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The migratory and reproductive response of spawning lake sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, 2010

Ministry of Natural Resources

Ontario

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The migratory and reproductive response of spawning lake sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, 2010

M.J. Friday

Ministry of Natural Resources

Ontario

Front cover photo: Drift nets set in Kaministiquia River below Kakabeka Falls. Courtesy of Mike Friday, Ministry of Natural Resources

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Abstract

At the base of Kakabeka Falls, on the Kaministiquia River, is a historical spawning site for lake sturgeon. However, this site is often dewatered during the spawning period for power production and scenic flows for Kakabeka Falls provincial park. Controlled spill flows over the falls were provided by Ontario Power Generation to determine the flows necessary for adult sturgeon to access this site, facilitate successful spawning, hatch, and larval drift. We examined flows of 23 $m^3 \cdot s^{-1}$ (2004 and 2005), 17 $m^3 \cdot s^{-1}$ (2006), "scenic flows" in 2007, uncontrolled flows (2008 and 2009) and 14 $m^3 \cdot s^{-1}$ (2010 and 2011). Scenic flows fluctuate between 0.5 $m^3 \cdot s^{-1}$ (at night), 4.25 $m^3 \cdot s^{-1}$ (on weekdays) and 8.5 $m^3 \cdot s^{-1}$ (on weekends). To monitor sturgeon movements into the spawning area radio telemetry was used. Adult sturgeon were tagged in the lower river (with external radio transmitters) when they were thought to be migrating upstream to spawn. Their movement into the spawning area and migration back downstream was monitored using an Advanced Telemetry Systems data logger. Larval drift netting was carried out to document spawning success under these different flow regimes. During flows of 23 $m^3 \cdot s^{-1}$ and 17 $m^3 \cdot s^{-1}$, access, and successful spawning occurred. While spill flows of 14 $m^3 \cdot s^{-1}$, and scenic flow conditions, resulted in limited access and reduced spawning success.

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Disclaimer

The views, conclusions, and recommendations are those of the authors and should not be construed as either policy or endorsement by the Ontario Ministry of Natural Resources.

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Introduction

The Ontario Ministry of Natural Resources (MNR) and Ontario Power Generation (OPG) commenced water management planning for the Kaministiquia River watershed in 2002. 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 (power flow) 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 used 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 over 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). Spacers were installed, in April 2010, at the Kakabeka dam to provide a minimum flow of 0.5 $m^3 \cdot s^{-1}$.

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, 2005) and 17 $m^3 \cdot s^{-1}$ (Friday 2006). We examined lake sturgeon movements and reproduction during scenic flows in 2007, and found that sturgeon spawned upstream and downstream of the generating station (Friday 2007). We attempted to examine another flow condition (14 $m^3 \cdot s^{-1}$) in 2008 and 2009, to determine if migration to the base of the falls and successful spawning would occur (Friday 2008, 2009). Due to high water conditions, spill flow, however, could not be controlled at 14 $m^3 \cdot s^{-1}$ during these years.

We again attempted to examine lake sturgeon spawning migrations and reproductive success in 2010, during controlled spill 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 spill 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

This study focused on an 800-metre stretch of the Kaministiquia River, stretching from the base of Kakabeka Falls downstream to the OPG generating station (Figure 1 and 2).

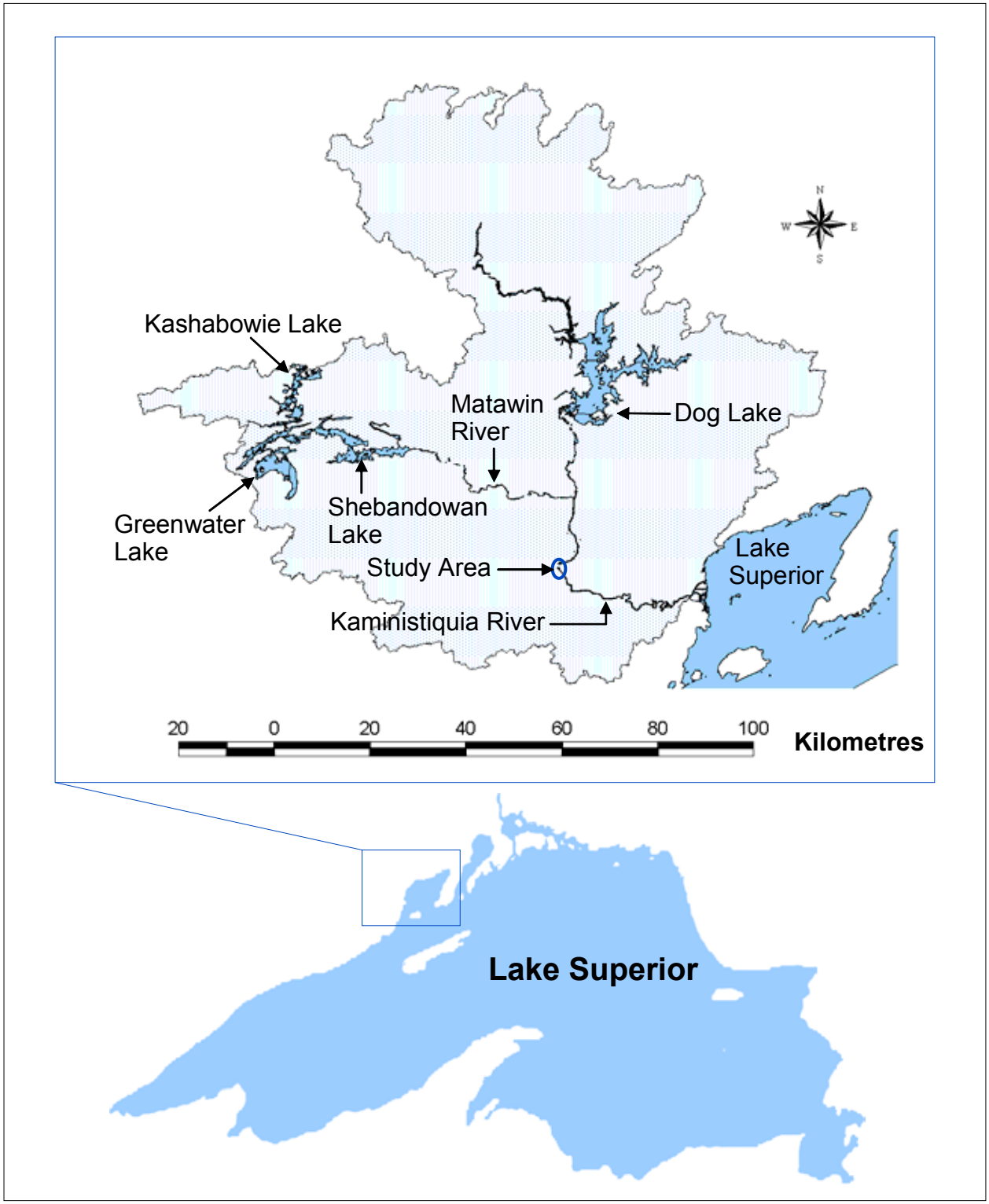


Figure 1. The Kaministiquia River watershed and reservoirs.

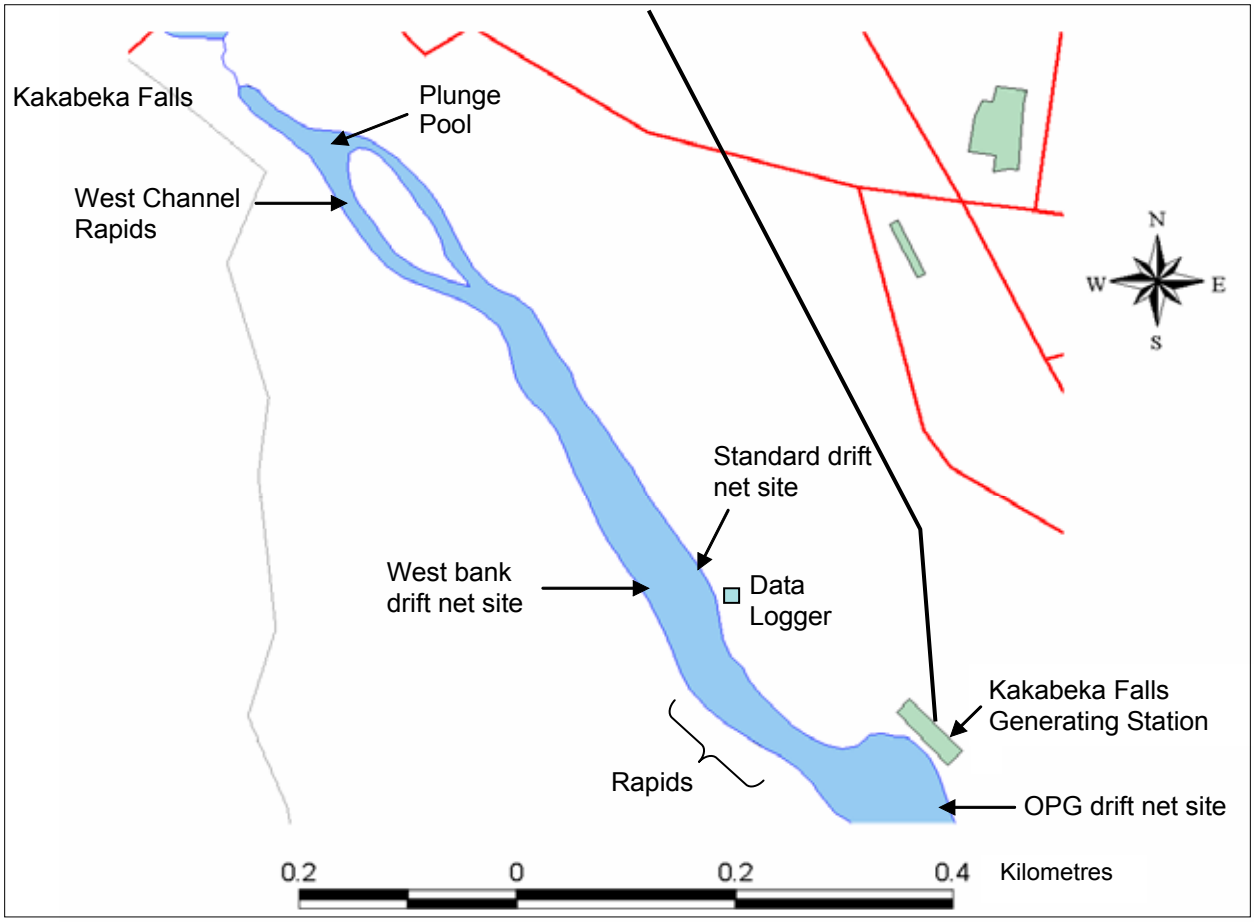


Figure 2. The study area from Kakabeka Falls downstream to the OPG generating station.

Materials and methods

Radio tagging

Radio telemetry equipment manufactured by Advanced Telemetry Systems (ATS) was used in this study[1]. Each radio transmitter (n=25) was identified by a unique frequency between 150.743 and 151.704 MHz. These 20-gram transmitters (model F2060) pulsed 55 times per minute and had a battery life of approximately 10 months.

In 2010, from April 15 to 16 and April 19 to 20, we attempted to radio tag lake sturgeon in the lower river (Figure 3) in the hope that they would migrate upstream to spawn. We set 46 m of 305 mm (12 inches to 7 sets) and 92 m of 305 mm (12 inches to 1 set) stretched mesh multifilament gill net overnight during water temperatures that ranged from 12.1 to 13.2°C and total river flows that averaged 15.5 $m^3 \cdot s^{-1}$. 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. Anaesthetic was not 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 16-digit passive 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 each captured fish.

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

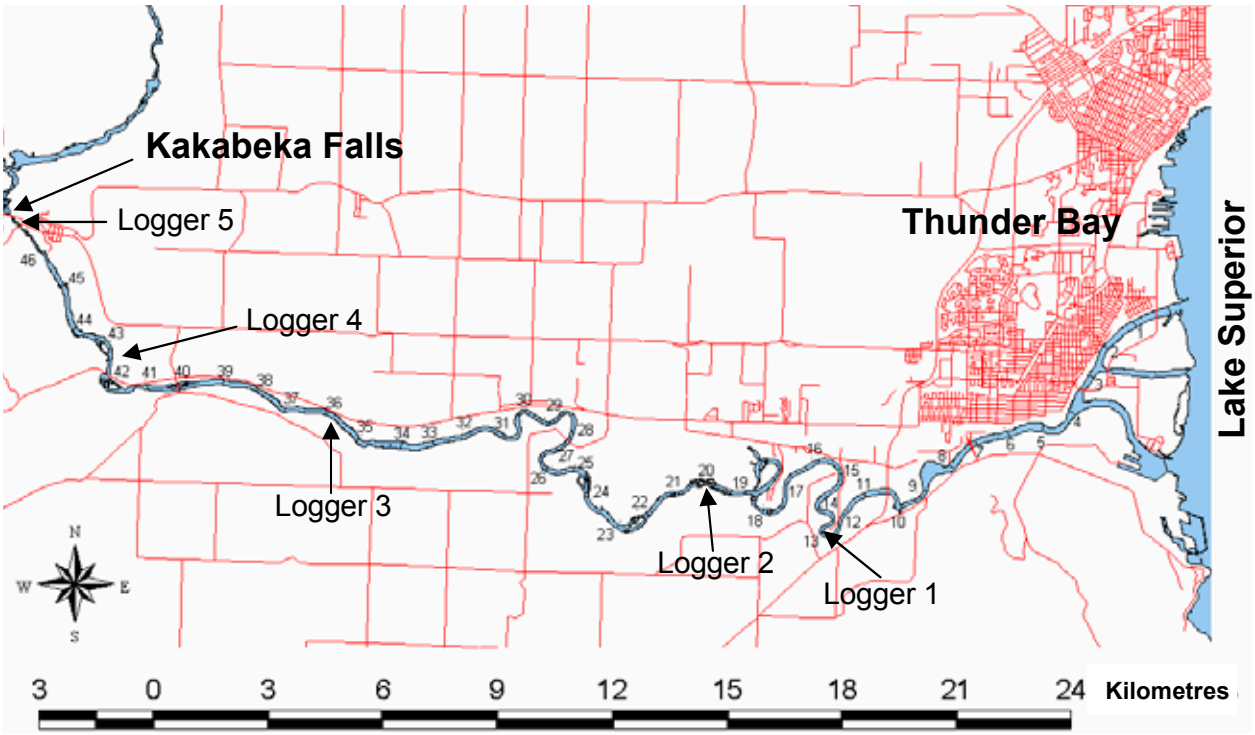


Figure 3. The location of radio telemetry base stations along a 34-km portion of the Kaministiquia River.

Tracking

A shoreline-based data logger (model R4500) was installed upstream of the generating station (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 generating station). The logger operated from April 23 to September 1, 2010.

A reference transmitter (150.893 MHz) was placed in the river upstream of the generating station and was logged every six hours to provide a known signal strength (average strength=150) 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.

Additional data loggers

Four additional data loggers were installed in April 2010, from river kilometre (rkm) 13 to 42 to track the upstream and downstream migration of radio-tagged sturgeon (Figure 3).

Drift netting

Drift netting took place at the standard site (12 nets) established in 2004, approximately 400 m downstream of Kakabeka Falls on the east shore of the river. We also set four nets (400 m downstream of Kakabeka Falls) on the west side of the river to examine drift within the main river channel where the majority of the flow over the falls was concentrated during these study flow conditions (Figure 2). All 16 nets were set from May 31 to June 1. 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-metre tapered mesh bag that terminated at collection container with filtering holes covered by 1,000 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, and live sturgeons were released downstream. Dead specimens were placed in glass vials and preserved in 70 percent ethanol. Other larval fish species captured were also preserved and later identified in the laboratory.

Drift netting was also carried out for Ontario Power Generation by Northern Bioscience downstream of the generating station from May 31 to June 10. Six nets were set in the same location as in 2007 and 2009 (Site 1) on the east bank of the River approximately 300 m downstream of the generating station (Foster and Harris 2010) (Figure 2).

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 generating station in 0.5 m of water. Temperature was recorded hourly from April 15 to September 15. Real-time water temperature information from the tailwater of the generating station 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

The MNR and OPG planned, in 2010, to examine lake sturgeon access to the base of Kakabeka Falls and reproduction during spill flows of approximately 14 $m^3 \cdot s^{-1}$ (from May 15 to June 25 with a five-day taper to scenic flows). This plan was altered due to low water conditions throughout the watershed (a Level 1 "low water condition" was declared by the Lakehead Region Conservation Authority in late April) and the absence of radio-tagged sturgeon at the Kakabeka Falls generating station prior to May 15. To examine migration under different flow conditions, we adopted an adaptive "see what happens approach" for spill flows by implementing a staged increase (from May 18–22) from dam leakage to a maximum of 16.6 $m^3 \cdot s^{-1}$ (over the falls). The study period was also adjusted to terminate on June 11 (with a four-day taper to scenic flow) as larval drift was complete.

Results

Radio tagging

External radio transmitters were attached to 25 lake sturgeon that ranged in total length from 111.6–117.2 cm and weighed 8 to 27.5 kg (Table 1).

Spill flow over the falls

Spill flow was initiated when radio-tagged sturgeon were tracked downstream of the GS on May 18 during total river flows of 16 $m^3 \cdot s^{-1}$ (Figures 4 and 5). In an attempt to document upstream migration of radio-tagged sturgeon from the tailrace of the GS into the study area, water flowing over Kakabeka Falls was increased in a staged manner, from the minimum flow to a maximum spill of 16.6 $m^3 \cdot s^{-1}$ as follows:

- Spill was increased from 0.5 $m^3 \cdot s^{-1}$–9.5 $m^3 \cdot s^{-1}$ on May 18 and maintained for 23 hours
- Spill was increased to 11.4 $m^3 \cdot s^{-1}$ on May 19 and maintained for 12 hours
- Spill was increased to 14 $m^3 \cdot s^{-1}$ on May 19 and maintained for 1.7 days
- Spill was increased to 16.6 $m^3 \cdot s^{-1}$ on May 21 and maintained for 1.5 days after which spill was decreased to 14 $m^3 \cdot s^{-1}$ and maintained until June 11

Migration

Ten radio-tagged sturgeon migrated to Kakabeka in 2010. Seven were radio-tagged in the present study (28% of those tagged in the spring of 2010) and three were tagged in the spring of 2009 (11% of those tagged in the spring of 2009). Upstream migration from the lower river to Kakabeka Falls coincided with a flow increase (rain event) that commenced on May 14 (Figure 4). Of ten sturgeon that migrated to Kakabeka, nine moved past logger 2 (rkm 20) on May 15 when flows increased from 14.9 to 28.7 $m^3 \cdot s^{-1}$. It took one to seven days for radio-tagged sturgeon to migrate 34 rkms from the lower river to Kakabeka (rkm 47) (Appendix 1).

Table 1. Fish attribute information and migration results for 25 adult lake sturgeon radio-tagged in 2009 and 2010.

Tag date (D-M-Y)	Flen (mm)	Tlen (mm)	Girth (mm)	Rwt (g)	Sex	Freq.	Migrated upstream of GS	Remained downstream of GS	Remained in the lower river
16-Apr-10	1200	1330	470	12000	?	151.424	X		
20-Apr-10	1500	1715	660	27500	?	151.682	X		
20-Apr-10	1310	1455	530	15500	?	151.344	X		
20-Apr-10	1140	1250	450	10500	?	151.243		X	
16-Apr-10	1220	1330	580	13000	?	151.543		X	
16-Apr-10	1070	1160	430	9500	?	151.623		X	
16-Apr-10	1280	1375	580	18500	?	151.584		X	
13-May-09	1378	1515	595	20500	?	150.743		X	
20-May-09	1220	1336	470	12000	?	151.103		X	
07-May-09	1300	1430	530	16000	?	151.162		X	
16-Apr-10	1330	1455	480	14500	?	151.443			X
16-Apr-10	1270	1400	500	14500	?	151.173			X
16-Apr-10	1440	1630	590	23000	?	151.302			X
16-Apr-10	1370	1500	540	20000	?	151.464			X
16-Apr-10	1270	1380	480	14500	?	151.284			X
16-Apr-10	1280	1400	520	15000	?	151.563			X
16-Apr-10	1330	1440	540	15000	?	151.403			X
16-Apr-10	1490	1670	480	17000	?	151.264			X
16-Apr-10	1450	1620	660	25000	?	151.223			X
16-Apr-10	1240	1350	480	8000	?	151.383			X
20-Apr-10	1480	1640	590	24000	?	151.704			X
20-Apr-10	1335	1455	580	18500	?	151.361			X
20-Apr-10	1390	1510	570	19500	?	151.524			X
20-Apr-10	1300	1400	560	18500	?	151.644			X
20-Apr-10	1395	1555	530	18000	?	151.482			X
20-Apr-10	1320	1460	470	14500	?	151.324			X
20-Apr-10	1200	1310	480	12000	?	151.505			X
20-Apr-10	1420	1580	550	19500	?	151.663			X

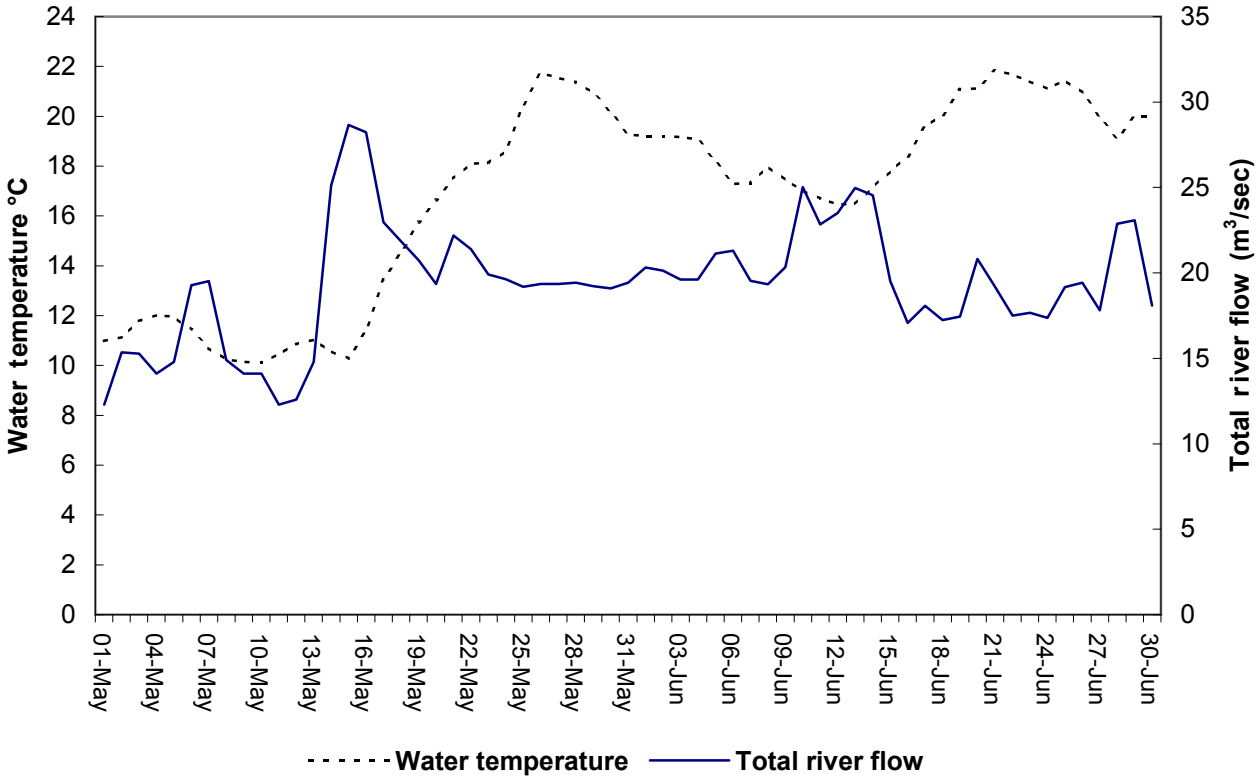


Figure 4. Water temperature and total river flow from May 1 to June 30, 2010.

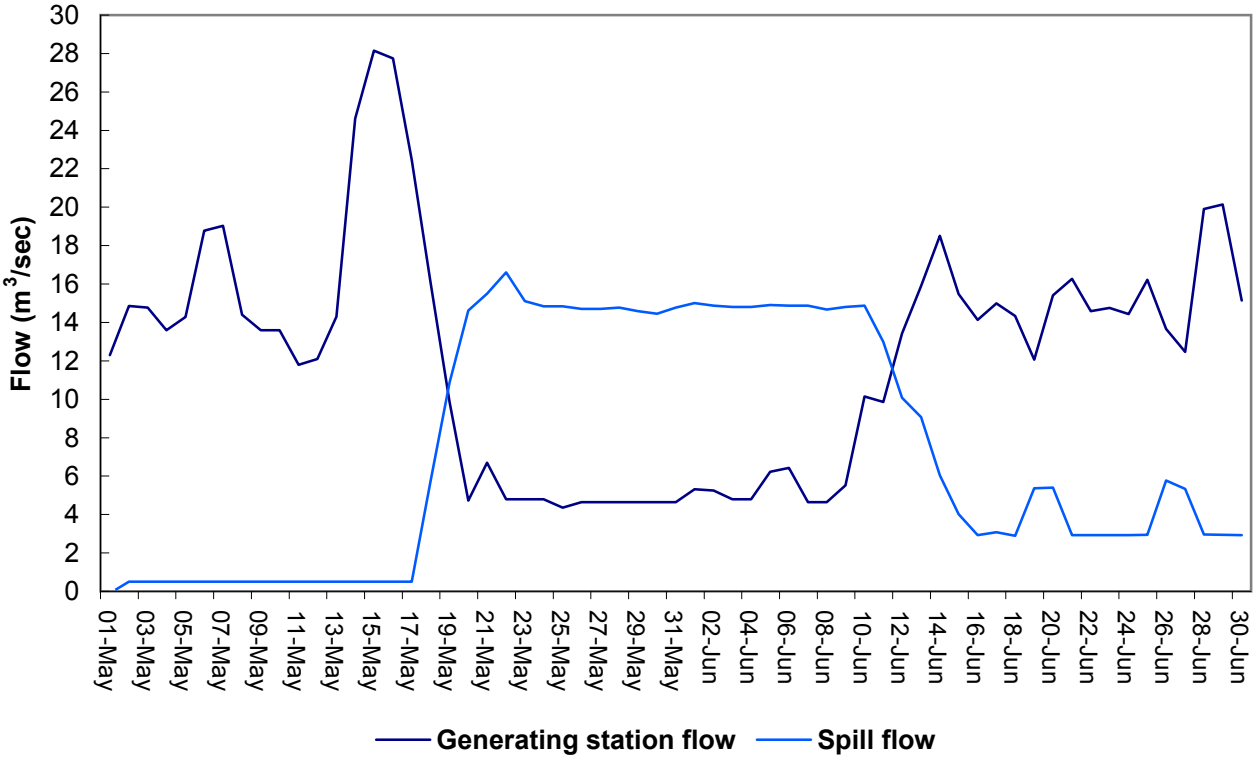


Figure 5. Mean daily spill flow over Kakabeka Falls and generating station flow from May 1 to June 30, 2010.

Kakabeka data logger

Radio tagged-sturgeon arrived at Kakabeka between May 16 (11.3°C) and May 19 (15.7°C) during total river flows that ranged from 20.7 to 28.2 $m^3 \cdot s^{-1}$. All were initially located in the tailrace of the generating station (Figure 6). Seven fish remained downstream of the generating station while three others (Frequency 151.682, 151.344, and 151.424) migrated upstream of the generating station on May 20 and 22 during total river flows from 19.0 to 21.4 $m^3 \cdot s^{-1}$ (Figure 6). Spill flows during migration were 14.6 to 16.6 $m^3 \cdot s^{-1}$ (Appendix 2). The upstream migration of these fish into the study area and subsequent movement downstream is described below:

Frequency 151.682 (27.5 kg, 171.5 cm TL)

This fish arrived at the generating station tailrace on May 18 (14.5°C) when the spill over Kakabeka Falls was 9.5 $m^3 \cdot s^{-1}$ and flow out of the generating station was 15.6 $m^3 \cdot s^{-1}$. It remained in the tailrace of the generating station for two days and migrated into the study area for a about two hours on May 19 (15.7°C) at approximately 12:00 hours during spill flows of 11.4 $m^3 \cdot s^{-1}$. It moved back downstream to the tailrace and remained there until May 20 when it moved into the study area on two separate occasions (06:00 and 15:00) during spill flows of 14.6 $m^3 \cdot s^{-1}$ and was recorded in the plunge pool on May 20 (18:00). It left the study area on May 22 (18.1°C) during spill flows of 16.6 $m^3 \cdot s^{-1}$ (Figure 6, Appendix 2).

Frequency 151.344 (15.5 kg, 145.5 cm TL)

This fish arrived at the generating station tailrace on May 18, 09:00 (14.1°C) when the spill over Kakabeka Falls was 0.5 $m^3 \cdot s^{-1}$ and flow out of the generating station was 15.9 $m^3 \cdot s^{-1}$. It remained in the generating station tailrace for two days during two staged spill increases from dam leakage (0.5 $m^3 \cdot s^{-1}$) to 9.5 and then 11.4 $m^3 \cdot s^{-1}$ before migrating downstream (May 19, 14:00) to logger 4 during total river flow of 19.3 $m^3 \cdot s^{-1}$. It returned to Kakabeka on May 22 during total river flows of 19.6 $m^3 \cdot s^{-1}$ and moved to the base of the falls during spill flows of 16.6 $m^3 \cdot s^{-1}$ and generating station flow of 4.8 $m^3 \cdot s^{-1}$. It remained in the plunge pool for three days (18.5°C) and migrated downstream on May 25 (06:00) during spill flows of 14.8 $m^3 \cdot s^{-1}$. (Figure 6, Appendix 2).

Frequency 151.424 (12 kg, 1330 TL)

This fish arrived at the generating station tailrace on May 19, 13:00 (16.1°C) when the spill over Kakabeka Falls was 11.4 $m^3 \cdot s^{-1}$ and flow out of the generating station was 9.7 $m^3 \cdot s^{-1}$. It remained downstream of the generating station from May 19 to May 22 when spill flows ranging from 11.4 $m^3 \cdot s^{-1}$ to 16.6 $m^3 \cdot s^{-1}$ were being maintained. It moved through the study area to the base of the falls during spill flows of 16.6 $m^3 \cdot s^{-1}$ and generating station flow of 4.8 $m^3 \cdot s^{-1}$. It remained in the plunge pool for two days (18.5°C) and migrated downstream on May 23 (22:00) during spill flows of 14.8 $m^3 \cdot s^{-1}$ (Figure 6, Appendix 2).

Spawning events

Telemetry

Based on similar departure dates of two fish from the generating station tailwater on May 19th, it is likely that a spawning event occurred downstream of the generating station (on the 19th) when the mean daily water temperature was 15.8°C and the mean daily generating station discharge was 10 $m^3 \cdot s^{-1}$ (Figure 6).

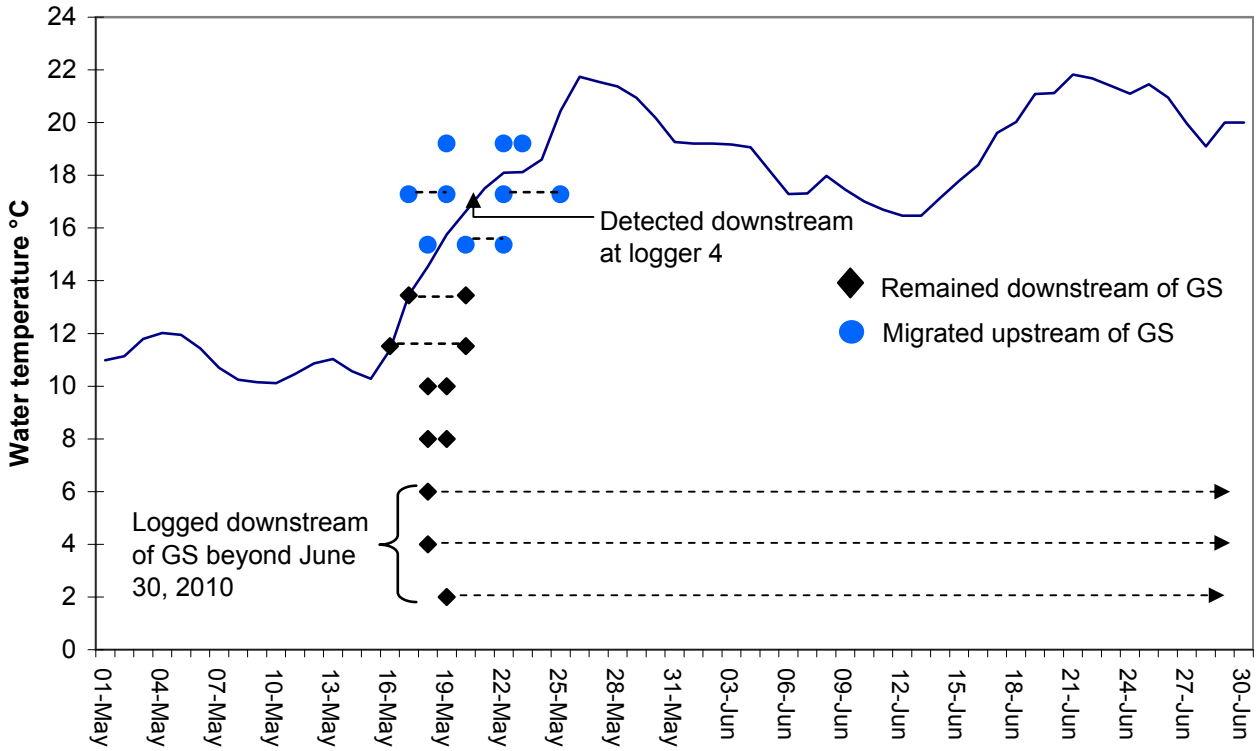
Based on the movement of three fish upstream of the generating station from May 20 to 22 and the earliest departure date (May 22), a second spawning event likely occurred on May 22 (upstream of the generating station) when the mean daily water temperature was 18.1°C and spill flows were maintained at 16.6 $m^3 \cdot s^{-1}$ (Figure 6).

Drift netting

Two separate larval drift events were documented. The first occurred downstream of the generating station and was sampled by OPG. The second occurred upstream of the generating station and was sampled by MNR (Figure 7, 8, and 9).

MNR sampling upstream of generating station standard site (east bank)

During 12 overnight sampling events (May 31 to June 11 with 12 nets) at the standard site upstream of the generating station, 98 larval lake sturgeon were captured (Figure 7 and 8). The catch per unit effort was 0.03 larvae/hour (3,121 sample hours).



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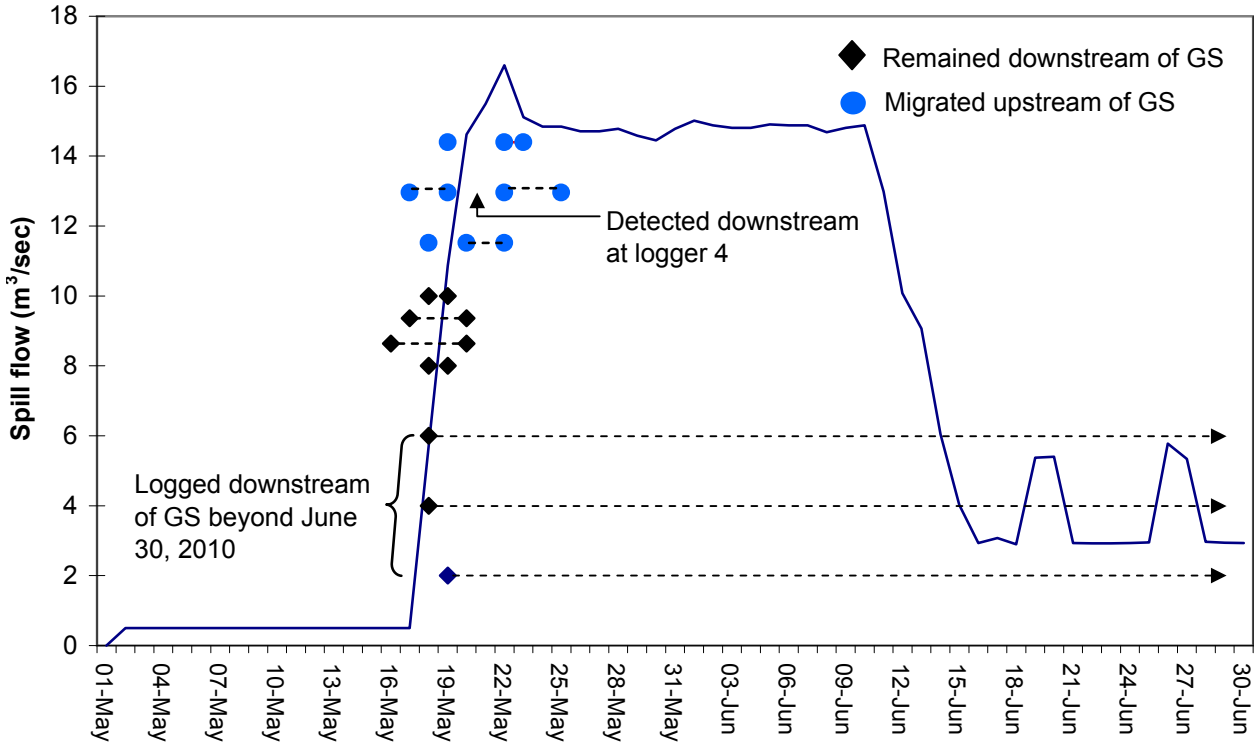

b)

Figure 6. The migration of radio-tagged lake sturgeon to the Kakabeka logger in relation to a) water temperature and b) mean daily spill flows from May 1 to June 30, 2010.

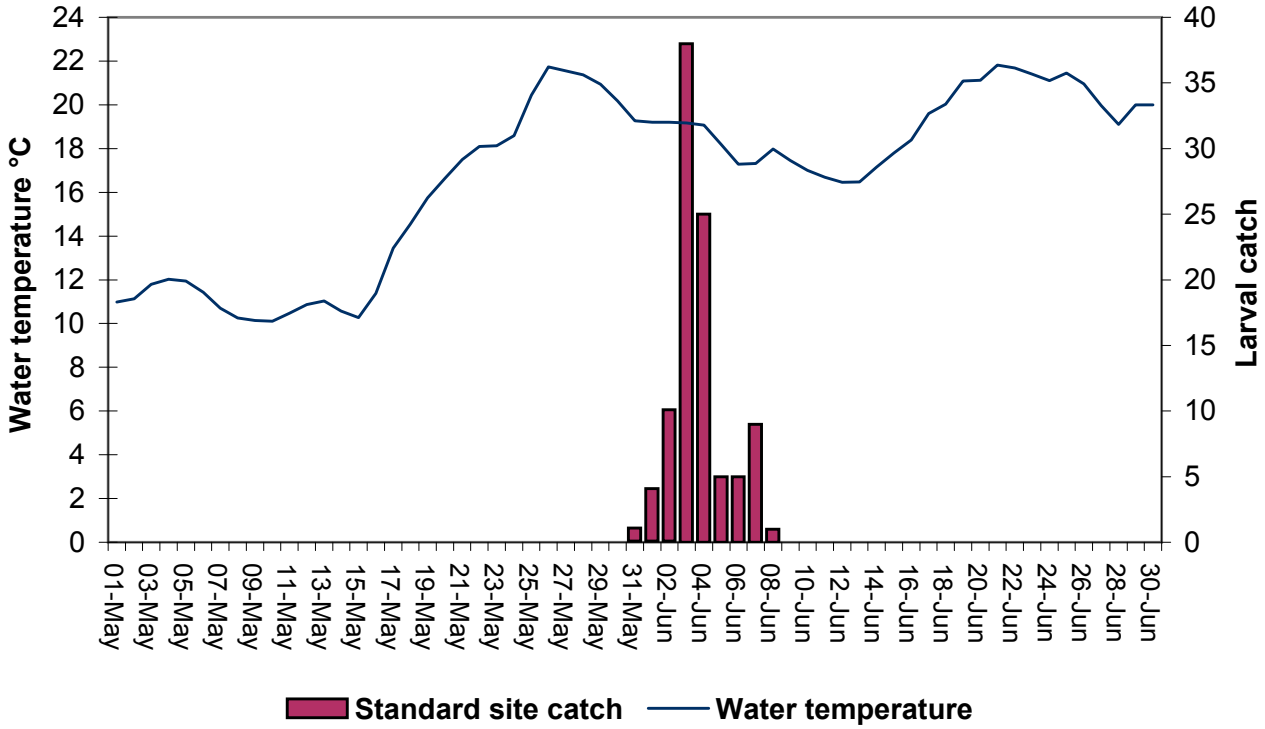

Figure 7. Mean daily water temperature and larval catch at the standard site upstream of the generating station.

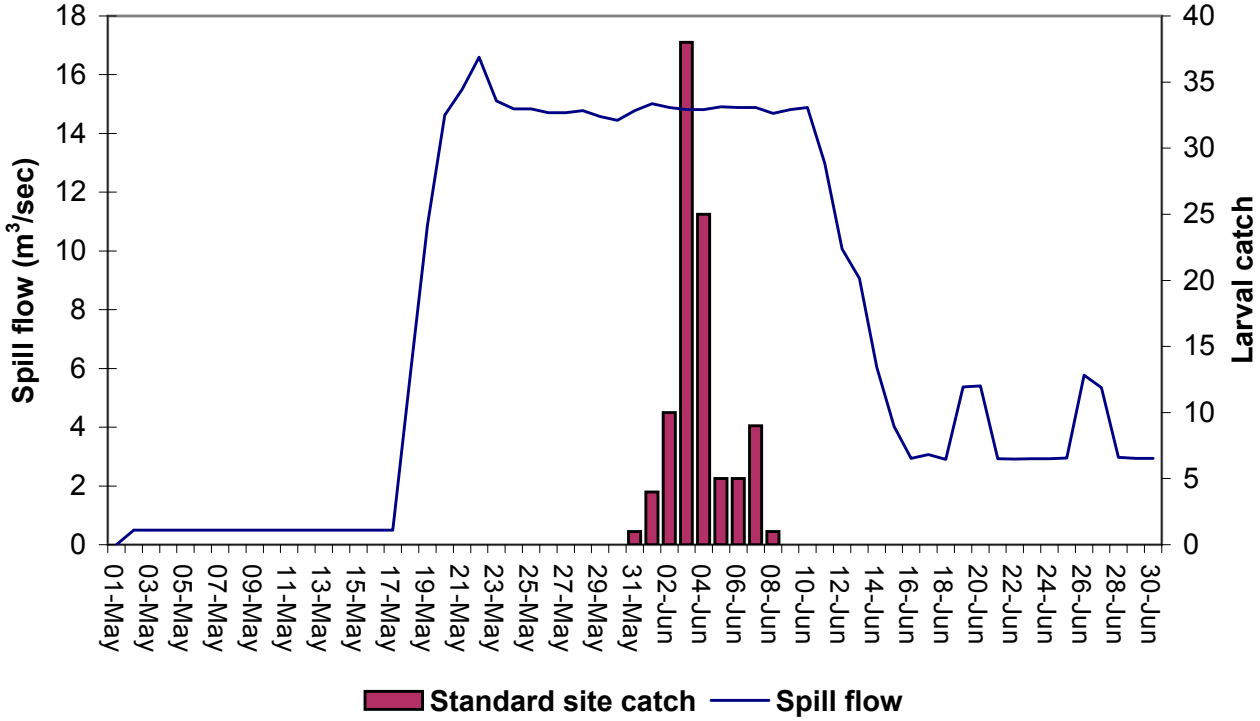

Figure 8. Mean daily spill flow in and larval catch at the standard site upstream of the generating station.

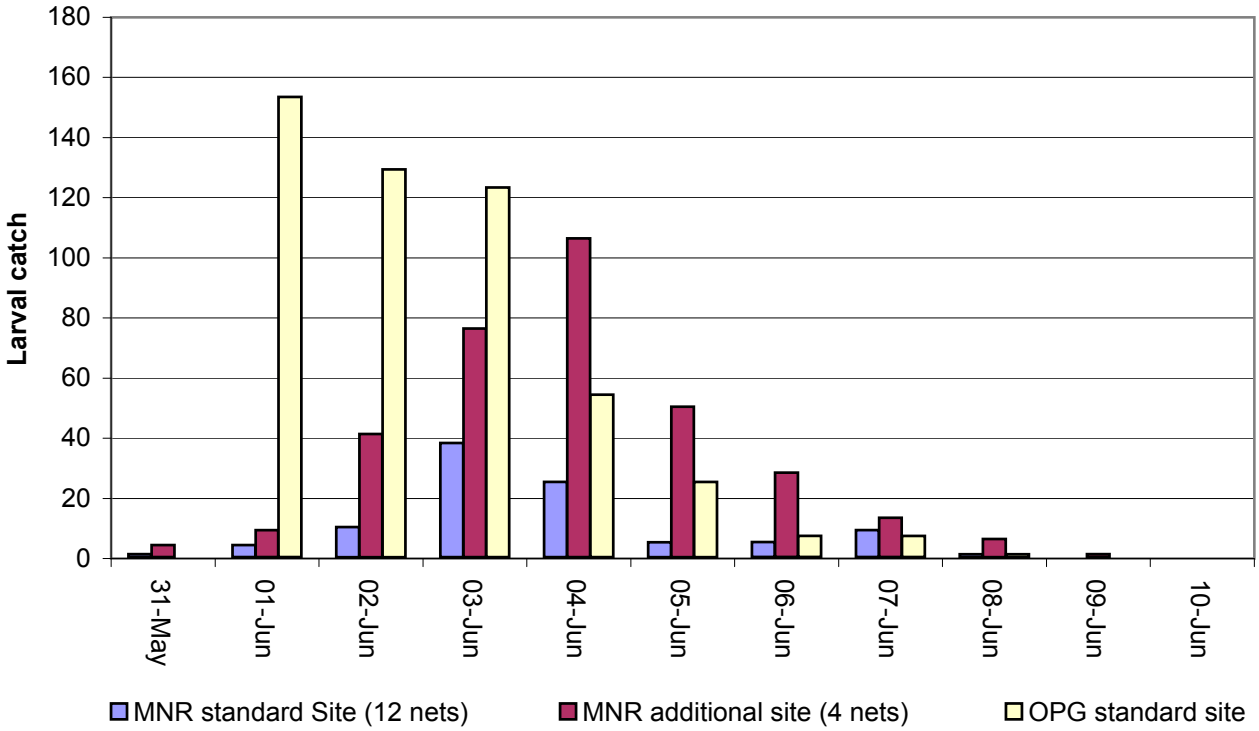

Figure 9. Daily caches of larval sturgeon upstream and downstream of the Kakabeka Falls generating station, 2010.

The first larval sturgeon (19 mm) was captured on May 31, approximately nine days after the suspected spawning date (May 22). The duration of the downstream movement of larvae from the spawning site was approximately nine days (May 31 to June 8). Larval sturgeon ranging in length from 15 to 25 mm were captured. During the period of downstream drift the mean hourly spill flows ranged from 14.7 to 15.0 $m^3 \cdot s^{-1}$, water velocity at the opening of each net ranged from 0.08 to 0.65 $m \cdot s^{-1}$ and water depth at the drift net site ranged from 24 to 61 cm. The mean daily water temperature from the spawning date (May 22) to the date when the first larva was collected (May 31) was 20°C. The mean daily water temperature during the period of downstream drift was 19.7°C (Figure 7 and 8).

Additional site (west bank)

During 12 overnight sampling events (May 31 to June 11 with four nets) at the west bank site where flows and depth are greatest, 334 larval lake sturgeon were captured (Figure 9). The catch per unit effort was 0.34 larvae per hour (979 sample hours).

The first larval sturgeon (15 mm) was captured on May 31, approximately nine days after the suspected spawning date (May 22). The duration of the downstream movement of larvae from the spawning site was approximately 10 days (May 31 to June 10). Larval sturgeon ranging in length from 15 to 25 mm were captured. During the period of downstream drift the mean hourly spill flows ranged from 14.7 to 15.0 $m^3 \cdot s^{-1}$, water velocity at the opening of each net ranged from 0.32 to 0.66 $m \cdot s^{-1}$, and water depth at the drift net site ranged from 43 to 60 cm. The mean daily water temperature from the spawning date (May 22) to the date when the first larva was collected (May 31) was 20°C. The mean daily water temperature during the period of downstream drift was 18.3°C. The incidental catch of other species was 444 larval fish, of which 276 were identified to the species level and 168 specimens were grouped by family (Table 2).

OPG sampling downstream of generating station

During 10 overnight sampling events (June 1 to 10 with six nets), 520 larval lake sturgeons were captured (Figure 9). The first larval sturgeon (18 mm) was captured on June 1, approximately 13 days after the suspected spawning date (May 19). Larval sturgeon ranged in total length from 13 to 25 mm and were captured during GS discharge flows that ranged from 4.7 to 8.8 $m^3 \cdot s^{-1}$ (Foster and Harris 2007).

Table 2. The drift netting incidental catch.

Common name	Scientific name	Catch
Brook stickleback	*Culaea inconstans*	1
Brook trout	*Salvelinus fontinalis*	2
Burbot	*Lota lota*	5
Central mudminnow	*Umbra limi*	6
Emerald shiner	*Notropis atherinoides*	2
Finescale dace	*Phoxinus neogaeus*	2
Johnny darter	*Etheostoma olmstedi*	4
Lake whitefish	*Coregonus clupeaformis*	19
Longnose dace	*Rhinichthys cataractae*	43
Northern pike	*Esox lucius*	13
Pink salmon	*Oncorhynchus gorbuscha*	49
Rainbow smelt	*Osmerus mordax*	43
Rock bass	*Ambloplites rupestris*	1
Ruffe	*Gymnocephalus cernuus*	1
Sculpin family	*Cottidae*	2
Sea lamprey	*Petromyzon marinus*	3
Smallmouth bass	*Mocropterus dolomieu*	28
Sucker family	*Catostomidae*	166
Trout perch	*Percopsis omiscomaycus*	11
Walleye	*Sander vitreus*	43

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 (2004 to 2009), we know that it takes approximately 150 CTUs to accumulate before larvae will start to drift after the first spawning event (Table 3). If we assume (from telemetry) that spawning occurred on May 19, 2010 (downstream of the GS), 188 CTUs had accumulated when the first larva was captured (June 1). This suggests that drift started earlier than when larvae were first captured. Unlike typical MNR drift catches, which show a bell-shaped distribution with a gradual initial increase, peak numbers of sturgeon were caught on the first day of netting below the generating station and gradually declined afterwards (Foster and Harris 2010). This indicates that the initial period of the drift was not sampled. Drift may have started to occur on May 29 when 147 CTUs had accumulated from the date of spawning (May 19).

We also know that it takes approximately 142 CTUs to accumulate from the date of spawning before larvae will start to drift after the second spawning event (Table 3). If we assume, from the telemetry and temperature data, that spawning occurred upstream of the generating station on May 22, 142 CTUs had accumulated by the time the first larvae was captured. This is consistent with other study years.

Summary

Telemetry

1. Upstream migration of radio-tagged sturgeon from the lower river began on May 15 during a river flow increase (from 14.9 to 28.7 $m^3 \cdot s^{-1}$). It took from one to seven days for radio-tagged sturgeon to migrate 34 km from the lower river to Kakabeka.
2. Three radio-tagged sturgeon migrated into the study area upstream of the generating station. One fish migrated upstream during mean daily spill flows of 14.6 $m^3 \cdot s^{-1}$, and two others migrated during spill flows of 16.6 $m^3 \cdot s^{-1}$.
3. Migration from the study area upstream of the generating station occurred from May 22 to 25. One fish migrated downstream during mean daily spill flows of 16.6 $m \cdot s^{-1}$, and two others migrated downstream during spill flows of 14.8 $m^3 \cdot s^{-1}$.

4. Seven radio-tagged sturgeon remained downstream of the generating station from May 16 to 20 when generating station power flows ranged 3.2–30 $m^3 \cdot s^{-1}$.

Drift netting

1. Sturgeon spawned downstream and upstream of the generating station.
2. The first period of drift occurred downstream of the generating station. At OPGs standard site, 520 larvae were captured from June 1 to 9.
3. The second period of drift occurred upstream of the generating station. At MNRs standard site 98 larvae were captured from May 31 to June 9.
4. An additional 334 larvae were captured upstream of the generating station, at the west bank site where water velocity and depths were the greatest.
5. Larval drift, upstream of the generating station was documented during mean daily spill flows that ranged from 14.7 to 15.0 $m^3 \cdot s^{-1}$.

Cumulative thermal units

1. Based on cumulative thermal units documented in past study years, the initial period of larval drift downstream of the generating station was likely not sampled.
2. If we assume from the telemetry and temperature data, that there was a spawning event upstream of the generating station on May 22, 142 CTUs had accumulated when the first larva was captured (May 31), which is consistent with previous study years.

Table 3. Cumulative daily thermal units (CTUs) for the time period from first spawning event and second spawning event to the start of larval drift in the Kaministiquia River.

Year	Spawning date (approx.)	Number of days from spawning to start of drift event (date)		CTU	Number 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)	289.0
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-05)	291.0
2006	21-May-06	12	(1-Jun-06)	130.5	27	(16-Jun-06)	332.0
2007	24-May-07	15	(7-Jun-07)	162.7	23	(15-Jun07)	263.0
2007	31-May-07	15	(14-Jun-07)	169.7	19	(18-Jun-07)	250.0
2008	7-Jun-08	20	(26-Jun-08)	159.3	37	(13-Jul-08)	351.9
2009	21-May-09	25	(15-Jun-09)	152.2	44	(3-Jul-09)	352.2
2009	5-Jun-09	20	(24-Jun-09)	176.9	29	(3-Jul-09)	279.8
2010	19-May-10	10	(29-May-10)	146.9	21	(8-June-10)	275.8
2010	22-May-10	10	(31-May-10)	142.3	21	(9-Jun-10)	277.0
Average CTU for first spawning event				**150.3**			**305.8**
Average CTU for second spawning event				**173.2**			**277.4**

Glossary

dam leakage
Refers to incidental flow that passes through and around Kakabeka Falls dam stop logs, as well as the flow that is provided by a spacer placed between certain stop logs. This flow is expected to provide a minimum flow of 0.5 $m^3 \cdot s^{-1}$ at all times.

drift event
The period of time (days) during which larval sturgeon are captured as they drift downstream from the spawning site.

GS
generating station

PIT tag
passive integrated responder: an internal tag inserted under the third dorsal scute (counting back from the head) of the sturgeon

plunge pool
Refers to the large pool at the base of Kakabeka Falls where sturgeon congregate during spawning.

power flows
Refers to flow that originates from the generating station.

reference tag
Refers to the radio tag that is situated within the study area to determine sturgeon location and verify logger function.

scenic flow
Water flowing 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
Flow over Kakabeka Falls that is in excess of scenic flows or dam leakage.

study area
Refers to the portion of the Kaministiquia River from Kakabeka Falls downstream to the generating station.

tailwater
Refers to waters located immediately downstream from the generating station.

uncontrolled flow
When flow over Kakabeka Falls is in excess of the study flows.

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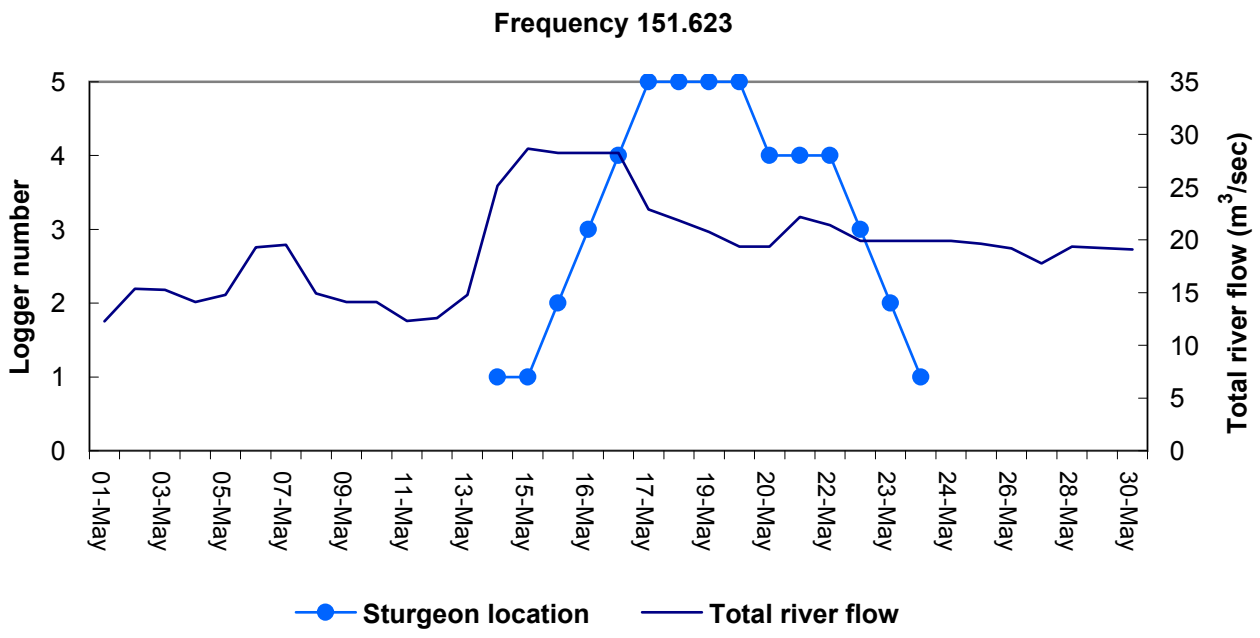
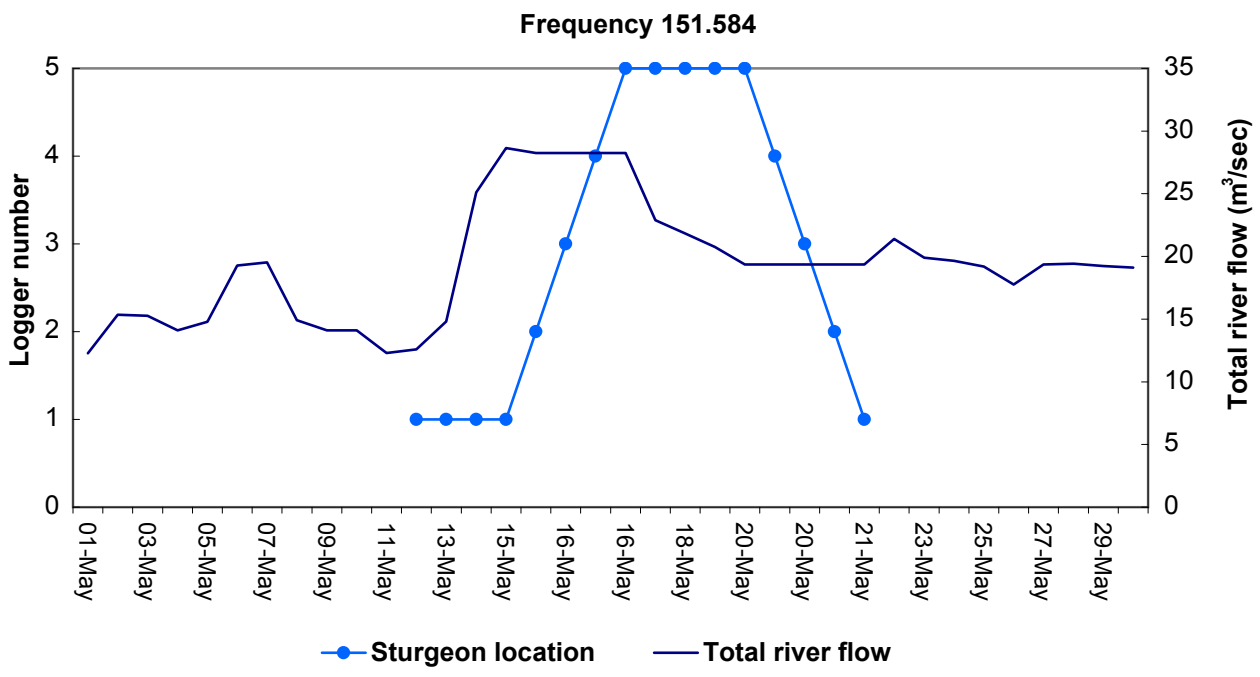
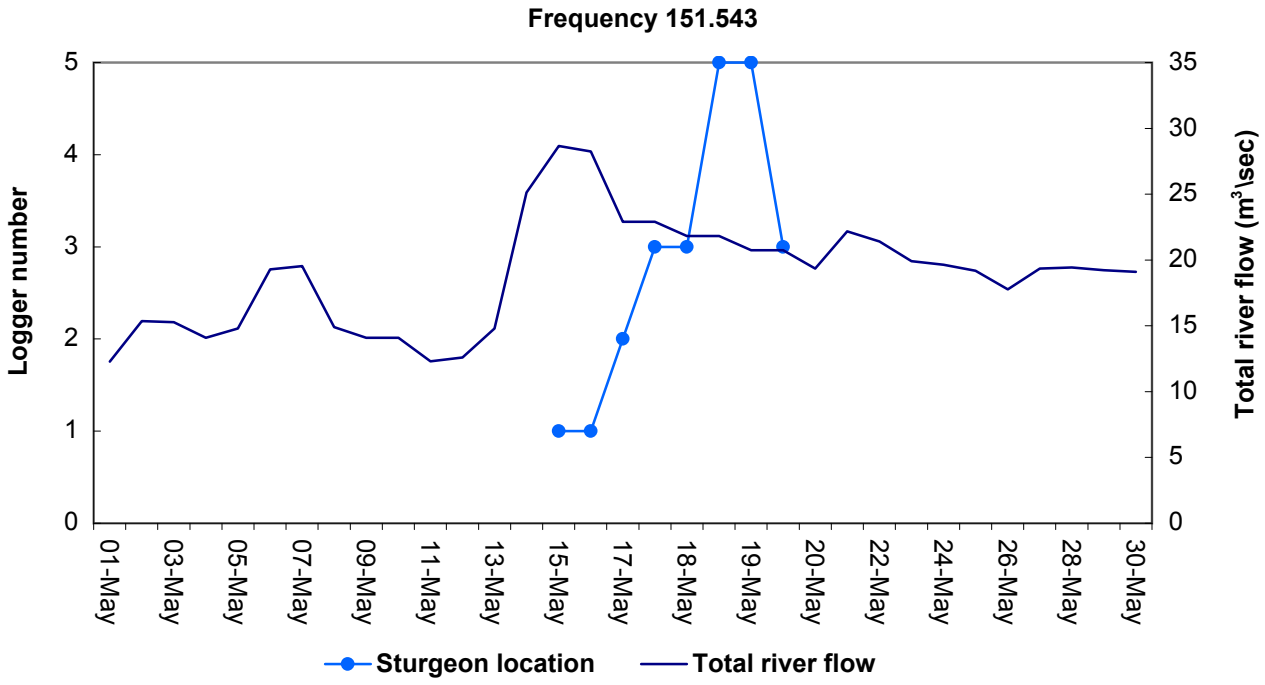
Appendices

Appendix 1

Upstream spawning migration of radio-tagged lake sturgeon detected by five land-based data loggers on the Kaministiquia River.



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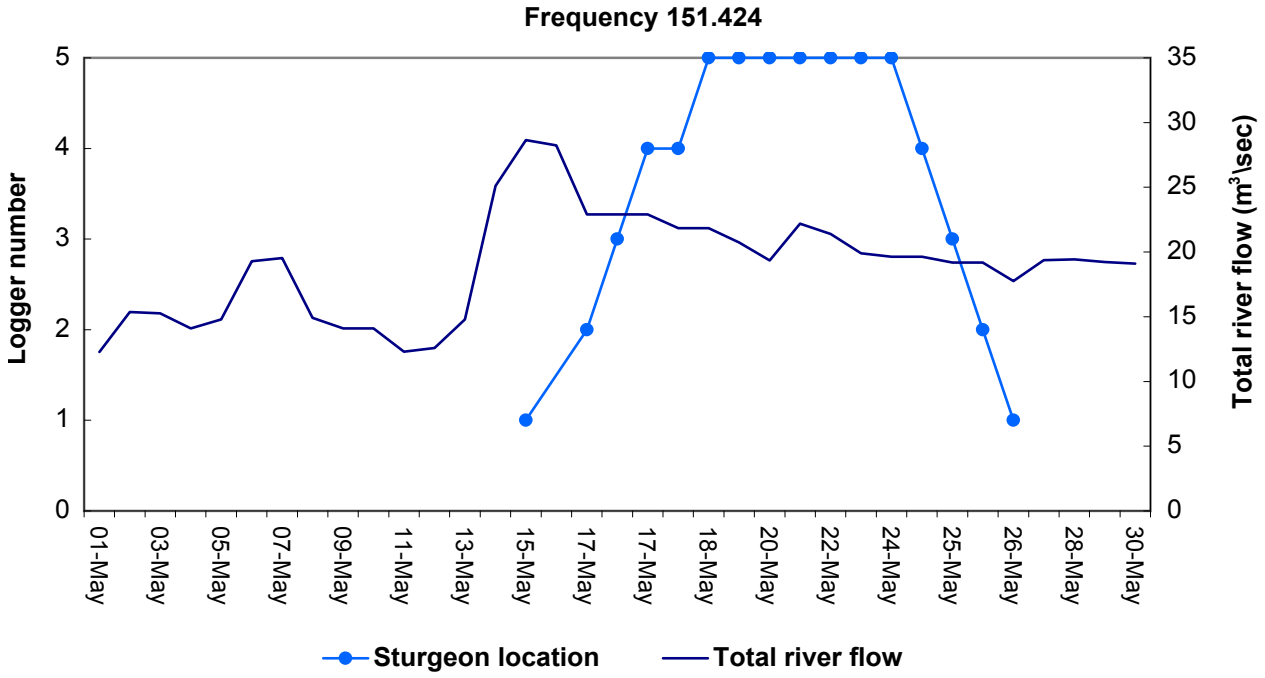
1
2
3
4
5
0
5
10
15
20
25
30
35
01-May
03-May
05-May
07-May
09-May
11-May
13-May
15-May
17-May
18-May
19-May
20-May
22-May
24-May
26-May
28-May
30-May
Sturgeon location
Total river flow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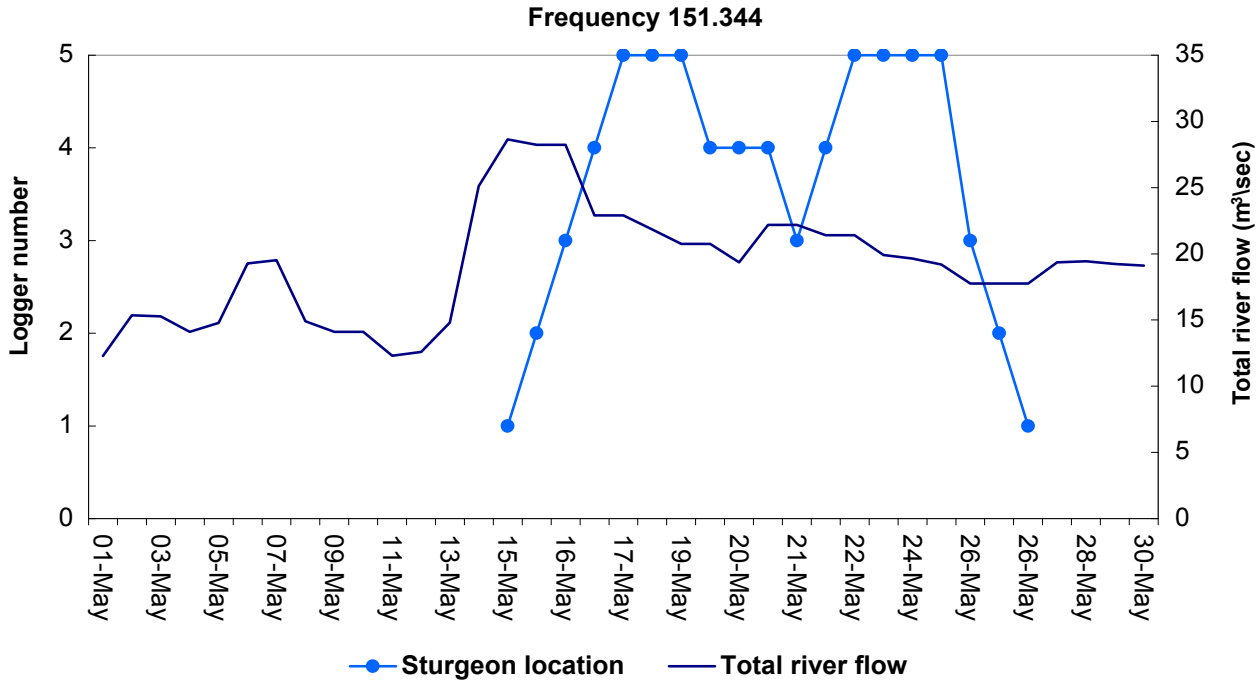
2
3
4
5
0
5
10
15
20
25
30
35
01-May
03-May
05-May
07-May
09-May
11-May
13-May
15-May
17-May
17-May
18-May
20-May
22-May
24-May
25-May
26-May
28-May
30-May
Sturgeon location
Total river flow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Logger number
Total river flow (m³\sec)
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2
3
4
5
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5
10
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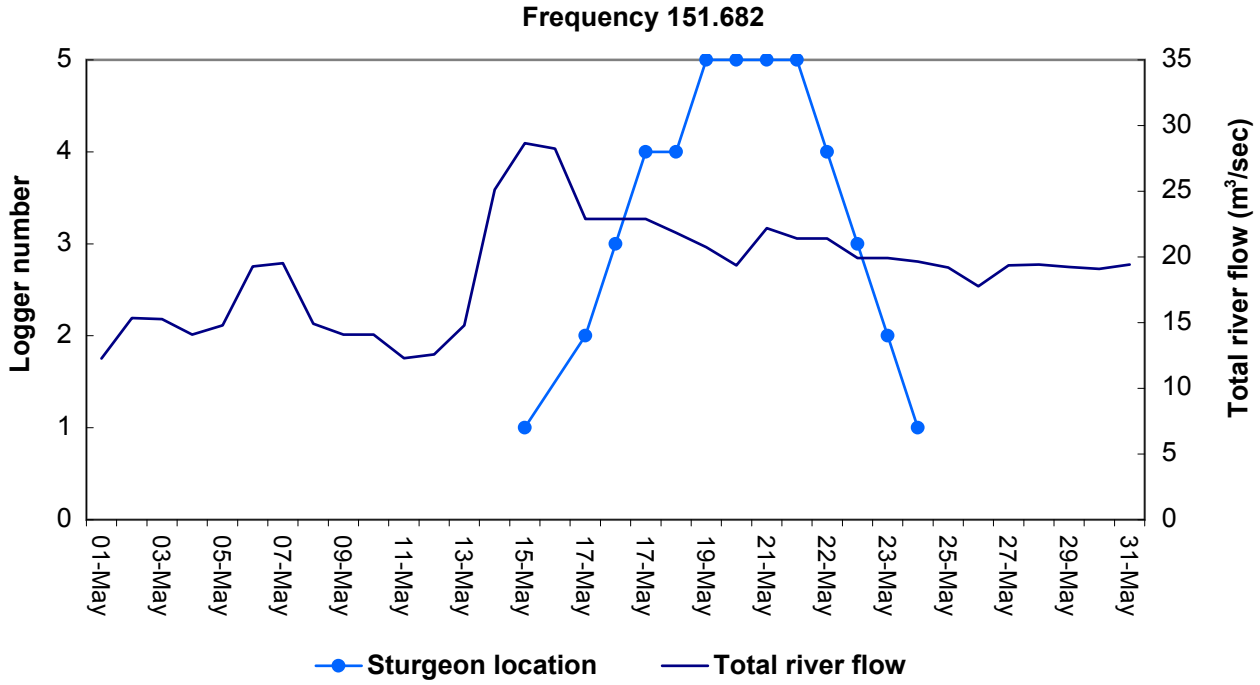
20
25
30
35
01-May
03-May
05-May
07-May
09-May
11-May
13-May
15-May
16-May
17-May
19-May
20-May
21-May
22-May
24-May
26-May
26-May
28-May
30-May
Sturgeon location
Total river flow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3
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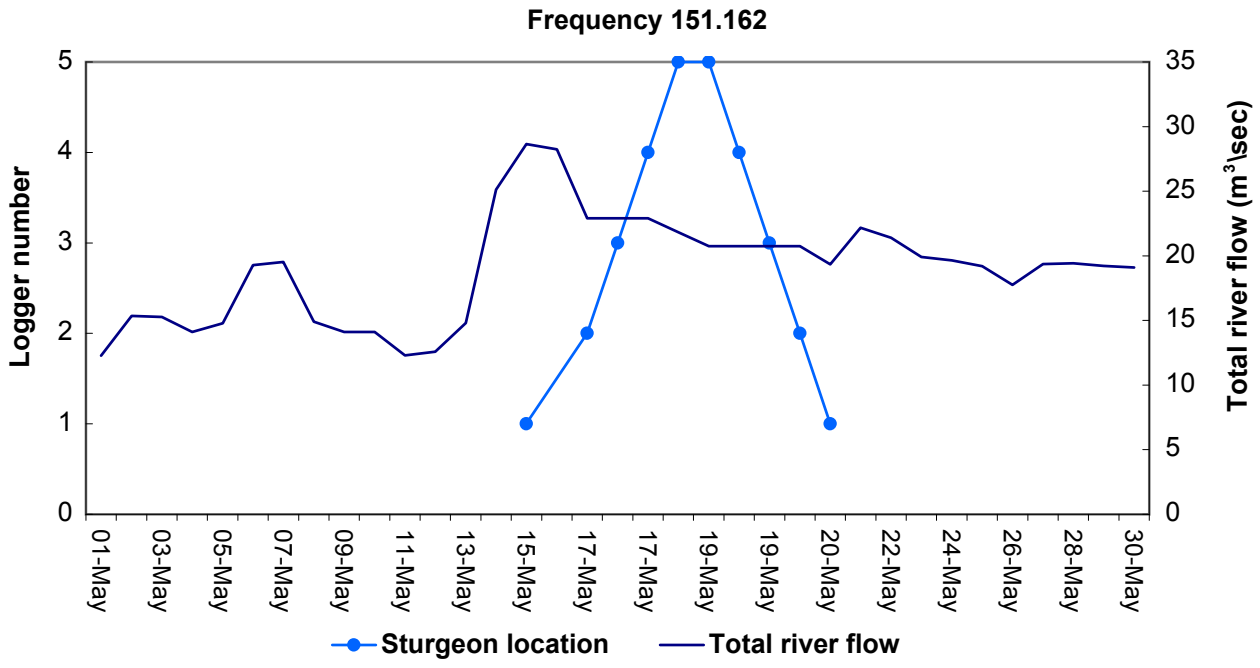
0
5
10
15
20
25
30
35
01-May
03-May
05-May
07-May
09-May
11-May
13-May
15-May
17-May
17-May
19-May
21-May
22-May
23-May
25-May
27-May
29-May
31-May
Sturgeon location
Total river flow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3
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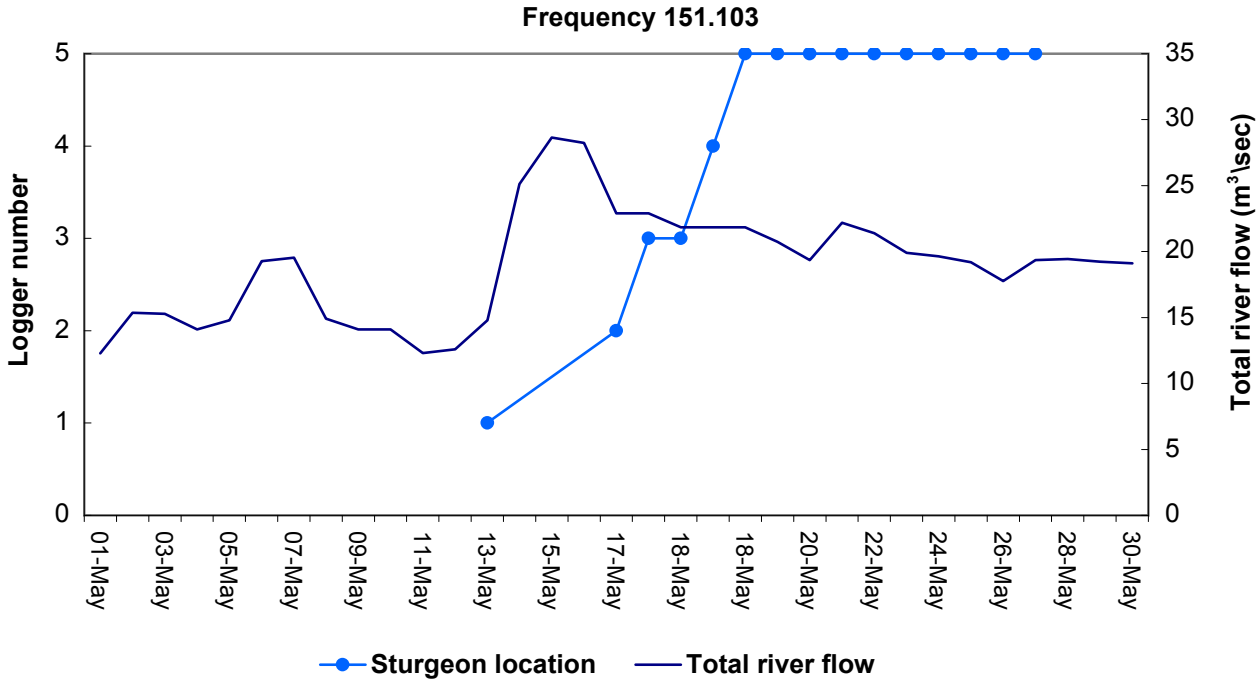
5
0
5
10
15
20
25
30
35
01-May
03-May
05-May
07-May
09-May
11-May
13-May
15-May
17-May
17-May
19-May
19-May
20-May
22-May
24-May
26-May
28-May
30-May
Sturgeon location
Total river flow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5
10
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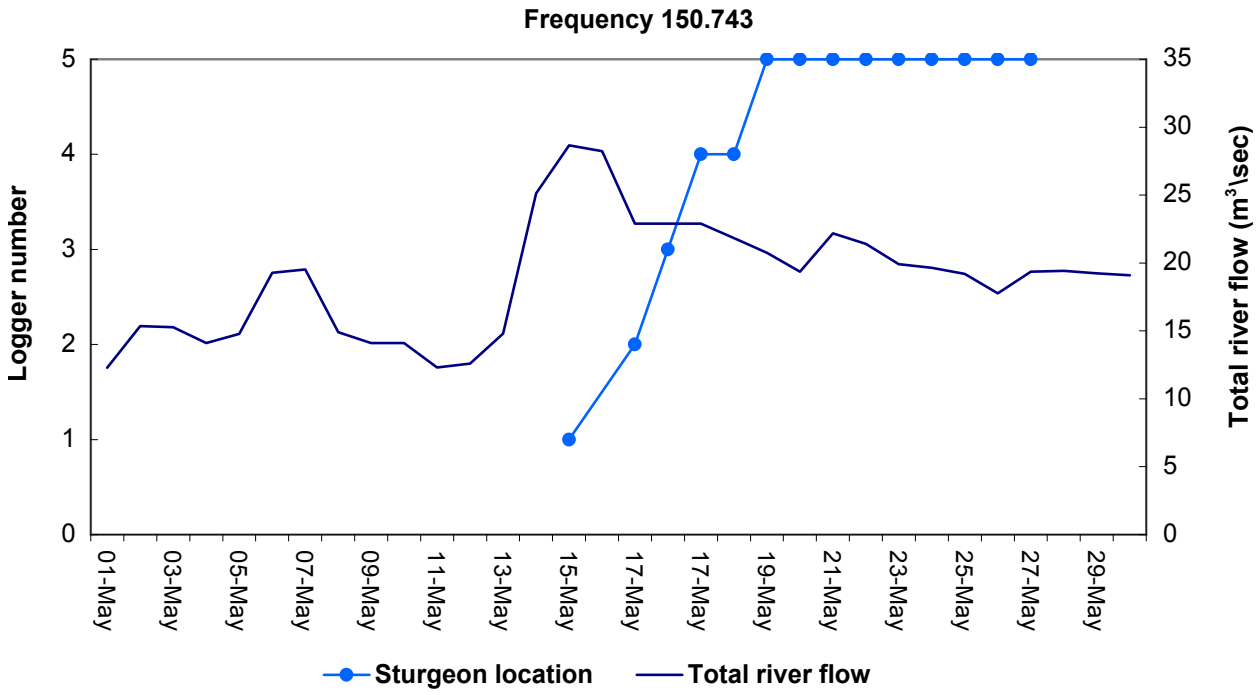
01-May
03-May
05-May
07-May
09-May
11-May
13-May
15-May
17-May
18-May
18-May
20-May
22-May
24-May
26-May
28-May
30-May
Sturgeon location
Total river flow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5
10
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20
25
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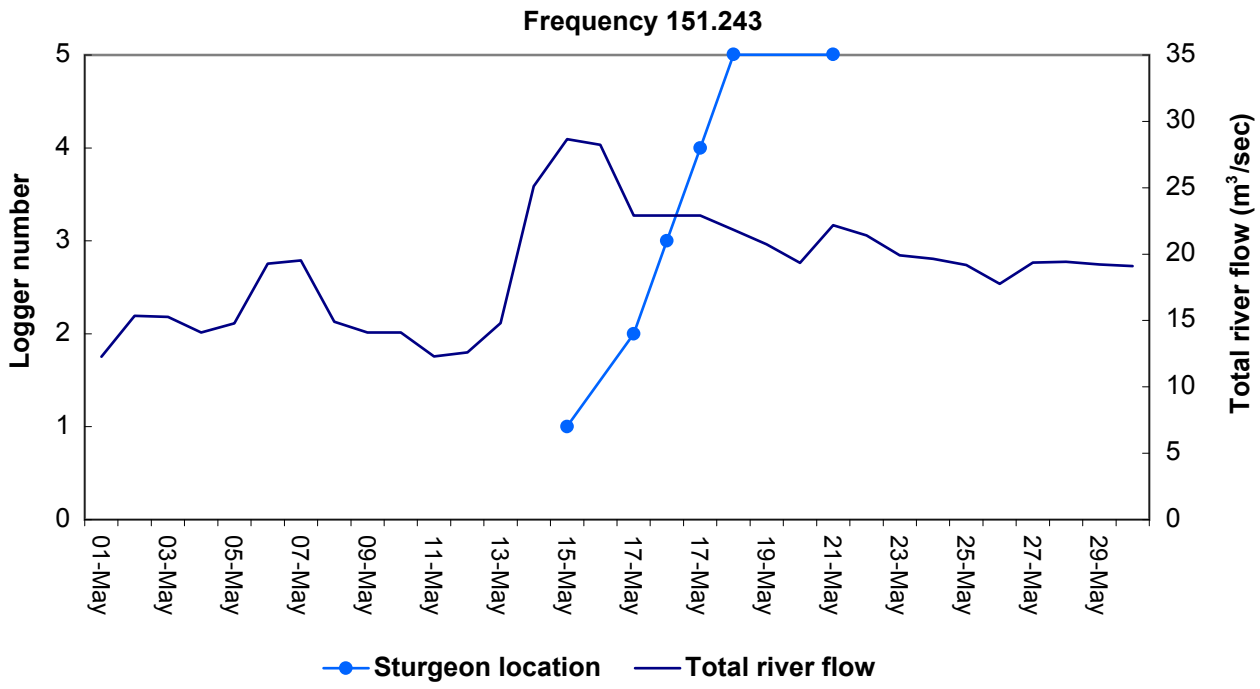
03-May
05-May
07-May
09-May
11-May
13-May
15-May
17-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
Sturgeon location
Total river flow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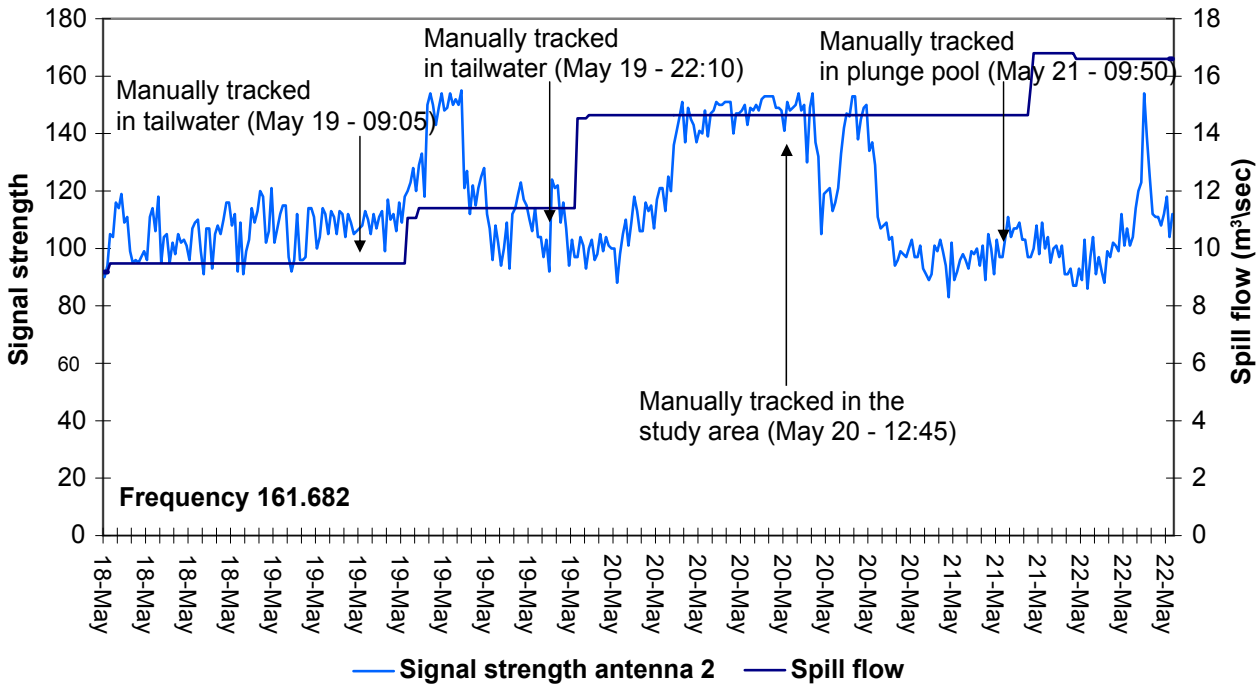
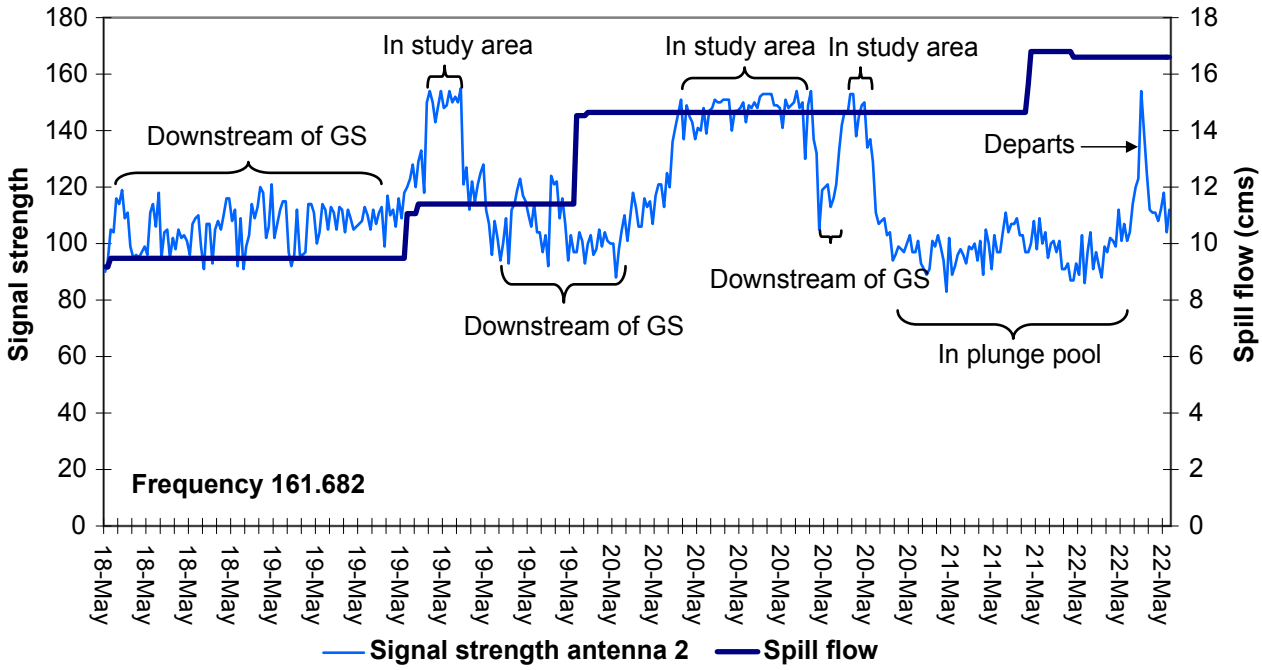
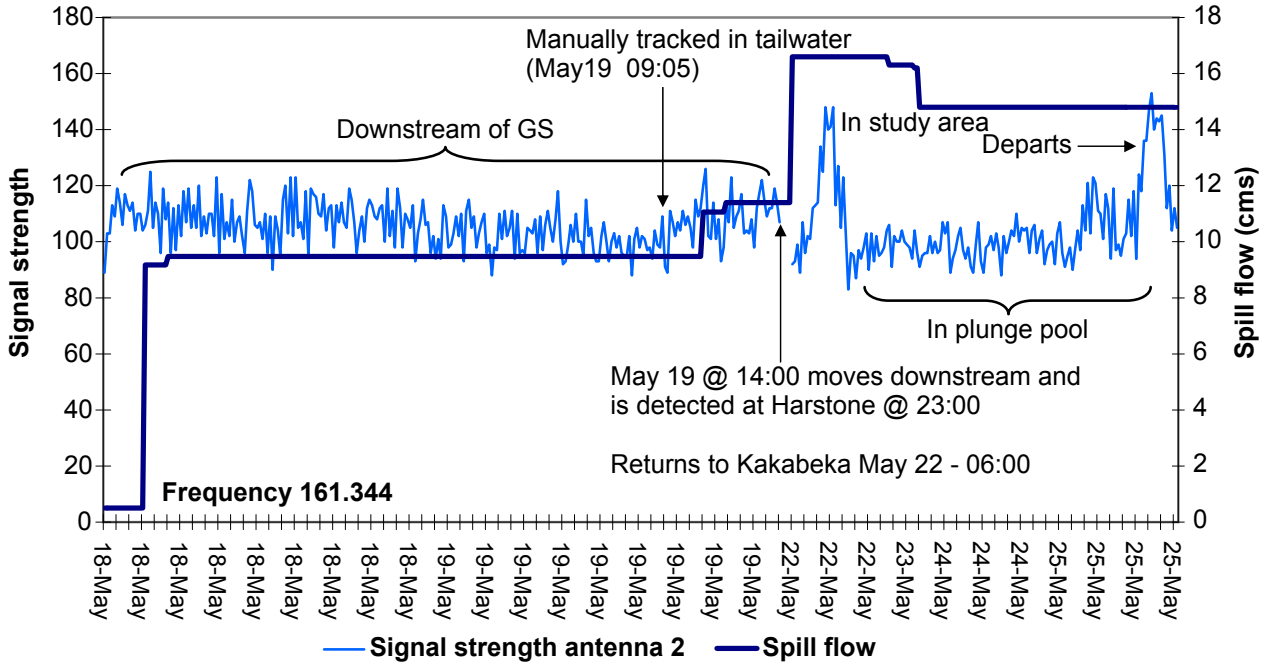
07-May
09-May
11-May
13-May
15-May
17-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
Sturgeon location
Total river flow

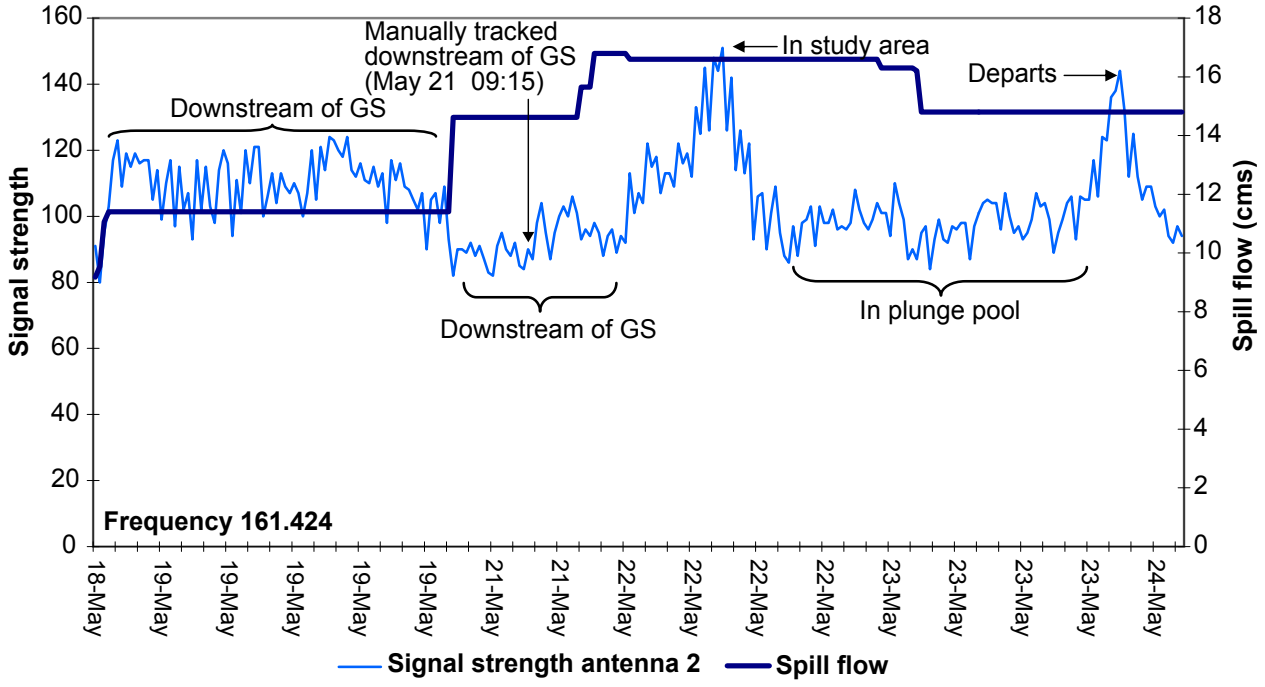
Appendix 2

Detailed movement of three radio-tagged sturgeon (151.682, 151.344, and 151.424) upstream of the generating station derived from signal strength of antenna two (blue line) and manual tracking within the study area.






Manually tracked in tailwater
(May19 09:05)
Downstream of GS
In study area
Departs
In plunge pool
May 19 @ 14:00 moves downstream and
is detected at Harstone @ 23:00
Returns to Kakabeka May 22 - 06:00
Frequency 161.344
Signal strength
Spill flow (cms)
Signal strength antenna 2
Spill flow


Manually tracked
downstream of GS
(May 21 09:15)
In study area
Departs
Downstream of GS
Downstream of GS
In plunge pool
Frequency 161.424
Signal strength
Spill flow (cms)
Signal strength antenna 2
Spill flow

(0 k P.R., 12 05 05)
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