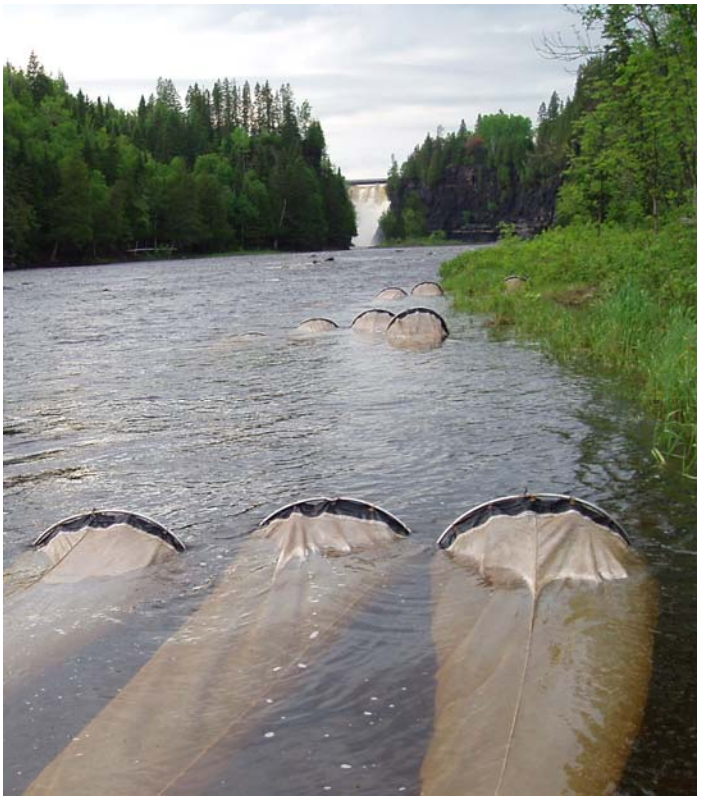
The Migratory and Reproductive Response of Spawning Lake Sturgeon to Controlled Flows over Kakabeka Falls on the Kaministiquia River, 2007



Upper Great Lakes Management Unit

Lake Superior

Technical Report 2007.01

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 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.

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 0.34 $m^3 \cdot s^{-1}$ on May 5, 2006.

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 $m^3 \cdot s^{-1}$ (2004 and 2005) and 17 $m^3 \cdot s^{-1}$ (2006).

Another component of the lake sturgeon study agreement was to examine lake sturgeon movements and reproduction during scenic flows conditions. The Lakehead Region Conservation Authority area of jurisdiction (which includes the Kaministiquia River system) was in a level II low water condition from November 26, 2006 to July 3, 2007. To take advantage of these low flow conditions, OMNR and OPG agreed to study the response of spawning sturgeon to scenic flow conditions over the Falls. It was hypothesized that sturgeon would not migrate upstream of the GS during these flows but would spawn at or downstream of the GS.

These flows would likely prevent or delay access to the spawning site at the base of the Falls and would allow OPG to investigate if spawning occurs downstream of the GS.

This report details the fourth year of research examining lake sturgeon spawning migrations and reproductive success.

The objectives of the studies were to:

1. Monitor movements and spawning upstream of the GS (OMNR) and downstream of the GS (OPG) using radio telemetry and drift netting.
2. Determine if lake sturgeon spawn in the tailrace of the GS.
3. Determine if the eggs incubate and hatch under GS outflow conditions (< 57 m^3/s).
4. Determine if lake sturgeon spawn in upstream of the GS.
5. Determine if the eggs incubate and hatch during scenic flows over the Falls.
6. 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 = 19) was identified by a unique frequency between 150.613 – 151.874 MHz. The 20 g transmitters (model F2060) pulsed 55 times per minute and had a battery life of approximately 10 months.

To catch sturgeon for tag attachment, 45 m of 304 mm (12”) stretched mesh multifilament gill net was set overnight at river kilometre (rkm) 19 (Figure 3). Netting was carried out from April 26 to April 29 (6 net sets) during water temperatures that averaged 9.1°C. Of twenty nine sturgeon captured, 19 individuals that had not been previously radio tagged during any other study were fitted with external transmitters (Table 1) following the procedures outlined in Friday (2004). All sturgeon were sampled for length (fork, total and legal), 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 genetic sample was also taken from the leading edge of the left pectoral fin. We attempted to determine fish gender by forcing eggs or milt from the genital opening.

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

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

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).

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.

An additional shoreline based data logger was set up approximately 6.5 km downstream of Kakabeka Falls on Harstone Drive to monitor the upstream and downstream movements of migrating sturgeon. This base station was situated where, in previous study years, sturgeon were often located before migrating to the Falls (Figure 3).

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 shoreline loggers 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 by OMNR was carried out upstream of the GS in case sturgeon accessed this area under scenic flows and spawned successfully below the Falls.

OMNR drift netting took place from June 5 to June 21 at two stations between the GS and Kakabeka Falls (Figure 2). Station 1 (6 nets) was located approximately 200 m downstream of the rapids at the base of Kakabeka Falls (where spawning is known to occur) and was intended to capture larvae that hatched from that site. Station 2 (6 nets) was located approximately 100 m downstream of the first set of rapids upstream of the GS. This site was selected to capture larvae if adult sturgeon were unable to access the base of the Falls but spawned in the first set of rapids upstream of the GS.

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 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.

Drift netting was also carried out by Ontario Power Generation (Northern Bioscience) downstream of the GS. Drift netting took place from June 6 to June 24, 2007. Nets were set on the east bank of the river, approximately 250 m downstream of the GS and on the west bank at two sites approximately 150 m downstream of the GS. Six nets were used on the east side and three nets were used on the west side (Figure 3) (Foster and Harris 2007).

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 25 to July 5. Water velocity ($m \cdot s^{-1}$ - recorded using a Marsh McBirney Flo-Mate) and depth (cm) was measured at the opening of each drift net upon deployment.

Study Flows

Scenic flows were initiated on Saturday May 19 (8.5 $m^3 \cdot s^{-1}$) and were maintained for the duration of the study period. There were no significant rain events that caused spill over Kakabeka Falls in excess of scenic flows (Figure 4 and 5).

RESULTS

Radio Tagging

External transmitters were attached to nineteen lake sturgeon. These fish ranged from 106 to 165.5 cm in total length and weighed 11 to 32 kg (Table 1).

Migration

Nine radio tagged sturgeon migrated to Kakabeka in 2007. Seven were radio tagged in the present study and two were tagged and migrated to Kakabeka Falls during a similar study in 2006 (Freq. 1032 and 973). Of the fish tagged in 2007 that did not migrate to Kakabeka (n = 12) eleven moved downstream from the tagging site and remained in the lower river throughout the summer. Another fish (Freq. 644) migrated approximately 23 km upstream from the tagging site and was detected by the Harstone logger but not by the Kakabeka logger (Figure 6).

The nine radio tagged sturgeon that migrated to Kakabeka began their upstream spawning migration during the last week of April when water temperature in the lower river was approximately 9°C.

Harstone Logger

The first sturgeon detected by the Harstone logger (Freq. 663, 1655 mm) arrived on May 3 (5.1°C) approximately 5 d after being radio tagged in the lower river. During this 5 d period of upstream migration it travelled 23 kms during mean daily total river flows that averaged 16.3 $m^3 \cdot s^{-1}$ and ranged from 13.5 to 24.6 $m^3 \cdot s^{-1}$. This fish remained in the vicinity of Harstone logger for 15 d when mean daily total river flows ranged from 10.3 to 19.9 $m^3 \cdot s^{-1}$ and water temperature ranged

from 5.1 to 16°C. Upstream migration from this location did not occur until May 18 when mean daily total river flows ranged from to 19.9 to 26.7 $m^3 \cdot s^{-1}$ (Figure 6).

Another fish detected by the Harstone logger (Freq. 1032, 1540 mm) arrived on May 6 and remained in the vicinity of Harstone logger for 9 d. During this 9 d period, the mean daily total river flows averaged 13.7 $m^3 \cdot s^{-1}$ and ranged from 10.3 to 17.8 $m^3 \cdot s^{-1}$ and water temperature ranged from 11.7 to 16°C. Upstream migration occurred on May 15 when total river flow averaged 17 $m^3 \cdot s^{-1}$ (Figure 6).

Frequency 644 (1400 mm) was first detected by the Harstone logger on May 6 (11.9°C) approximately 7 d after being radio tagged in the lower river. During this 7 d period of upstream migration it travelled 23 kms during mean daily total river flows that averaged 15.6 $m^3 \cdot s^{-1}$ and ranged from 13.5 to 20 $m^3 \cdot s^{-1}$ (Figure 6). This fish remained in the vicinity of Harstone logger for 5 d when mean daily total river flows ranged from 11.4 to 15.9 $m^3 \cdot s^{-1}$ and water temperature ranged from 11.1 to 15.9°C. This fish moved upstream of the logger on two occasions but did not move far enough to be detected by the Kakabeka logger. On May 8 (11:01) it moved upstream for 10 hrs when river flows were 14.2 $m^3 \cdot s^{-1}$ and water temperature was 12.5°C. On May 9 (03:32) it moved upstream for 34 hrs which was followed by migration back downstream on May 10 (13:23) and subsequent movement to the lower river by May 14.

All other radio tagged fish moved through this area quickly and were typically logged for less than a day before moving upstream to Kakabeka (Figure 6).

Kakabeka Logger

Radio tagged sturgeon arrived at Kakabeka between May 8 (12.1°C) and June 10 (16.6°C) and all were initially located in the tailrace of the GS (Figure 6). Six fish remained downstream of the GS while three others (Freq. 703, 716, and 773) migrated upstream of the GS on May 30 during scenic flows (Figures 6, 7 and 8). The upstream migration of these fish into the study area and subsequent movement downstream is described below:

Frequency 150.703

Arrived at the tailrace of the GS on May 26 (14.4°C) when spill over Kakabeka Falls was 4.8 $m^3 \cdot s^{-1}$ and flow out of the GS was 24.9 $m^3 \cdot s^{-1}$. It remained in the tailrace of the GS for 4 d and migrated into the study area on May 30 (16.2°C) at approximately 19:00 hrs during 4.1 $m^3 \cdot s^{-1}$ spill. This fish (1420 mm) navigated the entire length of the study area and reached the base of Kakabeka Falls approximately 2 hrs after it began moving upstream. It moved back downstream 7 d later on Sunday June 3 (19.4°C) during flow of 8.2 $m^3 \cdot s^{-1}$ (Figures 6, 7 and 8).

Frequency 150.716

Arrived at the tailrace of the GS on May 19 (13.6°C) when spill over Kakabeka Falls was 8.1 $m^3 \cdot s^{-1}$ and flow out of the GS was 15.9 $m^3 \cdot s^{-1}$. It remained in the tailrace of the GS for 11 d and migrated into the study area on May 30 (16.2°C)

at approximately 13:25 hrs during 4.1 $m^3 \cdot s^{-1}$ spill. This fish (1310 mm) navigated the entire length of the study area and reached the base of Kakabeka Falls approximately 3 hrs after it began moving upstream. It moved back downstream 10 d later on Saturday June 9 (16.6°C) during flow of 8.2 $m^3 \cdot s^{-1}$ and remained in the GS tailrace until June 12 (Figures 6, 7 and 8).

Frequency 150.773

Arrived at the tailrace of the GS on May 28 (13.7°C) when spill over Kakabeka Falls was 4.1 $m^3 \cdot s^{-1}$ and flow out of the GS was 20.5 $m^3 \cdot s^{-1}$. It remained in the tailrace of the GS for 2 d and migrated into the study area on May 30 (16.2°C) at approximately 21:00 hrs during 4.1 $m^3 \cdot s^{-1}$ spill. This fish (1250 mm) navigated the entire length of the study area and reached the base of Kakabeka Falls approximately 1.25 hrs after it began moving upstream. It moved back downstream 3 d later on Saturday June 2 (19.7°C) during flow of 8.2 $m^3 \cdot s^{-1}$ (Figures 6, 7 and 8).

Spawning Events

Based on similar departure dates of four fish (May 26 and 27) that remained downstream of the GS, it is likely that the first spawning event occurred around May 25 (downstream of the GS) when the mean daily water temperature was 14.8°C and the mean daily GS flow was 26.6 $m^3 \cdot s^{-1}$(Figure 6).

Based on the movement of three fish upstream of the GS on May 30 and similar departure dates of two fish (June 2 and 3), the second spawning event likely occurred on June 2 (upstream of the GS) when the mean daily water temperature was 19.7°C and spill flows fluctuated between dam leakage (0.34 $m^3 \cdot s^{-1}$) and 8.2 $m^3 \cdot s^{-1}$ (Figure 7 and 8).

DRIFT NETTING

Two separate larval drift events were documented. The first occurred downstream of the GS and was sampled by OPG. The second occurred upstream of the GS and was sampled by OMNR (Figure 9 and 10).

Sampling Downstream of GS (OPG)

During 14 overnight sampling events from June 6 to 24, at the east bank stations downstream of the GS, 60 larval lake sturgeons were captured. None were captured at the west bank stations during 10 overnight sampling events. The first larval sturgeon (18 mm) was captured on June 7; approximately 13 d after the suspected spawning date (Figure 9). Larval sturgeons ranged in total length from 18 to 27 mm and were captured during GS discharge flows that ranged from 17 to 57.1 $m^3 \cdot s^{-1}$ (Foster and Harris 2007).

Sampling Upstream of GS (OMNR)

During 15 overnight sampling events at each of two stations upstream of the GS in June (3141 sample hrs), 28 larval lake sturgeon were captured (Figure 10). Eleven were caught at site 1 (closest to the Falls) and 17 were caught at site 2 (Figure 2). The catch per unit effort was 0.009 larvae/hour. The incidental catch was 338 larval fish, of which 277 were identified to the species level and 61 specimens were grouped by family (Table 2).

The first larval sturgeon (19 mm) was captured on June 14, approximately 12 d after the suspected spawning date. The duration of the downstream movement of larvae from the spawning site was approximately 5 d (June 14 to 18) (Figure 9). Larval sturgeon ranging in length from 16 to 23 mm were captured. During the period of downstream drift the mean hourly spill flows ranged from 0.34 (overnight dam leakage) to 8.1 $m^3 \cdot s^{-1}$, water velocity at the opening of each net ranged from 0.13 to 0.56 $m \cdot s^{-1}$ and water depth at the drift net site ranged from 40 to 69 cm. The mean daily water temperature from the second suspected spawning date (June 2) to the date when the first larva was collected (June 14) was 18°C (Figure 10). The mean daily water temperature during the period of downstream drift was 22°C.

SUMMARY

TELEMETRY

1. All radio tagged sturgeon that migrated to Kakabeka were initially located in the tailrace of the GS.
2. Six sturgeon remained downstream of the GS for 3 to 21 d.
3. Three sturgeon moved upstream of the GS to the base of Kakabeka Falls during daylight hours at weekday scenic spill flows of 4.1 $m^3 \cdot s^{-1}$ and migrated downstream during weekend scenic flows of 8.2 $m^3 \cdot s^{-1}$. These fish were upstream of the GS for 3 to 11 d.
4. Based on similar departure dates of two groups of fish, there appeared to be two spawning events approximately 8 d apart.

DRIFT NETTING

1. Sturgeon spawned downstream and upstream of the GS.
2. There were two periods when larvae were captured drifting downstream.
3. The first period of drift occurred downstream of the GS from June 7 to 15, during which 60 larvae were captured.
4. The second period of drift occurred upstream of the GS from June 14 to 18, during which 28 larvae were captured.

ACKNOWLEDGEMENTS

This study was made possible through funding provided by the Canada Ontario Agreement respecting the Great Lakes Basin Ecosystem and the Great Lakes Sustainability Fund. The contributions of OMNR staff including Karen Schmidt and Jon Chicoine for their technical expertise, Kim Ahola for data entry, Kim Armstrong for 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, assisting with logistical aspects of the project and contributing their drift netting results to this report. Thanks to Ontario Parks for allowing us to carry out this research in the park and Grant Majala for the use of his property for a telemetry data logger.

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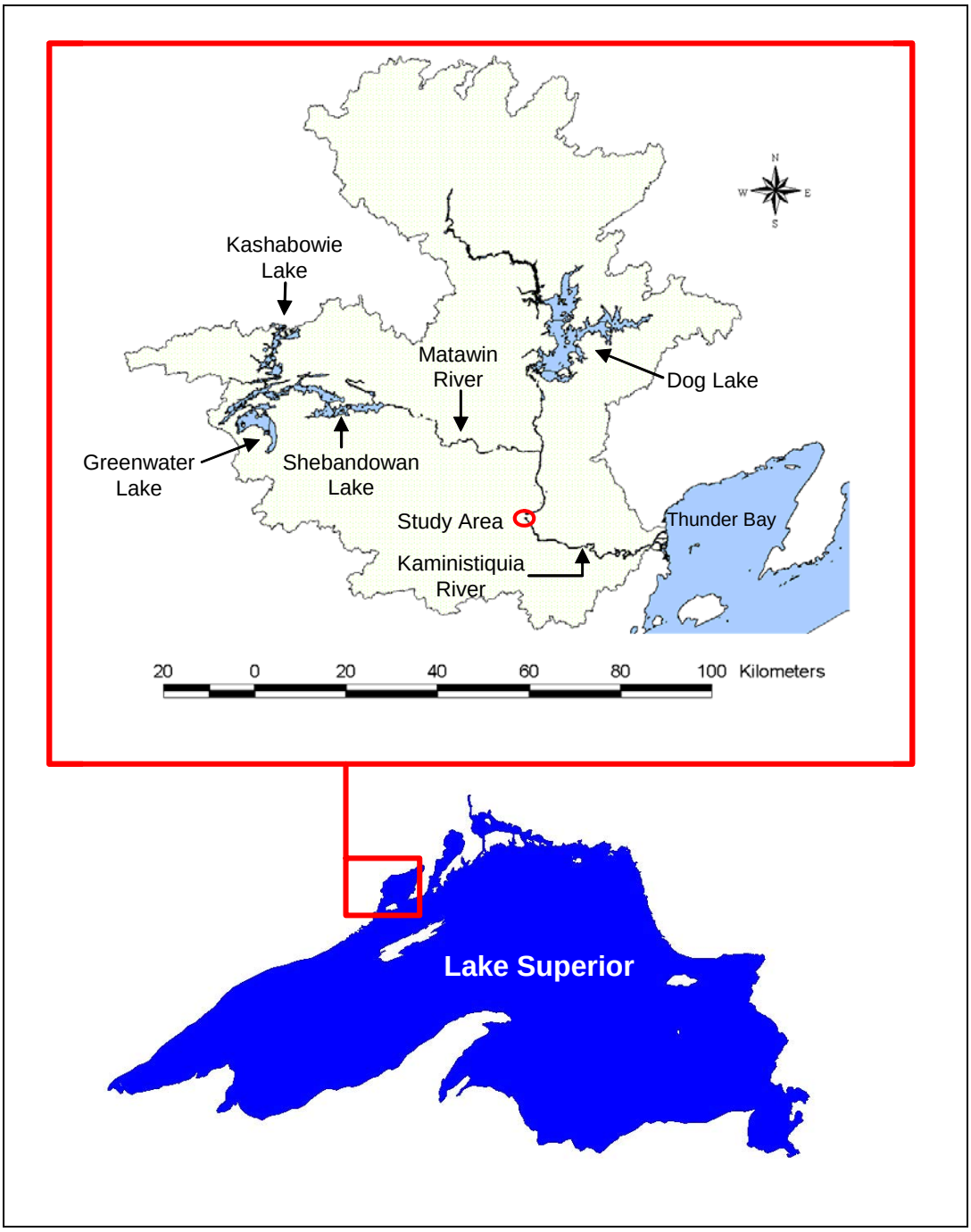

Figure 1. The Kaministiquia River watershed and major reservoirs.

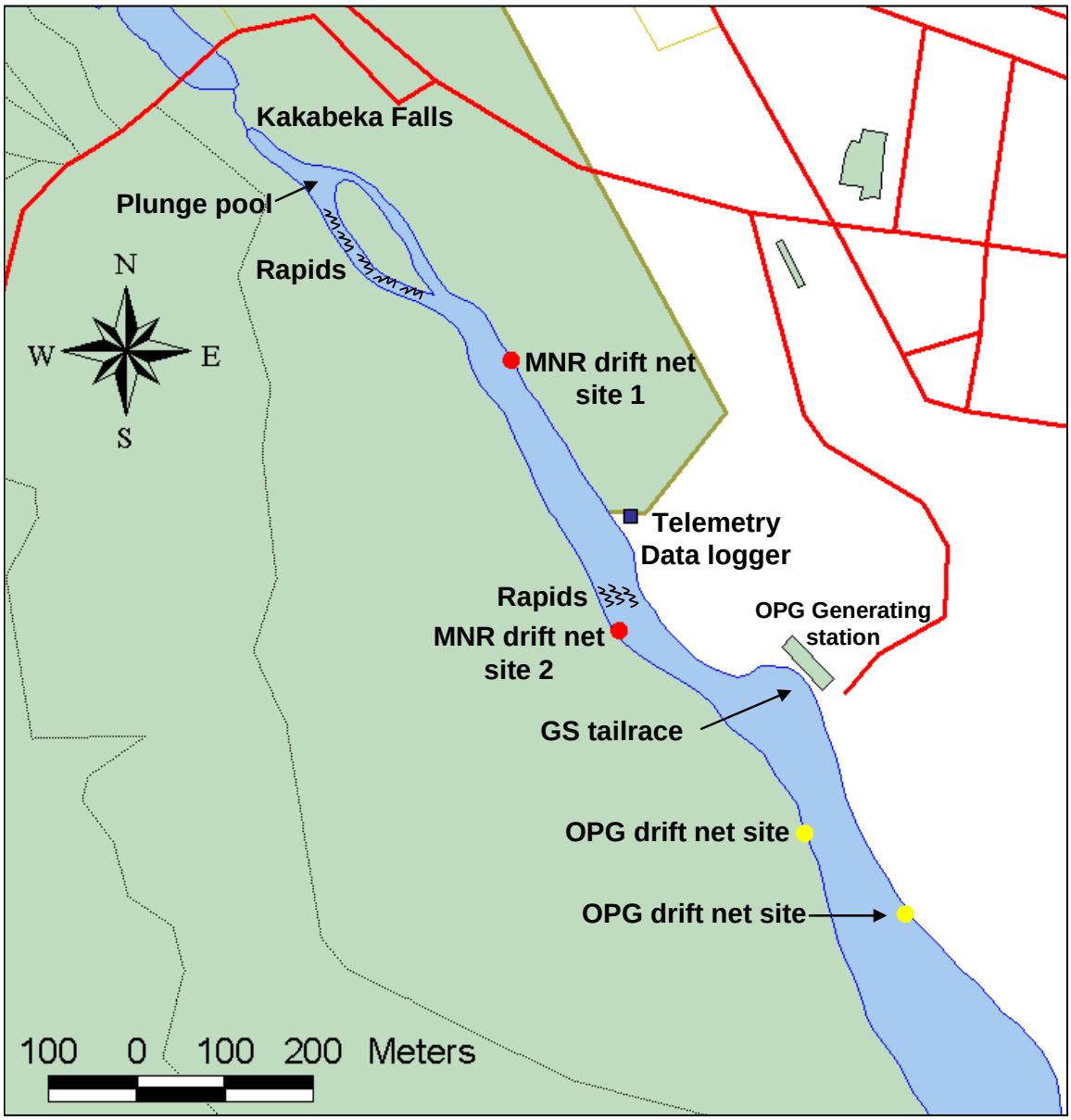

Figure 2. The study area from Kakabeka Falls downstream to the OPG generating station.

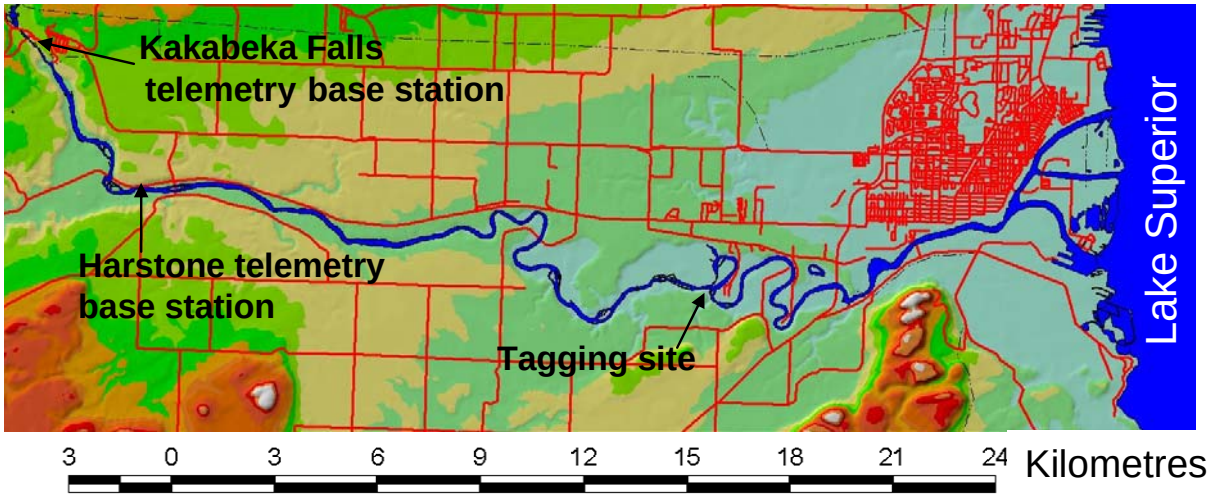

Figure 3. The Kaministiquia River from Kakabeka Falls downstream to Lake Superior.

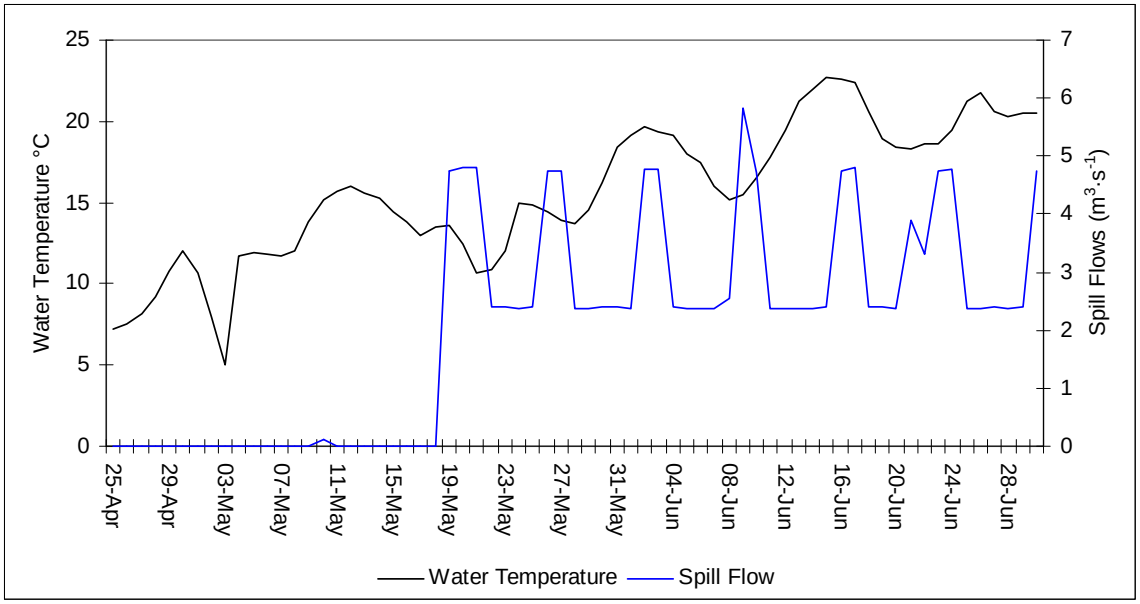

Figure 4. Water temperature and mean daily spill flow over Kakabeka Falls from April 25 to June 30, 2007.

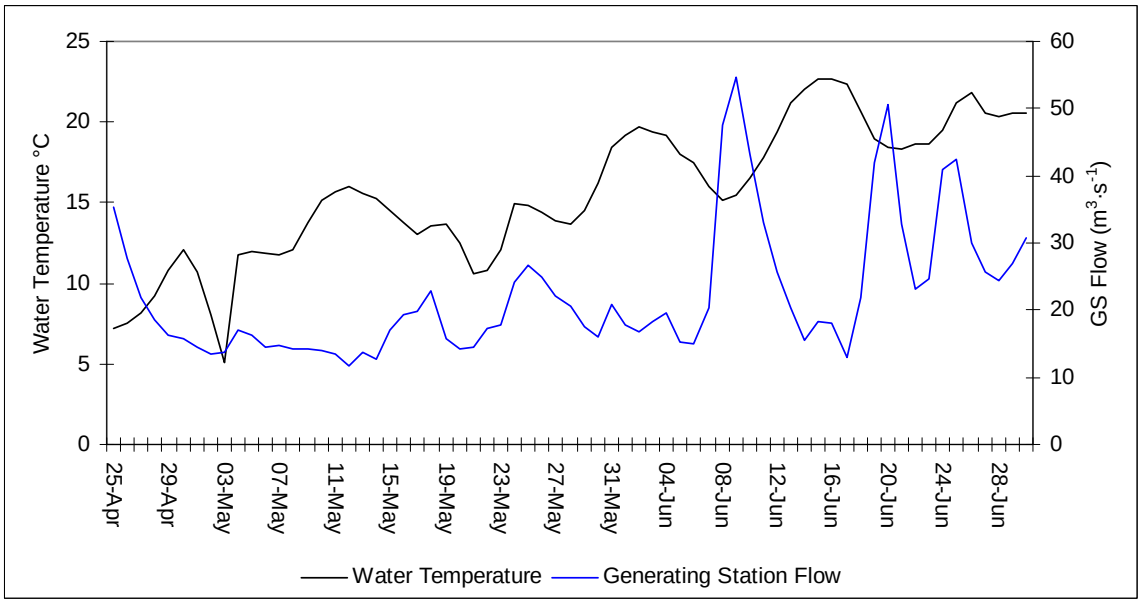

Figure 5. Water temperature and mean daily generating station flow from April 25 to June 30, 2007.

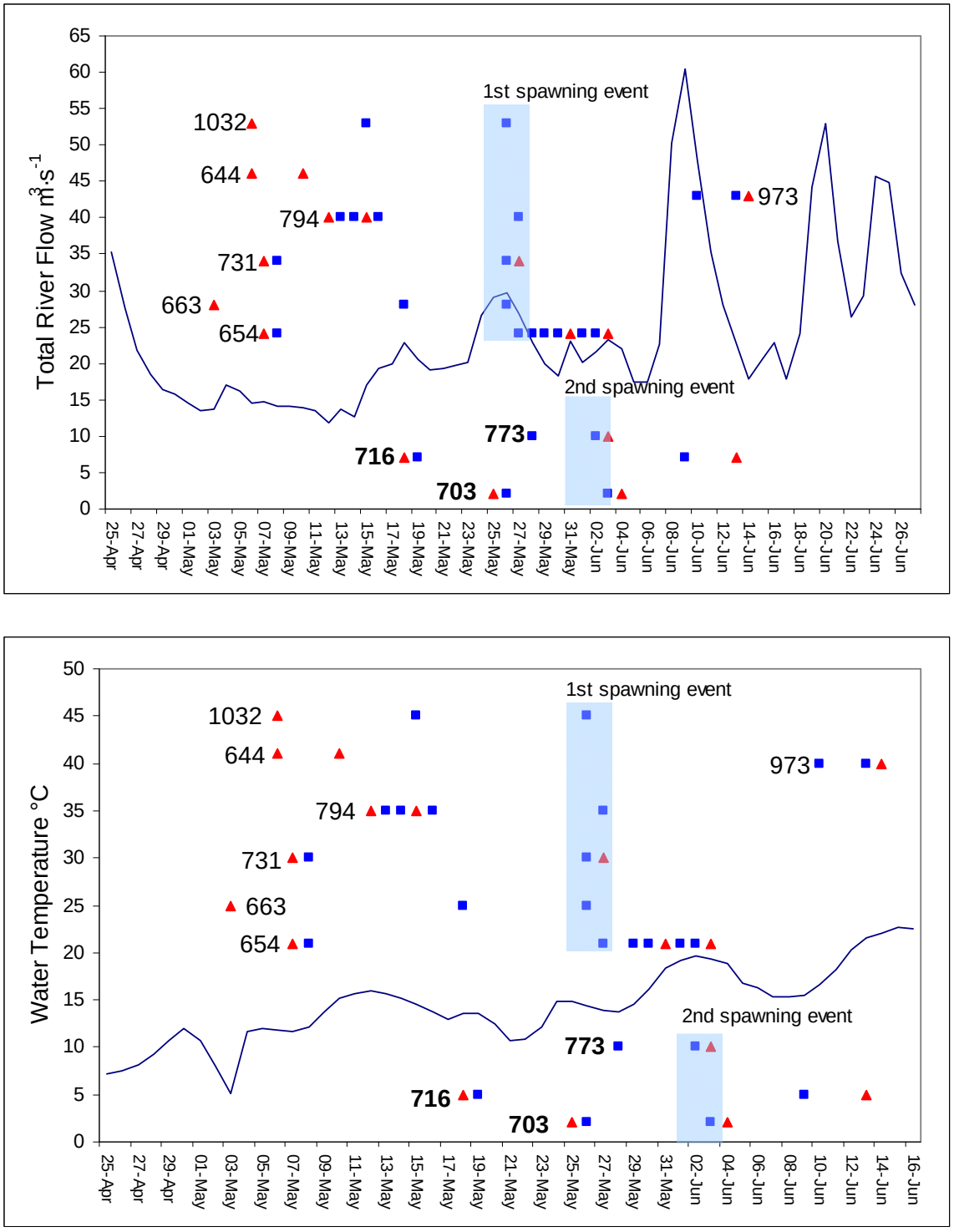

Figure 6. The migration of radio tagged sturgeon to the Harstone (red triangles) and Kakabeka (blue squares) loggers in relation to mean daily total river flows and water temperature (frequencies in bold represent fish that migrated to the base of Kakabeka Falls).

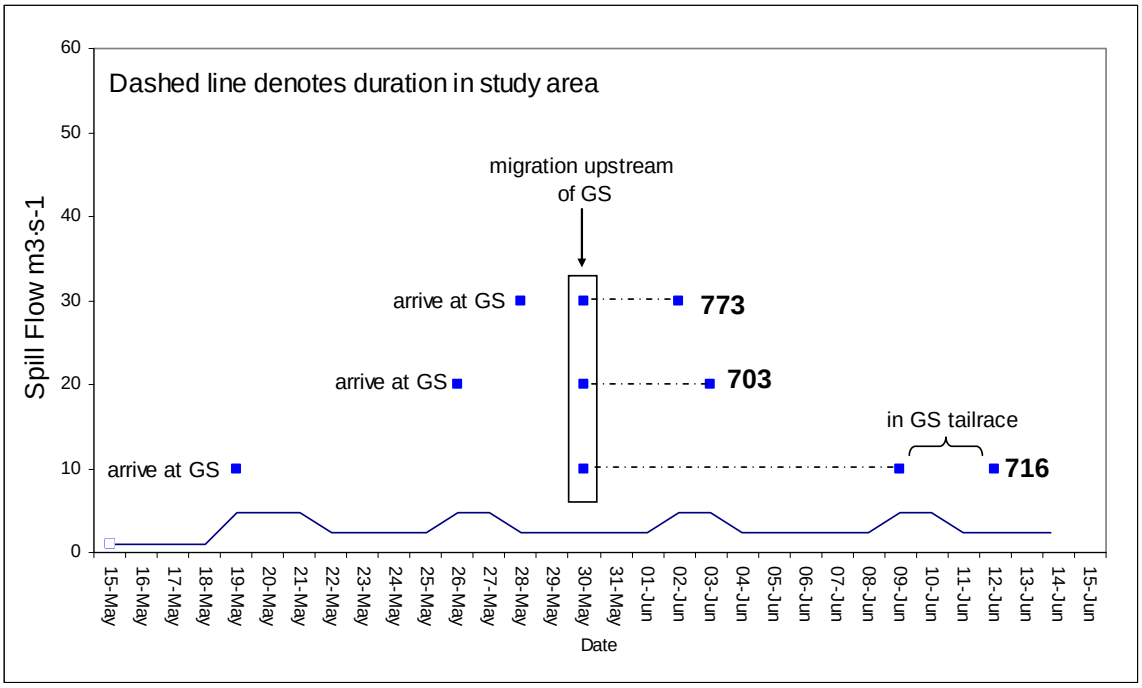

Figure 7. The migration of three radio tagged sturgeon to the base of Kakabeka Falls in relation to mean daily spill flow.

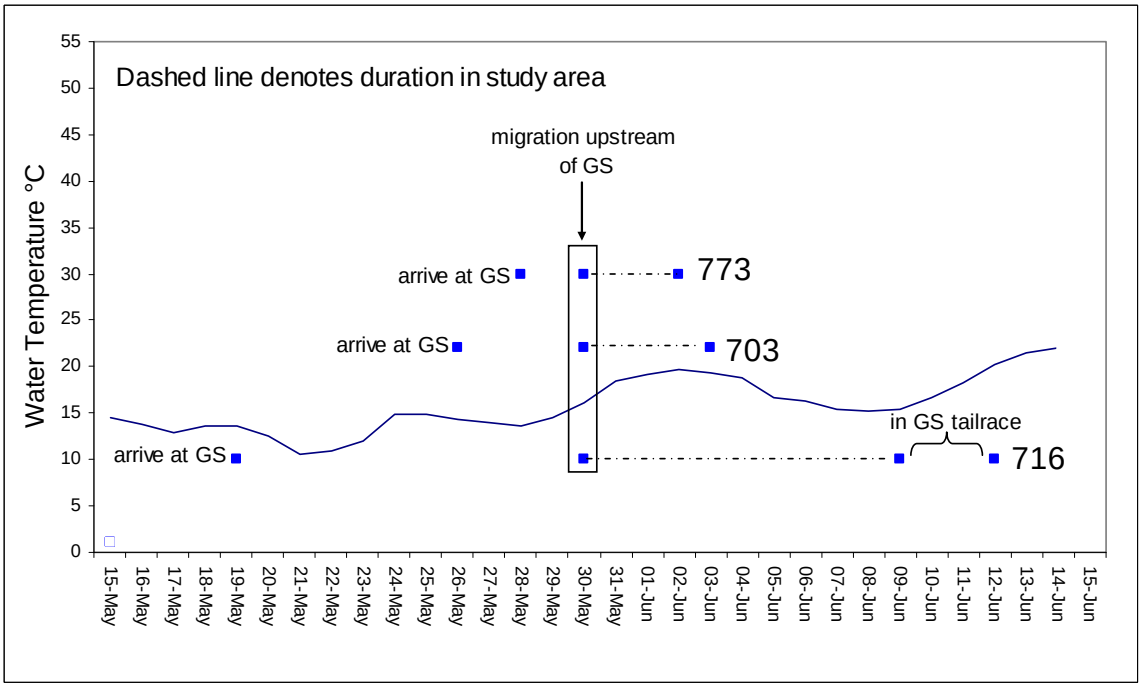

Figure 8. The migration of three radio tagged sturgeon to the base of Kakabeka Falls in relation to water temperature.

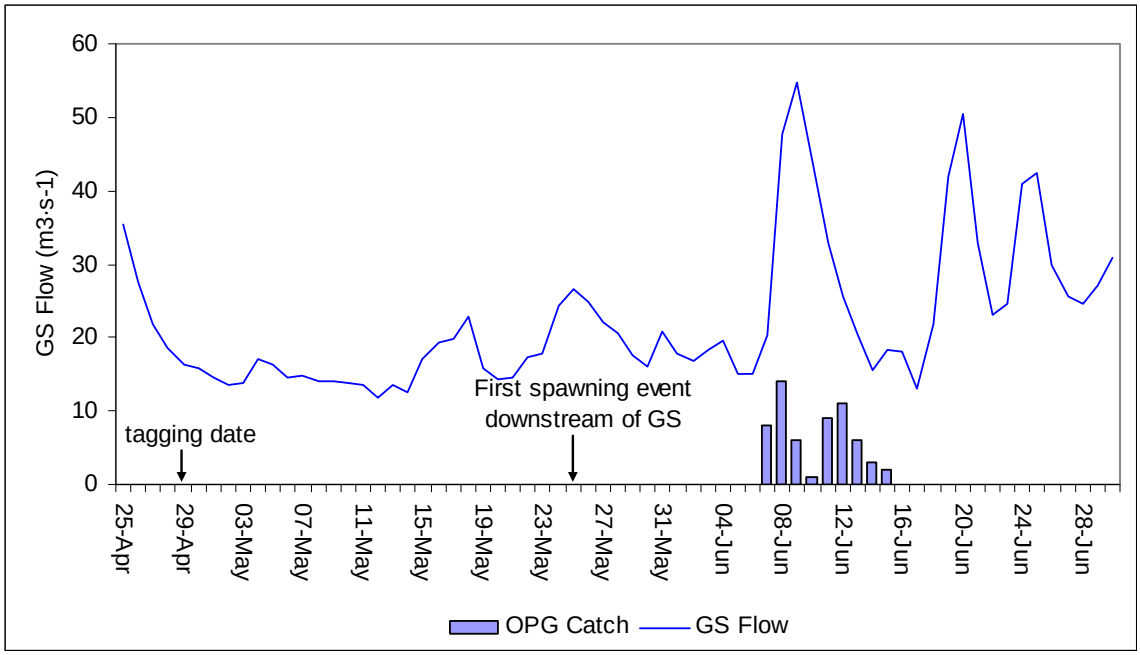

Figure 9. Larval sturgeon catch downstream of the generating station in relation to mean daily GS flow.

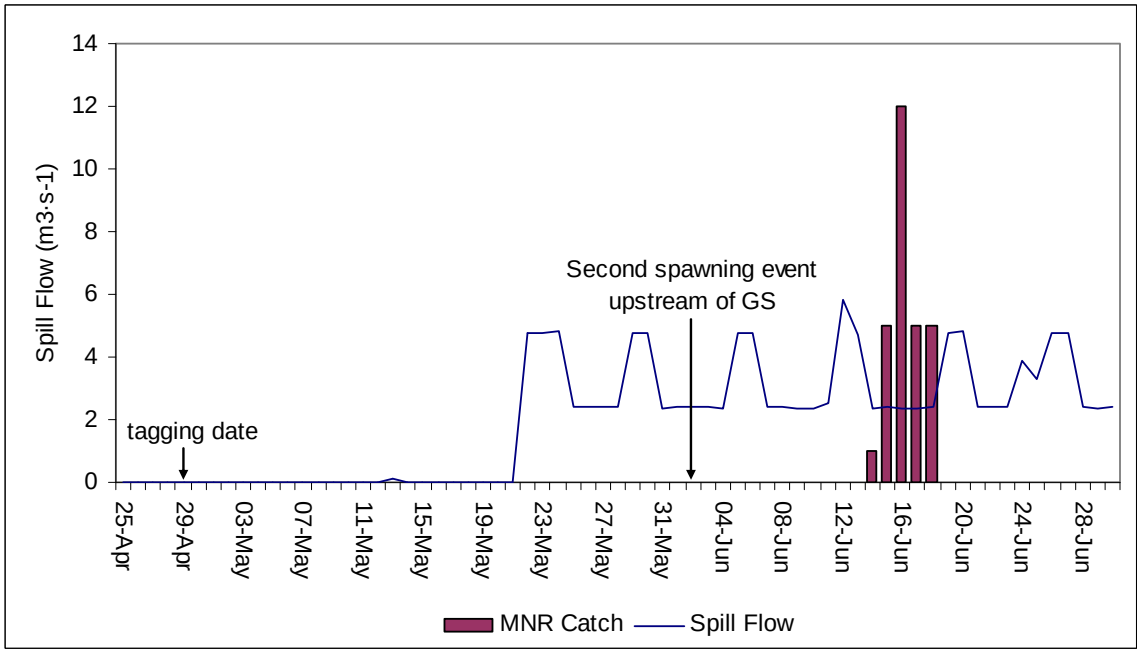

Figure 10. Larval sturgeon catch upstream of the generating station in relation to mean daily spill flow over Kakabeka Falls.

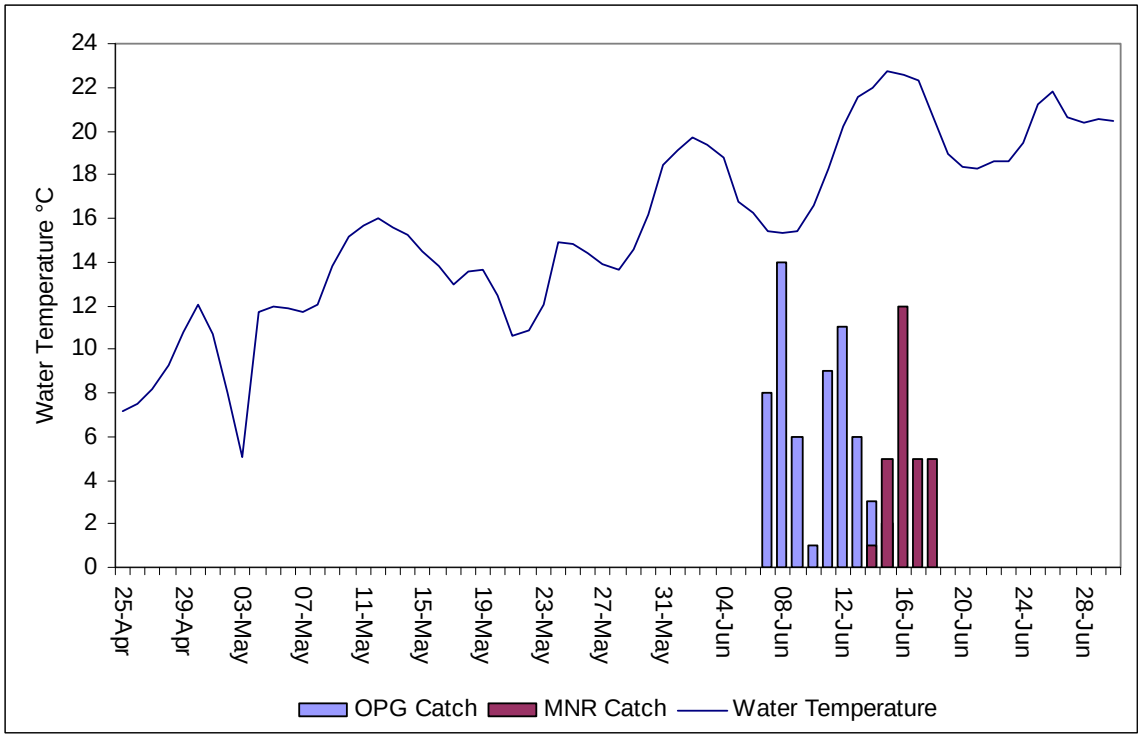

Figure 11. Larval sturgeon catch in relation to mean daily water temperature.

Table 1. Fish attribute information for 19 adult sturgeon radio tagged in 2007 and two tagged in 2006.

Tagging Date	Fork Length (mm)	Total Length (mm)	Girth (mm)	Weight (kg)	Sex	Frequency	Did fish migrate to spawning site in 2007?
27-Apr-07	1180	1250	505	14.5	?	773	yes
28-Apr-07	1300	1420	530	17.5	?	703	yes
28-Apr-07	1195	1310	490	14	?	716	yes
27-Apr-07	1490	1655	680	32	F	663	yes
28-Apr-07	1220	1310	510	16	?	794	yes
28-Apr-07	945	1060	385	8.5	?	731	yes
29-Apr-07	1150	1260	475	13.5	M	654	yes
27-Apr-07	965	1070	420	9.5	?	624	no
28-Apr-07	1110	1180	455	11	?	813	no
28-Apr-07	1085	1200	430	11	?	613	no
28-Apr-07	1200	1310	470	13.5	?	834	no
28-Apr-07	1120	1225	460	13	?	853	no
28-Apr-07	1230	1310	495	14.5	?	874	no
28-Apr-07	1285	1400	620	23.5	F	644	no
29-Apr-07	1165	1290	525	14.5	?	633	no
29-Apr-07	1080	1205	445	11	?	673	no
29-Apr-07	1210	1345	480	14.5	?	753	no
29-Apr-07	1130	1250	460	13.5	?	683	no
29-Apr-07	1110	1240	470	13	M	694	no
27-Apr-06	1410	1540	590	20.5	?	1032	yes
26-Apr-06	1295	1425	585	19	?	973	yes

Table 2. The drift netting incidental catch.

Common name	**Scientific name**	**Catch**
Blacknose dace	*Rhinichthys atratulus*	2
Brook trout	*Salvelinus fontinalis*	28
Burbot	*Lota lota*	22
Central mudminnow	*Umbra limi*	6
Chinook salmon	*Oncorhynchus tshawytscha*	4
Johnny darter	*Etheostoma nigrum*	3
Lake whitefish	*Coregonus clupeaformis*	1
Longnose dace	*Rhinichthys cataractae*	24
Minnow family	Cyprinidae	3
Northern pike	*Esox lucius*	3
Pink salmon	*Oncorhynchus gorbuscha*	3
Rainbow trout	*Oncorhynchus mykiss*	1
Rock bass	*Ambloplites rupestris*	1
Sculpin family	Cottidae	1
Smallmouth bass	Micropterus dolomieui	59
Spottail shiner	*Notropis hudsonuis*	1
Sucker family	Catostomidae	57
Trout perch	*Percopsis omiscomaycus*	5
Walleye	*Sander vitreus*	114