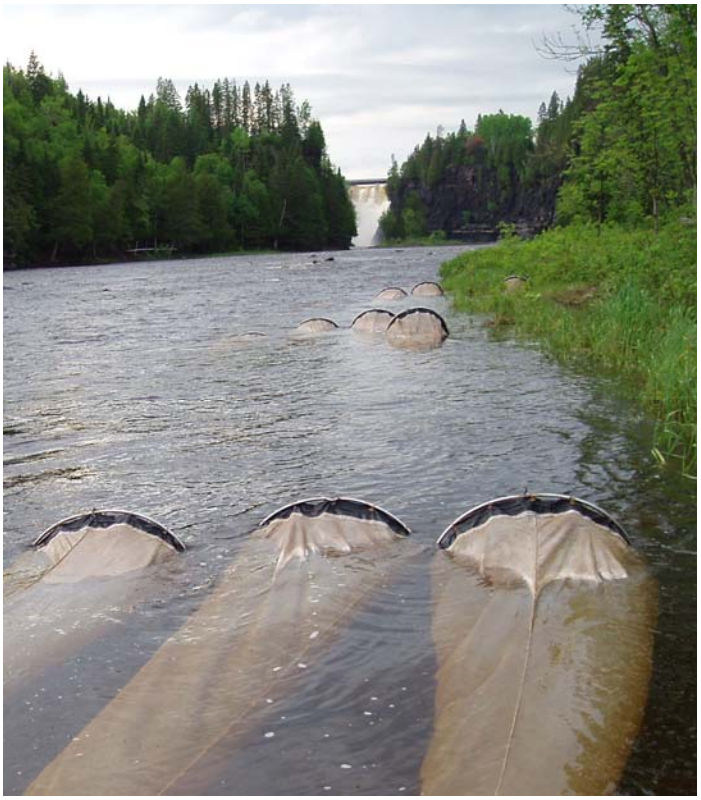
# The Migratory and Reproductive Response of Spawning Lake Sturgeon to Controlled Flows over Kakabeka Falls on the Kaministiquia River, 2009



UPPER GREAT LAKES MANAGEMENT UNIT

**Lake Superior**

Technical Report 2009

M.J. Friday

Ontario

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## INTRODUCTION

In 2002, the Ontario Ministry of Natural Resources (OMNR) and Ontario Power Generation (OPG) commenced water management planning for the Kaministiquia River watershed. The Water Management Plan that was developed included an agreement to study lake sturgeon in the Kaministiquia River (OPG 2005). One component of the agreement was to examine lake sturgeon spawning migrations and reproductive success during controlled flow conditions over Kakabeka Falls.

The river flow upstream of Kakabeka Falls is diverted by a control dam that transfers water (powerflow) through a series of penstocks to a four-unit generating station (GS) located approximately 800 m downstream of Kakabeka Falls. During periods of high river flows that exceed plant capacity (~ 57 $m^3 \cdot s^{-1}$) or when the generating station is shut down a second dam diverts water away from the station and spills it over the Falls (spill flow).

The second dam is also utilized to divert water over the Falls for viewing purposes at Kakabeka Falls Provincial Park. Flow is provided during daylight hours of the tourist season (i.e., Victoria Day weekend in May to Thanksgiving Day weekend in October) at flow rates of 4.25 $m^3 \cdot s^{-1}$ on weekdays and 8.5 $m^3 \cdot s^{-1}$ on weekends and statutory holidays (OPG 2005). These are commonly referred to as scenic flows and represent the minimum flow allowed to pass the Kakabeka Falls dam. These flow requirements were adopted in 1978 and are a component of the Kaministiquia River Water Management Plan approved in 2005 (OPG 2005). During the overnight hours of the tourism season leakage through the dam stop logs may provide the only flow over the Falls. Leakage was measured at 0.12 $m^3 \cdot s^{-1}$ on July 15, 2009 (downstream of the dam).

From 2004 to 2006 flow over the Falls was provided to allow sturgeon access to the spawning site at the base of the Falls. Studies conducted in each of these

years indicated that adult sturgeon reached the spawning site and spawned successfully during flows of 23 $m^3 \cdot s^{-1}$ (Friday 2004 and 2005) and 17 $m^3 \cdot s^{-1}$ (Friday 2006). In 2007 we examined lake sturgeon movements and reproduction during scenic flows and found that sturgeon spawned upstream and downstream of the GS (Friday 2007). In 2008, we attempted to examine another flow condition (14 $m^3 \cdot s^{-1}$) to determine if migration to the base of the Falls and successful spawning would occur (Friday 2008). Spill flows, however could not be controlled at 14 $m^3 \cdot s^{-1}$.

In 2009, we again attempted to examine lake sturgeon spawning migrations and reproductive success during controlled flows of 14 $m^3 \cdot s^{-1}$.

The objectives of the studies were to:

1. Determine if spawning lake sturgeon can successfully migrate upstream from the generating station to the base of the Falls during spill flows of 14 $m^3 \cdot s^{-1}$;
2. Determine if spawning lake sturgeon can successfully migrate out of the study area during flow conditions of 14 $m^3 \cdot s^{-1}$;
3. Determine the length of time spawning adults remain in the study area;
4. Determine the approximate date when spawning occurs;
5. Determine if the spawning was successful at spill flow rates of 14 $m^3 \cdot s^{-1}$;
6. Confirm, through the collection of larval sturgeon, that there are sexually mature adult sturgeon spawning in the study area;
7. Determine the timing and duration of downstream movement of larval lake sturgeon

## STUDY AREA

These studies focused on an 800 m stretch of the Kaministiquia River from the base of Kakabeka Falls downstream to the GS (Figure 1 and 2).

## MATERIALS AND METHODS

### Radio Tagging

Radio telemetry equipment manufactured by Advanced Telemetry Systems (ATS) was used in this study[1]. Each radio transmitter (n = 30) was identified by a unique frequency between 150.402 – 151. 452 MHz. These 20 g transmitters (model F2060) pulsed 55 times per minute and had a battery life of approximately 10 months.

From October 15 to 23, 2008 we attempted to radio tagged lake sturgeon (n = 9) at river kilometre (rkm) 9 in the hope that they would ascend the river to spawn in 2009. These were tags that we were unable to use in the spring of 2008 due to high river flows. We set 46 m (7 sets) and 91 m (7 sets) of 305 mm (12") stretched mesh multifilament gill net overnight (Figure 3) during water temperatures that ranged from 9 to 12 °C and total river flows from 85 to 104 $m^3 \cdot s^{-1}$. From May 7 to May 14, 2009 we attempted to radio tag lake sturgeon (n = 22) at rkm 19 in the hope that they would migrate to Kakabeka to spawn. We set 46 m of 305 mm (12" – 16 sets) and 254 mm (10" – 1 set) stretched mesh multifilament gill net overnight (Figure 3) during water temperatures that ranged from 8.9 to 11.1 °C and total river flows from 79 to 106 $m^3 \cdot s^{-1}$. To attach the transmitters, a hollow, bone marrow biopsy needle (# 11 Jamshidi) was pushed through the base of the dorsal fin until it exited the other side. One of two attachment wires was then threaded through the hollow needle until it passed through to the opposite side. After the needle was removed a backing plate and metal crimp were threaded down the wire and slid into position against the base of the dorsal fin. The crimp was securely fastened, excess wire was removed and the procedure was repeated for the second attachment wire. No anaesthetic was used during the procedure. All sturgeon were sampled for length (fork, total), weight, girth, body depth and were tagged with a five digit orange floy tag applied along the left hand side of the dorsal fin. A sixteen digit passive

[1] (Reference to trademark names does not imply endorsement by the Ontario government)

integrated transponder (PIT tag) was applied under the third dorsal scute of each fish (counting back from the head). This is a standard PIT tag insertion site for all lake sturgeon tagged in Lake Superior or its tributaries. A genetic sample was also taken from the leading edge of the left pectoral fin. We attempted to determine fish gender by expressing sexual products from captured fish.

**Tracking**

A shoreline based data logger (model R4500) was installed upstream of the GS (Figure 2) in mid April to track the movements of radio tagged sturgeon as they migrated to the study area. A two antenna system was used to interpret the direction of fish movement as one antenna was facing upstream (toward the Falls) and the other was facing downstream (toward the GS). The logger operated from April 23 to September 1.

A reference transmitter (150.893 MHz) was placed in the river upstream of the GS and was logged every six hours to provide a known signal strength from a fixed position. If radio tagged sturgeon were detected by the shoreline based data logger, their approximate position could be determined by comparing the signal strength of their transmitter to the reference tag signal strength.

Manual tracking in the study area was conducted using a portable receiver and hand held antenna. This was done to validate data being collected by the data logger and as a backup in case of logger malfunction or vandalism. A number of road accessible sections of the river were monitored to track the upstream and downstream progression of radio tagged fish.

**Drift Netting**

Drift netting took place at a standard site established in 2004, on the east shore of the river approximately 400 m downstream of Kakabeka Falls (Figure 2). Twelve nets were set from June 15 to July 3. To carry out another component of the study (distribution of larval drift across the river), one overnight sampling

event (at the standard site) scheduled from June 25 (set) to June 26 (lift) was not carried out.

To determine the distribution of larval drift across the width of the river, we redeployed the drift nets for one overnight sampling event (13 nets) from June 25 (set) to June 26 (lift) along a transect that started at the standard site and ended near the west shore of the river (Figure 2).

At all locations, stainless steel, D-frame drift nets were used that measured 0.76 m across the base, 0.53 m high and had a 3.6 m tapered mesh bag that terminated at collection container with filtering holes covered by 1000 µm mesh.

Drift nets were held in place by attaching a 4.5 kg fishing anchor to the bridle of each frame. To sample the catch, the cod end was lifted from the water and the collection container was detached and rinsed in a shallow white pan for examination. All sturgeon were removed, counted and measured. Live sturgeons were released downstream. Dead specimens were placed in glass vials and preserved in 70% ethanol. Other larval fish species captured were also preserved and later identified in the laboratory.

**Water Temperature, Velocity and Depth**

Water temperature in the study area was recorded using a Vemco Minilog- T data logger. The logger was located on the east side of the river, approximately 500 m upstream of the GS in 0.5 m of water. Temperature was recorded hourly from April 28 to September 1. Real time water temperature information from the tailwater of the GS was recorded by OPG with a permanently installed RBR data logger and was available via web link. Water velocity ($m \cdot s^{-1}$) was recorded using a Marsh McBirney Flo-Mate and depth (cm) was measured at the opening of each drift net upon deployment.

### Study Flow Plan

From May 15 to June 25, 2009 the study plan was to provide 14 $m^3 \cdot s^{-1}$ over the falls (inflows permitting). Starting on June 26 flow over the Falls would be reduced by 3 $m^3 \cdot s^{-1}$ and continue every 24 h until scenic flows were attained (June 30).

## RESULTS

### Spill Flows

As a result of high river flows prior to the study start date (spring freshet) and significant rainfall throughout the Kaministiquia watershed, flow over the falls could not be controlled at 14 $m^3 \cdot s^{-1}$ within the study period (Figure 4 and 5).

Flow over the falls remained uncontrolled until approximately June 30$^{th}$. To meet the overall study objectives, OPG agreed to continue to provide a minimum continuous flow over Kakabeka Falls from June 30 to July 3. The minimum spill target during this period was decreased to 12 $m^3 \cdot s^{-1}$ from the original study flow of 14 $m^3 \cdot s^{-1}$. The actual spill flow ranged from 12.2 to 14.1 $m^3 \cdot s^{-1}$.

### Radio Tagging

In the fall of 2008, external radio transmitters were attached to 8 lake sturgeon that ranged in total length from 123 to 145 cm and weighed 11.5 to 21.5 kg. In the spring of 2009, external radio transmitters were attached to 22 lake sturgeon that ranged in total length from 109 to 161 cm and weighed 9.5 to 22.5 kg (Table 1).

### Migration

Seventeen radio tagged sturgeon migrated to the base of Kakabeka Falls in 2009. Seven were radio tagged in the present study (32% of those tagged), nine were tagged during the fall of 2008 (100% of those tagged) and one was internally tagged (frequency 095) in the fall of 2000. Of the radio tagged fish that

moved to the base of the falls in 2009, one fish (frequency 095) also migrated to the base of the falls in 2004 and 2008.

Radio tagged sturgeon arrived at Kakabeka between May 9 (9.4°C) and June 4 (11.5°C) during spill flows that ranged from 41.8 to 73.1 $m^3 \cdot s^{-1}$. During the period that the logger operated (April 23 to September 1) fifteen fish were recorded moving out of the study area from May 24 (10.9°C) to August 2 (17.8°C) (Figure 5) during spill flows that ranged from 7.9 to 89.4 $m^3 \cdot s^{-1}$ (Figure 6). Two fish (150.423 and 151.293) remained in the plunge pool beyond the time period that the logger operated and were last located at this site (using a hand held receiver) on November 26. These fish however, were not located during a subsequent tracking event on February 2, 2010 and may have migrated downstream during spill that occurred from November 27 to December 17, 2009 (17 d) that ranged from 6 to 26 $m^3 \cdot s^{-1}$.

**Spawning Events**

**Telemetry**

Based on similar departure dates of two groups of fish (Group A and B) from the spawning area it is likely that two spawning events occurred.

Group A (3 fish) left from May 24 to 27, spent 5 to 27 d in the spawning area and participated in the first spawning event only. These fish migrated downstream prior to the second spawning event. It is likely that the first spawning occurred somewhere around May 24. Based on water temperature spawning may have actually occurred on May 21 when water temperatures averaged 11°C and peaked at 12.2°C (Figure 5).

Group B (11 fish) left from June 6 to June 14 and spent 5 to 24 d in the study area. The second spawning event likely occurred around June 5 when water temperature averaged 12.1°C and peaked at 12.7°C (Figure 5).

**Drift Netting**

During 18 sampling events from June 15 to July 3 (3770 sample hrs) 1533 larval lake sturgeon were captured. The catch per unit effort was .40 larvae/hour. There was one period (drift event) when sturgeon larvae were captured as they drifted downstream from the spawning site (June 15 to July 3) (Figure 7, 8). The incidental catch was 10,281 larval fish, of which 821 were identified to the species level and 9460 specimens were grouped by family (Table 2).

The first larval sturgeon (20 mm) was captured on June 15 which seems to support the assertion that there was a spawning event around May 21 when the mean daily water temperature was 11°C. The duration of the downstream movement of larvae from the spawning site was approximately 15 d (June 15 to 29) (Figure 7, 8). Larval sturgeons ranging in length from 10 (yolk sac larva) to 25 mm were captured. During the period of larval drift the mean daily spill flows ranged from 15.5 to 40.9 $m^3 \cdot s^{-1}$, water velocity ranged from 0.03 to 0.82 $m \cdot s^{-1}$ and water depth at the drift net site ranged from 19 to 75 cm. The mean daily water temperature from the suspected spawning date (May 21) to the date when the first larva was collected was 11.6°C. The mean daily water temperature during the period of larval drift was 16.8°C (Figure 8).

**Transect Drift Netting on June 25 and 26**

Thirteen nets were set from the east bank (net 1) to the west bank (net 13) at depths ranging from 24 to 67 cm and velocities from 0.16 to 0.87 $m^3 \cdot s^{-1}$. Mean daily spill flow averaged 15.5 $m^3 \cdot s^{-1}$ during this period of drift net deployment. A total of 1078 larvae were caught and individual net catches ranged from 1 – 372 larval sturgeon (Figure 9 and 10). The highest catches came from nets in proximity to the west bank where water velocity and depths were the greatest.

**Cumulative Thermal Units**

Kempinger (1988) developed an equation to determine approximate hatching dates based on cumulative daily water temperature units (CTU). Using this

equation, for drift data acquired on the Kaministiquia River (from 2004 to 2008), we know that it takes approximately 150 CTU's to accumulate before larvae will start to drift after the first spawning event (Appendix 1). If we assume that spawning occurred on May 21, 152 CTU's had accumulated when the first larva was captured (June 15), which is consistent with previous study years.

We also know that it takes approximately 182 CTU's to accumulate (from the date of spawning) before larvae will start to drift after the second spawning event (Appendix 1). If we assume, from the telemetry and temperature data, that spawning did occur on June 5, larval drift likely started to occur around June 24 when 177 CTU's had accumulated. Although the larvae from both spawning events drifted downstream during one overlapping event, based on CTU, the second event likely commenced around June 24. In previous study years, the period of larval drift associated with second spawnings has tended to be much shorter (5 to 8 d) than the period of larval drift associated with first spawnings (Friday 2004 and 2005). Based on these observations, the period of drift from the second spawning may have been from June 24 to 28 (5 d).

## SUMMARY

### TELEMETRY

1. One radio tagged sturgeon migrated into the study area prior to May 15 (the study start date) during mean spill flows of 40.6 $m^3 \cdot s^{-1}$ and mean daily water temperature of 9.4°C.
2. Migration into the study area ranged from May 9 to June 4.
3. Migration from the study area ranged from May 24 to sometime after November 26, 2009.
4. The first spawning event may have occurred around May 24 when two fish (Group A) departed the study area during mean daily spill flow of 63 $m^3 \cdot s^{-1}$ and water temperature of 11°C.

5. The second spawning event may have occurred around June 5 when eleven fish (Group B) left the study area from June 6 to June 14 when water temperature averaged 12.1°C and peaked at 12.7°C.
6. Three radio tagged sturgeon migrated from the study area after June 30 (the study end date). One of these fish departed during weekend scenic flows (August 2) of 7.9 $m^3 \cdot s^{-1}$. The other two departed sometime after November 26, 2009.

**DRIFT NETTING**

1. Sturgeon spawned successfully in the study area. A total of 1533 larvae were capture at the standard index station.
2. There was one period (15 days) when larvae were captured as they drifted downstream from the spawning site (June 15 to June 30).
3. Larval drift was documented during mean daily spill flows that ranged from 15.5 to 40.9 $m^3 \cdot s^{-1}$
4. Larval drift occurred outside of the timeframe in which flows were intended to be controlled (until June 25) and lasted until June 30.
5. A total of 1078 larvae were caught in thirteen nets set along a 88 m wide sampling transect The highest catches came from nets in proximity to the west bank where water velocity and depths were the greatest.

**CUMULATIVE THERMAL UNITS**

1. If we assume from the telemetry and temperature data, that there was a spawning event on May 21, 152 CTU's had accumulated when the first larva was captured (June 15), which is consistent with previous study years.

2. If we assume, from the telemetry and temperature data, that there was a second spawning event on June 5, larval drift likely started to occur around June 24 when 177 CTU's had accumulated.

## GLOSSARY

**Drift event** – The period of time (days) during which larval sturgeon drift downstream from the spawning site.

**Leakage** - Water that seeps through the gaps between dam stop logs. During the overnight hours of the tourism season (i.e., Victoria Day weekend in May to Thanksgiving Day weekend in October) leakage (0.34 $m^3 \cdot s^{-1}$) provides the only flow over the falls. Outside of the tourism season stop log leakage also accounts for flow over the falls.

**Scenic flows** - Flow over the falls that is provided (for Kakabeka Falls Provincial Park) during daylight hours of the tourist season (i.e., Victoria Day weekend in May to Thanksgiving Day weekend in October) at flow rates of 4.25 $m^3 \cdot s^{-1}$ on weekdays and 8.5 $m^3 \cdot s^{-1}$ on weekends and statutory holidays.

**Spill flow** – Any flow over Kakabeka Falls that is in excess of scenic flows or dam leakage.

**Uncontrolled flow** – When flow over Kakabeka Falls is in excess of the study flows (14 $m^3 \cdot s^{-1}$).

## ACKNOWLEDGEMENTS

This study was funded by the Canada Ontario Agreement respecting the Great Lakes Basin Ecosystem. The contributions of OMNR staff including Karen Schmidt (technical expertise), Kim Ahola (data entry), Kim Armstrong and Greg pope (report review) and the assistance of summer field staff are greatly appreciated. I would also like to thank Ontario Power Generation for monitoring spill flows, providing spill reports and assisting with logistical aspects of the project. Thanks to Ontario Parks for allowing us to carry out this research in the park.

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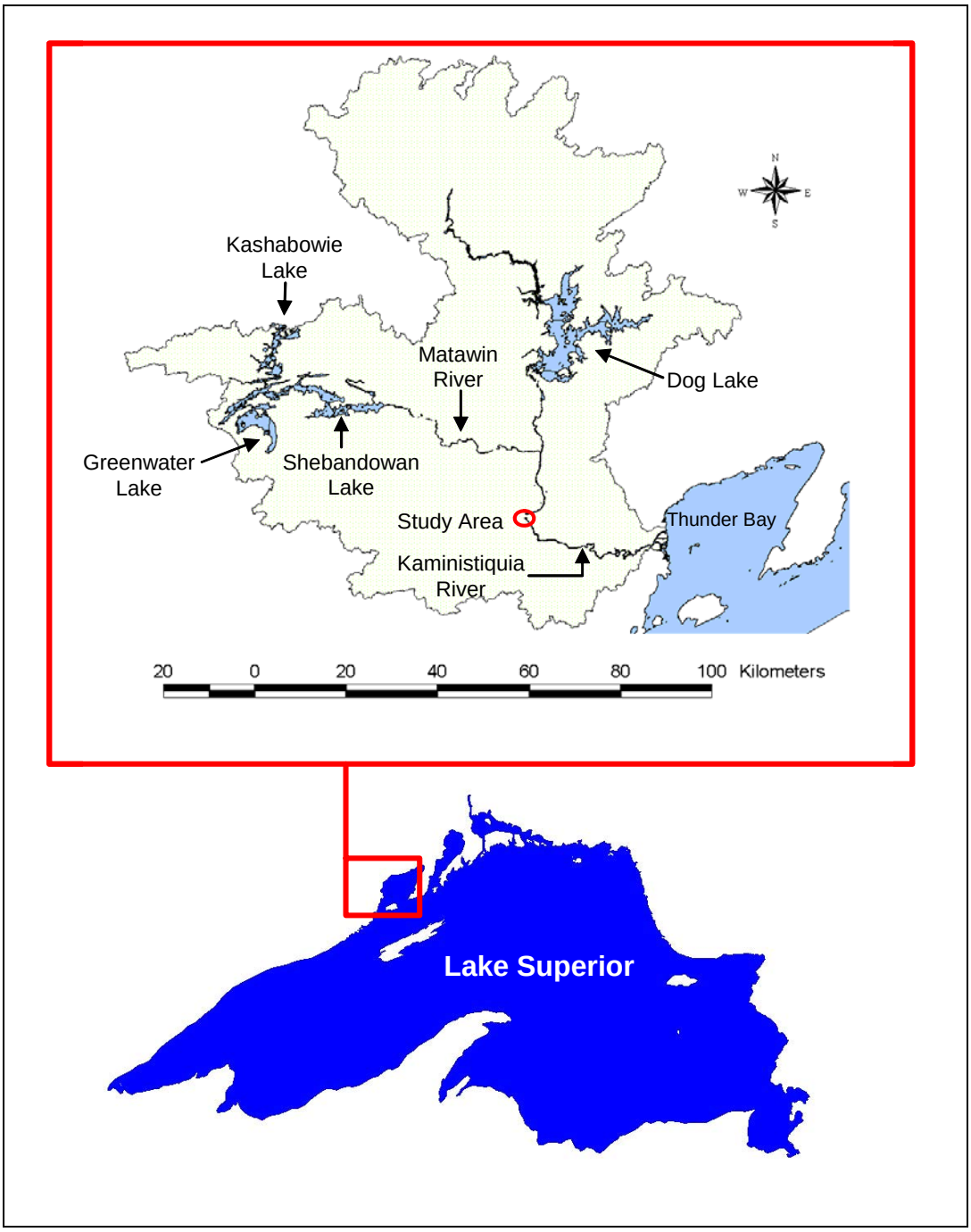


Figure 1. The Kaministiquia River watershed and major reservoirs.

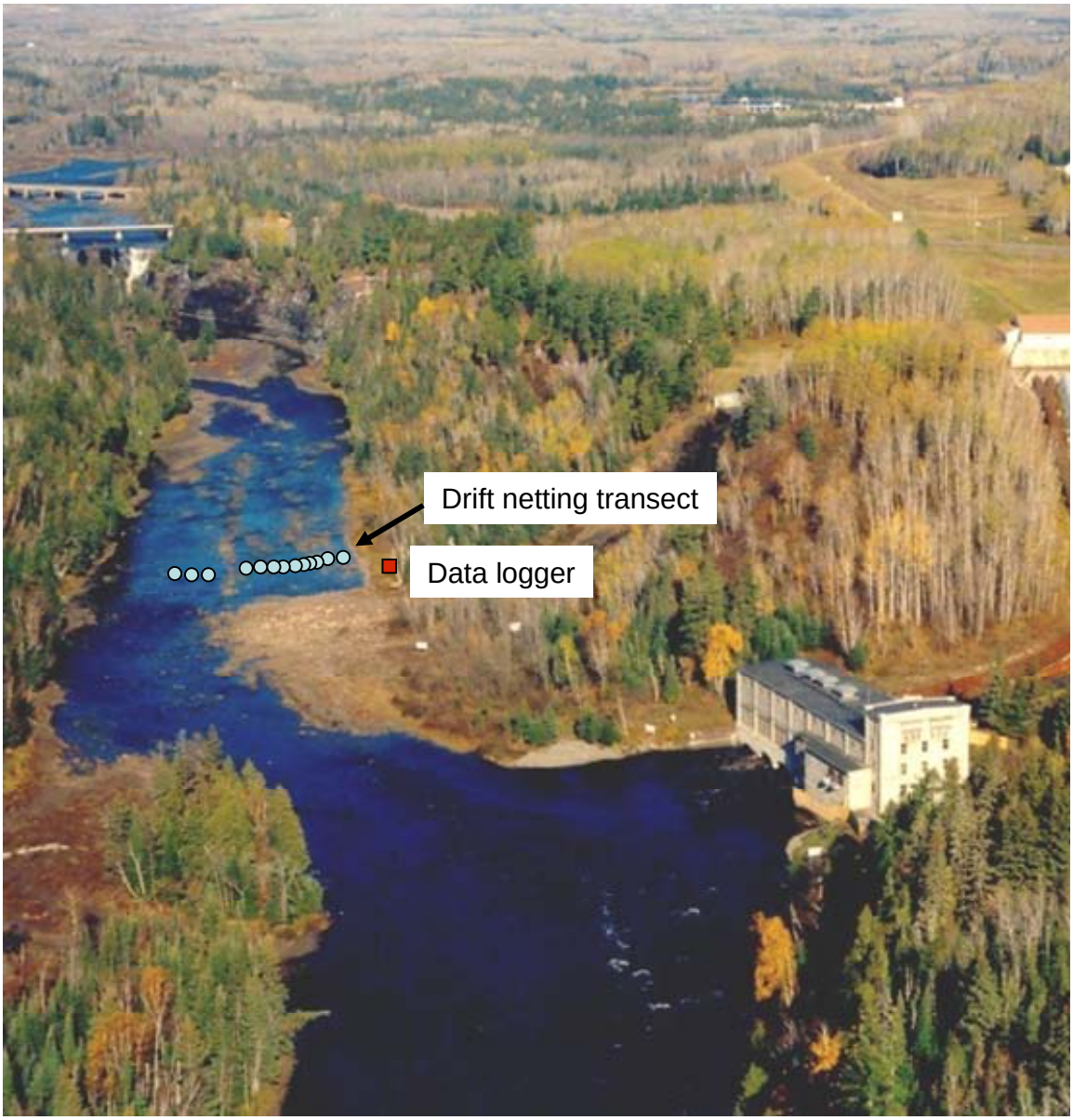


Figure 2. The study area from Kakabeka Falls downstream to the OPG generating station (photo was not taken during the 2009 study period).

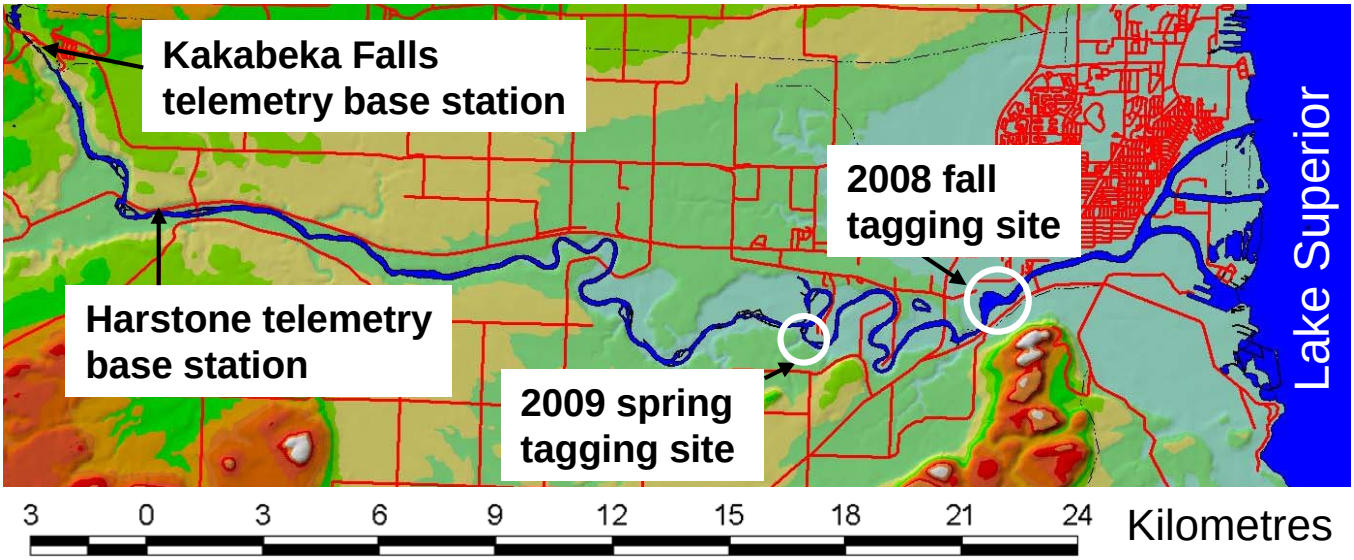


Figure 3. The Kaministiquia River from Kakabeka Falls downstream to Lake Superior.

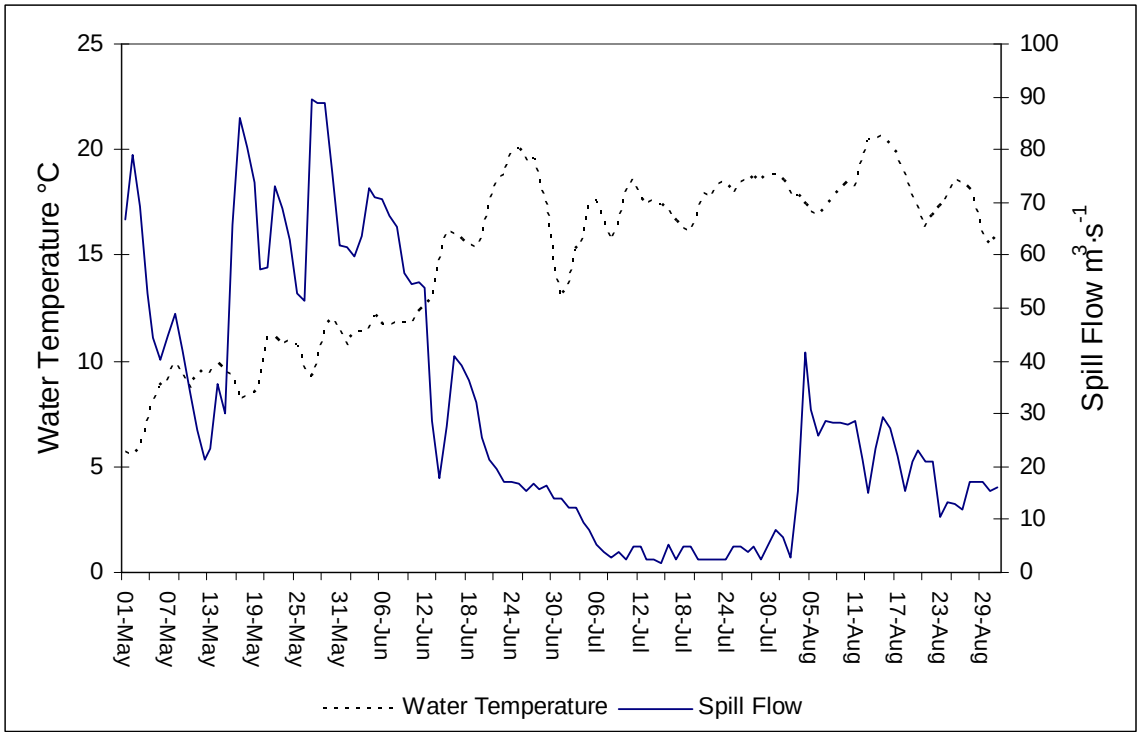


Figure 4. Water temperature and mean daily spill flow over Kakabeka Falls from May 1 to August 30, 2009.

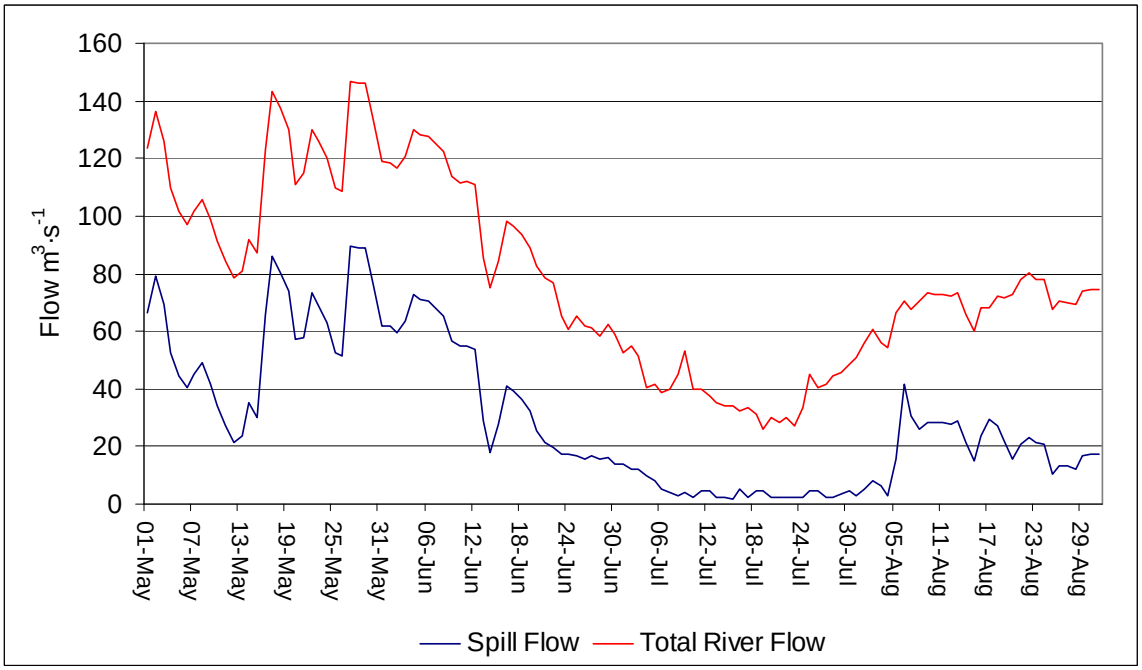


Figure 5. Mean daily spill flow over Kakabeka Falls and total river flow from May 1 to August 30, 2009.

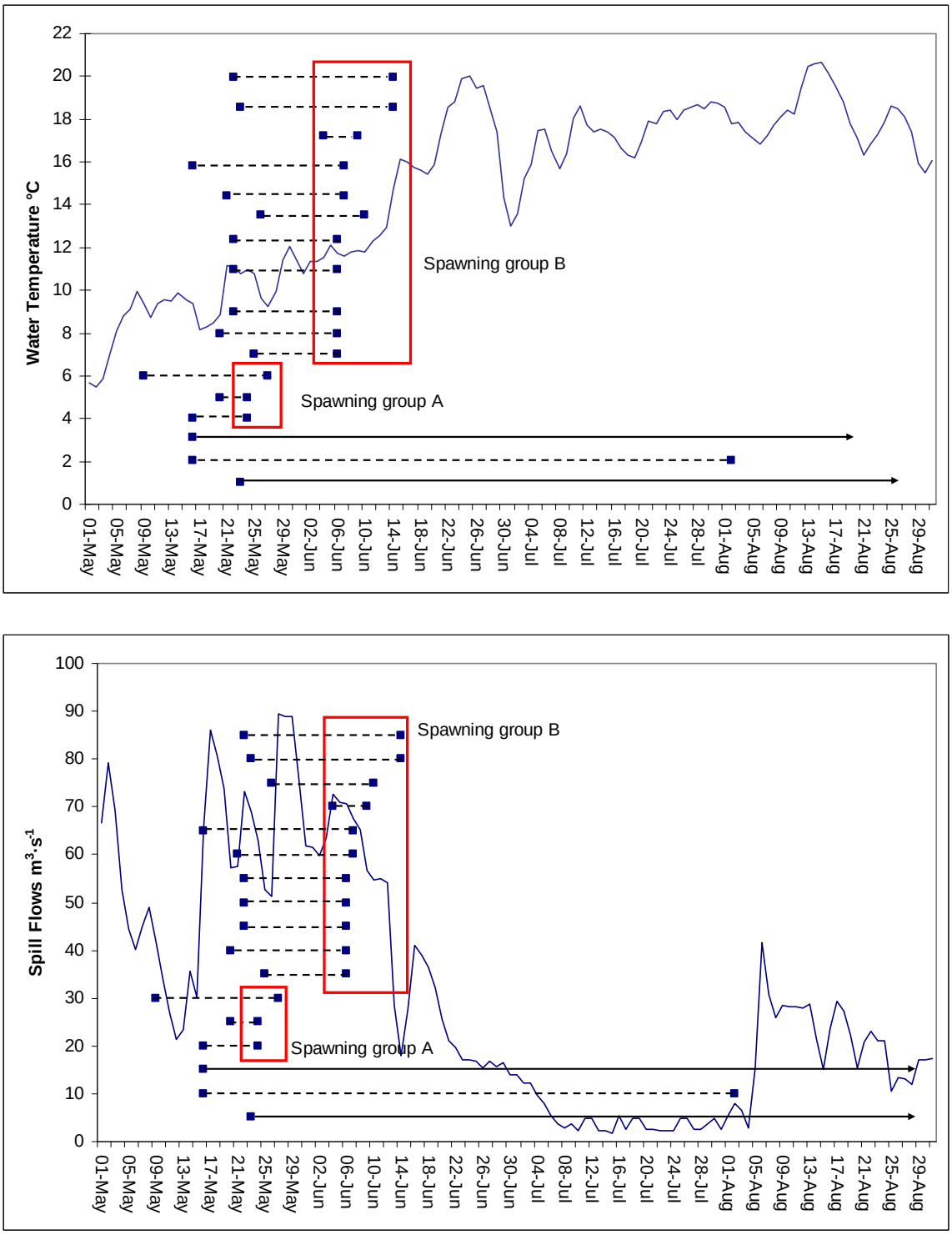


Figure 6. The migration of radio tagged lake sturgeon to the Kakabeka logger in relation to water temperature and mean daily spill flows. Dashed lines indicate duration of time within the study area. The solid line indicates fish that were still in the study area as of August 30, 2009.

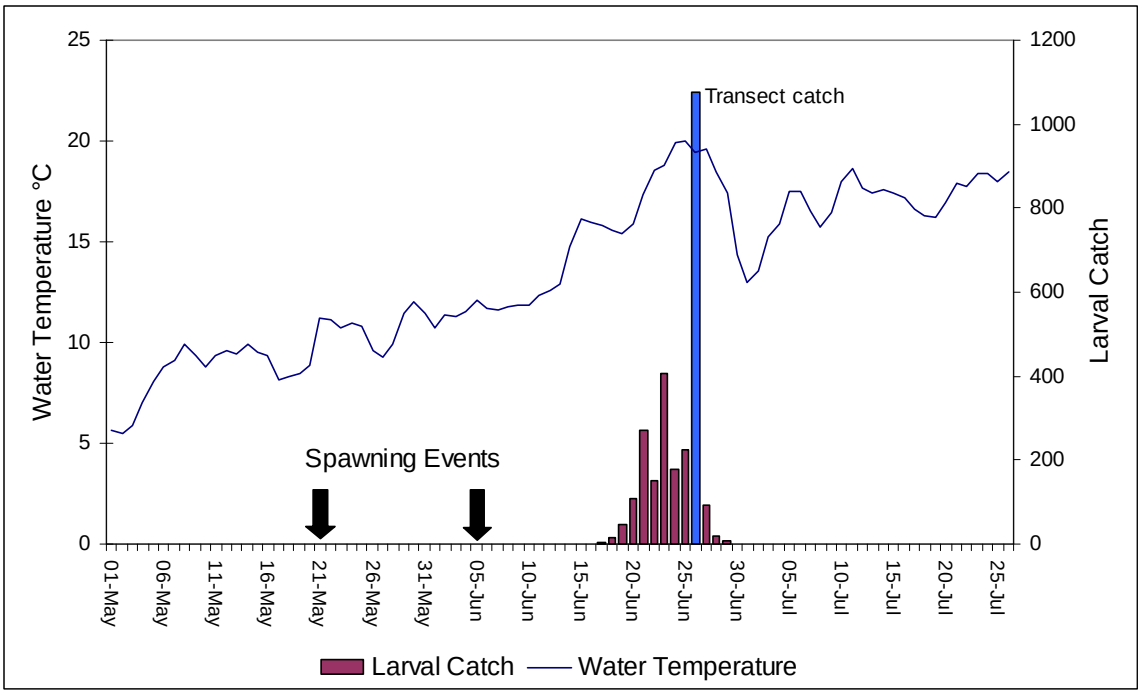


Figure 7. Mean daily water temperature in relation to approximate spawning dates and catches of downstream drifting larvae.

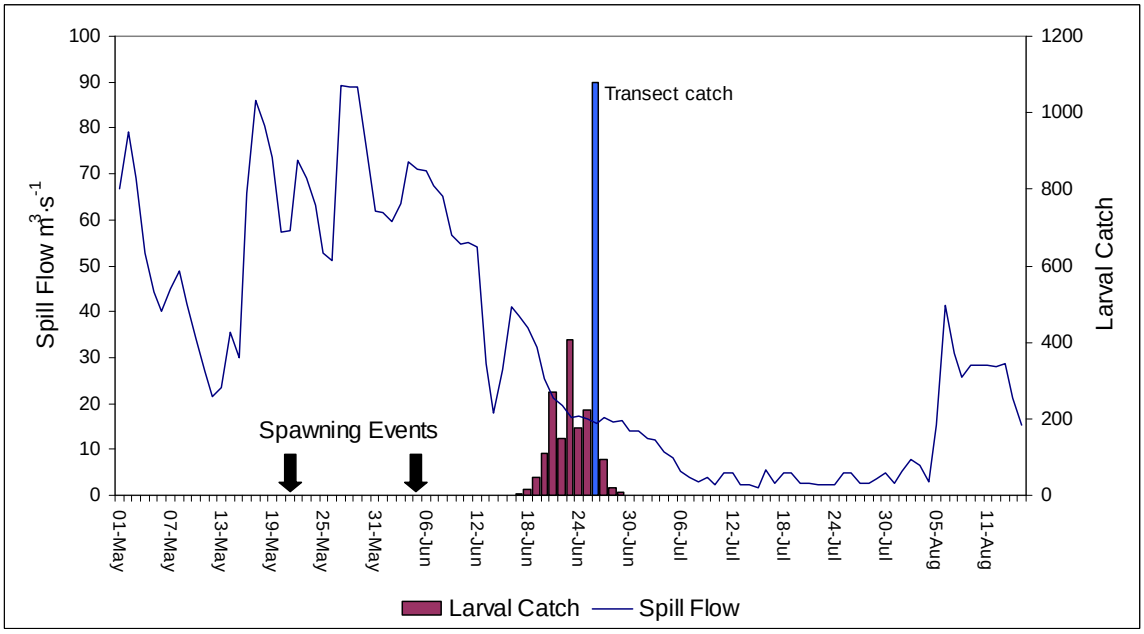


Figure 8. Mean daily spill flow in relation to approximate spawning dates and catches of downstream drifting larvae.

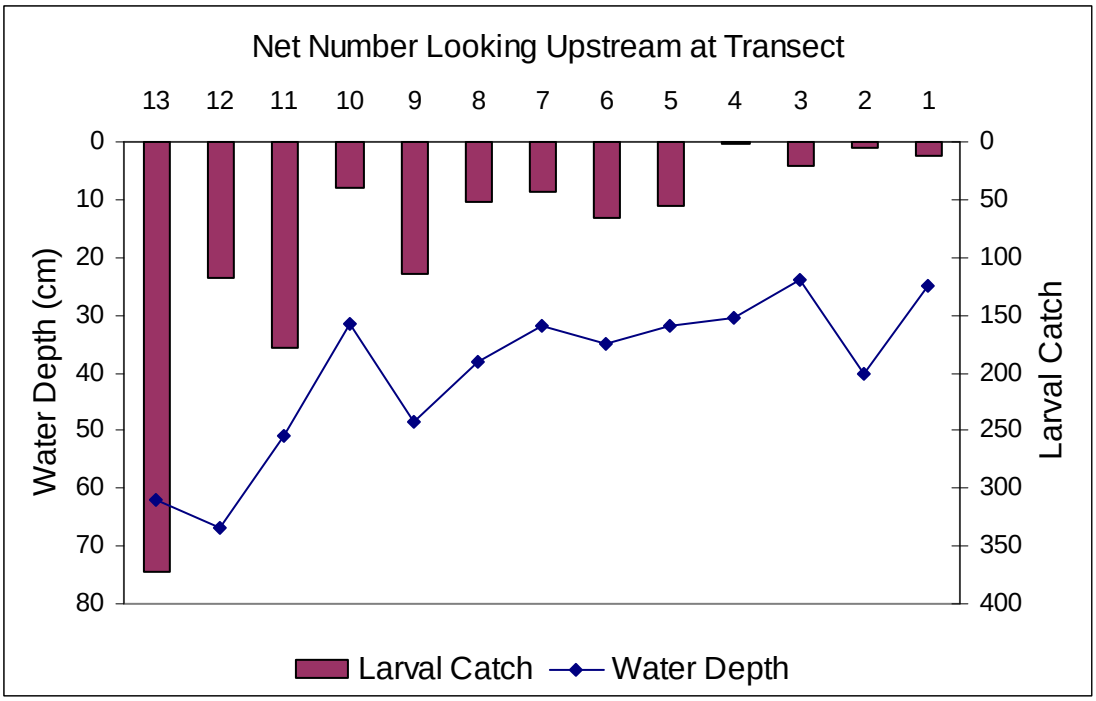


Figure 9. Catches of downstream drifting larvae in relation to water depth (cm) of each drift net.

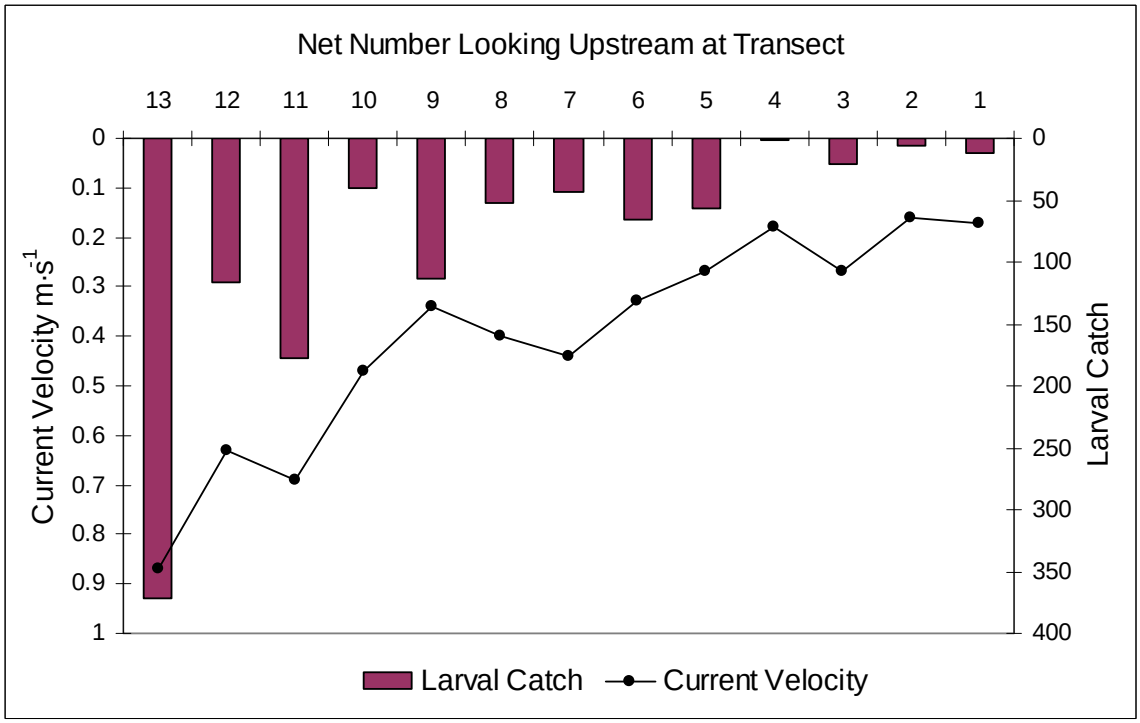


Figure 10. Catches of downstream drifting larvae in relation to water velocity at the opening of each drift net.

Table 1. Fish attribute information for 22 adult sturgeon radio tagged in 2009, nine tagged in 2008 and one internally tagged in 2000.

| TAG DATE | FLEN (MM) | TLEN (MM) | GIRTH (MM) | RWT (G) | SEX | FREQ. | DID FISH MIGRATE TO SPAWNING SITE IN 2009? |
|---|---|---|---|---|---|---|---|
| 06-Sep-00 | 1120 | 1189 | | 10900 | ? | 150.095 | yes |
| | | | | | | | |
| 17-Oct-08 | 1320 | 1440 | 565 | 20000 | ? | 150.402 | yes |
| 17-Oct-08 | 1235 | 1355 | 545 | 18000 | ? | 150.423 | yes |
| 17-Oct-08 | 1280 | 1450 | 615 | 21500 | F | 151.452 | yes |
| 17-Oct-08 | 1240 | 1375 | 445 | 14000 | ? | 150.503 | yes |
| 21-Oct-08 | 1000 | 1230 | 470 | 11500 | ? | 150.483 | yes |
| 21-Oct-08 | 1130 | 1250 | 450 | 12500 | ? | 151.253 | yes |
| 21-Oct-08 | 1180 | 1295 | 485 | 14500 | ? | 151.333 | yes |
| 22-Oct-08 | 1270 | 1395 | 575 | 21000 | ? | 151.393 | yes |
| 22-Oct-08 | 1180 | 1275 | 490 | 14000 | ? | 151.293 | yes |
| | | | | | | | |
| 05-May-09 | 1030 | 1118 | 390 | 7000 | ? | 150.702 | yes |
| 05-May-09 | 1185 | 1305 | 445 | 10800 | ? | 151.184 | yes |
| 05-May-09 | 1300 | 1430 | 530 | 16000 | ? | 151.162 | |
| 05-May-09 | 1115 | 1234 | 420 | 9500 | ? | 150.784 | yes |
| 05-May-09 | 1180 | 1325 | 480 | 12000 | ? | 150.722 | yes |
| 12-May-09 | 1150 | 1260 | 480 | 10200 | ? | 150.805 | |
| 12-May-09 | 1190 | 1299 | 430 | 11000 | ? | 150.884 | yes |
| 13-May-09 | 1188 | 1306 | 470 | 10300 | ? | 150.903 | yes |
| 13-May-09 | 1378 | 1515 | 595 | 20500 | F | 150.743 | |
| 14-May-09 | 1195 | 1322 | 540 | 14500 | ? | 150.823 | |
| 14-May-09 | 1295 | 1435 | 550 | 1800 | ? | 150.444 | |
| 14-May-09 | 1130 | 1241 | 440 | 8700 | ? | 150.922 | yes |
| 14-May-09 | 1190 | 1295 | 530 | 16000 | ? | 150.963 | |
| 15-May-09 | 1000 | 1090 | 430 | 7500 | ? | 150.763 | |
| 15-May-09 | 1170 | 1275 | 495 | 12500 | ? | 150.864 | |
| 15-May-09 | 1100 | 1214 | 480 | 11000 | ? | 150.943 | |
| 15-May-09 | 1325 | 1455 | 620 | 22000 | ? | 151.064 | |
| 15-May-09 | 1340 | 1465 | 575 | 22000 | ? | 150.984 | |
| 15-May-09 | 1265 | 1380 | 515 | 15000 | ? | 151.143 | |
| 15-May-09 | 1245 | 1370 | 535 | 15300 | ? | 150.604 | |
| 15-May-09 | 1050 | 1100 | 450 | 9500 | ? | 150.914 | |
| 15-May-09 | 1290 | 1400 | 550 | 17500 | ? | 151.001 | |

Table 2. The drift netting incidental catch.

| Common name | Scientific name | Catch |
|---|---|---|
| Blacknose dace | *Rhinichthys atratulus* | 2 |
| Burbot | *Lota lota* | 9 |
| Central mudminnow | *Umbra limi* | 34 |
| Chinook salmon | *Oncorhynchus tshawytscha* | 2 |
| Minnow family | *Cyprinidae* | 14 |
| Lake whitefish | *Coregonus clupeaformis* | 40 |
| Northern pike | *Esox lucius* | 271 |
| Pearl dace | *Semotilus margarita* | 2 |
| Pink salmon | *Oncorhynchus gorbuscha* | 98 |
| Rainbow smelt | *Osmerus mordax* | 209 |
| Sculpin family | *Cottidae* | 4059 |
| Sea lamprey | *Petromyzon marinus* | 5 |
| Sucker family | *Catostomidae* | 5385 |
| Trout perch | *Percopsis omiscomaycus* | 5 |
| Walleye | *Sander vitreus* | 142 |
| Yellow perch | *Perca flavescens* | 2 |

Appendix 1. Cumulative daily thermal units (CTU's) calculated for the time period from the first spawning event (highlighted grey) and second spawning event to the start of larval drift in the Kaministiquia River.

| YEAR | Spawning date (approx.) | # of days from spawning to start of drift event (date) | CTU | # of days to end of drift (date) | CTU |
|---|---|---|---|---|---|
| 2004 | 21-May-04 | 21 (10-Jun-04) | **145.9** | 39 (28-Jun-04) | **299.2** |
| 2004 | 27-Jun-04 | 23 (20-Jul-04) | **173.3** | 23 (20-Jul-04) | **289** |
| 2005 | 22-May-05 | 17 (7-Jun-05) | **154.2** | 28 (18-Jun-05) | **266.4** |
| 2005 | 31-May-05 | 20 (19-Jun-05) | **203.7** | 26 (25-Jun-2005) | **291** |
| 2006 | 21-May-06 | 12 (1-Jun-06) | **130.5** | 27 (16-Jun-2006) | **332** |
| 2007 | 24-May-07 | 15 ( 7-Jun-07) | **162.7** | 23 (15-Jun2007) | **263** |
| 2007 | 31-May-07 | 15 (14-Jun-07) | **169.7** | 19 ( 18-Jun-2007) | **250** |
| 2008 | 7-Jun-08 | 20 (26-Jun-2008) | **159.3** | 37 (13-Jul-2008) | **351.9** |
| 2009 | 21-May-09 | 25 (15-Jun-2009) | **152.2** | 44 (3-Jul-2009) | **352.2** |
| 2009 | 5-Jun-09 | 20 (24-Jun-1009) | **176.9** | 29 (3-Jul-09) | **279.8** |
| | | | | | |
| Average CTU for first spawning event | | | **150.8** | | **310.8** |
| | | | | | |
| Average CTU for second spawning event | | | **180.9** | | **277.5** |