Movement and Seasonal Distribution of Lake Sturgeon in the Namakan River, Ontario

PRELIMINARY REPORT
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ABSTRACT

Acoustic telemetry was used to assess movement and seasonal distribution of adult lake sturgeon in the Namakan River between Namakan Lake and Lac La Croix, Ontario from May 2007 to October 2008. Three hydroelectric generating facilities are proposed for development at Hay Rapids, High Falls, and Myrtle Falls by Ojibway Power and Energy Group (OPEG). Thirty-four sturgeon were sampled, surgically implanted with coded transmitters, and released. An array of 13 submersible, hydrophone receivers were deployed at points of rapid elevation change (falls and rapids) along the river extending from below Lady Rapids to above Snake Falls. Preliminary findings confirmed both upstream and downstream migration of sturgeon at most locations including Lady Rapids, Hay Rapids, Back Channel around Eva Island, Quetico Rapids, Twisted Rapids and Myrtle/Ivy Falls. Only downstream migration over High Falls was confirmed, along with movement into Quetico Provincial Park at two locations, including Quetico River and Bearpelt Creek below Wolseley Rapids. A total of 397 sturgeon (605 to 1,746 mm in length) were also tagged with 18 reported recaptures. Both tagged (n = 4) and telemetered (n = 20) lake sturgeon moved to and from the Namakan Reservoir (a shared international water with Minnesota). Potential spawning habitats exist at most natural rapids based on the presence or staging of fish during critical periods. Selection of preferred habitats was confirmed in the three lake environments and below major rapids or falls. Sturgeon avoided shallow rapids in winter with no detected movement after freeze-up, and over-winter habitats selected by individual fish were also documented. Mean speed of travel for movements exceeding 10 km was 3.4 km/day. Fish moved through shallow rapids and falls at water flows ranging from 33 to 464 m^3/sec and temperatures ranging from 11.0 to 24.9°C. Movements of lake sturgeon were evaluated in relation to season, water flow and temperature, for consideration in environmental assessments and water management planning. Preliminary results of this study provide insight into the importance of the entire river system to the continued sustainability of the population.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

Little is known about the status, distribution, and exploitation of lake sturgeon *(Acipenser fulvescens)* in the Namakan River, especially since access to the system was limited historically. Their life history, the historic and intense exploitation, and the effects of dams and pollution on reproduction have all contributed to low population levels of lake sturgeon elsewhere in Canada (Scott and Crossman, 1998). In the Great Lakes, the decline in lake sturgeon populations has been primarily attributed to three factors: physical impacts on spawning and nursery habitat; barriers to migration; and over-fishing (Brousseau, 1987; Auer, 1999). Anthropogenic modifications of rivers and estuarine habitats have also reduced the growth and recruitment of other sturgeon species throughout their native range (Ziegeweid et al., 2008).

A proposal to develop three hydro-electric generation sites at Hay Rapids, High Falls, and Myrtle Falls on the Namakan River lead to the preparation of an Environmental Field Study Plan (OPEG, 2007) and commencement of an Environmental Screening process in 2006. Lake sturgeon are known to occur throughout the Namakan River from Lac La Croix downstream to Namakan Reservoir, therefore an investigation of their movements and habitat use was identified as part of a larger fisheries data collection effort, including population assessment, genetics, and habitat evaluation.

Water levels in the Namakan River are currently unregulated. However, there are two control dams downstream in the Namakan Reservoir at Kettle Falls and Squirrel Falls that regulate water levels based on a "rule curve" established by the International Joint

Commission (IJC) through the International Rainy Lake Board of Control (IRLBC). Recent changes to water regulation in 2000 lead to the development of a long-term monitoring strategy to evaluate aquatic ecosystem impacts in which a lake sturgeon inventory and assessment program was included (IRLBC, 1999; Kallemeyn, 2000; Adams et al., 2006).

Exploitation of lake sturgeon is limited to First Nation subsistence fishing for food and low levels of angling by both residents and non-residents. Although there is little history of commercial fishing on the Namakan River, commercial fishing licenses previously existed downstream in Namakan Reservoir from 1916 to 2001; and upstream on Lac La Croix from 1959 to 1966. Annual commercial harvest records are only available since 1924, with no information on harvest prior to this period. Historical accounts indicate that a commercial pound-net fishery for lake sturgeon and whitefish existed on both Namakan Reservoir and Lac La Croix in the 1890's (Pearson, 1963). Records from Namakan Reservoir suggested a total reported Ontario harvest of 33,090 kg from 1924-1999, for a mean annual harvest of 435 kg/yr. To date, creel surveys have not been completed to fully evaluate angling effort and harvest in the Namakan River. Any harvest of lake sturgeon is likely incidental and similar to Namakan Reservoir where the majority of angler effort is generated by non-residents (99%) and directed at walleye (*Sander vitreus*; 85 %) (Elder, 2001).

Effective July 1, 2008, the catch and possession limit for recreational angling of lake sturgeon was changed from one to zero throughout Ontario. Prior to this change, the daily catch and possession limit of one fish included a minimum size limit, whereby only fish greater than 190 cm (74.8") in total length could be retained. Moreover, prior to January 1, 2008, there was no size restriction on the Namakan River and the open season for angling of lake sturgeon was June 30 to May 15 each year until 2008, when it was changed to July 1 to April 30.

Lake sturgeon are currently designated as a species of "Special Concern" in Ontario and regulated under the Endangered Species Act (S.O. 2007). A similar designation exists in Minnesota, but the legal context is different. In Canada, the species is under review by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) for possible designation under the Species At Risk Act (S.C. 2002). From an international perspective, lake sturgeon are also regulated through the Convention on International Trade in Endangered Species of Fauna and Flora (CITES – Appendix II). Conservation status for lake sturgeon is listed as "Vulnerable" by the American Fisheries Society (AFS, 2008), while status of the species is "G3-Vulnerable" globally and "S3-Vulnerable" provincially (NatureServe, 2008).

In 1994, the Ontario-Minnesota Fisheries Committee established a Border Waters Lake Sturgeon Management Committee, which recommended that additional studies be completed on lake sturgeon populations where little or no information currently exists (OMNR and MDNR, 1995). Although previous tagging and telemetry studies have been completed in the border waters area including Lake of the Woods and Rainy River (Mosindy and Rusak, 1991; Stewig, 2005), Rainy Lake (Adams et al., 2006), and the

Seine River (McLeod, 1999), none have examined the lake sturgeon population found in the Namakan River. Seasonal movement patterns can be highly variable in other large lakes and rivers based on telemetry studies on other populations (Thuemler, 1997; Rusak and Mosindy, 1997; McKinley et al., 1998; Borkholder et al., 2002; Knights et al., 2002; Friday, 2006). Given this variability, managers require knowledge of seasonal movements and habitat use in order to protect or improve areas critical for survival and reproduction (Rusak and Mosindy, 1997). More recent studies have used acoustic telemetry to evaluate fish movements in relation to river discharge and temperature as well as passage around dams (Holbrook et al., 2009; Lallaman et al., 2008).

The objective of this study was to evaluate movement patterns, seasonal distribution, and generalized habitat use of lake sturgeon through the use of bio-telemetry and tagging. There is a need to determine fish movements, if any, through the proposed development sites and other rapids/falls along the Namakan River. This information, along with the identification of potential spawning areas and timing of movement in relation to water flows and temperature, will contribute to the evaluation of potential impacts of hydro-electric development. This study of fish movement should also provide valuable baseline data for the development of water management plans and long-term effectiveness monitoring, particularly if development proposals proceed.

STUDY AREA

The Namakan River is located immediately downstream of Lac La Croix and upstream of Namakan Reservoir (Figure 1), approximately 80 km southeast of Fort Frances, Ontario. This mesotrophic river is found in the southern range of the boreal forest in North America, and is typical of Canadian Shield lakes and rivers with soft water and little submerged aquatic vegetation. The Namakan River drains close to 8,860 km^2 in Ontario with an elevation drop of 19.2 m over a distance of 30.5 km from Lac La Croix to Namakan Reservoir (OPEG, 2007). It provides approximately 75% of the inflow to Namakan Reservoir; and contributes the largest single source of inflow with a mean discharge of 109 m^3/sec (Kallemeyn et al., 2003). Table 1 provides a summary of known physical and chemical characteristics, and reflects current knowledge of the three lakes situated along the Namakan River, including Little Eva Lake (281 ha), Bill Lake (134 ha), and Three Mile Lake (399 ha).

A number of potential barriers to fish migration exist along the river from the outlet of Lac La Croix downstream to the Namakan Reservoir. The following elevation changes are reported for the various rapids/falls under average flow conditions: 3.2 m at Snake Falls, 4.0 m at Myrtle Falls and Ivy Falls, 1.0 m at Twisted Rapids, 0.7 m at Quetico Rapids, 6.8 m at High Falls, 7.0 m at the Back Channel (over 2 km and 8-9 rapids), 3.0 m at Hay Rapids, and 1.6 m at Lady Rapids (Figure 1) (OPEG, 2007).

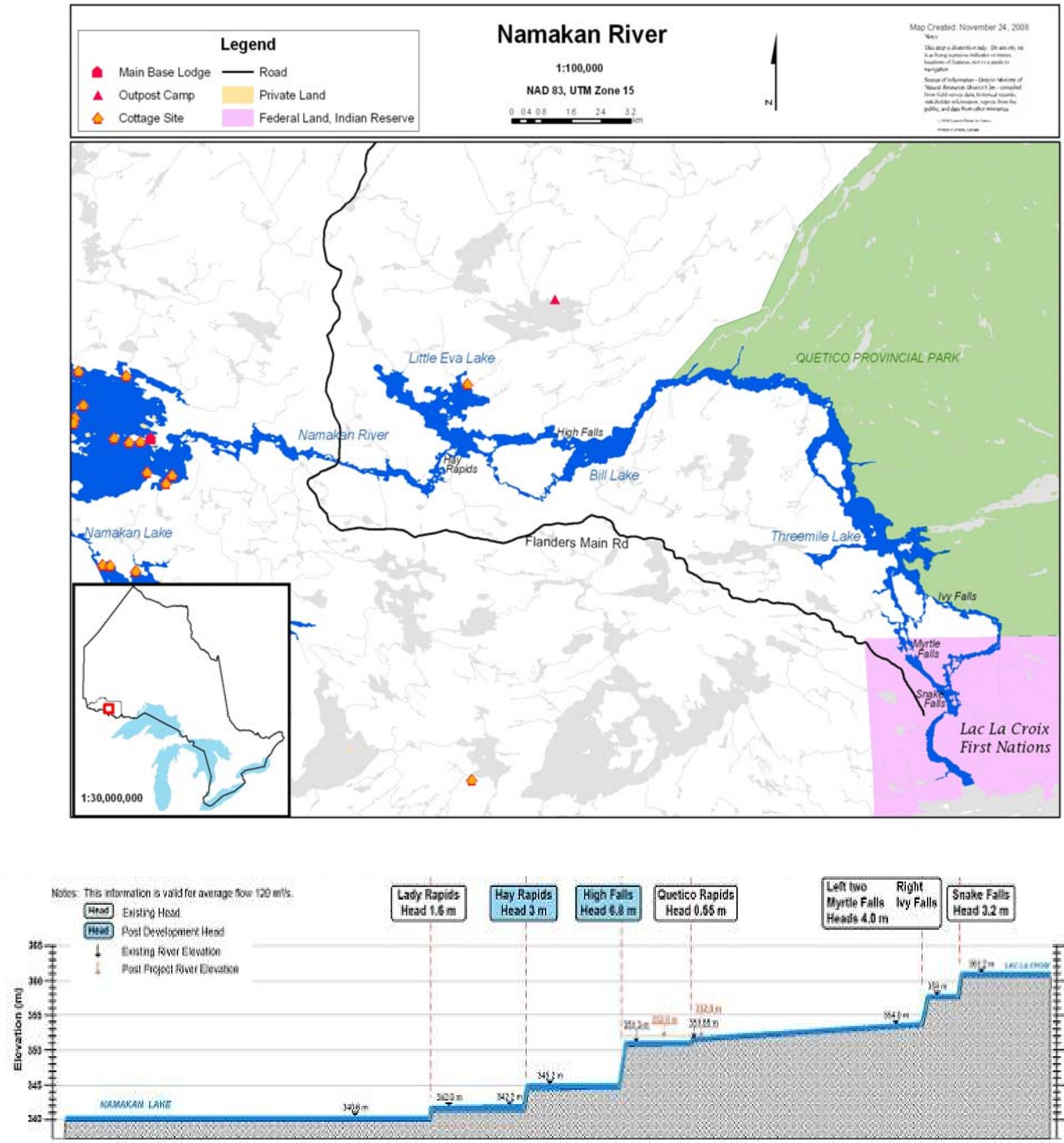


Figure 1: Location of the Namakan River, Ontario. Proposed hydro development sites are located at Hay Rapids, High Falls and Myrtle Falls. Elevations are based on a mean flow of 120 m^3/s.

Table 1: Physical and chemical characteristics of the Namakan River, Ontario.

Parameter	Little Eva Lake	Bill Lake	Three Mile Lake	Namakan River
Surface Area (ha)	281	134	399	1,252
Mean Depth (m)	5.1	4.5	-	-
Maximum Depth (m)	18.1	23.0	-	23.0
Mean Summer Secchi Depth (m)	2.5	2.5	-	2.5
Perimeter Shoreline (km)	25.5	7.6	-	-
Island Shoreline (km)	4.0	0.7	-	-
T.D.S. (mg/L)	45	45	-	45
M.E.I.	8.82	10.0	-	-

Namakan Reservoir is located immediately downstream of the river and consists of five large lakes including Namakan, Sand Point, Crane, Little Vermilion, and Kabetogama Lakes. The combined surface area is 26,000 ha, with approximately 23% in Ontario (Kallemeyn et al., 2003). The reservoir has a drainage basin area of 19,300 km^2 and is part of the headwaters of the Winnipeg-Nelson River system (OMNR and MDNR, 2004).

Water levels and flows in the Namakan River are not regulated. A Meteorological Service of Canada (Environment Canada) water level gauge at the outlet of Lac La Croix provides relevant information on inflows to the Namakan River since 1921 (LWCB, 2008). A maximum flow of 771 m^3/sec was recorded in June, 1950 while a minimum flow of 15 m^3/sec was recorded in January, 1977 and February, 1924. Annual flow metrics derived from a recent 20-year period (1980-1999) provides a mean and median flow of 118 m^3/sec and 87 m^3/sec respectively. Time exceeded (percentile) flows are estimated at 182 m^3/sec (20%) and 51 m^3/sec (80%). Other major inlets downstream of Lac La Croix include Bearpelt Creek and Quetico River flowing from adjacent Quetico Provincial Park, as well as Bullmoose Creek and an intermittent connection to Wisa Lake.

Little fisheries information is available and no aquatic habitat inventory (lake or river survey) has been completed. More recently, several fisheries investigations have been completed including Fall Walleye Index Netting (FWIN) studies on Little Eva Lake in 2006 (McLeod and Rob, 2008) and Bill Lake in 2007 (Rob and McLeod, 2008); a lake sturgeon population estimate for Little Eva Lake (McLeod, 2008a); and a lake sturgeon population assessment (McLeod, 2008b). A diverse coolwater fish community with 14 species was found to be present in Bill and Little Eva Lakes, while a total of 43 fish species are known to occur immediately downstream in the Namakan Reservoir (McLeod and Trembath, 2007).

Development on the shoreline of Namakan River consists of one private cottage/outpost camp, three commercial boat caches, and several recreational boats on Little Eva Lake; and nine commercial boat caches, and one recreational boat on Three Mile Lake. Portage trails exist at Little Eva Lake, Lady Rapids, Hay Rapids, High Falls, Quetico River, Bearpelt Creek (Wolseley Lake), Ivy Falls, and Snake Falls; as well as boat access from Wisa Lake off the Flanders Road. Lac La Croix First Nation (LLCFN, also known as Neguaguon Lake 25D) is situated in the upper reaches of the river, with a population of 274 on-reserve and 123 off-reserve residents (INAC, November 2008). Quetico Provincial Park borders the north side of the river for approximately 13 km from LLCFN to the mouth of Quetico River. The entire inland area south of the river falls within the Agreement of Co-Existence between LLCFN and the Province of Ontario (Ontario, 1994).

METHODS

Lake sturgeon were first captured, sampled, and tagged in Little Eva Lake using large mesh gill nets during the period of October 10-11, 2006. Fish were captured using 178 mm (7"), 203 mm (8"), 228 mm (9"), 254 mm (10"), and 305 mm (12") stretched mesh, multifilament gill nets. Each net panel was 91 m (300') long and 2.8 m (9') high. All mesh sizes were white in colour with the exception of the 228 mm (9”) mesh which was light green. Nine net lifts occurred at nine different sample locations, and included a random selection of mesh sizes.

Additional sampling occurred from May 14-24, 2007 at four locations along the Namakan River in conjunction with a bio-telemetry, tagging, and genetics study of lake sturgeon. Selected sampling locations included: below Hay Rapids; below the back channel in Little Eva Lake; below Quetico Rapids in Bill Lake; and below Ivy Falls in Three Mile Lake. Thirteen net lifts occurred at ten different net locations, using a random selection of stretched mesh sizes (203-305 mm) and a similar net configuration used in October, 2006.

Lake sturgeon were also captured and tagged on Little Eva Lake during the period of October 9-19, 2007, using the same large mesh, multifilament gill nets. Twenty-one net lifts occurred, and included a random selection of mesh sizes. Sturgeon were also captured during FWIN studies on Little Eva Lake from October 2-6, 2006, and Bill Lake from October 1-4, 2007 with monofilament mesh sizes of 127 mm (5”) and 152 mm (6”). Further sampling was completed from May 30-June 2, 2008 immediately below Snake

Falls. Six net lifts occurred, using a random selection of stretched mesh sizes, and a similar net configuration used in October, 2006. Final sampling occurred from October 6-10, 2008 in Little Eva Lake deploying only 178 (7”), 203 mm (8”), and 356 mm (14”) stretched mesh gill nets. Fourteen net lifts occurred at fourteen different net locations. In all sampling events, nets were set overnight with durations ranging from 15.3 to 24.5 hours. Nets were set as close to perpendicular (90^o) from shore as each net site would allow.

Immediately upon capture, all fish were examined for external tags and pectoral fin ray clips. Fish with existing tags were released at the capture location after recording the individual tag number, while all other fish were temporarily retained in a large plastic transportation bin filled with ambient lake water. As needed, fish were placed in a single compartment (12 m^3) holding net with a floating plastic frame anchored to shore near the daily sample location.

All lake sturgeon were sampled for total and fork length (mm), girth (mm), and round weight (g); tagged with an individually numbered Carlin disk dangler tag; and live released. Yellow OMNR tags were attached immediately below the centre of the dorsal fin with 0.5 mm stainless steel wire following methods outlined by Minnesota DNR (Stewig, 2005). A 3-4 cm section of the large, marginal ray of the left pectoral fin was removed for age determination, and provided a secondary mark. Sex and maturity of individual fish were only determined externally for ripe fish during the spawning period, or from internal observations of gonad development during surgical implantation of acoustic transmitters (Bruch et al., 2001). All aging structures were assessed by the OMNR Northwest Regional Aging Facility in Dryden, Ontario. Data were compiled and analyzed using FISHNET2 (Lester and Korver, 1996).

In May 2007, 30 individual fish were selected for surgical implantation of acoustic transmitters (V16-4L; Vemco - Amirix Systems Inc., Halifax, Nova Scotia) at four different sample locations: below Hay Rapids (n = 10), below the Eva Island back channel in Little Eva Lake (n = 10), below Quetico Rapids in Bill Lake (n = 5), and below Ivy Falls in Three Mile Lake (n = 5). An additional 4 fish were captured and selected for transmitter implants in April/May 2008 at another sample location below Snake Falls. The transmitters operated at 69 kHz, were 68 x 16 mm in size, and weighed 10 g in water, therefore did not exceed 2% of the total body weight for any given fish. Each transmitter emitted a unique code on a random interval of 60 to 120 seconds with a programmed operating life of 2,190 days.

An array of 13 submersible acoustic receivers (VR2W; Vemco) with Bluetooth wireless download capability was used to collect data on lake sturgeon locations and movements. The receivers were 308 x 73 mm in size and weighed 1,450 g in air, with an 8 MB flash memory (1 million detections). Each receiver contained a 3.6 v lithium battery with an expected operating life of 12-15 months. At selected sample locations, each stationary receiver was suspended vertically approximately 1 m off bottom with a nylon rope, 15 kg cement anchor, and round net buoy in water depths of 3- 6 m to avoid winter freeze-up.

Anchors were also attached to an exposed shore anchor or treed shrub with 20-30 m of lead core rope in order to provide easy deployment and retrieval.

The vendor-provided interface software (Vemco User Environment, VUE) was used for initialization, configuration, data upload, and storage from each receiver. The VUE software package also allowed data from multiple receivers and transmitters to be combined into a single integrated database. Each submersible receiver detects and decodes the ultrasonic pulses from transmitters within 500 m, logging the date, time, and individual transmitter code for each detection to internal storage. Verification of detection efficiency was conducted at one location prior to deployment and was verified to a minimum 300 m with direct line of sight. A collaborative Namakan Reservoir study initiated in 2008 by Voyageurs National Park (VNP) and South Dakota State University (SDSU) also reported 100% detection efficiency to a maximum distance of 525 m. However, the maximum detection efficiency was only 125 m at one site, and was highly variable based on site location, substrate and bathymetry (Stephanie Shaw, pers. comm). Most sites were strategically located near natural constrictions in the lake or river, and provided a detection range that likely exceeded the width of the river.

A manual tracking acoustic receiver and directional hydrophone (VR100 and VH110; Vemco) mounted on a hand-held aluminium pole was also used to locate individual fish and ensure proper transmitter function prior to release. In most cases, fish were manually tracked by boat/canoe immediately after release, or the next day, to help ascertain post-operative dispersal from the release site.

In preparation for surgical implantation of transmitters, a 350-litre fish holding tank was filled with 300 litres of clean water and 1.5 kg of salt (NaCl) was added. Lake sturgeon that were sampled and selected for surgical implantation, were placed ventral side up in a canvass cradle suspended in the holding tank and water was continually flushed over the gills using a small pump and hose. A disinfectant solution was prepared by adding 50 ml of Germiphene germicidal concentrate to 4 litres of distilled water. Surgical instruments and transmitters were immersed in this solution for at least 10 minutes to ensure full spectrum disinfection then subsequently rinsed with sterile saline solution prior to surgery.

Surgical procedures followed guidelines by Hart and Summerfelt (1975), and were similar to Adams et al. (2006). Lake sturgeon were not anaesthetized for the procedure. A sterile, fenestrated polylined towel (Convertors) was placed over the ventral surface with the opening centred over the implant location. A 3-5 cm incision was made with a surgical scalpel on the ventral surface approximately 1 cm off the midline and 3-4 cm anterior to the pelvic girdle. The transmitter was inserted into the abdominal cavity with minimal pressure exerted on the internal organs. Following implantation, the peritoneum and associated muscle tissue were closed with a continuous modified Cushings suture technique (3-0 Ethicon PDS II, ½" CT-2 needle) followed by five simple interrupted sutures (2-0 Ethicon Prolene, ½" SH needle) to close the skin. Post-operative fish were released at the surgical site which was in close proximity to the capture site.

Telemetry data obtained from fish implanted with transmitters were used to examine seasonal distribution, over-wintering areas, distance and timing of fish movement, daily movement speeds, and range of travel within the Namakan River. Movement of individual lake sturgeon throughout the river was determined by recording the first daily detection at each station for every fish detected, and their range within the river was determined using detections from the two extreme receiver stations traveled. Movement past each receiver station was examined in relation to temperature and daily water flow to determine if those factors had any influence on movement patterns. Water flows were obtained using gauge data at the outlet of Lac La Croix, while surface water temperatures (1 m) were obtained from a HOBO temperature logger located at Lady Rapids.

The seasonal distribution of fish detections by receiver location, and the diel movements through distinct rapids/falls were analyzed based on the solstice periods. Four separate seasons were described as winter (December 21-March 19), spring (March 20-June 20), summer (June 21-September 21), and fall (September 22-December 20). Analyses of both upstream and downstream movements through shallow rapids/falls were based on the last detection from the departing receiver and the first detection from the arriving receiver, depending on the direction of travel.

Speed of movement was also calculated for individual fish that were detected by a minimum four receivers and had travelled a minimum distance of 10 km, using the last detection from the “departure” location to the first detection of the “arrival” location during periods of intense movement (less than two weeks travel time). Total distance traveled per month within the Namakan River was determined for every individual fish by calculating the cumulative distance traveled between receiver locations. Lastly, upstream and downstream diel movements were determined using daily solar rise and set times (NRC, 2009) and were grouped seasonally for every individual detected to examine the timing of daily movement through shallow rapids/falls. All statistical analyses were conducted using Microsoft Office Excel (Microsoft Corporation 2003) with a significance of $p < 0.05$.

RESULTS

A total of 430 lake sturgeon were captured at the five sample locations over the sampling period (Table 2). Of the 430 fish captured, 407 were biologically sampled and 397 were externally tagged and released, including 362 fish exceeding 1,000 mm total length. Water temperatures during the seven capture periods ranged from 3.0-15.0°C. Catches from a single gill net ranged from 0 to 29 fish. Incidental catch was minimal with only two northern pike (*Esox lucius*) and one walleye caught and released. Only one sturgeon died prior to release as a result of gill damage and bleeding during capture.

Eighteen tagged fish where recaptured during the study period, with two fish recaptured on two separate occasions. Three additional fish were reported recaptured in Minnesota waters, including two in VNP netting efforts and one by a recreational angler. Eight of these recaptured fish provided information on movements within the Namakan River. Downstream (n = 5) and upstream (n = 3) movement was confirmed between Namakan Lake and Little Eva Lake through both Hay and Lady Rapids.

Table 2: Summary of lake sturgeon capture and tagging efforts in the Namakan River, 2006-2008.

Dates	Location	# Sturgeon Captured	# Sturgeon Tagged	# Sturgeon Recaptured
October 2-6, 2006	Little Eva Lake	4	3	0
October 10-11, 2006	Little Eva Lake	106	97	0
May 14-25, 2007	Namakan River	99	98	1
October 1-4, 2007	Bill Lake	5	0	0
October 9-18, 2007	Little Eva Lake	157	147	10
April 29–May 2, 2008	Below Snake Falls	4	4	0
October 6-10, 2008	Little Eva Lake	55	48	7
Total	**-**	**430**	**397**	**18**

From May 15 to 25, 2007, 30 fish were implanted with Vemco transmitters and released at five locations in the Namakan River including ten fish below Hay Rapids (downstream of all three proposed hydro developments); ten in Little Eva Lake (between proposed developments at High Falls and Hay Rapids); five in Bill Lake below Quetico Rapids and five in Three Mile Lake below Ivy Falls (between proposed developments at Myrtle Falls and High Falls). From April 30 to May 2, 2008, four additional fish were implanted with transmitters at released below Snake Falls (upstream of Ivy Falls and the proposed development at Myrtle Falls). Table 3 provides a summary of the fish description, ID code and release location of all lake sturgeon implanted with transmitters.

Lake sturgeon implanted with transmitters (n = 34) had a mean total length of 1,211 mm (863-1,662 mm), mean fork length of 1,095 mm (780-1,527 mm), mean girth of 426 mm (329-659 mm), and mean round weight of 11,453 g (4,250-30,800 g) (Table 3). These values were similar to all tagged fish (n = 397), which had a the mean total length of 1,211 mm (605-1,746 mm), mean fork length of 1,092 mm (531-1,577 mm), mean girth of 442 mm (195-766 mm), and a mean round weight of 11,858 g (1,100-36,350 g). Mean age of transmitter fish was 27.9 years (16-47 years) compared to 26.1 years (7-61 years) for all sampled and tagged fish. Based on the round weight of individual fish, implanted transmitters ranged from 0.03 to 0.23% of body weight.

Eleven submersible Vemco receivers were deployed in the Namakan River on May 15 to 25, 2007, at the specific locations outlined in Table 4. Sites were selected to evaluate fish movement through the numerous rapids and falls situated along the Namakan River and in Quetico Provincial Park. Receiver locations were also selected at both the upstream and downstream sections of the Back Channel, a shallow 2 km stretch of river around High Falls and Eva Island between Bill and Little Eva Lakes. On April 30 and May 22, 2008, two additional receivers were deployed below and above Snake Falls, in order to investigate potential movements of fish through Myrtle, Ivy and Snake Falls in the upper most reaches of the Namakan River. Table 4 provides a summary of the serial number, description and location of all receivers deployed in the study.

Table 3: Fish description, transmitter code and capture/release location for lake sturgeon implanted with coded transmitters in the Namakan River, Ontario in 2007 and 2008.

Transmitter ID Code	OMNR Fish Tag No.	Release Date	TLEN (mm)	FLEN (mm)	Girth (mm)	Weight (g)	Sex *	Age (years)	Capture/Release Location
4739	63802	15-May-07	1194	1091	455	11850	U	21	Namakan River - below Hay Rapids
4740	63813	15-May-07	1257	1150	458	13050	FI	29	Namakan River - below Hay Rapids
4741	63888	15-May-07	1156	1048	415	10100	U	27	Namakan River - below Hay Rapids
4742	63893	15-May-07	1220	1106	448	11900	MM	23	Namakan River - below Hay Rapids
4743	63876	15-May-07	1293	1168	391	11100	U	27	Namakan River - below Hay Rapids
4744	63855	16-May-07	1524	1389	463	18720	U	44	Namakan River - below Hay Rapids
4745	63809	16-May-07	1622	1494	606	29150	FI	27	Namakan River - below Hay Rapids
4746	63871	16-May-07	863	780	329	4250	U	20	Namakan River - below Hay Rapids
4747	63835	16-May-07	1076	972	375	7700	U	-	Namakan River - below Hay Rapids
4748	63848	16-May-07	1292	1167	506	14600	U	34	Namakan River - below Hay Rapids
4749	63720	17-May-07	1348	1224	401	11950	U	42	Little Eva Lake – below back channel
4750	63735	17-May-07	1160	1038	382	8600	U	25	Little Eva Lake – below back channel
4751	63738	17-May-07	1183	1050	390	8750	U	21	Little Eva Lake – below back channel
4752	63791	17-May-07	1662	1527	659	30800	FM	47	Little Eva Lake – below back channel
4753	63798	17-May-07	1038	920	360	6150	M	22	Little Eva Lake – below back channel
4588	63732	18-May-07	1136	1016	371	6850	U	25	Little Eva Lake – below back channel
4589	63733	18-May-07	1045	930	377	6700	U	16	Little Eva Lake – below back channel
4590	63734	18-May-07	1111	987	421	8250	U	16	Little Eva Lake – below back channel
4591	63793	18-May-07	1162	1046	419	8800	M	16	Little Eva Lake – below back channel
4592	63796	18-May-07	1187	1101	458	11400	MM	29	Little Eva Lake – below back channel
4593	63700	23-May-07	1188	1061	379	8700	M	26	Bill Lake – below Quetico Rapids
4594	63714	23-May-07	1485	1378	505	19400	FM	32	Bill Lake – below Quetico Rapids
4595	63728	23-May-07	1158	1035	426	9450	M	28	Bill Lake – below Quetico Rapids
4596	63756	23-May-07	1146	1037	384	8400	U	30	Bill Lake – below Quetico Rapids
4597	63777	23-May-07	1128	1002	399	7750	U	34	Bill Lake – below Quetico Rapids
4598	63718	24-May-07	996	889	385	6650	U	33	Three Mile Lake – below Ivy Falls
4599	63707	24-May-07	1203	1092	434	11100	M	22	Three Mile Lake – below Ivy Falls
4600	63761	25-May-07	991	889	340	5200	U	23	Three Mile Lake – below Ivy Falls
4601	63783	25-May-07	1317	1204	456	13350	MM	28	Three Mile Lake – below Ivy Falls
4602	63781	25-May-07	1346	1190	520	16500	FI	27	Three Mile Lake – below Ivy Falls
8491	50447	30-Apr-08	1075	959	378	7600	U	24	Namakan River – below Snake Falls
8492	50448	30-Apr-08	1214	1151	439	12650	FI	38	Namakan River – below Snake Falls
8493	50446	02-May-08	1255	1130	428	13000	FI	38	Namakan River – below Snake Falls
8494	50445	02-May-08	1134	1019	349	9000	U	28	Namakan River – below Snake Falls
Mean			**1211**	**1095**	**426**	**11453**		**27.9**	

*F = female, maturity unknown; FM = female, mature (gravid); FI = female, developing; M = male, maturity unknown; MM = male, mature (ripe); MI = male, developing; U = unknown.

Table 4: Serial number, description and location of VR2W submersible acoustic receivers in the Namakan River, Ontario in 2007 and 2008.

Receiver Serial No.	UTM Location	GPS Waypoint	Date of Deployment	Time of Deployment	Location Description
100847	547347 5365369	NAM 1	15-May-07	17:57	Namakan River - below Hay Rapids
100846	548468 5366363	NAM 2	17-May-07	17:50	Little Eva Lake – above Hay Rapids
100855	549195 5365895	NAM 3	17-May-07	11:22	Namakan River – back channel above first rapids
100853	550641 5366874	NAM 4	18-May-07	13:50	Little Eva Lake – below High Falls
100849	555250 5369250	NAM 5	22-May-07	16:00	Quetico River – above first rapids (QPP)
100848	553224 5367427	NAM 6	22-May-07	16:25	Namakan River – above Quetico (Bill) Rapids
100851	544310 5366389	NAM 7	22-May-07	18:40	Namakan River – below Lady Rapids (VNP)
100852	550984 5365634	NAM 8	23-May-07	17:25	Bill Lake – above back channel
100850	560161 5363439	NAM 9	24-May-07	16:45	Three Mile Lake – below Ivy and Myrtle Falls channel
100689	558319 5367294	NAM 10	24-May-07	19:07	Three Mile Lake – above Twisted Rapids
100854	560235 5364154	NAM 11	25-May-07	10:18	Three mile Lake – mouth of Bearpelt Creek (QPP)
100851	540596 5366483	NAM 12 *	28-May-07	15:00	Namakan River – mouth of Namakan Lake
100649	555305 5369225	NAM 13 **	18-Sept-07	11:40	Quetico River – below second rapids
100854	562169 5364364	NAM 14 **	12-Oct-07	10:48	Bearpelt Creek - below Wolseley Lake (QPP)
101942	561210 5360316	NAM 15	30-April-08	11:20	Namakan River – below Snake Falls
103459	561160 5358657	NAM 16	22-May-08	15:15	Namakan River – above Snake Falls (OPEG)
100689	558003 5367479	NAM 17****	18-Sept-07	14:09	Namakan River - below Twisted Rapids

* moved from NAM 7 due to disturbance by anglers, and more suitable, long-term location.

** moved from NAM 5 further upstream to deeper water below second rapids to avoid potential freeze-in during winter months.

*** moved from NAM 11 to planned location within QPP. Low water prevented boat access to Bearpelt Creek prior to Oct/07.

**** moved from NAM 10 to below Twisted Rapids to better evaluate habitat use below the rapids, while still documenting fish passage through the rapids

A total of 1,391,970 detections were recorded throughout the Namakan River over the 2007-2008 sampling period (Table 5). Most of the detections occurred in summer (52%) and the least occurred in winter (8%), while a similar amount of detections were received during spring and fall (19% and 21% respectively). The receiver location in Little Eva Lake above Hay Rapids had the most fish detections for each season, while the location above Snake Falls had no detections for any season (Fig 2a-d). No fish were detected at nine of the 13 receivers during the winter season. All winter detections were recorded in the four lakes (Namakan, Little Eva, Bill and Three Mile Lakes).

Table 5: Lake sturgeon detections by receiver location in the Namakan River, Ontario from May, 2007 to October, 2008.

Location No.	Location Description	Distance Upstream (km)	Receiver Serial No.	No. Detections	No. Transmitters Detected
1	Below Lady Rapids	0	100851	152,862	33
2	Below Hay Rapids	7.4	100847	69,432	26
3	Little Eva Lake	9.1	100846	720,811	30
4	Below High Falls	11.7	100853	15,906	16
5	Lower Back Channel	10.2	100855	852	10
6	Bill Lake	12.6	100852	180,553	14
7	Above Quetico Rapids	14.7	100848	4,092	16
8	Quetico River	17.5	100849	498	1
9	Below Twisted Rapids	20.0	100689	42,711	18
10	Bearpelt Creek*	27.4	100854	6,400	8
11	Three Mile Lake	24.7	100850	33,689	15
12	Below Snake Falls	28.8	101942	164,164	8
13	Above Snake Falls	30.5	103459	0	0
Total	**-**	**-**	**13**	**1,391,970**	**195**
Mean	**-**	**-**	**-**	**107,074**	**15.0**

* only 2 fish detected at revised location after October 12, 2007

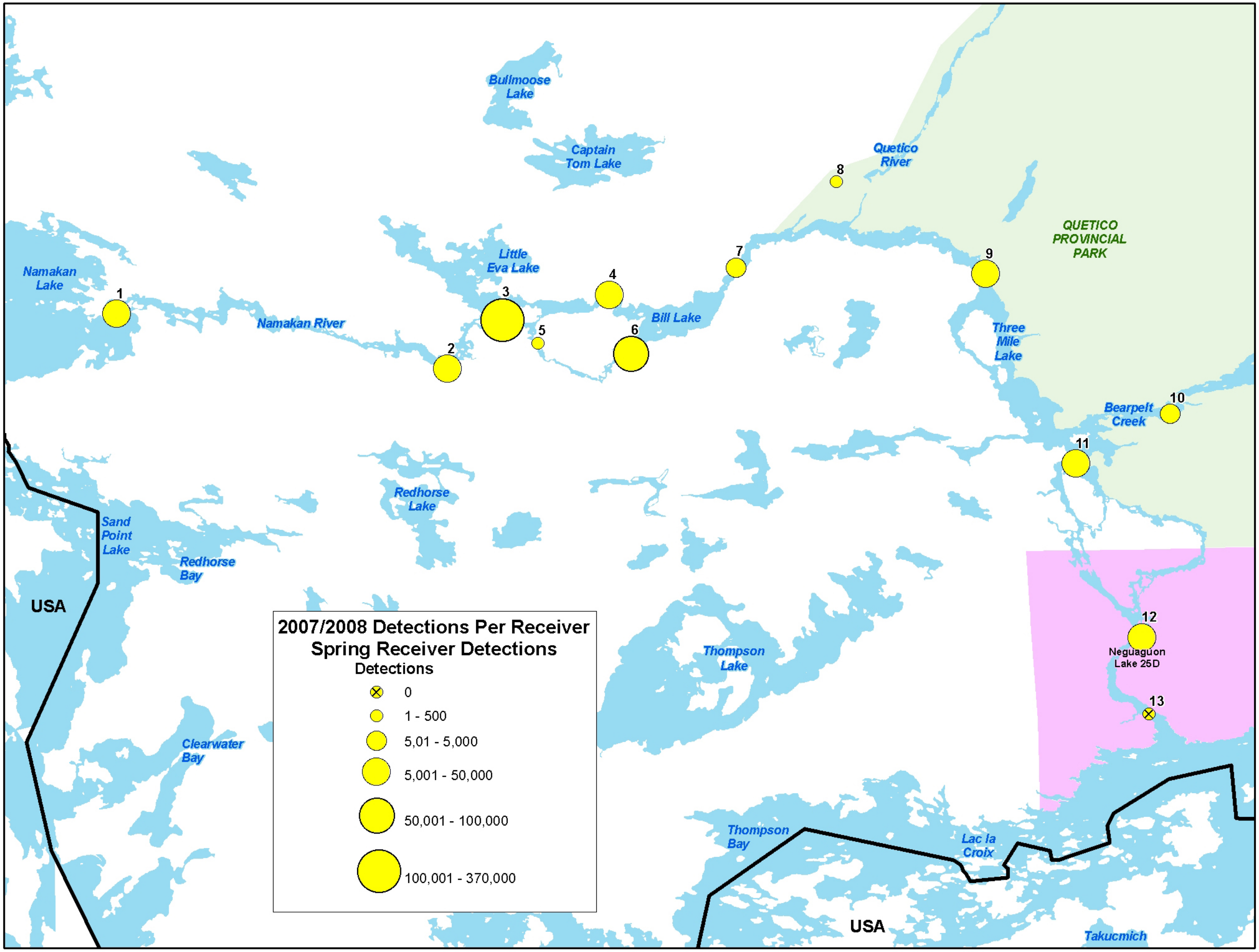


Figure 2a: Number of detections per receiver in the Namakan River during spring 2007 and 2008.

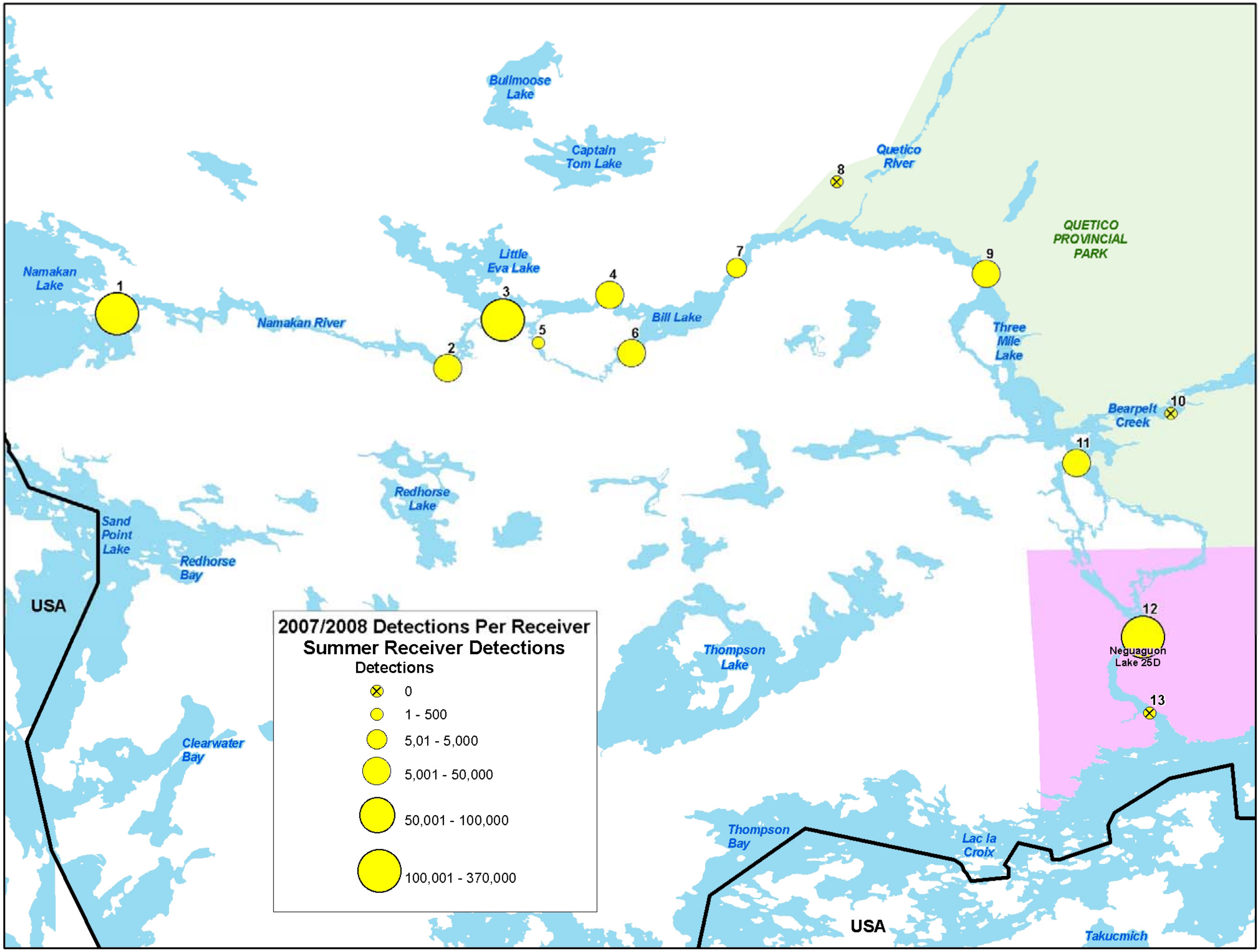


Figure 2b: Number of detections per receiver in the Namakan River during summer 2007 and 2008.

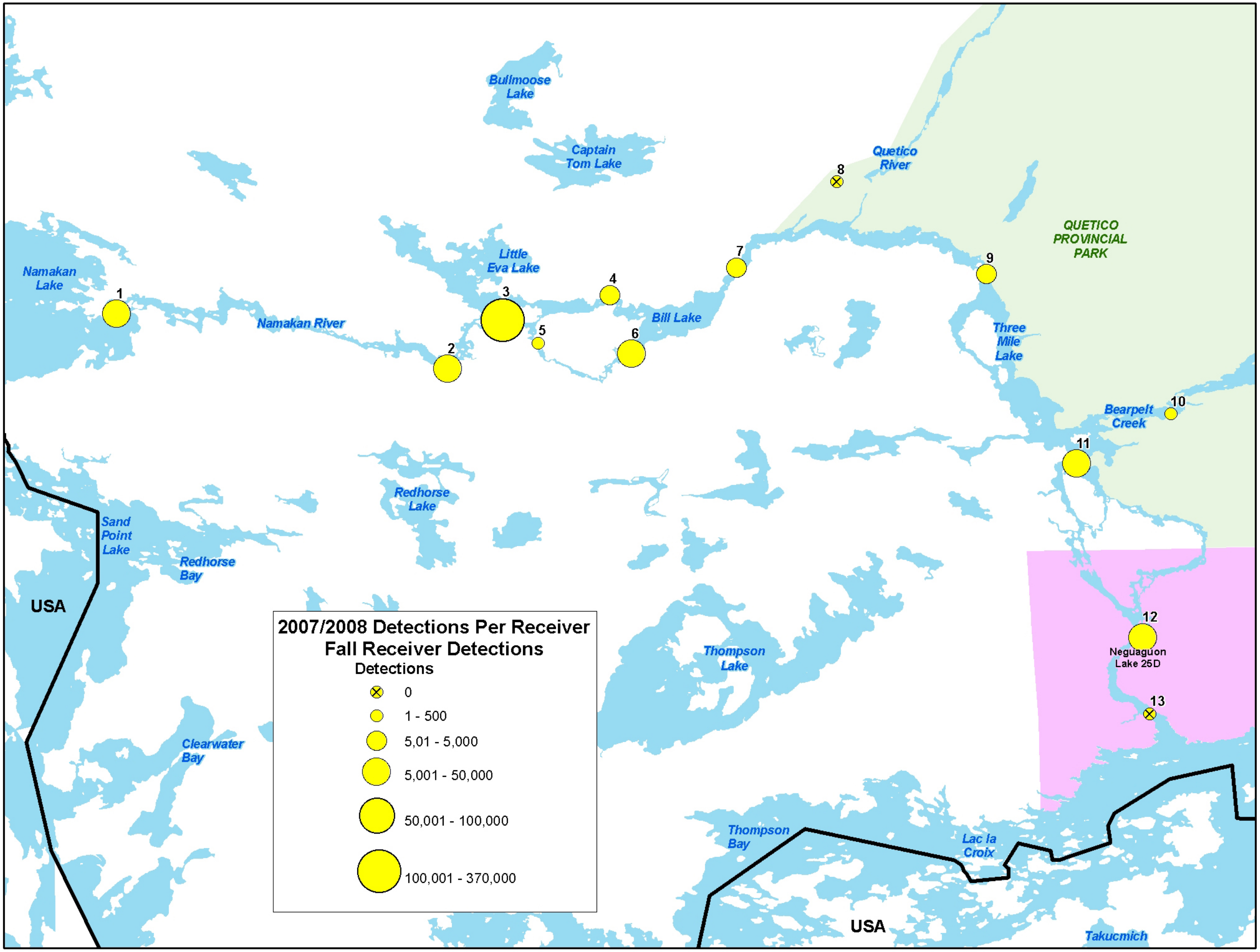


Figure 2c: Number of detections per receiver in the Namakan River during fall 2007 and 2008.

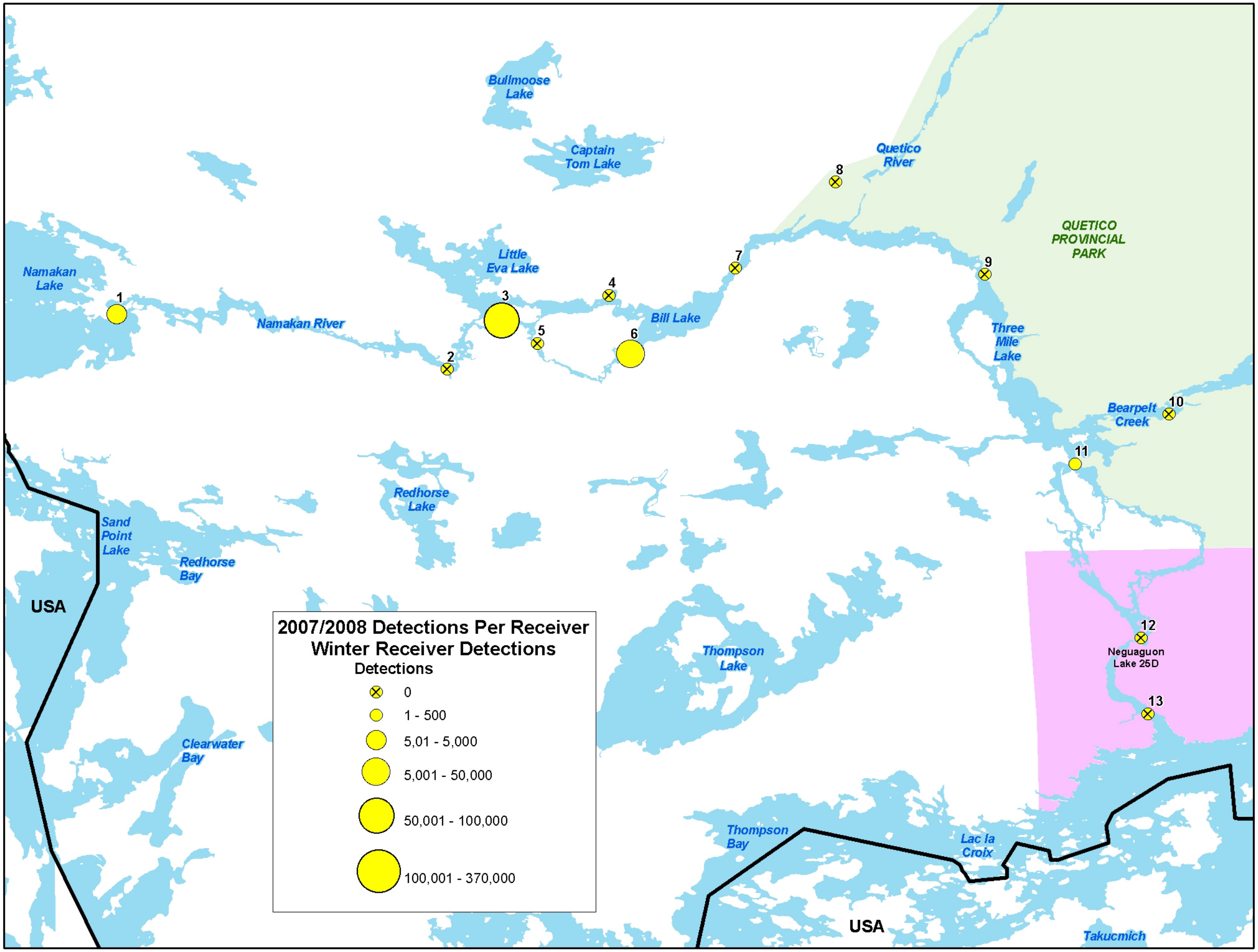


Figure 2d: Number of detections per receiver in the Namakan River during winter 2007 and 2008.

Daily movement patterns between all 13 receiver locations were analyzed for each individual lake sturgeon implanted with a transmitter in 2007 and 2008 (Appendix I and II respectively). All 34 implanted sturgeon, along with an additional 13 individuals from the collaborative Namakan Reservoir study, were detected at a minimum of one receiver location in the Namakan River (Table 6). The maximum number of detections from a single fish was 196,709 (ID 4753), while the minimum was 249 (ID 4745). One individual (ID 4602) was detected at 11 of the 13 stations, over a distance of 28.8 km. Nine individuals were detected at one station only, and the mean number of receivers at which an individual fish was detected at was 4.2 (SE = 0.4). Each receiver detected a mean of 15.0 fish (SE = 2.8) with a range of 0-33 (Table 5).

Distribution of total monthly movements over the entire study period is illustrated in Figure 3. Mean distance traveled differed significantly between months of movement from May to October (ANOVA; $F_{5, 272} = 4.137$, $p = 0.001$, $n = 278$). Movement throughout the Namakan River peaked in June with a mean monthly distance traveled of 11.1 km (SE = 2.1), and was lowest in August with a mean of 2.8 km (SE = 1.1). A maximum monthly movement of 48.9 km was observed in June, and movement ceased entirely from November to April each year.

Table 6: Individual lake sturgeon detections and last known date/location by transmitter code in the Namakan River, Ontario from May, 2007 to October, 2008. Shaded rows represent transmitters detected from the Namakan Reservoir study.

Transmitter ID Code	Release Date	Release Location	Last Detection Date	Last Known Location	No. Detections	No. Receivers
4739	15-May-07	Below Hay Rapids	21-Oct-08	Little Eva Lake	19,676	3
4740	15-May-07	Below Hay Rapids	21-Oct-08	Little Eva Lake	22,107	4
4741	15-May-07	Below Hay Rapids	21-Oct-08	Little Eva Lake	98,045	9
4742	15-May-07	Below Hay Rapids	23-Aug-08	Namakan Lake	39,093	3
4743	15-May-07	Below Hay Rapids	29-May-07	Namakan Lake	5,751	2
4744	16-May-07	Below Hay Rapids	16-Oct-08	Little Eva Lake	42,645	2
4745	16-May-07	Below Hay Rapids	26-Aug-08	Namakan Lake	249	2
4746	16-May-07	Below Hay Rapids	20-Oct-08	Below Hay Rapids	52,288	1
4747	16-May-07	Below Hay Rapids	18-May-07	Namakan Lake	453	2
4748	16-May-07	Below Hay Rapids	27-Aug-08	Namakan Lake	55,195	2
4749	17-May-07	Little Eva Lake	28-May-08	Namakan Lake	2,889	4
4750	17-May-07	Little Eva Lake	23-Aug-08	Namakan Lake	9,667	3
4751	17-May-07	Little Eva Lake	03-Oct-07	Namakan Lake	51,733	3
4752	17-May-07	Little Eva Lake	02-Oct-08	Below Hay Rapids	36,198	4
4753	17-May-07	Little Eva Lake	21-Oct-08	Little Eva Lake	196,709	1
4588	18-May-07	Little Eva Lake	21-Oct-08	Little Eva Lake	18,933	3
4589	18-May-07	Little Eva Lake	20-July-08	Namakan Lake	3,207	3
4590	18-May-07	Little Eva Lake	21-June-07	Namakan Lake	1,592	4
4591	18-May-07	Little Eva Lake	6-Aug-08	Namakan Lake	23,139	3
4592	18-May-07	Little Eva Lake	08-Oct-08	Three Mile Lake	151,876	8
4593	23-May-07	Bill Lake	18-0ct-08	Namakan Lake	10,672	9
4594	23-May-07	Bill Lake	05-Sept-08	Namakan Lake	28,407	8
4595	23-May-07	Bill Lake	11-Oct-08	Three Mile Lake	10,915	6
4596	23-May-07	Bill Lake	20-Oct-08	Bill Lake	101,046	1
4597	23-May-07	Bill Lake	16-Jun-08	Bill Lake	3,276	4
4598	24-May-07	Three Mile Lake	16-Oct-08	Three Mile Lake	12,063	3
4599	24-May-07	Three Mile Lake	15-Oct-08	Three Mile Lake	12,613	4
4600	25-May-07	Three Mile Lake	09-Oct-08	Bill Lake	57,131	5
4601	25-May-07	Three Mile Lake	31-May-08	Namakan Lake	26,316	8
4602	25-May-07	Three Mile Lake	01-Sept-08	Namakan Lake	15,407	11
8491	30-Apr-08	Below Snake Falls	28-Jul-08	Below Snake Falls	1,984	1
8492	30-Apr-08	Below Snake Falls	16-Oct-08	Below Snake Falls	28,196	1
8493	02-May-08	Below Snake Falls	16-Oct-08	Below Snake Falls	4,041	1
8494	02-May-08	Below Snake Falls	16-Oct-08	Below Snake Falls	126,657	1
8495	14-May-08	Sand Point Lake	05-Sept-08	Namakan Lake	531	1
49630	20-May-08	Namakan Lake	21-Oct-08	Little Eva Lake	15,508	7
49632	15-May-08	Sand Point Lake	20-Oct-08	Quetico Rapids	4,631	9
49633	21-May-08	Namakan Lake	21-Oct-08	Little Eva Lake	23,545	9
49634	21-May-08	Namakan Lake	15-Oct-08	Three Mile Lake	3,153	8
49635	20-May-08	Namakan Lake	21-Oct-08	Little Eva Lake	13,620	4
49637	21-May-08	Namakan Lake	16-Oct-08	Three Mile Lake	3,162	8
49638	20-May-08	Namakan Lake	05-Sept-08	Namakan Lake	11,386	1
49640	14-May-08	Sand Point Lake	21-Oct-08	Little Eva Lake	16,868	4
49642	07-May-08	Crane Lake	21-Oct-08	Little Eva Lake	6,895	3
49643	07-May-08	Crane Lake	21-Oct-08	Little Eva Lake	12,449	3
49644	07-May-08	Crane Lake	15-Oct-08	Three Mile Lake	5,669	9
49653	14-May-08	Sand Point Lake	21-Oct-08	Little Eva Lake	4,384	2
Total	**47**	**-**	**-**	**-**	**1,391,970**	**13**
Mean	**-**	**-**	**-**	**-**	**29,616**	**4.2**

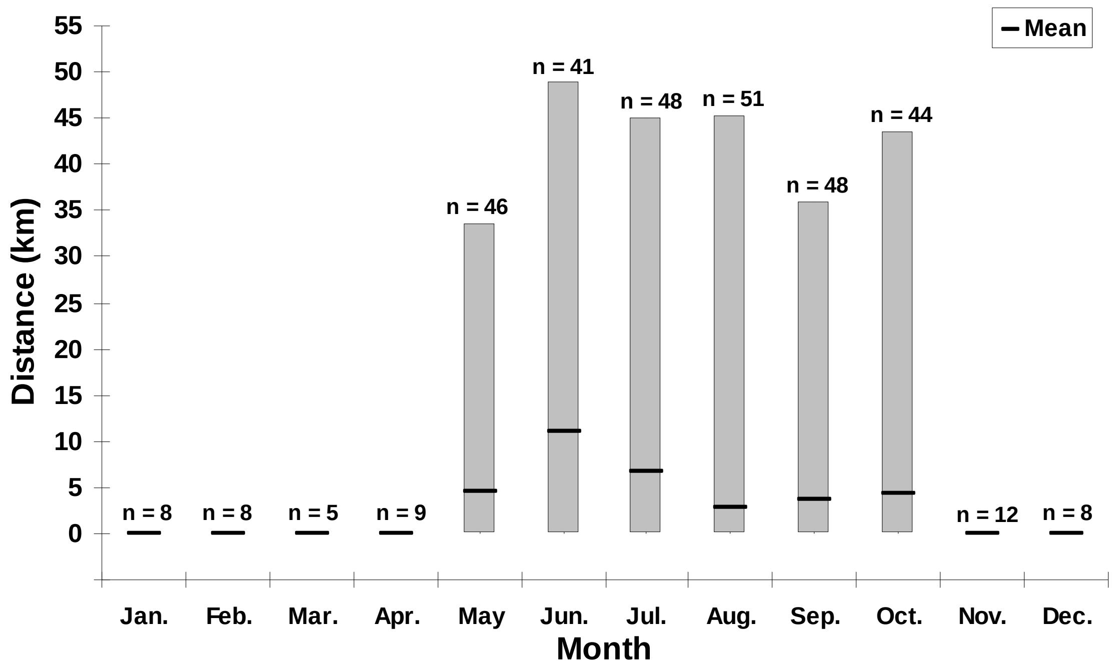


Figure 3: Total monthly movement of lake sturgeon between fixed receiver locations in the Namakan River, from May 2007 to October 2008.

Examination of seasonal and diel movement through shallow rapids revealed more frequent movements during the day in both spring and summer, and more frequent movements at night in the fall (Table 7). Moreover, 52% of movements occurred during daylight hours on an annual basis, and movements were limited to the spring, summer, and fall seasons.

Table 7: Diel and seasonal movements of lake sturgeon through shallow rapids/falls in the Namakan River, Ontario based on sunrise and sunset times.

Season	DAY (No. of movements)	NIGHT (No. of movements)	Total
Spring	53	34	**87**
Summer	60	43	**103**
Fall	6	34	**40**
Winter	0	0	**0**
Total	**119**	**111**	**230**

Movements of individual fish through shallow rapids and falls along the river were also evaluated based on detections from both upstream and downstream receivers (Table 8). Movements through the proposed hydro development sites at Hay Rapids, Hay Falls, Back Channel, and Ivy/Myrtle Falls were documented (Appendix III), as well as all other undeveloped sites along the Namakan River and Quetico River (Appendix IV). The only exceptions were that no movements were recorded through Snake Falls or upstream over High Falls. The maximum number of movements (n = 64) was observed at Twisted Rapids at the outlet of Three Mile Lake, and were equally distributed between upstream and downstream over the sampling period. The most significant observations were 7 recorded downstream movements of 5 individual fish over High Falls, an elevation drop of 6.8 m. In addition, both upstream and downstream movements of sturgeon through the Back Channel first occurred in October, 2007. Of the 19 recorded fish movements, the majority (74%) were moving upstream from Little Eva Lake to Bill Lake.

Table 8: Movements of lake sturgeon through undeveloped rapids/falls in the Namakan River, Ontario from May 15, 2007 to Oct. 21, 2008. Locations are listed from downstream to upstream, and proposed hydro development sites are in bold.

Location	Elevation* (m)	Upstream	Downstream	Total
Lady Rapids	1.6	20	24	44
Hay Rapids	**3.0**	**21**	**17**	**38**
Back Channel (Eva Island)	**7.0**	**14**	**5**	**19**
High Falls	**6.8**	**0**	**7**	**7**
Quetico Rapids	0.7	20	20	40
Quetico River (QPP)	-	1	1	2
Twisted Rapids	-	32	32	64
Bearpelt Creek (QPP)	-	2	2	4
Ivy/Myrtle Falls	**4.0**	**6**	**6**	**12**
Snake Falls	3.2	0	0	0

* change in elevation at an average flow of 120 m^3/sec.

Time and speed of both upstream and downstream travel between a minimum of four stations are provided in Table 9. For extensive upstream movements in excess of 10 km, travel duration ranged from 1.4 to 12.5 days with a mean speed of 3.8 km/day (SE = 0.6). Duration of downstream travel ranged from 1.2 to 13.3 days with a mean speed of 3.1 km/day (SE = 0.5). Data for travel speeds were also pooled for all fish since a one-way analysis of variance (ANOVA) indicated no significant difference between upstream and downstream speed ($P > 0.05$). Mean speed of all fish movements ($n = 37$) ranged from 1.1 to 9.9 km/day, with a mean of 3.4 km/day (SE = 0.6). The maximum travel distance observed in the river was 28.8 km (ID 4602) from Namakan Lake upstream to below Snake Falls. Least squares linear regressions (Zar, 1999) indicated that the duration for upstream movements increased significantly with an increase in distance traveled ($p = 0.02$, $r^2 = 0.33$), however it was not significant for downstream movements ($p = 0.14$, $r^2 = 0.10$) (Figure 4).

Table 9: Duration, speed and direction of lake sturgeon movements between fixed receiver locations (minimum 4 receivers and 10 km in travel distance) in the Namakan River, Ontario in 2007 and 2008.

Fish ID	Departure Date	Receivers	Distance traveled (km)	Duration (days)		Speed (km/day)
				Upstream	Downstream	
4602	Oct. 19, 2007	3 to 9	10.9	1.4		8.0
49633	Jul. 7, 2008	3 to 11	15.6	1.6		9.9
4593	Sep. 25, 2008	6 to 11	12.1	2.2		5.6
4740	Aug. 1, 2008	1 to 4	11.7	2.8		4.2
4595	Jun. 28, 2008	7 to 12	14.1	2.8		5.0
4592	Jun. 19, 2008	3 to 12	19.7	3.3		6.0
4741	Jul. 25, 2007	1 to 4	11.7	5.5		2.1
4741	May 27, 2008	3 to 11	15.6	4.7		3.3
4742	Jul. 17, 2008	1 to 4	11.7	5.7		2.1
49630	Jun. 22, 2008	1 to 6	12.6	5.9		2.1
49633	Jun. 24, 2008	1 to 4	11.7	6.5		1.8
49633	Jul. 10, 2008	11 to 4	13.0	7.5		1.7
49632	Jun. 28, 2008	1 to 11	24.7	10.6		2.3
4592	May 23, 2008	3 to 12	19.7	10.9		1.8
4741	Jun. 26, 2008	2 to 11	17.3	12.0		1.4
49634	Jun. 23, 2008	2 to 11	17.3	12.5		1.4
4590	Jun. 17, 2007	4 to 1	11.7		3.7	3.2
4592	Jun. 06, 2008	12 to 3	19.7		13.3	1.5
4593	Jul. 18, 2007	11 to 6	12.1		9.8	1.2
4593	Oct. 1, 2007	11 to 6	12.1		4.2	2.9
4593	Oct. 8, 2007	6 to 1	12.6		10.2	1.2
4594	Jun. 8, 2007	10 to 1	27.4		5.2	5.3
4595	Jul. 2, 2008	12 to 6	16.2		9.6	1.7
4595	Jun. 26, 2008	12 to 7	14.1		2.5	5.7
4597	May 28, 2008	11 to 6	12.1		6.6	1.8
4600	May 31, 2007	11 to 6	12.1		6.4	1.9
4601	May 22, 2008	9 to 1	20.0		9.7	2.1
4602	Jun. 1, 2007	11 to 1	24.7		7.6	3.2
4602	Jun. 4, 2008	12 to 1	28.8		5.0	5.8
4741	Jul. 24, 2008	11 to 6	12.1		3.2	3.8
4741	Jun. 10, 2008	11 to 2	17.3		6.5	2.6
4749	May 27, 2007	4 to 1	11.7		1.2	9.9
4752	Sep. 17, 2007	4 to 1	11.7		3.2	3.6
49630	Jul. 9, 2008	9 to 3	10.9		4.0	2.7
49632	Jul. 12, 2008	11 to 6	12.1		8.7	1.4
49632	Oct. 14, 2008	11 to 6	12.1		5.1	2.4
n	–	–	36	16	20	36
Mean	–	–	15.0	5.9	6.3	3.4*
Min	–	–	10.9	1.4	1.2	1.2
Max	–	–	28.8	12.5	13.3	9.9

*A one-way analysis of variance (ANOVA) indicated no significant difference between upstream and downstream speed (P > 0.05), therefore data were pooled.

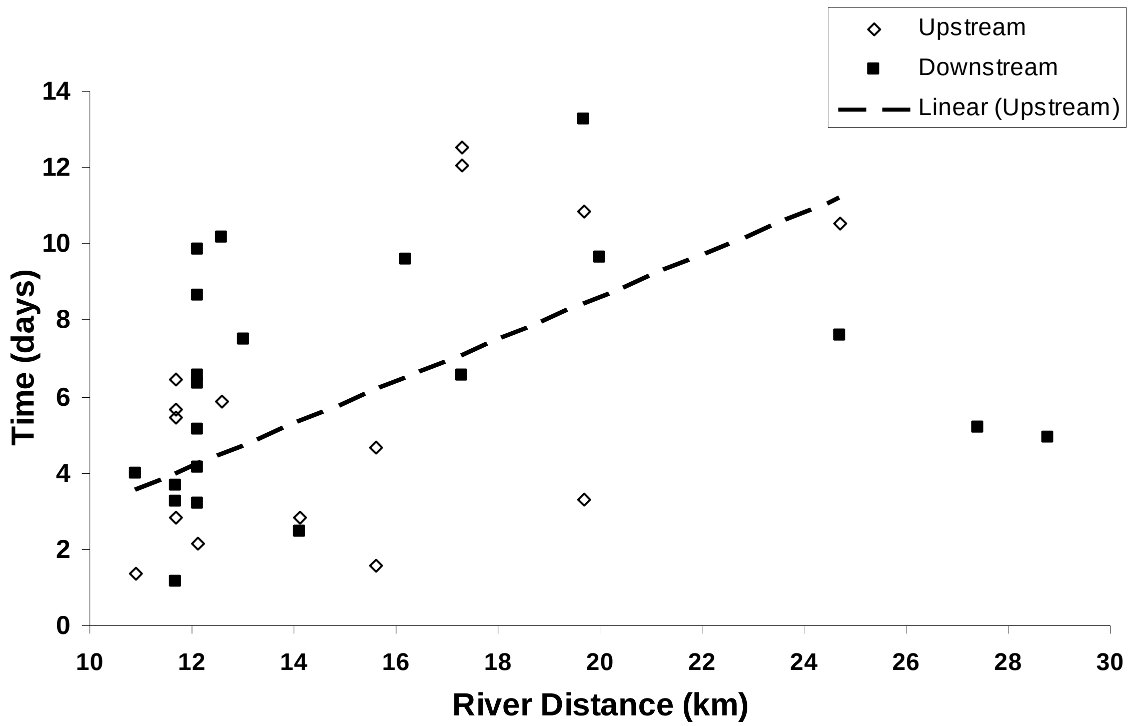
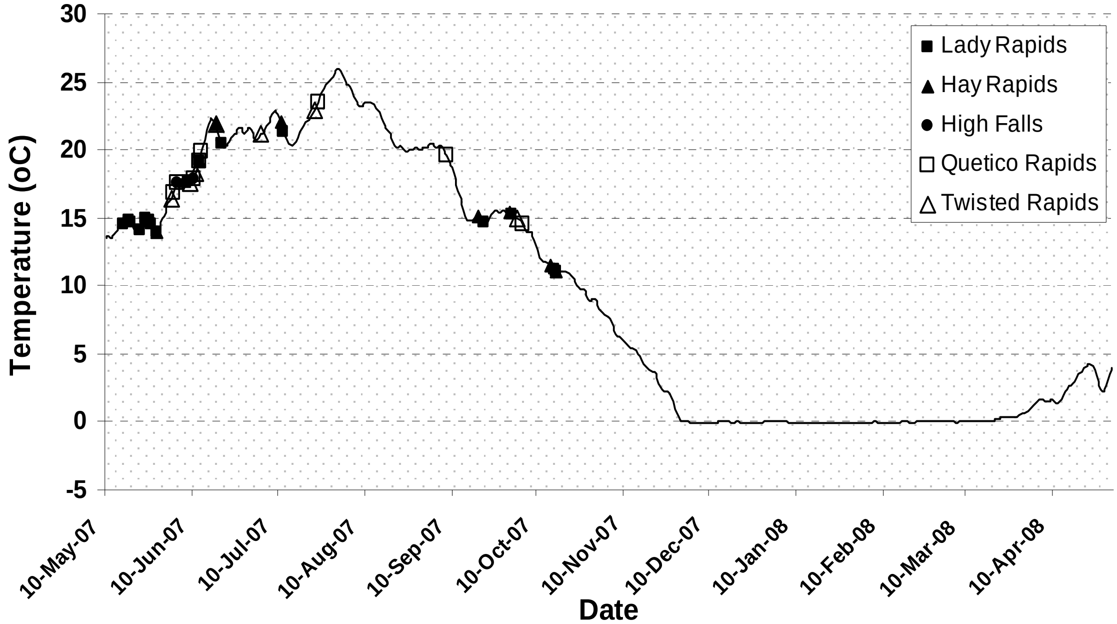


Figure 4: Linear relationship between time and distance traveled by individual lake sturgeon upstream ($y = 0.5572x – 2.5303$, $r^2 = 0.3337$, $n = 15$, $p = 0.02$) and downstream ($y = 0.1180x + 0.4058$, $n = 21$, $p = 0.10$) in the Namakan River.

Mean daily water temperatures from a HOBO temperature logger were also obtained for Lady Rapids from May 10, 2007 to May 1, 2008 (Appendix V). Movements through the rapids/falls occurred between temperatures of 11-23.5°C downstream and 11-24.9°C upstream (Figure 5). In general, no movement of fish through shallow rapids/falls were recorded when temperatures were lower than 11°C. Details of downstream and upstream movements in relation to temperature through each undeveloped rapids/falls are provided in Appendix VI. Additional analysis was not completed since temperature logger data was unavailable beyond May 1, 2008.

A)



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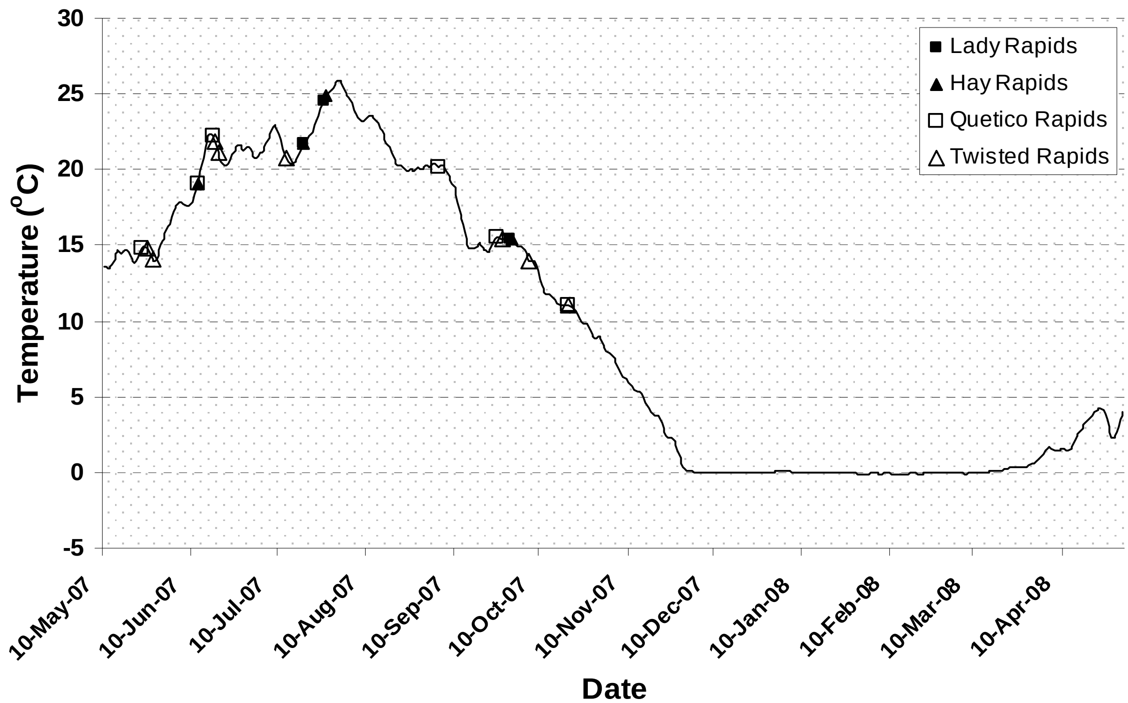


Figure 5: Downstream (A) and upstream (B) movement of lake sturgeon in relation to mean daily temperature through undeveloped rapids/falls in the Namakan River.

Estimated daily outflows from Lac La Croix for 2007-2009 were provided by the Lake of the Woods Control Board (LWCB, 2008), and were used to represent the flow conditions in the Namakan River (Appendix VII). Downstream or upstream movements of lake sturgeon were related to daily mean water flows at each of the undeveloped rapids/falls along the river (Table 10). There were no documented movements of fish at Snake Falls, and water flow information was not available for Quetico River and Bearpelt Creek within QPP. Water flows from the river could not be extrapolated and used for the Back Channel where only a portion of the natural flow occurs around Eva Island and High Falls. Detailed flow information for this channel is being collected by OPEG and is not yet available.

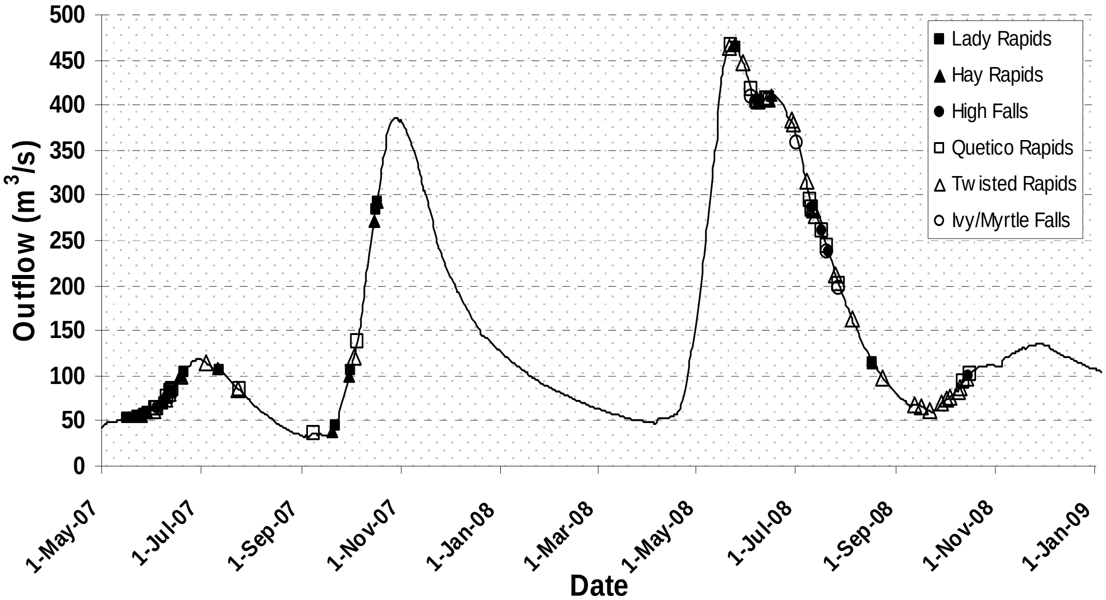
Ivy/Myrtle Falls had the highest mean flow for both downstream and upstream movements at 331 m^3/sec and 410 m^3/sec respectively. Lady Rapids had the lowest mean flow for downstream movements at 117 m^3/sec, while Twisted Rapids had the lowest mean flow for upstream movements at 167 m^3/sec. The minimum flow used by sturgeon at any of the shallow rapid/falls was 33 m^3/sec at Quetico Rapids, which also had the least elevation change. Lake sturgeon were also able to move upstream at river flows as high as 464 m^3/sec at both Quetico Rapids and Ivy/Myrtle Falls.

Movements through undeveloped rapids/falls also occurred during periods of increasing and decreasing outflow from May through November (Figure 6). The majority of fish movements in 2008 occurred in both directions during a lengthy period of decreasing outflow from June 1 to September 30. In contrast, no movement was documented during the period of increasing flows in spring 2008. Details of downstream and upstream movements through each undeveloped rapids/falls in relation to outflow are provided in Appendix VIII.

Table 10: Mean and range of water flows for lake sturgeon movements through undeveloped rapids/falls in the Namakan River, Ontario from May 15, 2007 to Oct. 21, 2008. Locations are listed from downstream to upstream, and proposed hydro development sites are in bold.

Location	Downstream			Upstream		
	n	Mean (m^3/s)	Range (m^3/s)	n	Mean (m^3/s)	Range (m^3/s)
Lady Rapids	24	117	44 - 464	20	207	67 - 407
Hay Rapids	**17**	**162**	**39 - 467**	**21**	**213**	**67 - 411**
High Falls	**7**	**204**	**64 - 403**	**0**	**-**	**-**
Quetico Rapids	20	211	36 - 467	20	243	33 - 464
Twisted Rapids	32	187	61 - 464	32	167	56 - 444
Ivy/Myrtle Falls	**6**	**331**	**197 - 409**	**6**	**410**	**373 - 464**

A)



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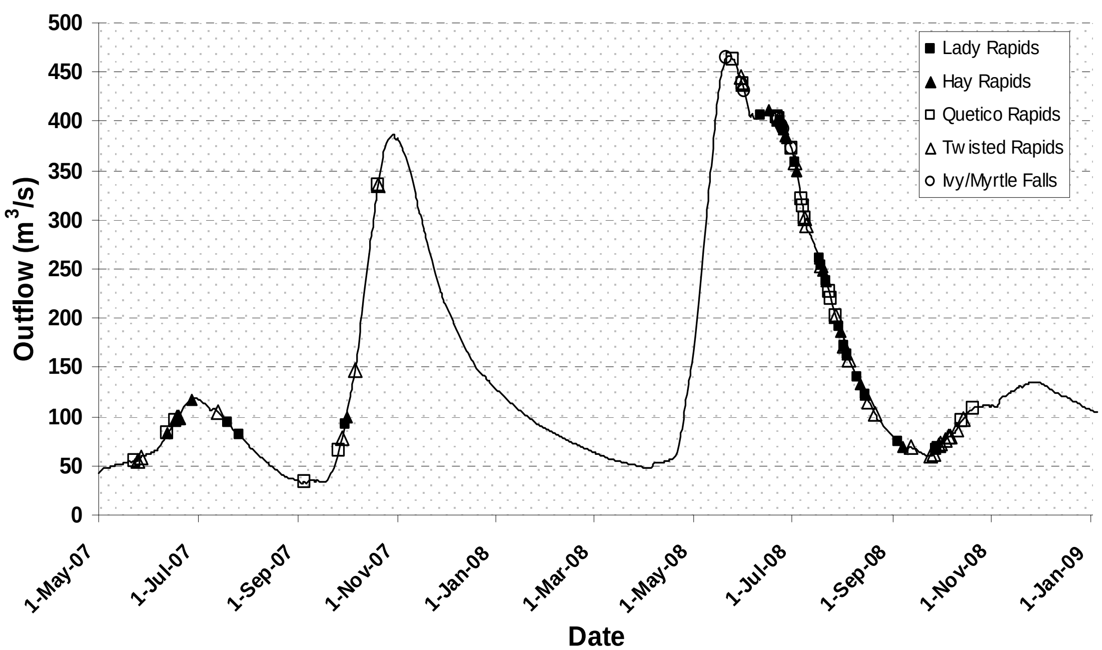

Figure 6: Downstream (A) and upstream (B) movement of lake sturgeon in relation to mean daily outflow through undeveloped rapids/falls in the Namakan River.

DISCUSSION

Acoustic telemetry has provided an effective means of evaluating the movement, seasonal distribution and general habitat use of lake sturgeon in the Namakan River, and continues to provide important information for both the river and Namakan Reservoir downstream. Individual movements of 34 telemetered fish and 18 recaptures of tagged fish have contributed new information from a previously unstudied system. This sample of lake sturgeon represented a broad segment of the adult population, with total lengths ranging from 605 to 1,746 mm and ages ranging from 16 to 47 years.

The seasonal distribution of telemetry data suggests that lake sturgeon are widely distributed in the Namakan River in spring, summer, and fall. There are preferred areas by season, with the majority (52%) of fish detections occurring in Little Eva Lake across all four seasons in 2007/08, followed closely by the river mouth below Lady Rapids and the area below Snake Falls in summer. Winter detections clearly indicate a preference for lake habitats within Little Eva Lake, Bill Lake, Three Mile Lake, and the Namakan Reservoir. Moreover, shallow rapids and falls are avoided in winter based on the absence of detections. Scott and Crossman (1998) suggested that sturgeon moved from shallow waters to deeper areas in summer, back to shallow areas in fall and back to deep areas in winter.

Bemis and Kynard (1997) reported on the potamodromous behaviour of sturgeon to migrate within a river system for two basic purposes: feeding and reproduction. They postulated three possible spawning migration patterns: one step, short two step, and long two step. One step spawning migrations are those in which fish move directly upstream to the spawning site and return downstream. The short two step migration involves upstream movement, usually in the fall, followed by over-wintering near the spawning site, followed by a very short migration to spawn the following spring. This pattern may enable fish to use bio-energetic reserves gained during summer foraging for their initial long upstream migration. Lastly, the long two step spawning migrations refer to fish that make an initial upstream migration followed by seasonal staging, then followed by a long upstream migration to the spawning site. This pattern of migration is characteristic of larger sturgeon species (*acipenseriforms*) in the longest rivers, but is not typical of lake sturgeon. This is supported by our observations in the Namakan River, where telemetered lake sturgeon only exhibited the first two spawning migration patterns. This may be due to the high complexity of this river system, and the relatively short migration distance of 30 km from Namakan Reservoir to Lac La Croix.

Lake sturgeon can be highly mobile and exhibit complex behaviour, especially in large systems where movements are not restricted. In the Upper Mississippi River system, reported movements ranged from 3 to 198 km (median of 56 km) (Knights et al., 2002). Spawning migrations from lakes to rivers are often as long as 125 km and may be as far as 400 km (Scott and Crossman, 1998). Auer (1999) found that lake sturgeon left spawning grounds in the Sturgeon River, MI and dispersed 70 to 280 km throughout southern Lake Superior with males and females using different locations. Lake sturgeon utilized spawning grounds along the full 140 km of the Rainy River and its tributaries, but made extensive feeding movements during the late spring and summer throughout the south basin of Lake of the Woods (Rusak and Mosindy, 1997). Sandilands (1986) also reported movements of 130 km and 180 km for fish in the Kenogami River in northern Ontario.

This study confirmed a smaller range of movements from 0 to 28.8 km, which represents the entire distance of the Namakan River. The total distance travelled by these fish will likely increase as additional movements are documented downstream in the Namakan Reservoir. Although movements of 100 km or more have been observed in other populations, the majority of lake sturgeon may exhibit more sedentary behaviour with movement ranges less than 20 km (Sandilands, 1986; Nowak and Jessop, 1987; and Block, 2001). Several fish (n = 7) in this study showed very limited movement with detections at only one receiver location. The interrupted pattern of detections indicated that the fish were still alive and occasionally moving outside the detection range of the receiver through the monitoring period. The extent of movement within a season was also highly variable among fish; some fish readily moved among habitats while movements of others were more constrained. The size, maturity, and stage of sexual development were likely an important factor in the movement pattern of telemetered fish. Haynes et al. (1978) observed that larger white sturgeon with higher metabolic rates required more food than smaller fish, and therefore tended to travel longer distances.

Based on movement patterns of individual fish, potential spawning areas exist in the Namakan River at the following sites: Snake Falls, Ivy/Myrtle Falls, Bearpelt Creek, Twisted Rapids, Quetico River, the Back Channel around Eva Island, and Hay Rapids.

However, these sites were based only on fish movements in relation to date and water temperature, as well as limited data on sexual maturation and development for individual fish. Suitable substrates and flow conditions were observed at each of these potential locations during the field study. The preferred spawning habitat for lake sturgeon includes shallow, flowing waters with substrates consisting of a combination of gravel, cobble, boulder and/or rock (Scott and Crossman, 1998; Block, 2001).

In addition to spawning, the factors influencing movement can include water temperature, flow, depth and substrate selection. Movements in other lake sturgeon populations are reported to be highly correlated with water temperature (Lallaman et al., 2008; Rusak and Mosindy, 1997). Temperatures near or above 20°C can cause of decrease in movement (McKinley et al., 1998), and sturgeon will avoid waters where temperatures exceed 23°C. In this study, no movements of sturgeon through shallow rapids/falls were recorded at temperatures above 24.9°C or below 11°C.

Lake sturgeon have been reported to begin their upstream (spawning) migration in the Mattagami River as early as January, with the pattern continuing through May as fish appeared at spawning locations with water temperatures of 8-10°C. Fish dispersed further downstream as spring water temperatures approached 13°C and continued throughout the summer (McKinley et al., 1998). In the Kaministiquia River, radio-tagged sturgeon began their upstream spawning migration in late April as water temperatures in the lower river increased from 6.5°C to a maximum of 10°C (Friday, 2006). Fish appeared below the Kakabeka Falls spawning area with daily mean water temperatures of

9.1-11.6°C; with two separate spawning events occurring 10-12 days apart at temperatures of 13.6°C and 15.2°C. Bruch and Binkowski (2002) found that males moved onto the spawning grounds and began searching for females when water temperatures rose to 6.6-16.0°C. Females would move on to a site at temperatures of 8.8-19.1°C, with most activity occurring at 11.5-16.0°C. Spawning was typically short duration occurring for 2-4 days at each site, with rapid post-spawn dispersal from the site. This behaviour was exhibited by several potential spawning fish in this study. In the Namakan River, lake sturgeon appear to move upstream in the late summer and fall to possibly forage and over-winter in lake environments, as well as in early spring to reach potential upstream spawning areas.

Both upstream and downstream movements of sturgeon in the Namakan River appear to be highly influenced by discharge, but does occur over a wide range of flow conditions (33 to 467 m^3/sec) experienced in 2007 and 2008. Movement through most rapids/falls occurred during very low spring flows in 2007, with the exception of the Back Channel where detailed flow information is not available. In 2008, fish movements occurred in both directions immediately after the peak in discharge, and continued throughout the spring and summer under declining flows. Borkholder et al. (2002) found that sturgeon movement in the Kettle River, MN was also highly correlated with change in discharge, with upstream movements occurring during periods of rising discharge and downstream movements during falling discharge. Lallaman et al. (2008) also indicated that upstream and downstream migration movements in the Manistee River, MI varied with discharge. In the Kaministiquia River, Friday (2006) confirmed upstream migration and spawning of lake sturgeon at low flows of 14-23 m^3/sec, while other fish moved upstream under mean daily flows of 20-60 m^3/sec. More recent telemetry studies in 2008 indicate sturgeon migrating upstream with mean daily river flows of 92-121 m^3/sec (M. Friday, pers. comm).

After spawning, lake sturgeon are reported to return to home areas and/or feeding areas followed by a late summer migration to areas where they spend the winter (Thuemler, 1997; Rusak and Mosindy, 1997; Scott and Crossman, 1998; Sandilands, 1986; Block, 2001; Adams et al., 2006). Moreover, Bruch and Binkowski (2002) suggested an autumn pre-spawn migration to staging areas within the spawning tributaries. Both these behaviour patterns were observed in the Namakan River in 2007 and 2008.

Downstream movements to Little Eva Lake or even Namakan Reservoir would suggest that these fish were seeking more productive foraging areas lower in the system. While a significant portion of lake sturgeon exhibited migratory behaviour in the Namakan River, it appeared that some telemetered fish did not make large-scale movements and remained sedentary for extended periods of time. According to a model by Northcote (1978), fish migrate among three basic types of habitat (spawning, feeding, and wintering) to optimize feeding and reproduction, avoid unfavourable conditions and enhance colonization. Presumably, the choice of winter habitat balances the need to feed, and the energetic cost of migrating from spawning or feeding habitats.

Previous studies of movement and habitat use by lake sturgeon have noted distinct areas preferred by groups of adult fish within riverine environments. In the Upper Mississippi River system, sturgeon moved throughout a large geographic area, but extensively used cores areas (Knights et al., 2002). These core areas were sites with unique hydraulic characteristics, such that depositional substrates were common yet flow was present; and that these areas probably provide important feeding habitat for lake sturgeon. In this study, Little Eva Lake represented a core area for sturgeon and provided the majority of fish detections. This is consistent with the very high population density and biomass estimates for this lake in October 2007 (McLeod, 2008a). Smith and King (2005) suggested that core areas of activity may be more important for sturgeon inhabiting flowing (lotic) environments compared to lake (lentic) environments. Telemetry results indicate that adult lake sturgeon exhibit a high degree of site fidelity to specific areas in the Kaministiquia River, Ontario (M. Friday, pers. comm). Another study of the Lake of the Woods/Rainy River system found two distinct populations of sturgeon differentiated by winter habitat preferences (Rusak and Mosindy, 1997). One group, which over-wintered in the lake, only entered the river during spawning migrations. The “river” population made extensive foraging movements in the lake during late spring and summer, returning to the river in late summer and fall to over-winter at specific locations.

The Namakan River provides a unique mix of river and lake environments with three small (<400 ha) lakes including Little Eva, Bill and Three Mile. These lake habitats may provide preferred areas for foraging based on suitable substrates and water depth. Little Eva Lake represents such an area where further habitat investigations may be warranted.

Lake sturgeon are generally believed to be bottom dwellers but previous movement studies revealed that they spend extensive amount of time in the water column above the bottom (Block, 2001). In Round Lake and Winnipeg River, Manitoba, lake sturgeon generally selected fine and medium sand when in contact with the substrate. Benson et al. (2005) suggest that shallow, riverine areas with sand substrates, low current velocity and predominance of dipteran larvae should be protected as important nursery habitats in tributaries that support spawning populations of lake sturgeon.

Monthly movements within the Namakan River indicate that individual sturgeon travelled over a range of 0 to 48.9 km/month from May to October. Distance moved by month was highest in June (mean of 11.1 km) and lowest in August (mean of 2.8 km); while no movement of fish was observed between receiver locations from November to April over the two study years. This lack of fish movement between receivers in late fall and winter was likely due to the cold water temperatures in shallow water and ice conditions.

Seasonal and diel movements within the Namakan River suggest that lake sturgeon move through shallow rapids and falls equally during the day and night, with the exception of the fall season. The shorter daylight period in the fall may have contributed to increased movements during the night. In contrast, Parsley et al. (2008) found that white sturgeon moved to shallow water at night and showed greater activity, inferred by rates of movement, than during the daytime. White sturgeon were absent from river sections with high flow during the winter, consistent with our observations on lake sturgeon. On the

Namakan River, the majority (45%) of fish movements through shallow rapids (n = 230) occurred during the summer season with no movement during the winter (November to April).

Daily movements of lake sturgeon in the Namakan River also suggest that the existing rapids and falls do not represent barriers to migration. Telemetry findings confirm movements through all natural restrictions in the system with the exception of Snake Falls and upstream movement at High Falls, which have an elevation drop of 3.8 and 6.8 m respectively under average flow conditions. Although the Back Channel around Eva Island and High Falls has an elevation change of approximately 7.0 m, the numerous shallow rapids help dissipate this change over a distance of approximately 2 km. Lake sturgeon use this natural by-pass channel to migrate both upstream and downstream around High Falls. Movements occurred only when daily flows in the Namakan River exceeded 243 m^3/sec.

The return in spring 2008 of 8 fish that departed the river during summer/fall 2007, and the upstream movement of another 13 fish from the reservoir in 2008 indicates a high degree of preference to the Namakan River. The return of individual fish and re-occupation of areas previously inhabited showed that some lake sturgeon exhibit site fidelity in this system, similar to white sturgeon (Parsley et al., 2008). In association with this study, a genetics evaluation by Welsh (2008) suggested that fish in the Namakan River upstream to Snake Falls represent a single population and that existing rapids/falls do not represent reproductive barriers. Additional studies are underway downstream in the Namakan Reservoir to evaluate population discreteness and distribution based on telemetry, tagging and genetics.

In the Menominee River, MI, the lake sturgeon population was found to fragment into sections by hydroelectric dams (Thuemler, 1997). Knights et al. (2001) also found that dams appeared to be intermittent barriers to upstream passage, since upstream passage events were fewer than downstream events. However, tagged fish did move both downstream and upstream of upper Mississippi River navigation dams. Haxton and Findlay (2008) reported that relative abundance of lake sturgeon was greater in unimpounded than impounded reaches, and that water power management appears to the primary factor affecting lake sturgeon in the Ottawa River. Higher abundance in an unregulated system like the Namakan River is reflected in the high catch rates observed and the low proportion of tag recaptures since 2006 (n = 18 recaptures or 4.2%).

Duration and speed of travel were also evaluated for fish that moved in excess of 10 km and were detected at a minimum of 4 receiver locations. Both upstream and downstream movements over these distances occurred quickly with short durations ranging from 1.2 to 13.3 days. Mean travel speed for these extensive movements was 3.4 km/day, with a maximum of 9.9 km/day. Hatin et al. (2002) also used acoustic telemetry to determine that Atlantic sturgeon in the St. Lawrence River travelled a mean distance of 13.7 km/day with a mean speed of 1.6 km/hour. Adams et al. (2006) found a maximum movement rate for lake sturgeon of 0.80 km/day and a minimum movement rate of 0.17 km/day on Rainy Lake, while Knights et al. (2002) found a mean spring movement rate of 0.50

km/day on the Upper Mississippi River. Similarly, Rusak and Mosindy (1997) found the highest movement rates occurred in spring (0.84 km/day) and summer (0.76 km/day), with the lowest rate during the winter (0.11 km/day). Juvenile lake sturgeon larger than 900 mm displayed longer median daily linear movements and occupied larger home ranges than did juveniles smaller than 900 mm in Black Lake, MI (Smith and King, 2005).

Knowledge of movements and activity patterns will be important for identifying and protecting critical habitats for lake sturgeon in the Namakan River. Although there were minor gaps in the spatial coverage of fixed receivers, acoustic telemetry has increased our knowledge and will help evaluate potential impacts of hydroelectric development. This study confirms that lake sturgeon travel, spawn and feed throughout the Namakan River system. These fish also share movement and habitat use characteristics with populations in other riverine systems in North America. Lake sturgeon do inhabit and make extensive use of both the Namakan River and Namakan Reservoir, and represent a shared, international fish stock. With the documented movements of lake sturgeon between Ontario and Minnesota waters, coordination of management efforts among provincial, state, and federal agencies will be important and challenging. Continuation of this study is planned through 2010, including the addition of telemetry receivers near Myrtle and Ivy Falls. This will provide more detailed movement information at these sites, along with continued investigation of the variables influencing lake sturgeon movements, including water temperature and flows.

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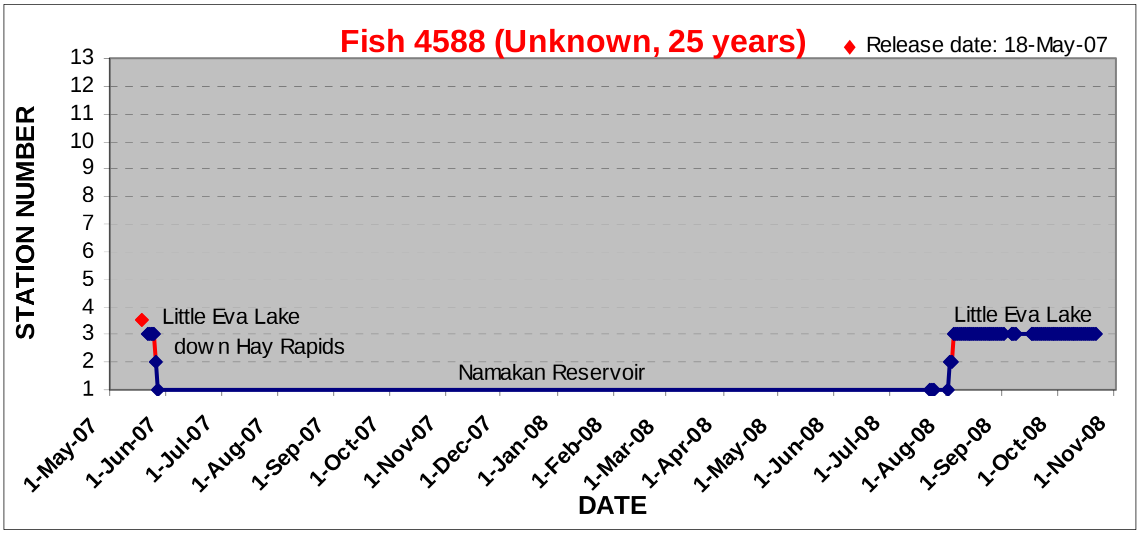
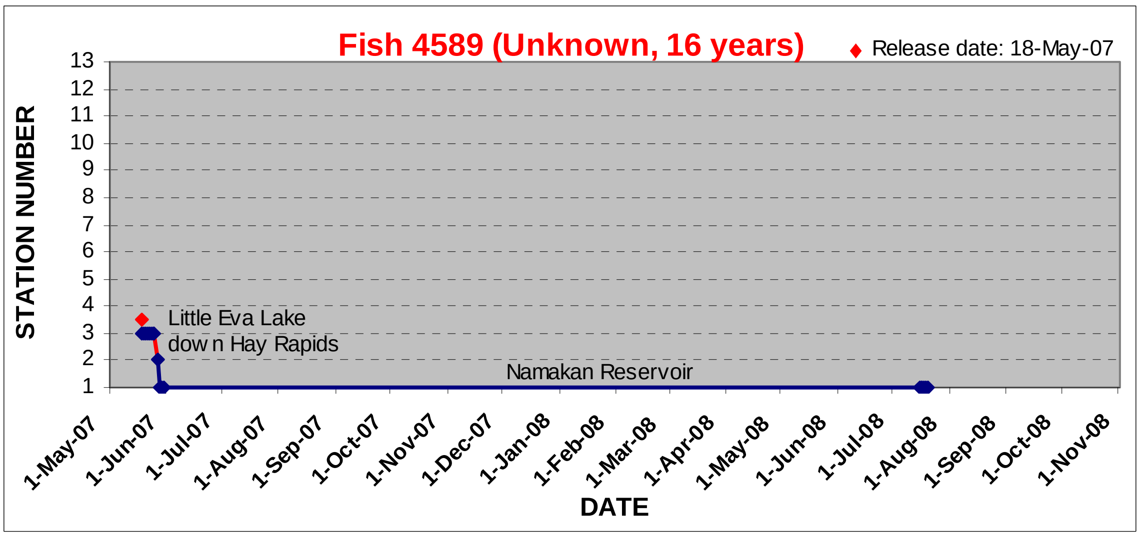
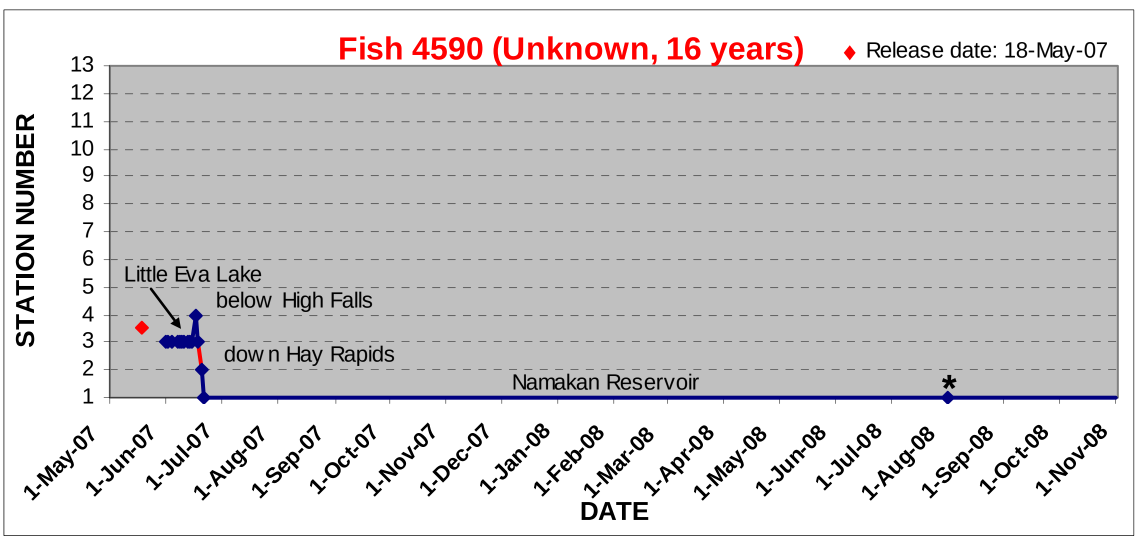
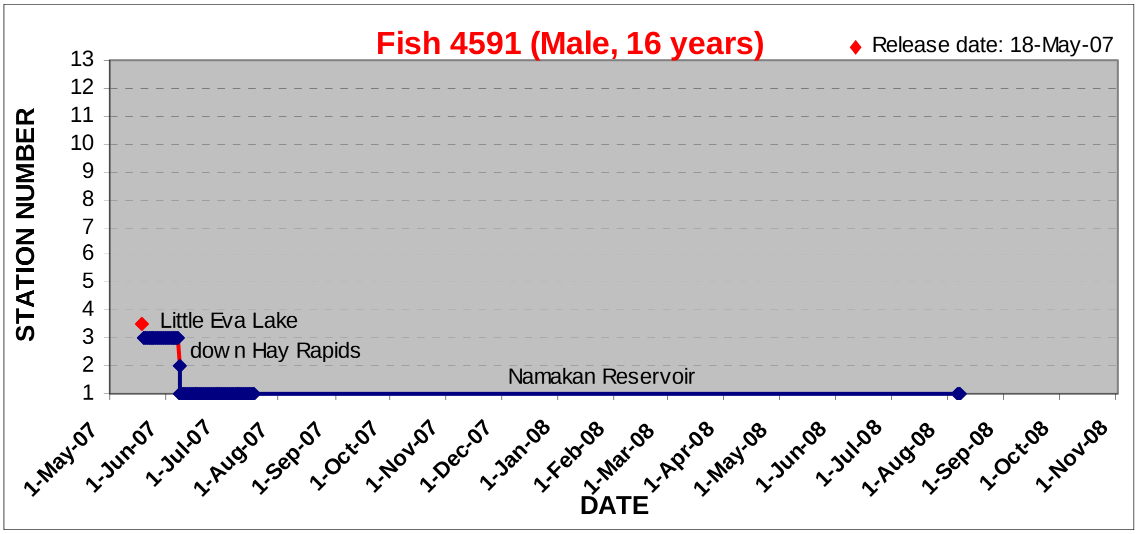
Appendix I: Movement of individual lake sturgeon released in 2007 within the Namakan River, Ontario.

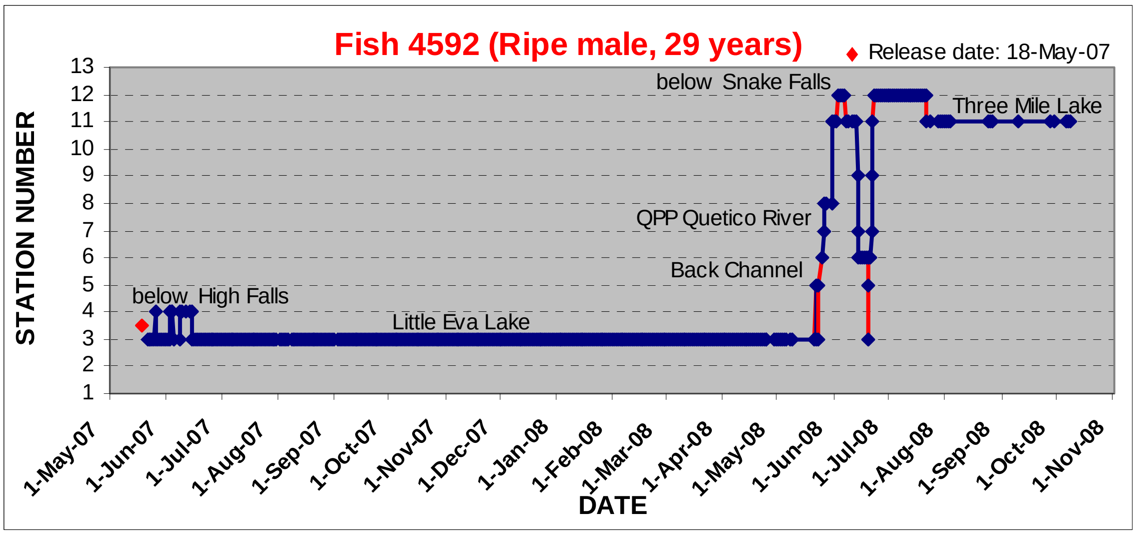


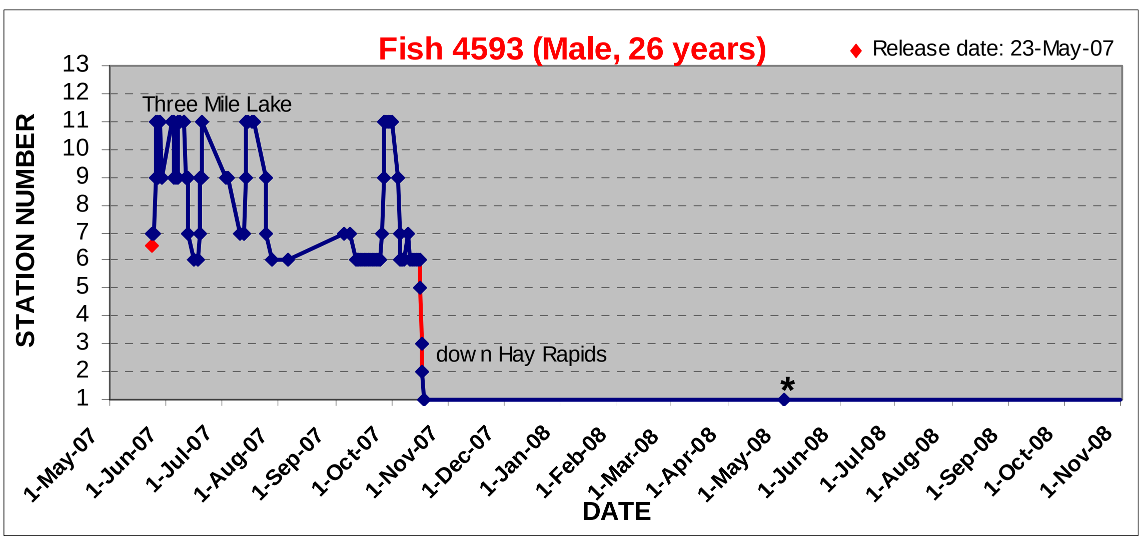


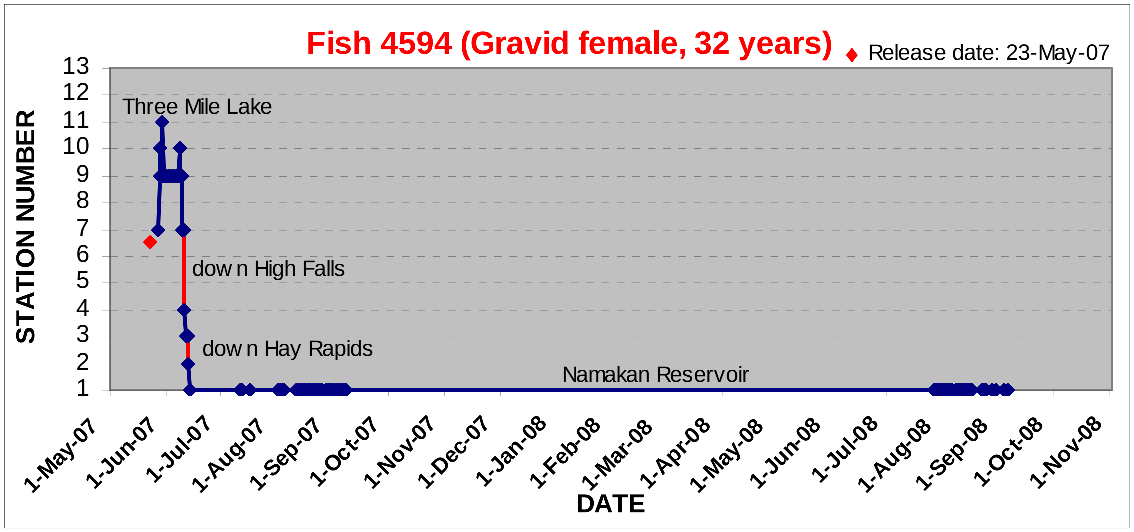


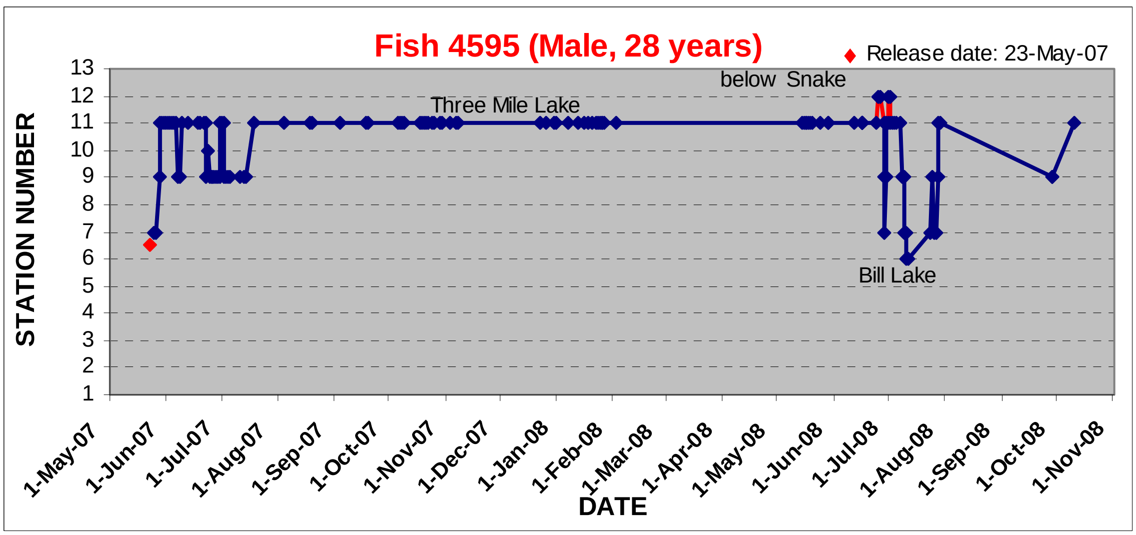
* **Red line segments represent movement through proposed development sites.**

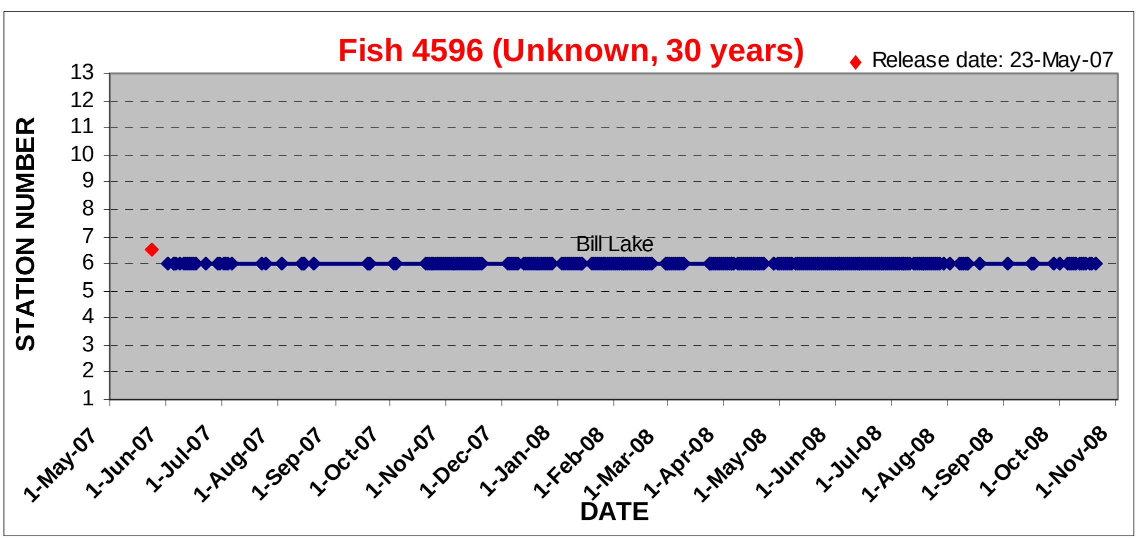


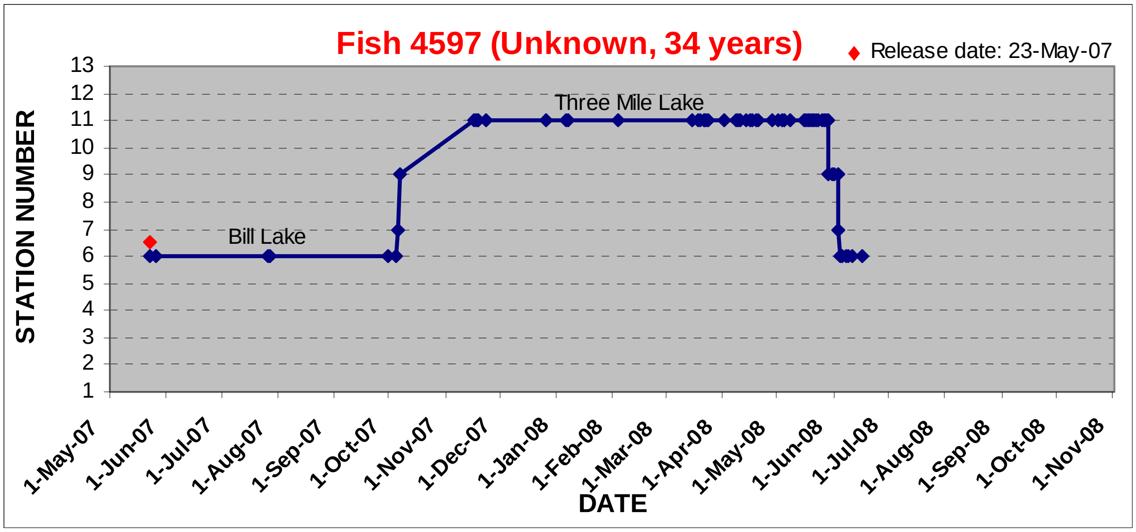




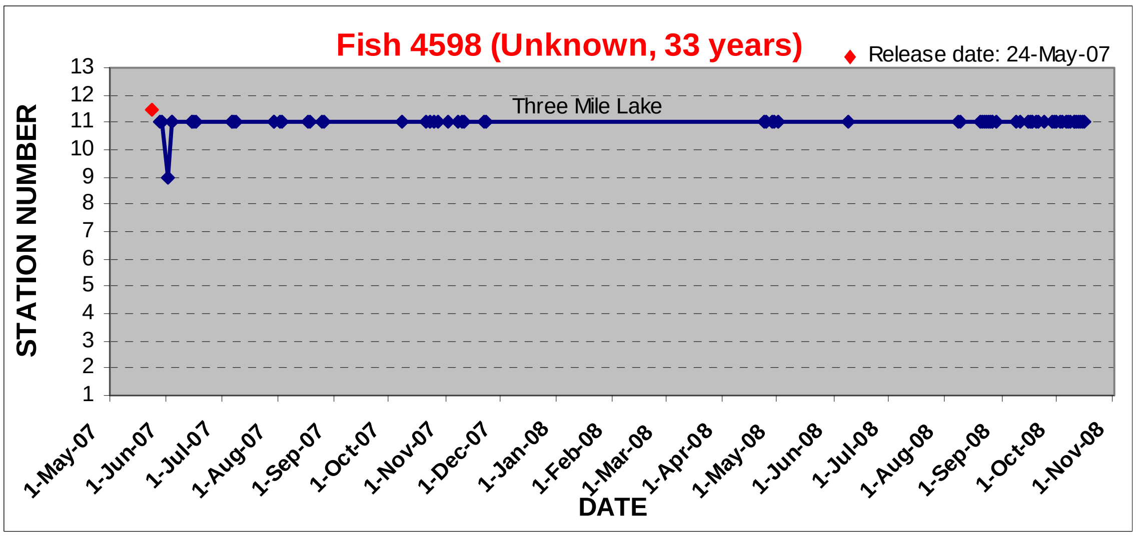

Fish 4594 (Gravid female, 32 years)
Release date: 23-May-07
STATION NUMBER
Three Mile Lake
dow n High Falls
dow n Hay Rapids
Namakan Reservoir
DATE


Fish 4595 (Male, 28 years)
Release date: 23-May-07
STATION NUMBER
below Snake
Three Mile Lake
Bill Lake
DATE

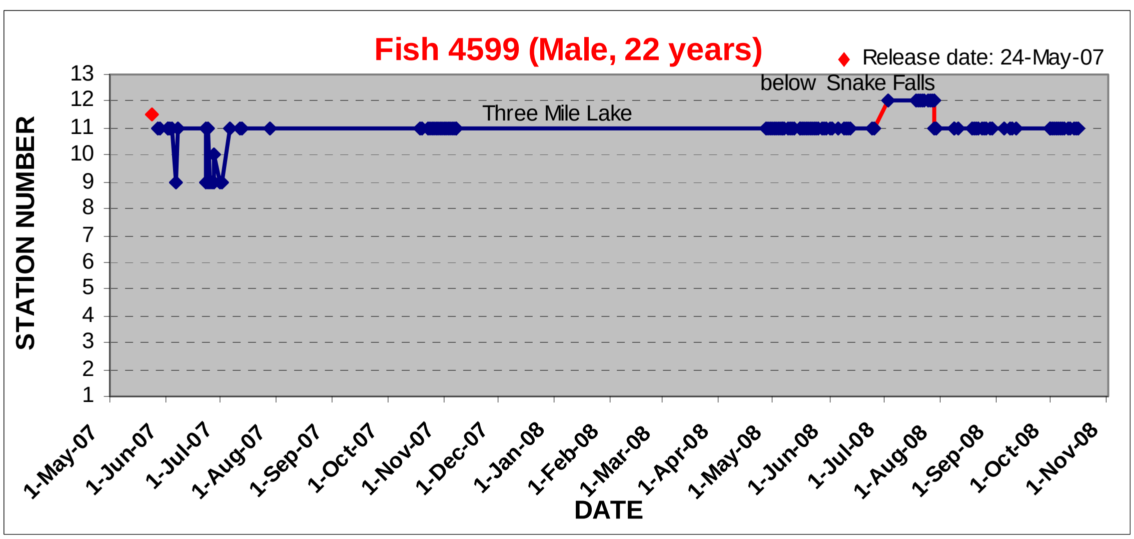

Fish 4596 (Unknown, 30 years)
Release date: 23-May-07
STATION NUMBER
Bill Lake
DATE



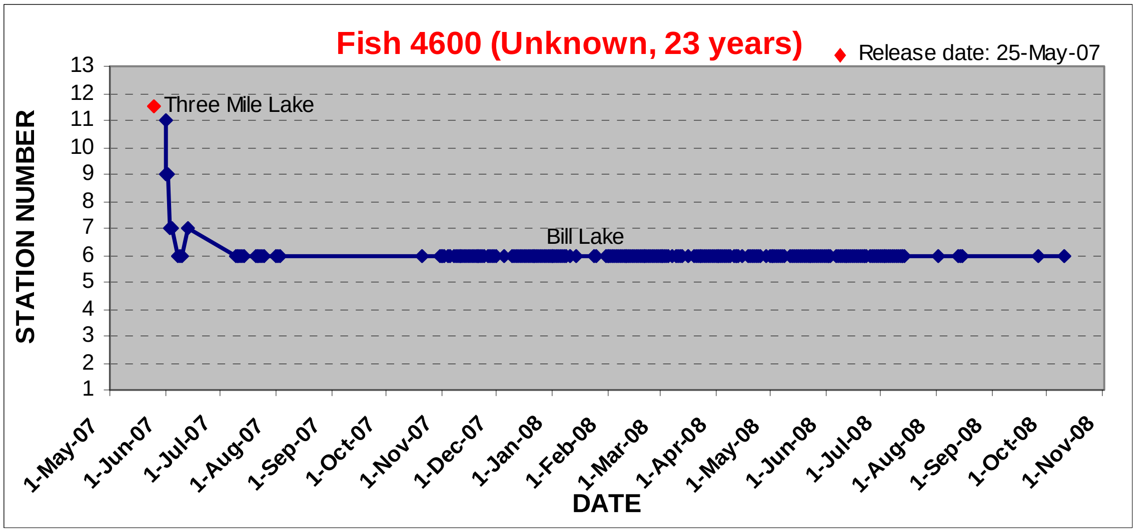
Fish 4597 (Unknown, 34 years)
Release date: 23-May-07
STATION NUMBER
Bill Lake
Three Mile Lake
13
12
11
10
9
8
7
6
5
4
3
2
1
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

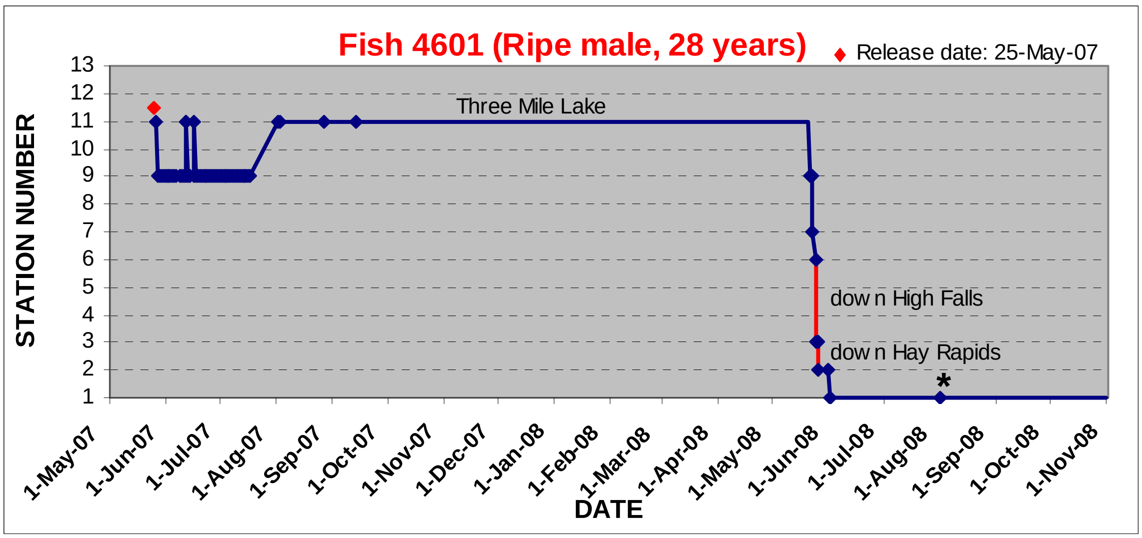


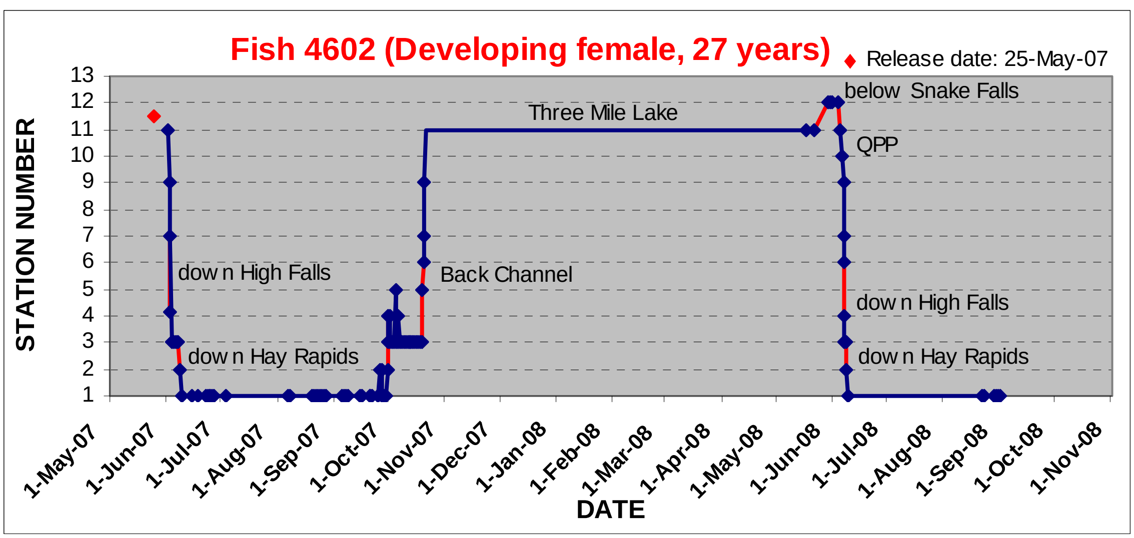
Fish 4598 (Unknown, 33 years)
Release date: 24-May-07
STATION NUMBER
Three Mile Lake
13
12
11
10
9
8
7
6
5
4
3
2
1
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

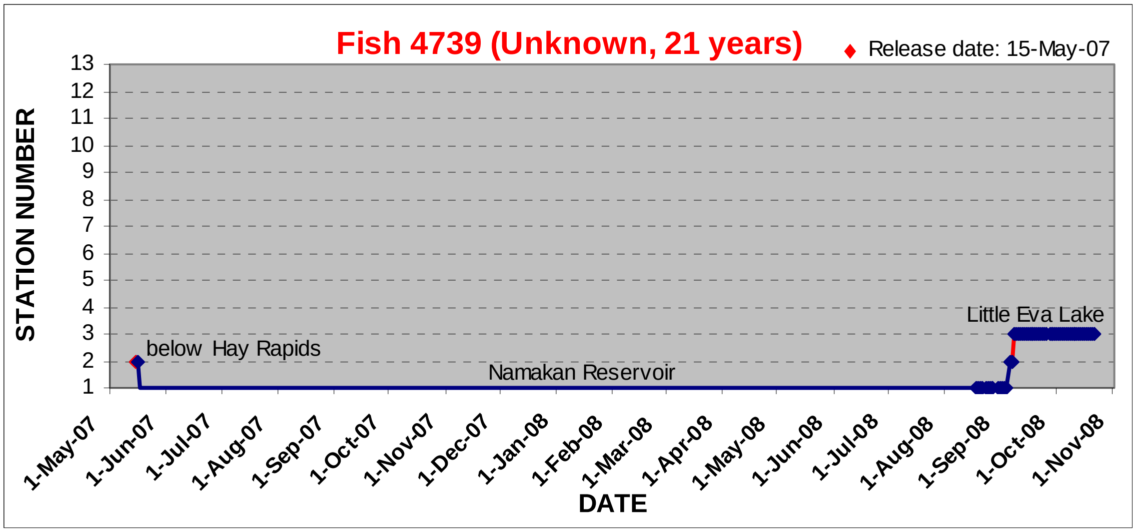


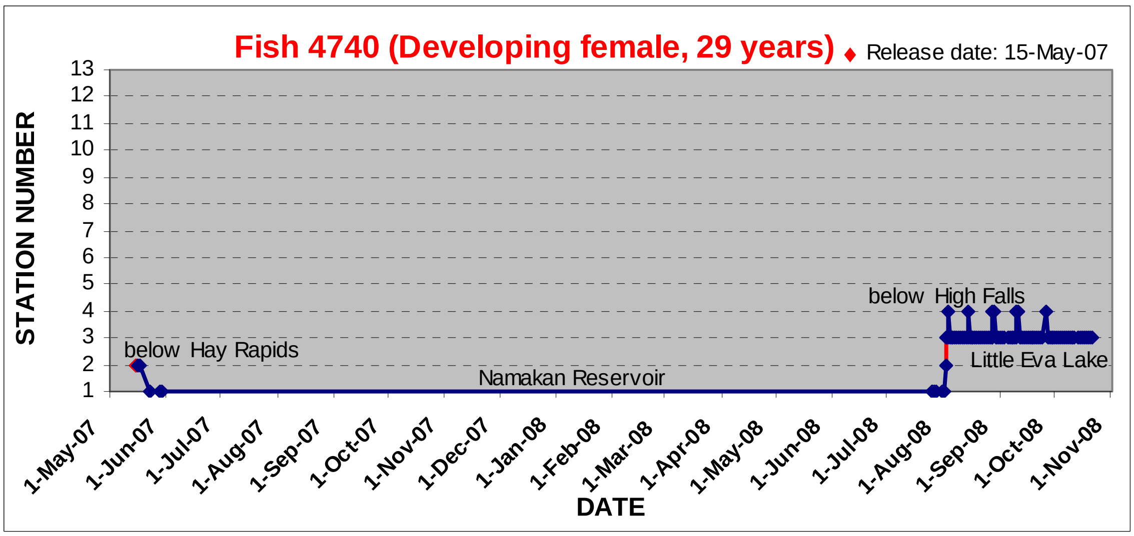
Fish 4599 (Male, 22 years)
Release date: 24-May-07
STATION NUMBER
below Snake Falls
Three Mile Lake
13
12
11
10
9
8
7
6
5
4
3
2
1
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

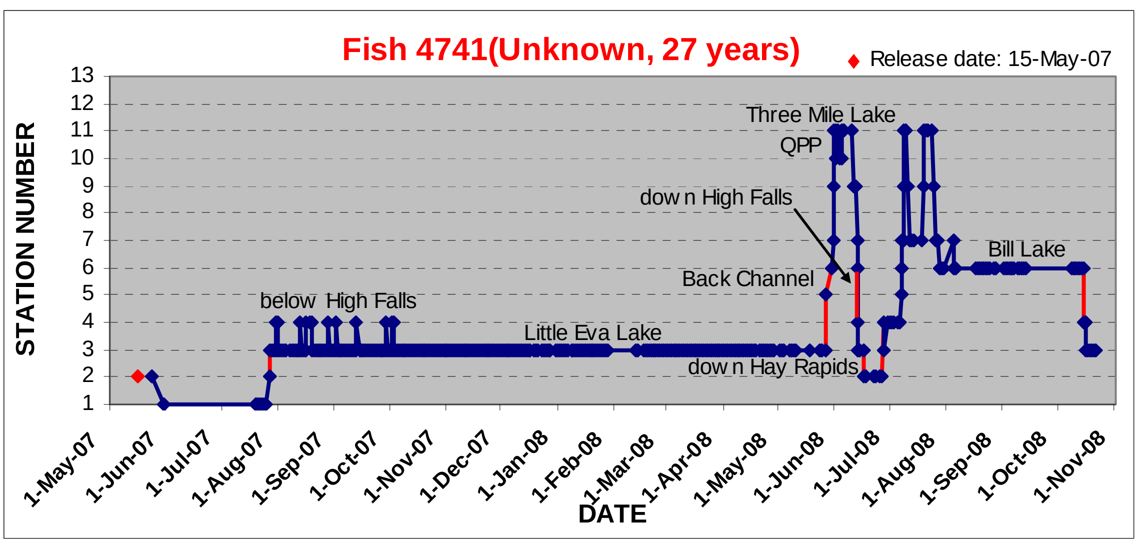

Fish 4600 (Unknown, 23 years)
Release date: 25-May-07
STATION NUMBER
Three Mile Lake
Bill Lake
DATE
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08

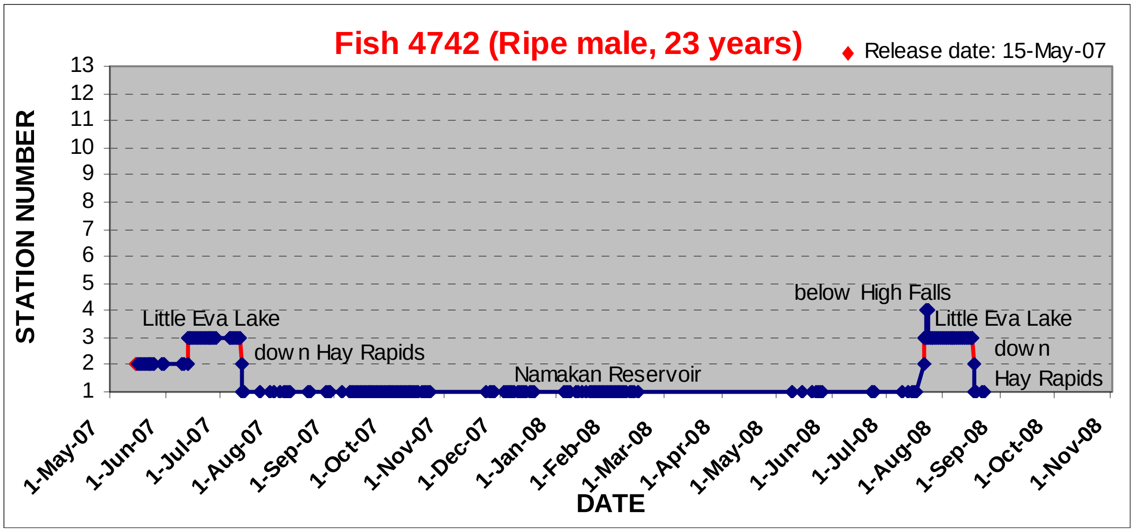

Fish 4601 (Ripe male, 28 years)
Release date: 25-May-07
STATION NUMBER
Three Mile Lake
dow n High Falls
dow n Hay Rapids
*
DATE

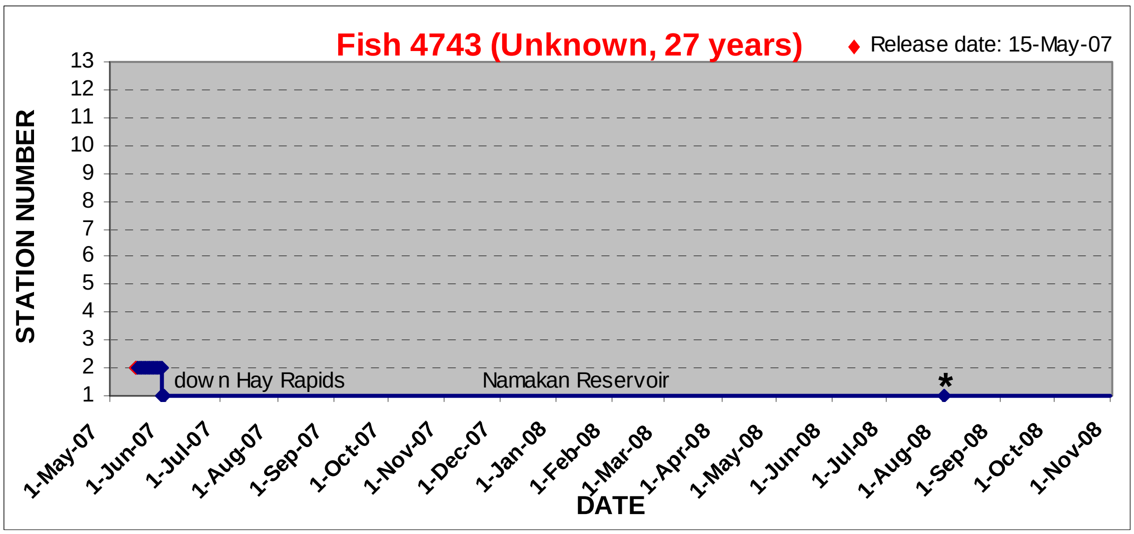

Fish 4602 (Developing female, 27 years)
Release date: 25-May-07
STATION NUMBER
below Snake Falls
Three Mile Lake
QPP
dow n High Falls
Back Channel
dow n High Falls
dow n Hay Rapids
dow n Hay Rapids
DATE

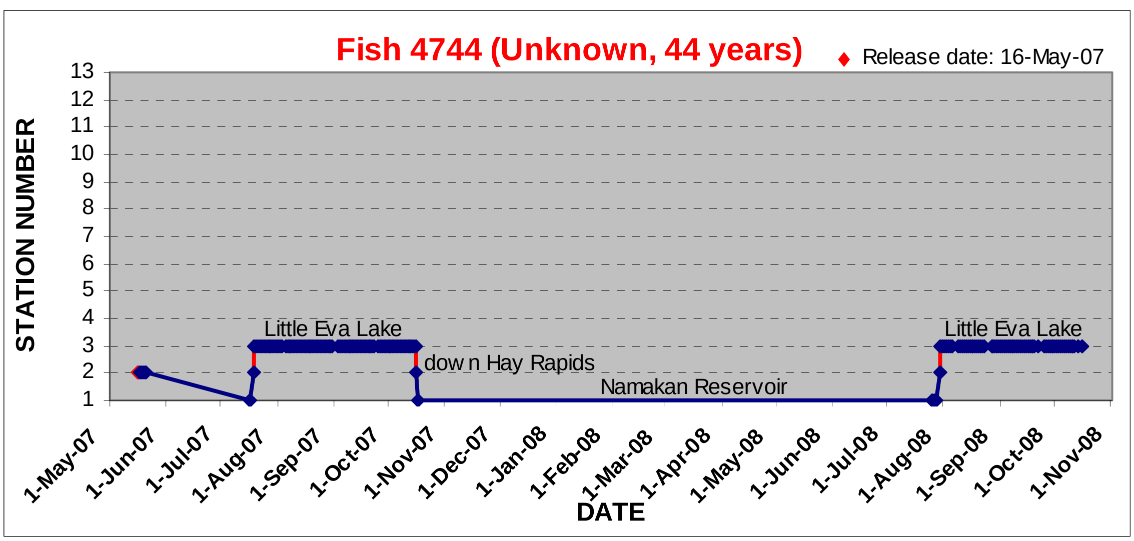

Fish 4739 (Unknown, 21 years)
Release date: 15-May-07
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Little Eva Lake
below Hay Rapids
Namakan Reservoir
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

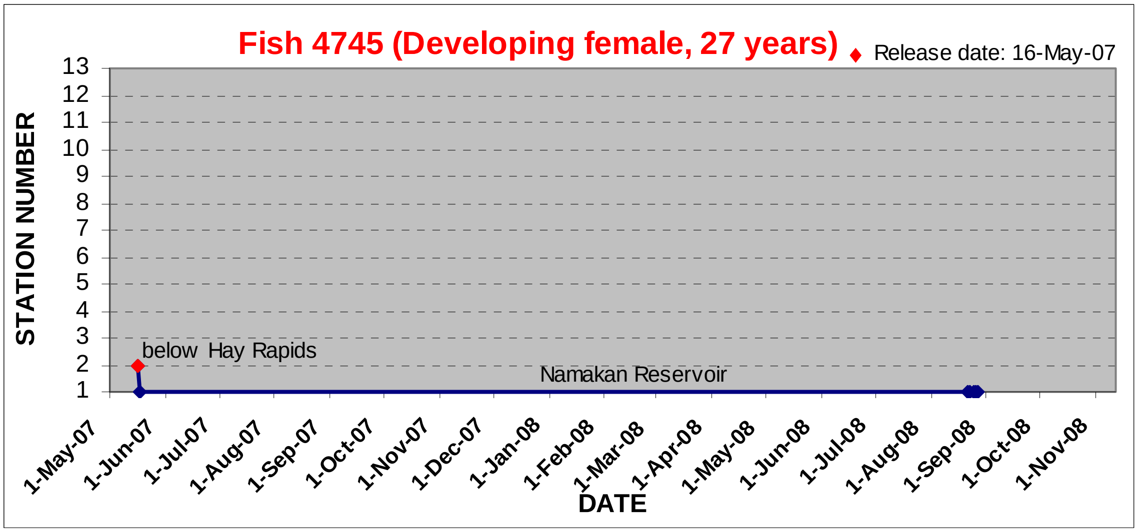

Fish 4740 (Developing female, 29 years)
Release date: 15-May-07
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
below High Falls
below Hay Rapids
Little Eva Lake
Namakan Reservoir
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

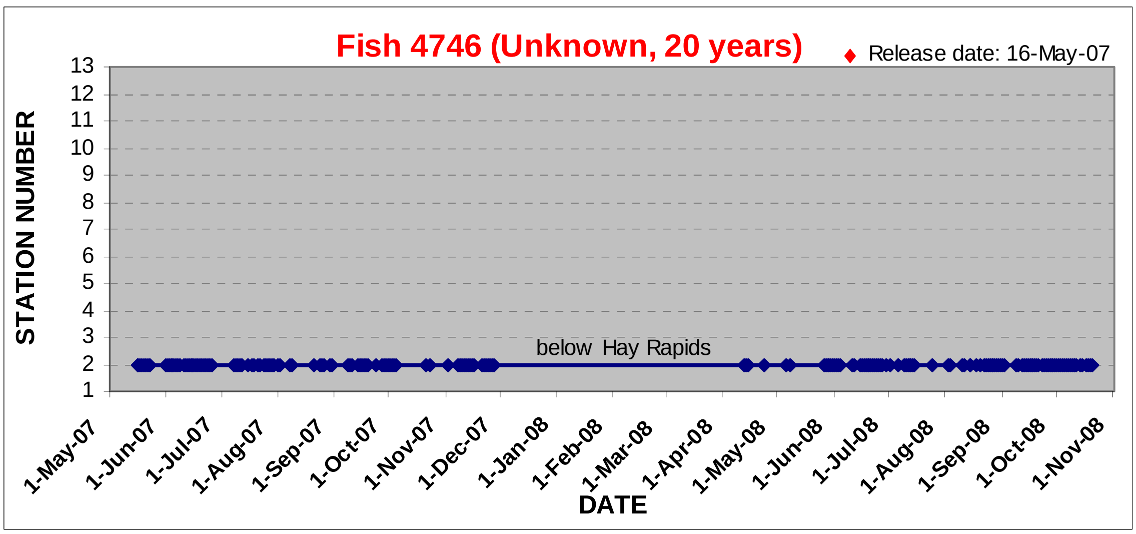

Fish 4741(Unknown, 27 years)
Release date: 15-May-07
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Three Mile Lake
QPP
dow n High Falls
Bill Lake
Back Channel
below High Falls
Little Eva Lake
dow n Hay Rapids
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

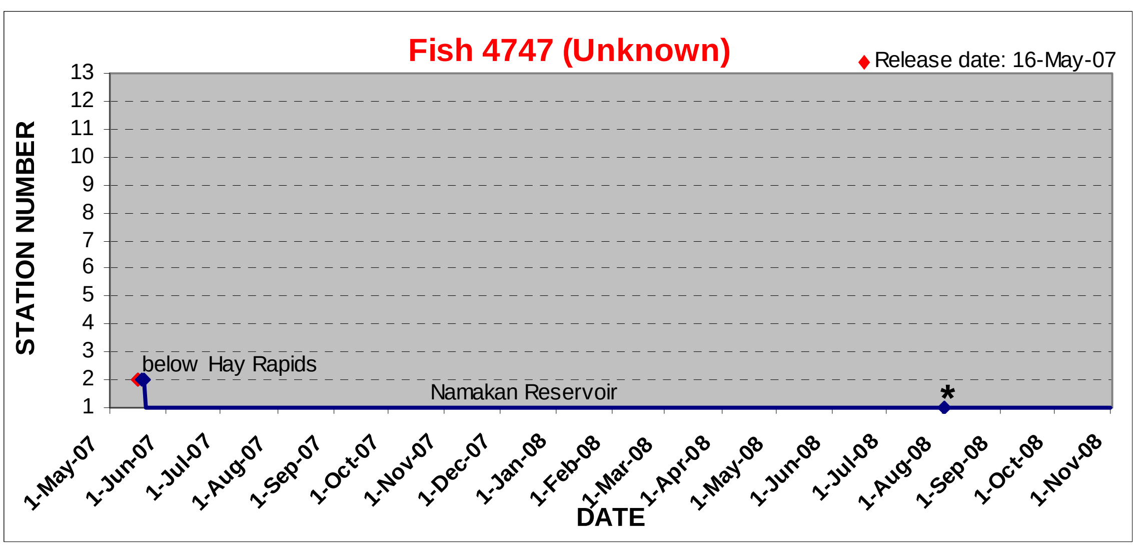

Fish 4742 (Ripe male, 23 years)
Release date: 15-May-07
STATION NUMBER
DATE
Little Eva Lake
down Hay Rapids
Namakan Reservoir
below High Falls
Little Eva Lake
down
Hay Rapids

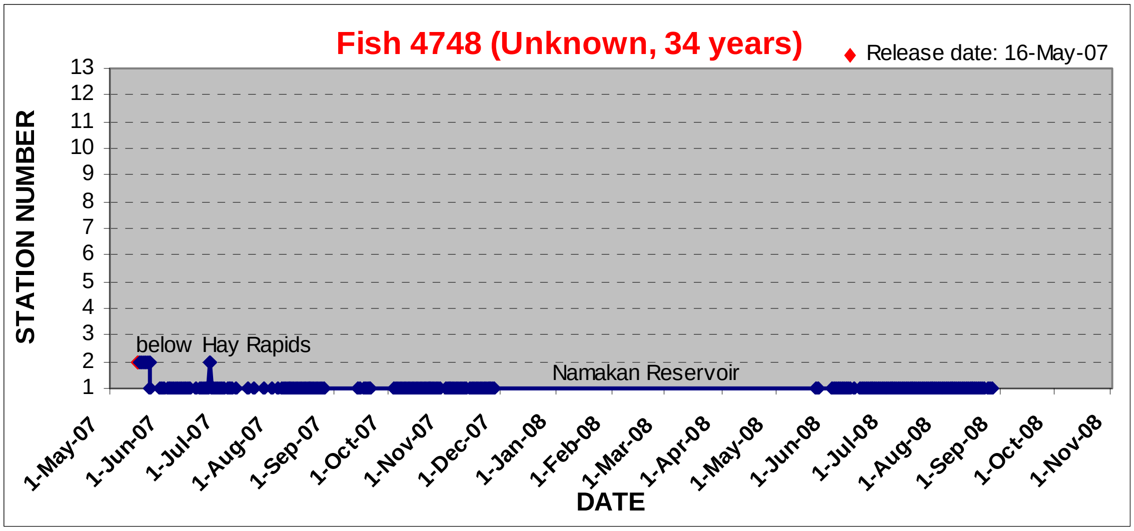

Fish 4743 (Unknown, 27 years)
Release date: 15-May-07
STATION NUMBER
DATE
down Hay Rapids
Namakan Reservoir
*

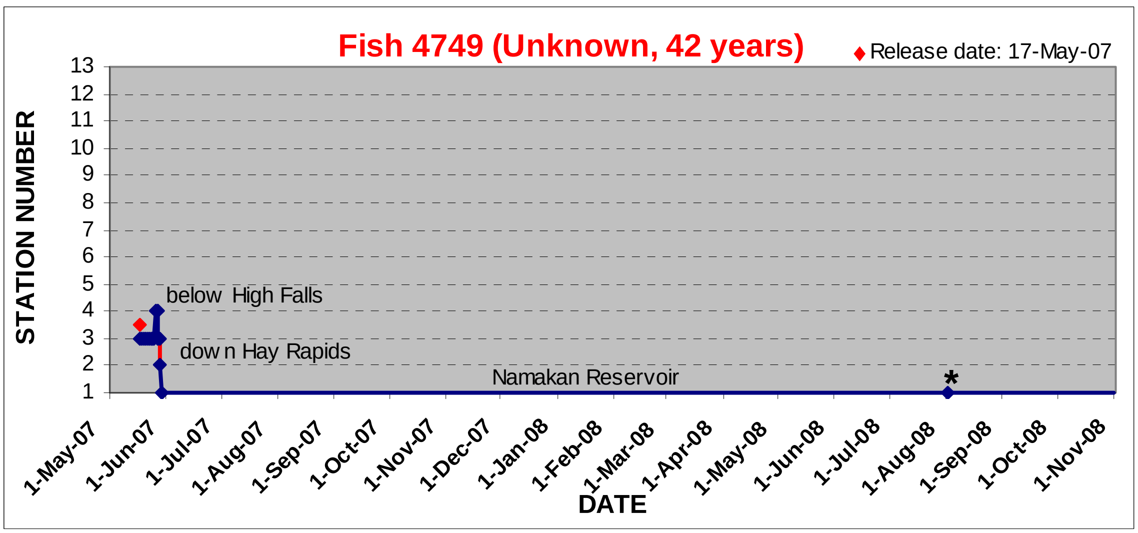

Fish 4744 (Unknown, 44 years)
Release date: 16-May-07
STATION NUMBER
DATE
Little Eva Lake
down Hay Rapids
Namakan Reservoir
Little Eva Lake

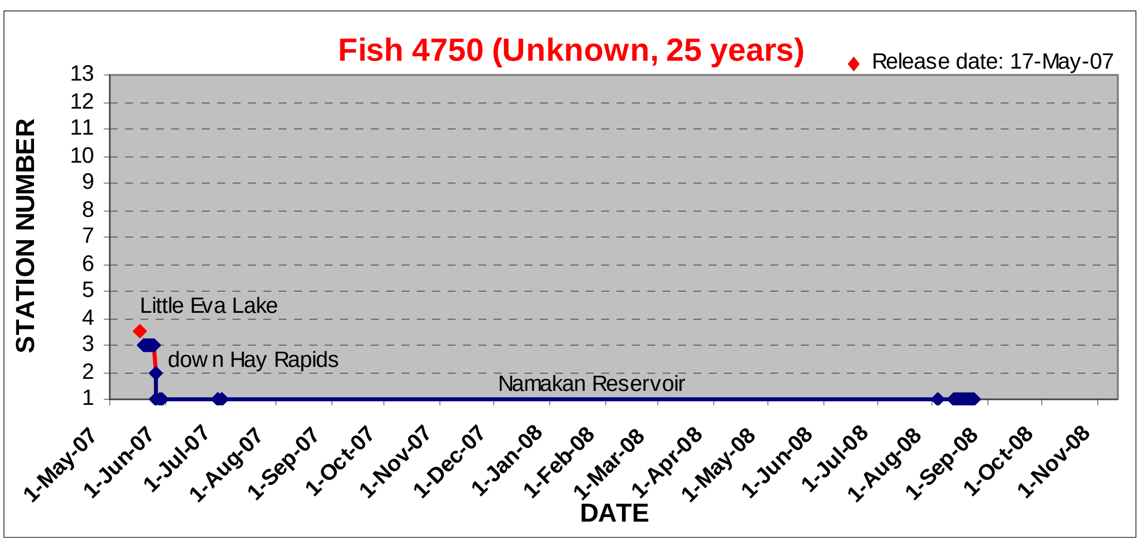

Fish 4745 (Developing female, 27 years)
Release date: 16-May-07
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
below Hay Rapids
Namakan Reservoir
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

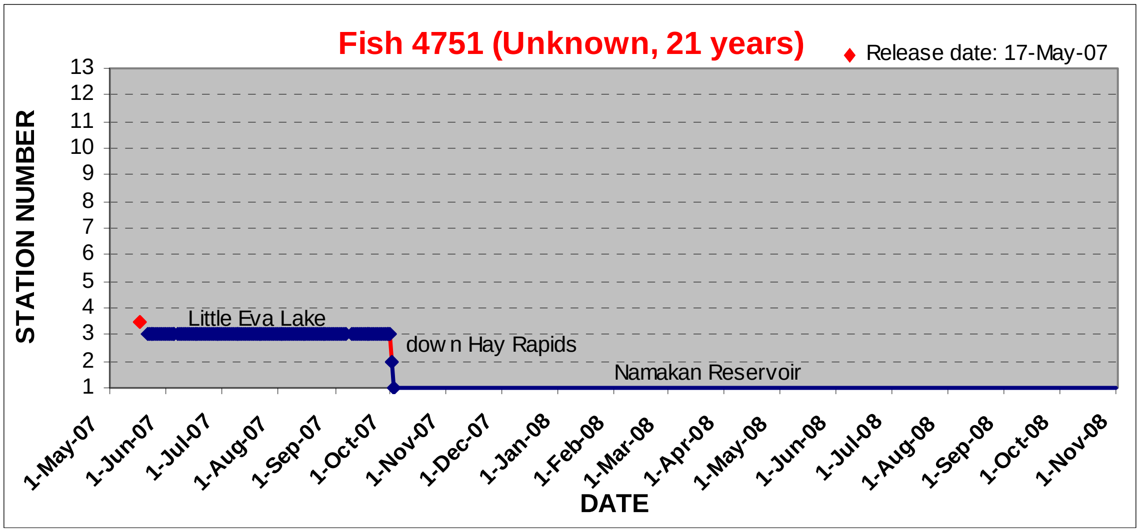

Fish 4746 (Unknown, 20 years)
Release date: 16-May-07
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
below Hay Rapids
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

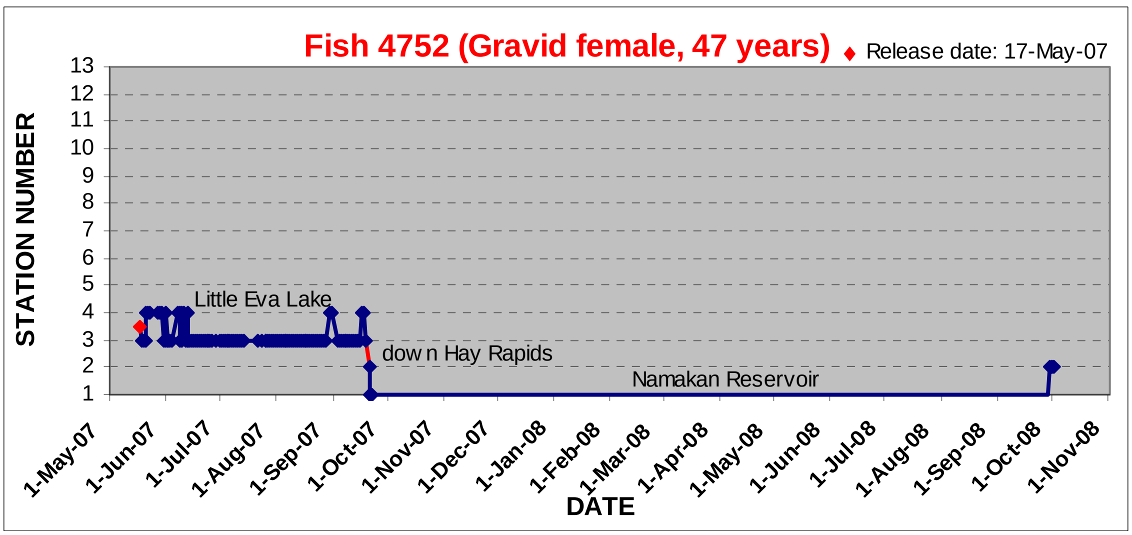

Fish 4747 (Unknown)
Release date: 16-May-07
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
below Hay Rapids
Namakan Reservoir
*
1-May-07
1-Jun-07
1-Jul-07
1-Aug-07
1-Sep-07
1-Oct-07
1-Nov-07
1-Dec-07
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

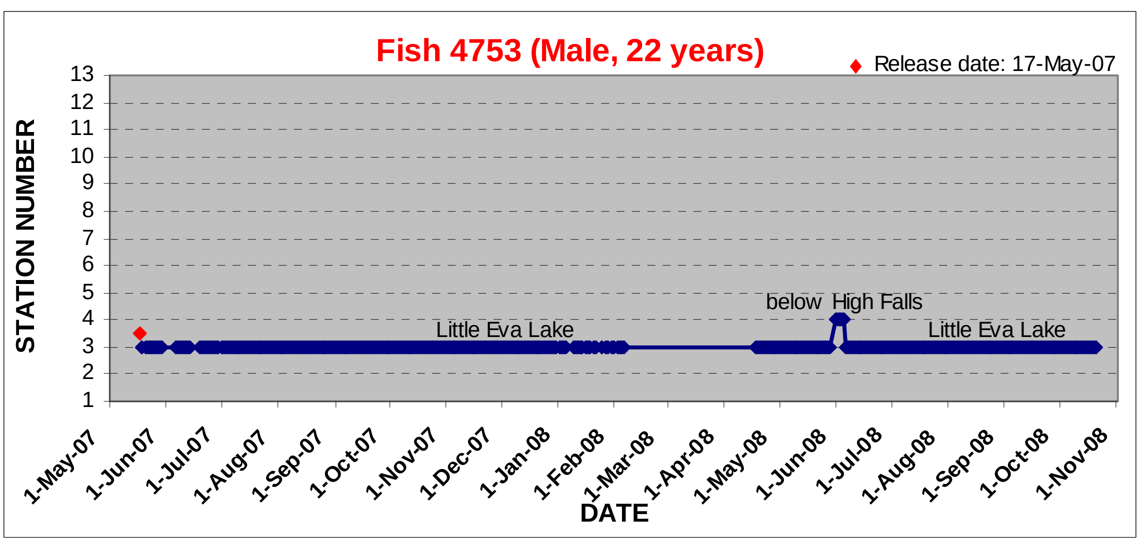

Fish 4748 (Unknown, 34 years)
Release date: 16-May-07
STATION NUMBER
below Hay Rapids
Namakan Reservoir
DATE


Fish 4749 (Unknown, 42 years)
Release date: 17-May-07
STATION NUMBER
below High Falls
dow n Hay Rapids
Namakan Reservoir
*
DATE


Fish 4750 (Unknown, 25 years)
Release date: 17-May-07
STATION NUMBER
Little Eva Lake
dow n Hay Rapids
Namakan Reservoir
DATE

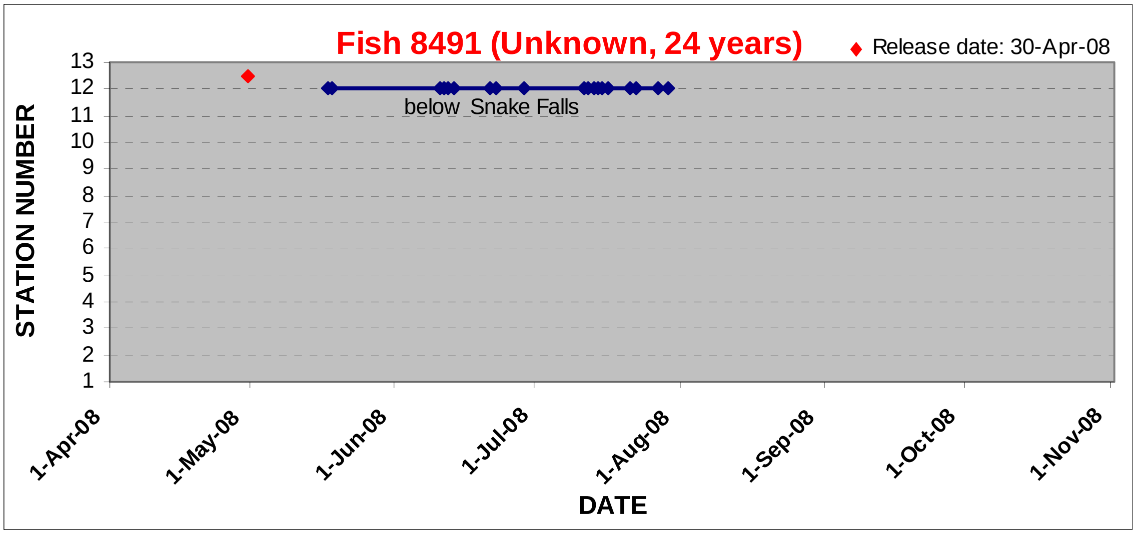


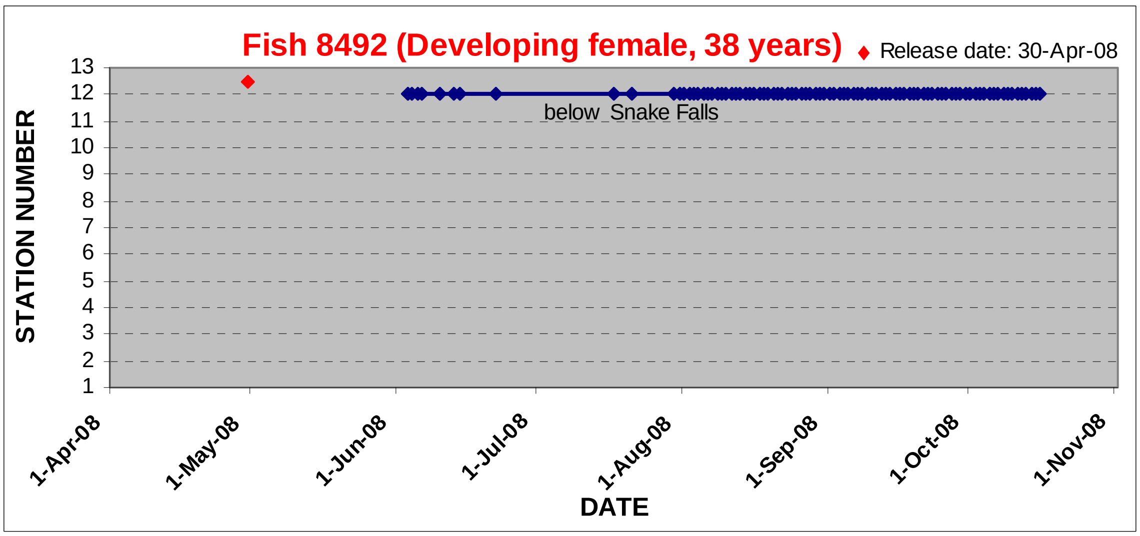


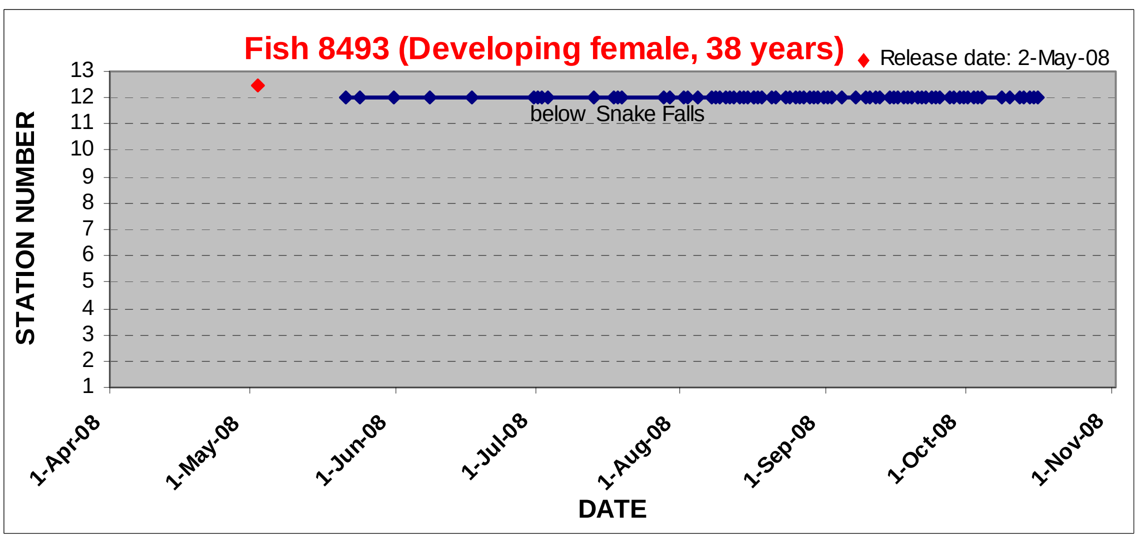


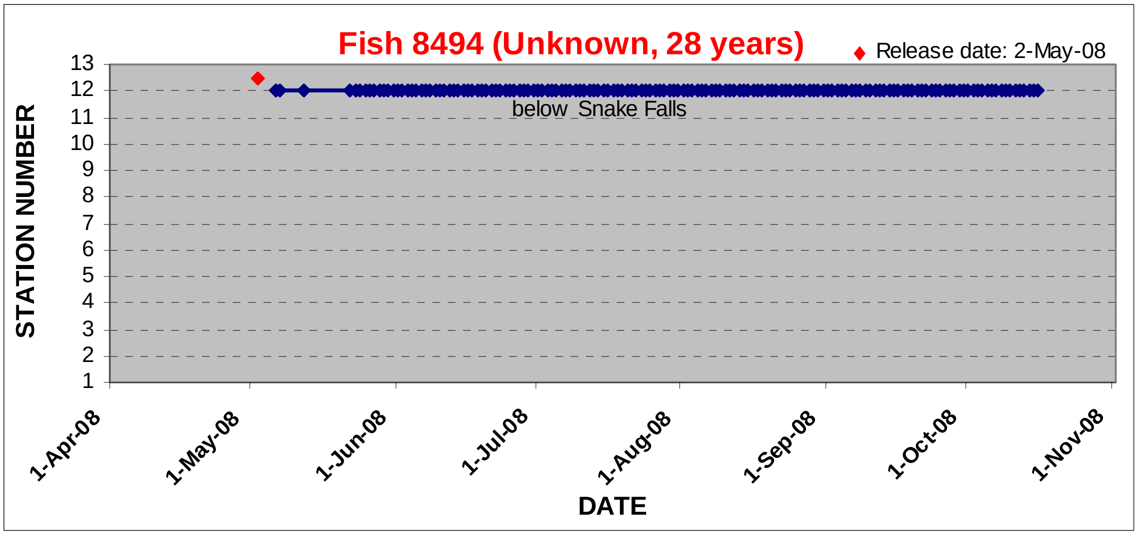
* Detected in Namakan Reservoir by the US Namakan Reservoir study.

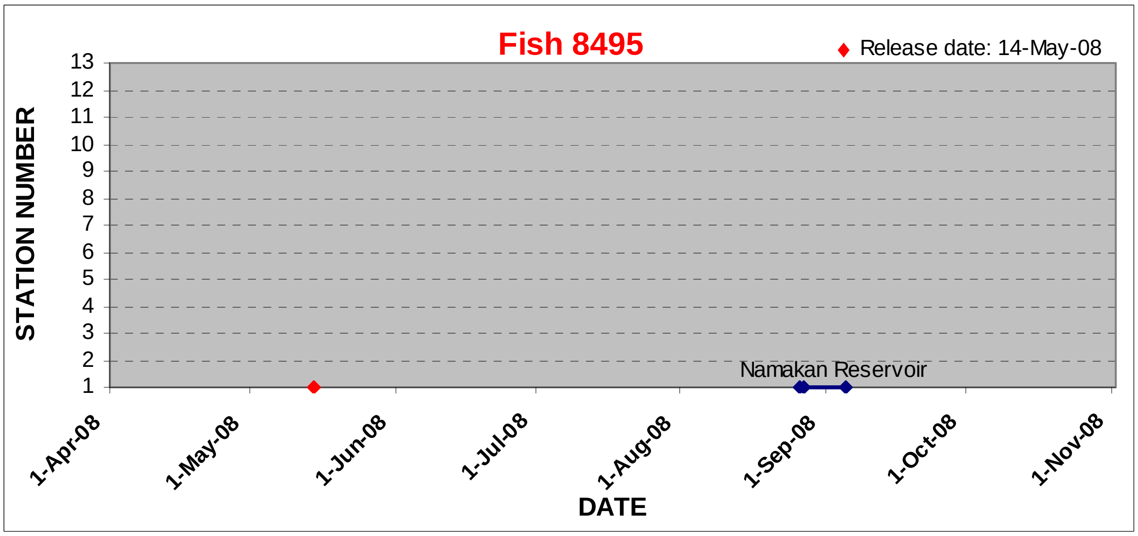
Appendix II: Movement of individual lake sturgeon released in 2008 within the Namakan River, Ontario.

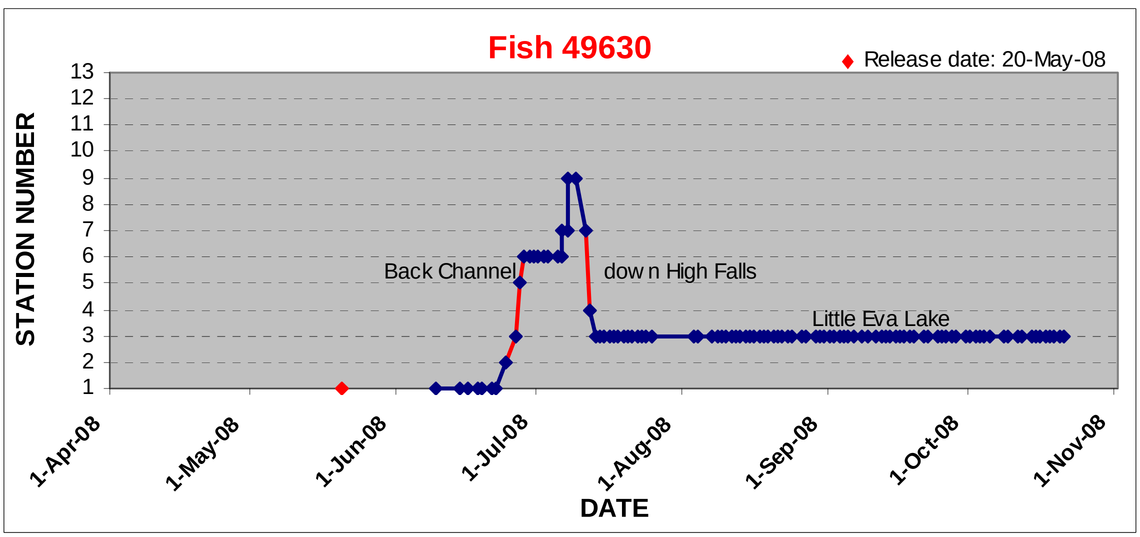


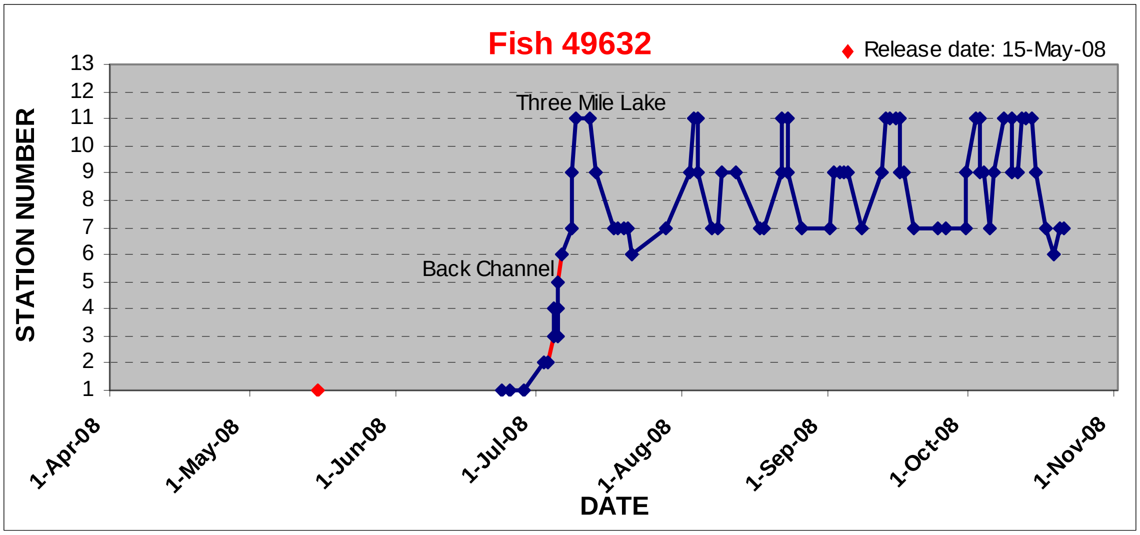


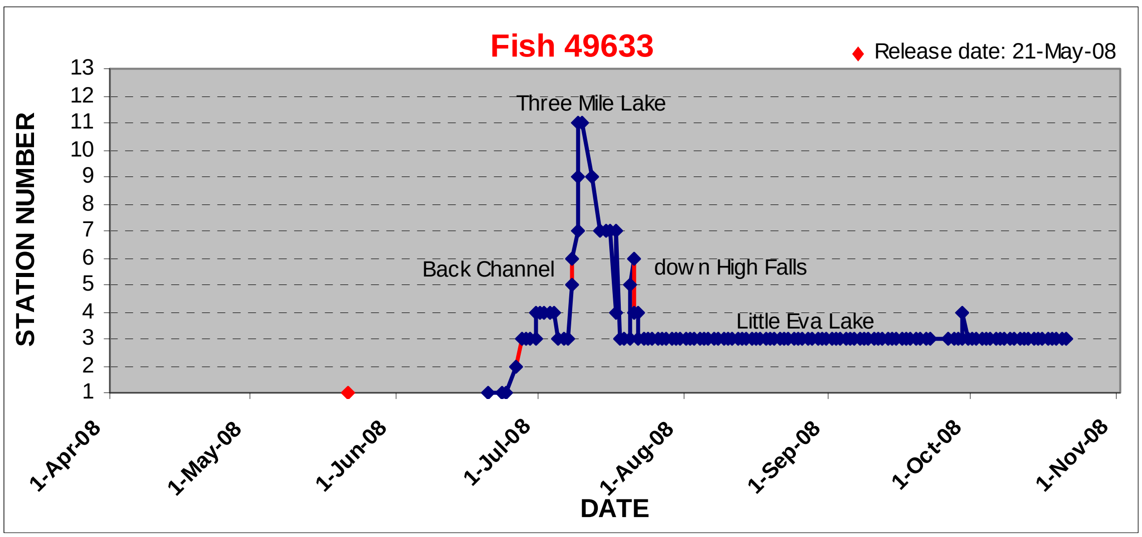


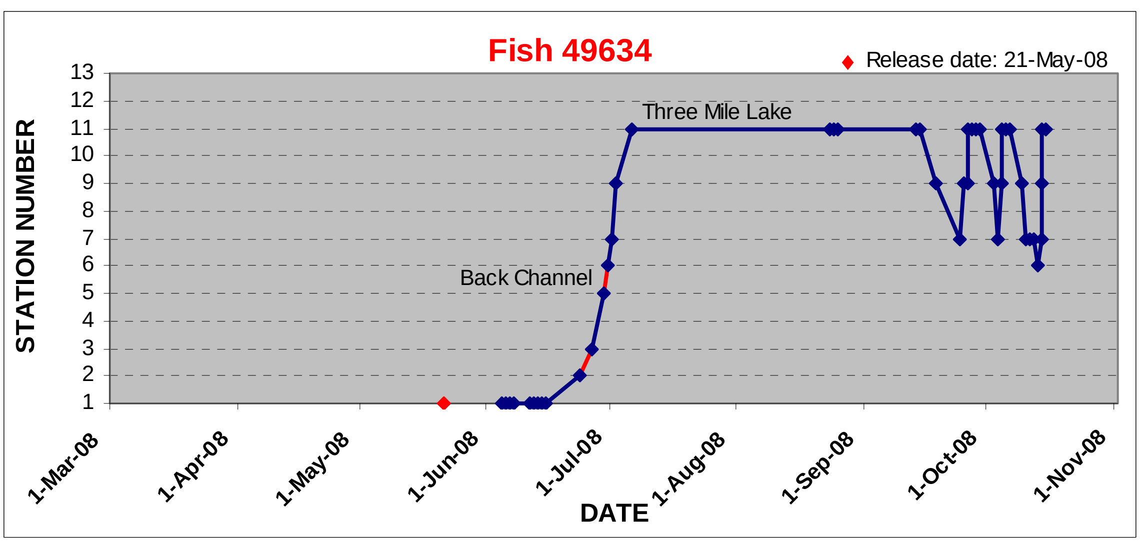

Fish 8494 (Unknown, 28 years)
Release date: 2-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
below Snake Falls
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

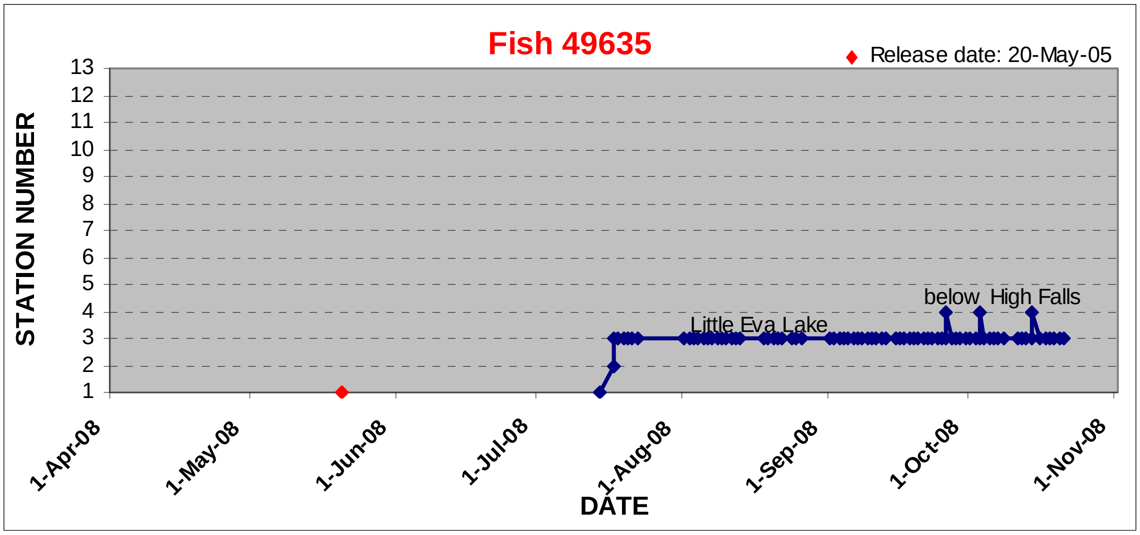

Fish 8495
Release date: 14-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Namakan Reservoir
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

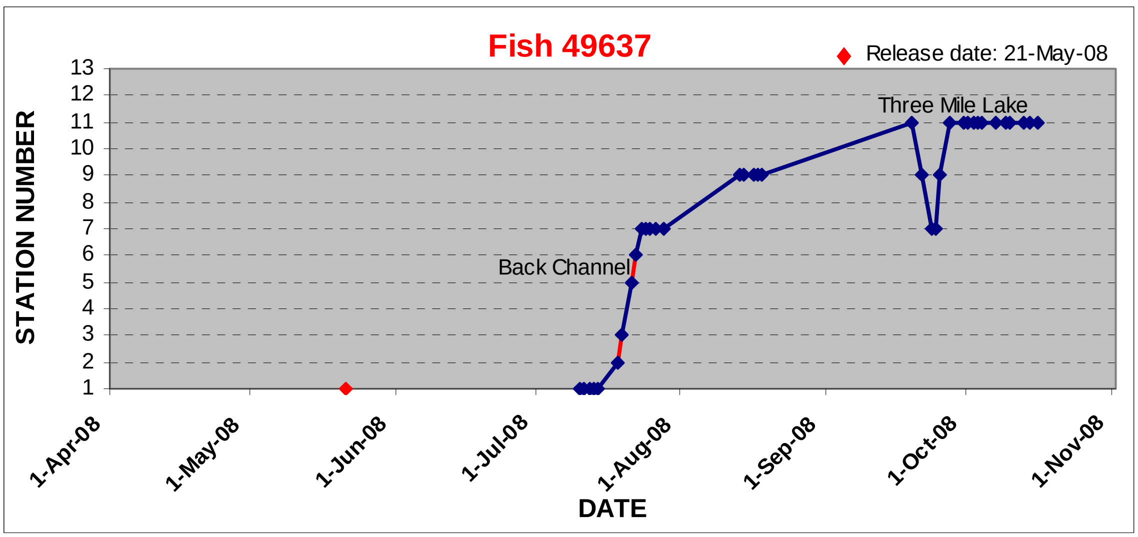

Fish 49630
Release date: 20-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Back Channel
dow n High Falls
Little Eva Lake
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

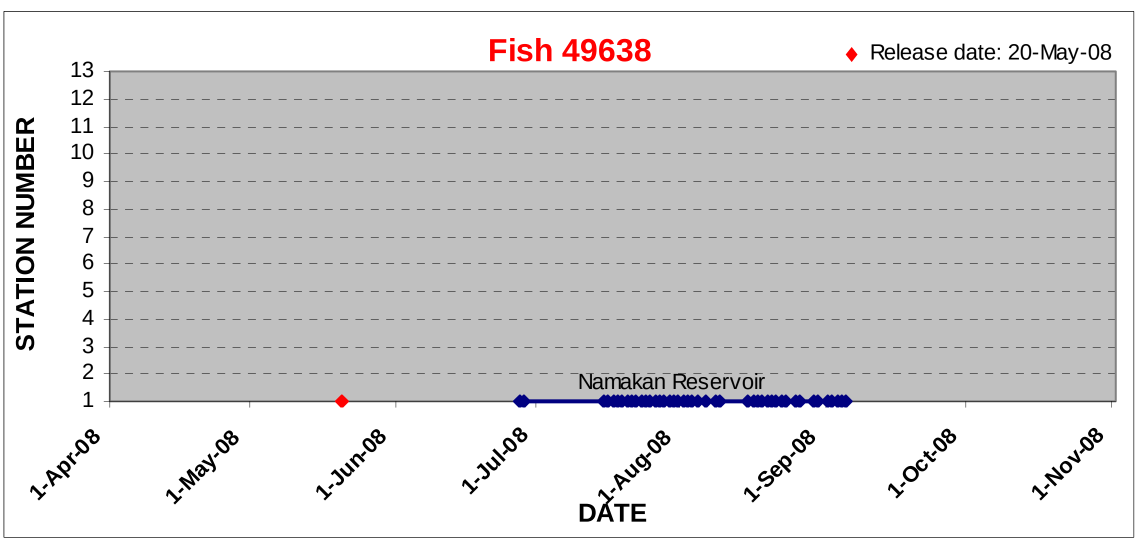

Fish 49632
Release date: 15-May-08
STATION NUMBER
Three Mile Lake
Back Channel
13
12
11
10
9
8
7
6
5
4
3
2
1
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

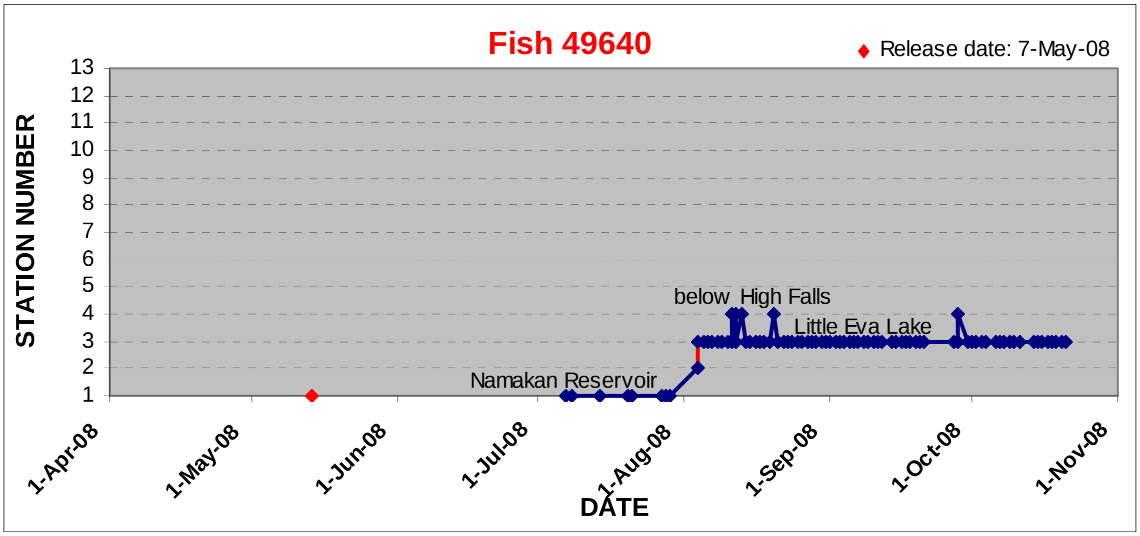

Fish 49633
Release date: 21-May-08
STATION NUMBER
Three Mile Lake
Back Channel
dow n High Falls
Little Eva Lake
13
12
11
10
9
8
7
6
5
4
3
2
1
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

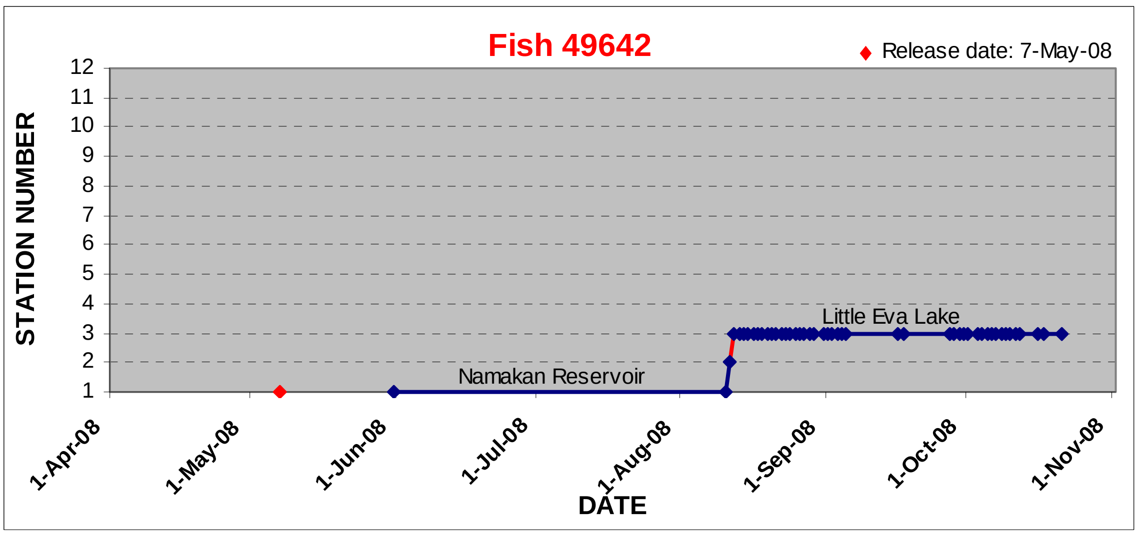

Fish 49634
Release date: 21-May-08
STATION NUMBER
Three Mile Lake
Back Channel
13
12
11
10
9
8
7
6
5
4
3
2
1
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

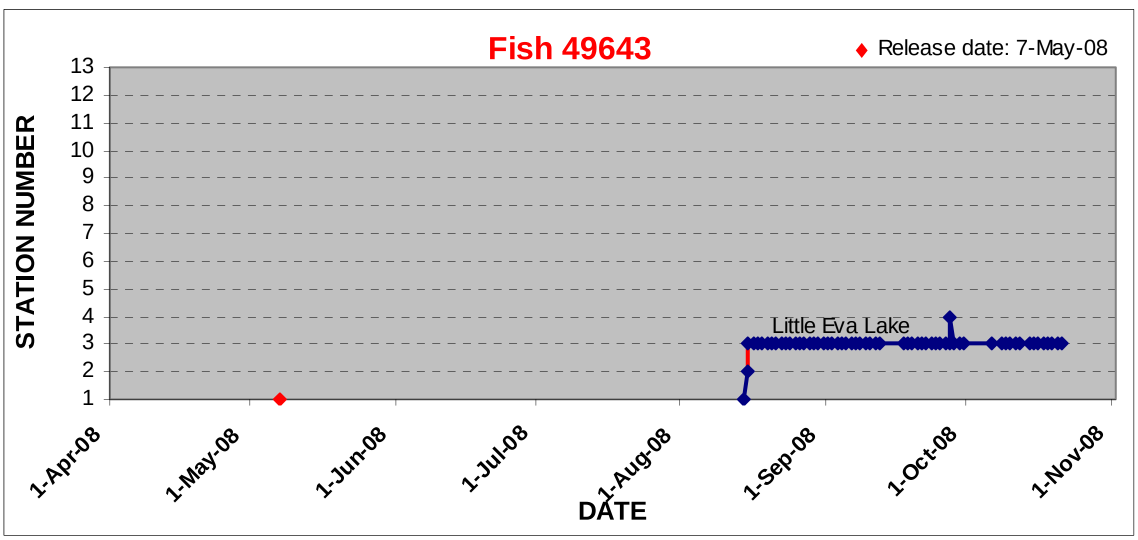

Fish 49635
Release date: 20-May-05
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Little Eva Lake
below High Falls
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

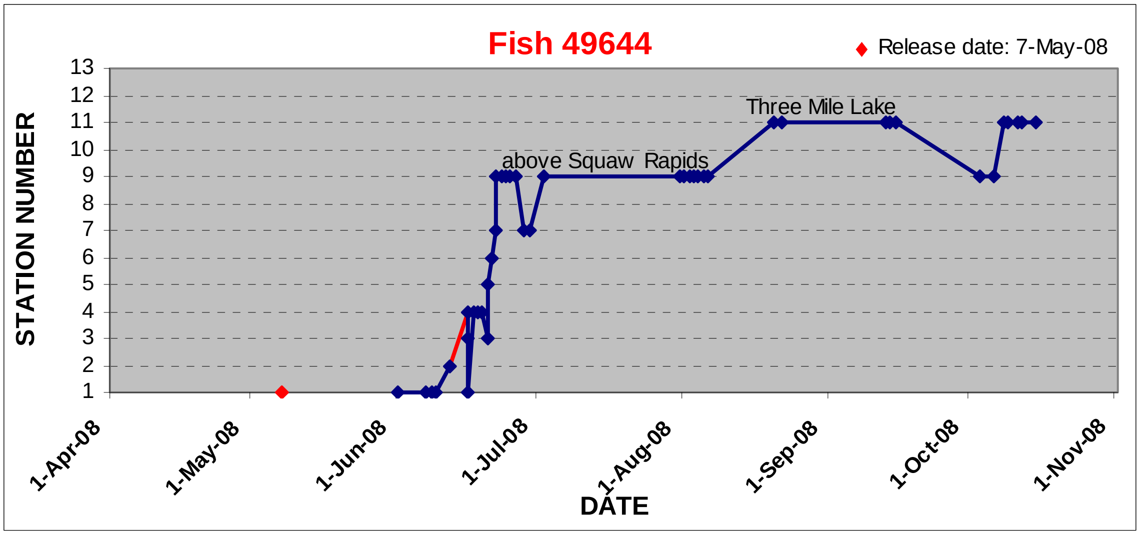

Fish 49637
Release date: 21-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Three Mile Lake
Back Channel
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

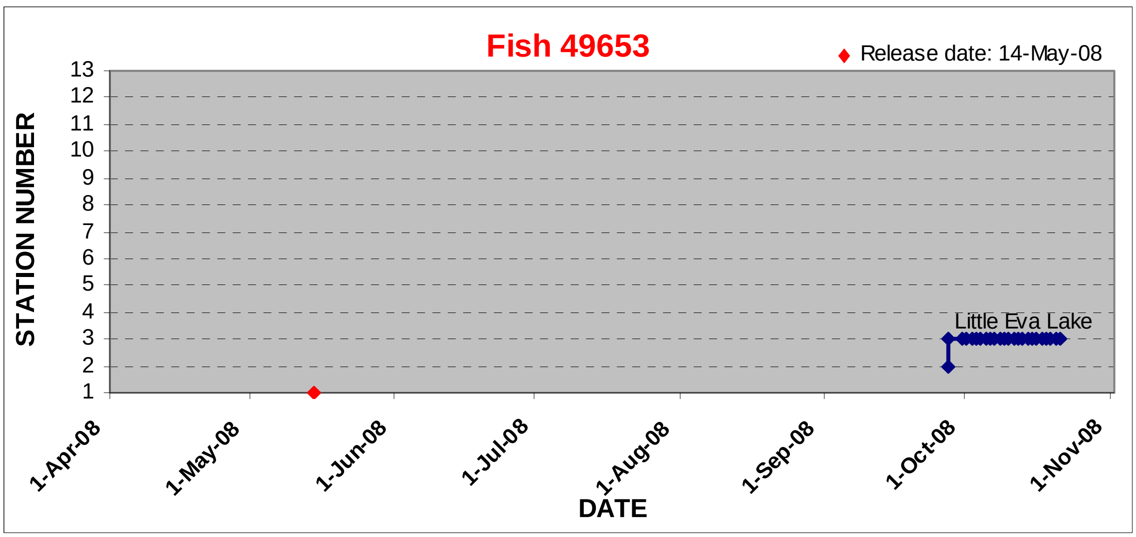

Fish 49638
Release date: 20-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Namakan Reservoir
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE


Fish 49640
Release date: 7-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
below High Falls
Little Eva Lake
Namakan Reservoir
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE


Fish 49642
Release date: 7-May-08
STATION NUMBER
12
11
10
9
8
7
6
5
4
3
2
1
Little Eva Lake
Namakan Reservoir
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE


Fish 49643
Release date: 7-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Little Eva Lake
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE


Fish 49644
Release date: 7-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Three Mile Lake
above Squaw Rapids
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE


Fish 49653
Release date: 14-May-08
STATION NUMBER
13
12
11
10
9
8
7
6
5
4
3
2
1
Little Eva Lake
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
DATE

Appendix III: Movement of lake sturgeon through proposed hydro development sites (weir locations) on Namakan River, Ontario in 2007 and 2008.

Location Description	Transmitter ID Code	Direction of Movement	Date/Time of Movement START	Date/Time of Movement END	Temperature (°C)	Water Flow (m^3/s)
Ivy/Myrtle Falls	4602	Downstream	Jun. 03, 2008 22:37	Jun. 04, 2008 22:07		409
	4592	Downstream	Jun. 06, 2008 07:38	Jun. 07, 2008 16:39		403
	4595	Downstream	Jun. 25, 2008 23:10	Jun. 28, 2008 00:46		384
	4595	Downstream	Jul. 01, 2008 21:24	Jul. 02, 2008 12:53		358
	4592	Downstream	Jul. 21, 2008 04:08	Jul. 21, 2008 13:37		238
	4599	Downstream	Jul. 27, 2008 20:33	Jul. 28, 2008 18:42		197
	4602	Upstream	May 21, 2008 23:56	May 29, 2008 18:40		464
	4592	Upstream	Jun. 01, 2008 20:41	Jun. 02, 2008 19:50		431
	4592	Upstream	Jun. 22, 2008 13:24	Jun. 22, 2008 21:50		403
	4595	Upstream	Jun. 24, 2008 12:21	Jun. 24, 2008 21:30		396
	4599	Upstream	Jun. 25, 2008 00:13	Jul. 03, 2008 00:38		391
	4595	Upstream	Jun. 30, 2008 14:18	Jul. 01, 2008 13:07		373
High Falls	4602	Downstream	Jun. 03, 2007 18:24	Jun. 05, 2007 02:31	17.6	64
	4594	Downstream	Jun. 10, 2007 02:19	Jun. 11, 2007 01:41	17.9	77
	4602	Downstream	Jun. 07, 2008 07:04	Jun. 08, 2008 10:03		403
	49630	Downstream	Jul. 11, 2008 18:46	Jul. 12, 2008 11:05		287
	49633	Downstream	Jul. 17, 2008 04:52	Jul. 17, 2008 12:48		260
	49633	Downstream	Jul. 21, 2008 02:44	Jul. 22, 2008 05:51		238
	4741	Downstream	Oct. 15, 2008 05:15	Oct. 15, 2008 21:28		99
Back Channel	4593	Downstream	Oct. 15, 2007 22:48	Oct. 16, 2007 06:15	11.2	
	4601	Downstream	May 23, 2008 21:05	May 24, 2008 17:01		
	4602	Downstream	Jun. 07, 2008 07:04	Jun. 07, 2008 12:25		
	4741	Downstream	Jun. 13, 2008 04:24	Jun. 13, 2008 15:36		
	4592	Downstream	Jun. 19, 2008 01:41	Jun. 19, 2008 13:05		
	4602	Upstream	Oct. 4, 2007 19:40	Return to Little Eva Lake	14.8	
	4602	Upstream	Oct. 19, 2007 04:34	Oct. 19, 2007 20:27	11.1	
	4592	Upstream	May 21, 2008 19:40	Return to Little Eva Lake		

Back Channel	4592	Upstream	May 23, 2008	00:35	May 25, 2008	03:34		
	4741	Upstream	May 27, 2008	06:18	May 30, 2008	12:38		
	4592	Upstream	Jun. 19, 2008	15:29	Jun. 20, 2008	00:41		
	49644	Upstream	Jun. 20, 2008	17:16	Jun. 21, 2008	03:58		
	49630	Upstream	Jun. 26, 2008	21:10	Jun. 27, 2008	21:55		
	49634	Upstream	Jun. 28, 2008	23:50	Jun. 30, 2008	07:57		
	49632	Upstream	Jul. 05, 2008	17:04	Jul. 06, 2008	13:44		
	4741	Upstream	Jul. 07, 2008	00:30	Jul. 07, 2008	11:26		
	49633	Upstream	Jul. 07, 2008	20:56	Jul. 08, 2008	14:52		
	49633	Upstream	Jul. 19, 2008	23:20	Jul. 20, 2008	19:19		
	49637	Upstream	Jul. 20, 2008	20:48	Jul. 22, 2008	15:59		
Hay Rapids	4588	Downstream	May 24, 2007	23:12	May 25, 2007	23:13	15.0	56
	4750	Downstream	May 25, 2007	02:23	May 25, 2007	23:47	14.9	56
	4589	Downstream	May 25, 2007	03:02	May 27, 2007	02:13	14.9	56
	4749	Downstream	May 28, 2007	01:32	May 28, 2007	05:38	14.0	59
	4602	Downstream	Jun. 07, 2007	11:36	Jun. 08, 2007	05:51	17.7	70
	4591	Downstream	Jun. 07, 2007	12:53	Jun. 08, 2007	03:03	17.7	70
	4594	Downstream	Jun. 12, 2007	08:31	Jun. 12, 2007	17:53	19.1	83
	4590	Downstream	Jun. 18, 2007	05:53	Jun. 19, 2007	22:46	21.9	99
	4742	Downstream	Jul. 11, 2007	11:45	Jul. 12, 2007	00:24	22.0	107
	4752	Downstream	Sept. 19, 2007	04:40	Sept. 20, 2007	23:57	15.2	39
	4751	Downstream	Sept. 30, 2007	19:24	Oct. 1, 2007	22:54	15.4	99
	4744	Downstream	Oct. 15, 2007	22:11	Oct. 16, 2007	13:41	11.5	272
	4593	Downstream	Oct. 17, 2007	00:49	Oct. 17, 2007	08:18	11.0	293
	4601	Downstream	May 24, 2008	20:57	May 25, 2008	13:28		467
	4602	Downstream	Jun. 08, 2008	06:06	Jun. 08, 2008	09:33		402
	4741	Downstream	Jun. 16, 2008	10:32	Jun. 17, 2008	01:32		411
	4742	Downstream	Aug. 17, 2008	02:05	Aug. 17, 2008	22:03		115
	4742	Upstream	Jun. 12, 2007	03:12	Jun. 12, 2007	14:52	19.1	83
	4744	Upstream	Jul. 19, 2007	09:37	Jul. 19, 2007	17:59	21.8	94
	4741	Upstream	Jul. 26, 2007	22:10	Jul. 27, 2007	10:02	24.9	80
	4602	Upstream	Sept. 29, 2007	23:22	Sept. 30, 2007	06:56	15.4	99
	49644	Upstream	Jun. 11, 2008	23:09	Jun. 16, 2008	10:49		411
	49634	Upstream	Jun. 23, 2008	16:00	Jun. 25, 2008	23:41		391

Hay Rapids	49630	Upstream	Jun. 24, 2008 15:45	Jun. 26, 2008 09:52		386
	49633	Upstream	Jun. 25, 2008 23:21	Jun. 27, 2008 16:12		383
	4741	Upstream	Jun. 26, 2008 05:08	Jun. 27, 2008 00:45		383
	49632	Upstream	Jul. 02, 2008 19:27	Jul. 03, 2008 23:10		350
	49635	Upstream	Jul. 17, 2008 05:35	Jul. 17, 2008 11:57		260
	49637	Upstream	Jul. 18, 2008 18:21	Jul. 19, 2008 03:14		249
	4742	Upstream	Jul. 21, 2008 00:43	Jul. 21, 2008 15:22		238
	4744	Upstream	Jul. 29, 2008 20:41	Jul. 30, 2008 08:53		185
	4740	Upstream	Aug. 02, 2008 09:45	Aug. 02, 2008 17:35		173
	4588	Upstream	Aug. 03, 2008 21:37	Aug. 04, 2008 19:42		163
	49640	Upstream	Aug. 04, 2008 05:57	Aug. 04, 2008 11:40		163
	49642	Upstream	Aug. 10, 2008 20:22	Aug. 12, 2008 07:45		132
	49643	Upstream	Aug. 15, 2008 03:02	Aug. 15, 2008 11:15		122
	4739	Upstream	Sept. 6, 2008 22:44	Sept. 7, 2008 22:43		70
	49653	Upstream	Sept. 27, 2008 02:14	Sept. 27, 2008 06:36		67

Appendix IV: Movement of lake sturgeon through other flowing (undeveloped) rapids on Namakan River, Ontario in 2007 and 2008.

Location Description	Transmitter ID Code	Direction of Movement	Date/Time of Movement START	Date/Time of Movement END	Temperature (°C)	Water Flow (m^3/s)
Twisted Rapids	4600	Downstream	Jun. 02, 2007 04:29	Jun. 03, 2007 09:51	16.4	62
	4602	Downstream	Jun. 02, 2007 20:25	Jun. 03, 2007 17:09	16.4	65
	4594	Downstream	Jun. 09, 2007 04:13	Jun. 09, 2007 16:48	17.6	74
	4593	Downstream	Jun. 11, 2007 21:42	Jun. 12, 2007 05:50	18.3	80
	4593	Downstream	Jun. 18, 2007 07:22	Jun. 18, 2007 14:11	21.9	99
	4593	Downstream	Jul. 04, 2007 00:44	Jul. 10, 2007 07:27	21.1	114
	4593	Downstream	Jul. 23, 2007 23:54	Jul. 24, 2007 10:57	22.9	85
	4593	Downstream	Oct. 1, 2007 03:04	Oct. 3, 2007 23:13	14.9	121
	4600	Downstream	-	May 21, 2008 17:09		464
	4597	Downstream	May 28, 2008 10:44	May 29, 2008 13:07		446
	4602	Downstream	Jun. 06, 2008 16:30	Jun. 06, 2008 22:38		407
	4741	Downstream	Jun. 10, 2008 12:47	Jun. 11, 2008 13:41		407
	4592	Downstream	Jun. 13, 2008 06:39	Jun. 14, 2008 05:19		407
	4595	Downstream	Jun. 28, 2008 02:24	Jun. 28, 2008 07:34		384
	4595	Downstream	Jun. 29, 2008 12:50	Jun. 29, 2008 17:05		380
	4595	Downstream	Jul. 07, 2008 08:12	Jul. 07, 2008 23:10		315
	49633	Downstream	Jul. 10, 2008 00:38	Jul. 12, 2008 04:16		283
	4741	Downstream	Jul. 10, 2008 18:03	Jul. 11, 2008 17:11		287
	49632	Downstream	Jul. 12, 2008 03:06	Jul. 13, 2008 14:43		278
	4741	Downstream	Jul. 24, 2008 15:17	Jul. 25, 2008 06:27		213
	4595	Downstream	Jul. 29, 2008 17:39	Sept. 28, 2008 01:00		69
	49632	Downstream	Aug. 04, 2008 03:47	Aug. 04, 2008 11:32		163
	49632	Downstream	Aug. 23, 2008 08:09	Aug. 23, 2008 13:07		96
	49634	Downstream	Sept. 14, 2008 06:21	Sept. 17, 2008 22:34		65
	49644	Downstream	Sept. 15, 2008 02:41	Oct. 3, 2008 00:43		76
	49632	Downstream	Sept. 16, 2008 04:14	Sept. 16, 2008 15:47		65
	49637	Downstream	Sept. 19, 2008 00:59	Sept. 21, 2008 16:46		61
	49634	Downstream	Sept. 29, 2008 18:57	Oct. 1, 2008 19:15		73

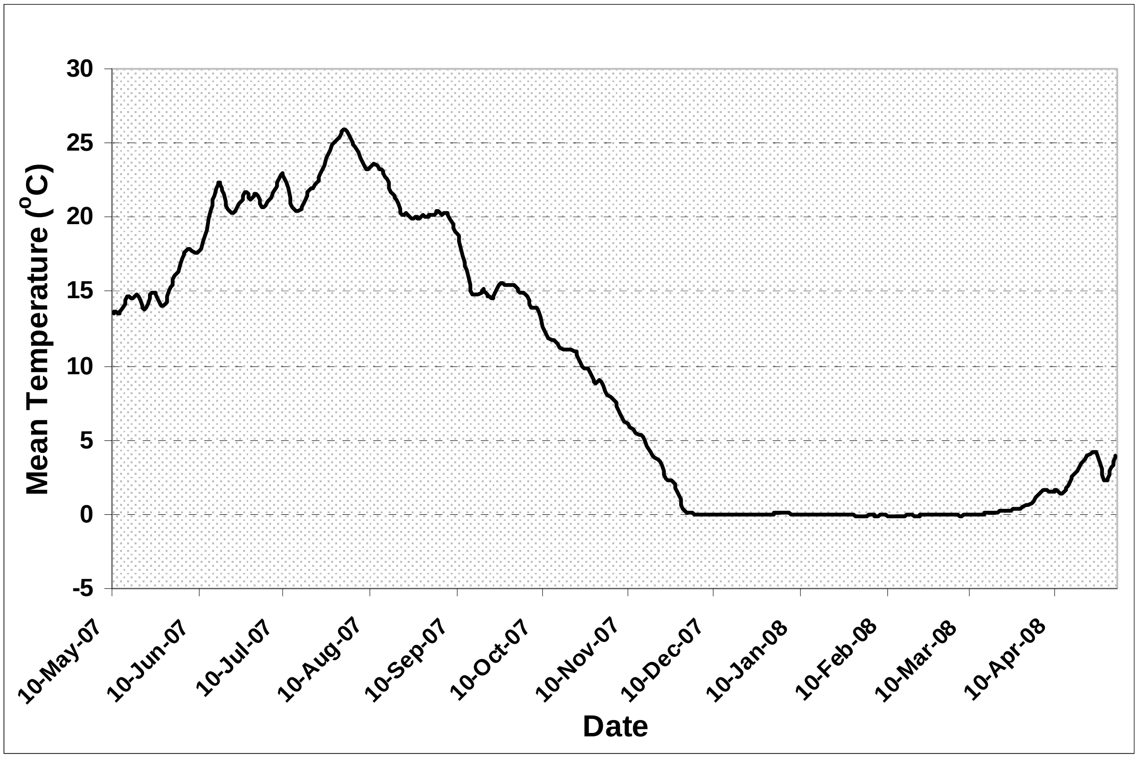
Twisted Rapids	49632	Downstream	Oct. 02, 2008 23:09	Oct. 3, 2008 18:28		76
	49634	Downstream	Oct. 06, 2008 01:26	Oct. 9, 2008 07:02		83
	49632	Downstream	Oct. 10, 2008 22:46	Oct. 10, 2008 06:45		87
	49632	Downstream	Oct. 13, 2008 19:03	Oct. 14, 2008 21:33		98
	4593	Upstream	May 23, 2007 21:21	May 25, 2007 22:17	14.9	56
	4595	Upstream	May 26, 2007 14:13	May 27, 2007 19:08	14.1	58
	4594	Upstream	May 27, 2007 07:44	May 27, 2007 22:40	14.1	58
	4593	Upstream	Jun. 17, 2007 22:46	Jun. 18, 2007 03:47	21.9	99
	4593	Upstream	Jun. 19, 2007 12:37	Jun. 19, 2007 18:39	21.1	99
	4593	Upstream	Jul. 13, 2007 08:00	Jul. 13, 2007 21:38	20.7	105
	4593	Upstream	Sept. 27, 2007 00:09	Sept. 27, 2007 07:58	15.4	78
	4597	Upstream	Oct. 06, 2007 20:34	Nov. 15, 2007 21:29	14.0	147
	4602	Upstream	Oct. 20, 2007 10:20	-	11.0	335
	4592	Upstream	May 30, 2008 21:05	May 31, 2008 05:35		444
	4741	Upstream	May 31, 2008 14:12	May 31, 2008 18:26		439
	4592	Upstream	Jun. 22, 2008 08:01	Jun. 22, 2008 12:54		403
	49634	Upstream	Jul. 02, 2008 04:21	Jul. 06, 2008 04:50		358
	4741	Upstream	Jul. 08, 2008 02:51	Jul. 08, 2008 06:04		302
	49632	Upstream	Jul. 08, 2008 15:44	Jul. 09, 2008 01:22		302
	49633	Upstream	Jul. 09, 2008 01:59	Jul. 09, 2008 08:46		295
	4741	Upstream	Jul. 18, 2008 19:18	Jul. 19, 2008 05:23		253
	4595	Upstream	Jul. 27, 2008 21:42	Jul. 28, 2008 14:05		202
	49632	Upstream	Aug. 02, 2008 12:20	Aug. 03, 2008 16:01		173
	49644	Upstream	Aug. 05, 2008 22:01	Aug. 19, 2008 20:29		158
	49637	Upstream	Aug. 17, 2008 21:26	Aug. 18, 2008 22:27		115
	49632	Upstream	Aug. 21, 2008 22:17	Aug. 22, 2008 12:51		104
	49632	Upstream	Sept. 12, 2008 01:55	Sept. 12, 2008 23:17		69
	49637	Upstream	Sept. 24, 2008 22:11	Sept. 27, 2008 11:30		61
	49634	Upstream	Sept. 26, 2008 00:08	Sept. 26, 2008 10:33		63
	4595	Upstream	Sept. 29, 2008 10:30	Oct. 11, 2008 01:19		70
	49632	Upstream	Sept. 30, 2008 12:45	Oct. 2, 2008 00:53		72
	49634	Upstream	Oct. 03, 2008 19:43	Oct. 4, 2008 03:17		76
	49632	Upstream	Oct. 05, 2008 23:06	Oct. 8, 2008 02:20		79
	49644	Upstream	Oct. 06, 2008 05:01	Oct. 8, 2008 05:09		81

	49632	Upstream	Oct. 10, 2008 21:04	Oct. 12, 2008 09:02		87
	49634	Upstream	Oct. 14, 2008 05:40	Oct. 14, 2008 14:11		98
Quetico River	4592	Downstream	May 30, 2008 21:05	May 31, 2008 05:35		
	4592	Upstream	May 25, 2008 23:18	May 26, 2008 02:22		
Bearpelt Creek	4741	Downstream	Jun. 04, 2008 10:30	Jun. 04, 2008 16:34		
	4602	Downstream	Jun. 06, 2008 16:30	Jun. 06, 2008 22:38		
	4741	Upstream	Jun. 02, 2008 16:38	Jun. 03, 2008 12:23		
	4602	Upstream	Jun. 04, 2008 22:16	Jun. 05, 2008 21:46		
Quetico Rapids	4602	Downstream	Jun. 03, 2007 18:24	Jun. 04, 2007 14:31	16.9	64
	4600	Downstream	Jun. 04, 2007 00:34	Jun. 06, 2007 22:52	17.6	64
	4594	Downstream	Jun. 10, 2007 02:19	Jun. 10, 2007 13:41	17.9	77
	4593	Downstream	Jun. 12, 2007 06:42	Jun. 15, 2007 05:11	19.1	83
	4600	Downstream	Jun. 13, 2007 00:16	Jul. 09, 2007 13:14	19.9	85
	4593	Downstream	Jul. 24, 2007 11:25	Jul. 28, 2007 03:31	23.5	84
	4593	Downstream	Sept. 08, 2007 05:56	Sept. 11, 2007 04:38	19.6	36
	4593	Downstream	Oct. 05, 2007 03:37	Oct. 5, 2007 06:52	14.5	138
	4600	Downstream	May 22, 2008 12:39	May 23, 2008 21:01		467
	4597	Downstream	Jun. 03, 2008 16:16	Jun. 04, 2008 00:33		417
	4602	Downstream	Jun. 07, 2008 04:52	Jun. 07, 2008 06:38		403
	4741	Downstream	Jun. 13, 2008 01:57	Jun. 13, 2008 04:06		406
	4592	Downstream	Jun. 14, 2008 12:13	Jun. 14, 2008 15:57		407
	4595	Downstream	Jul. 09, 2008 19:01	Jul. 10, 2008 04:55		295
	49630	Downstream	Jul. 11, 2008 18:46	Jul. 11, 2008 23:05		287
	49633	Downstream	Jul. 17, 2008 04:52	Jul. 17, 2008 05:48		260
	49632	Downstream	Jul. 20, 2008 12:55	Jul. 20, 2008 19:16		243
	4741	Downstream	Jul. 27, 2008 13:11	Jul. 27, 2008 19:32		202
	49634	Downstream	Oct. 12, 2008 00:55	Oct. 13, 2008 00:02		94
	49632	Downstream	Oct. 16, 2008 22:27	Oct. 18, 2008 22:28		102
	4593	Upstream	May 23, 2007 14:00	May 23, 2007 18:36	14.7	55
	4600	Upstream	Jun. 09, 2007 06:01	Jun. 12, 2007 21:58	19.1	83
	4593	Upstream	Jun. 17, 2007 16:00	Jun. 17, 2007 21:19	22.2	97
	4593	Upstream	Sept. 25, 2007 05:43	Sept. 25, 2007 19:18	15.6	65
	4593	Upstream	-	Sept. 4, 2007 21:33	20.1	33
	4602	Upstream	Oct. 20, 2007 00:18	Oct. 20, 2007 03:35	11.0	335

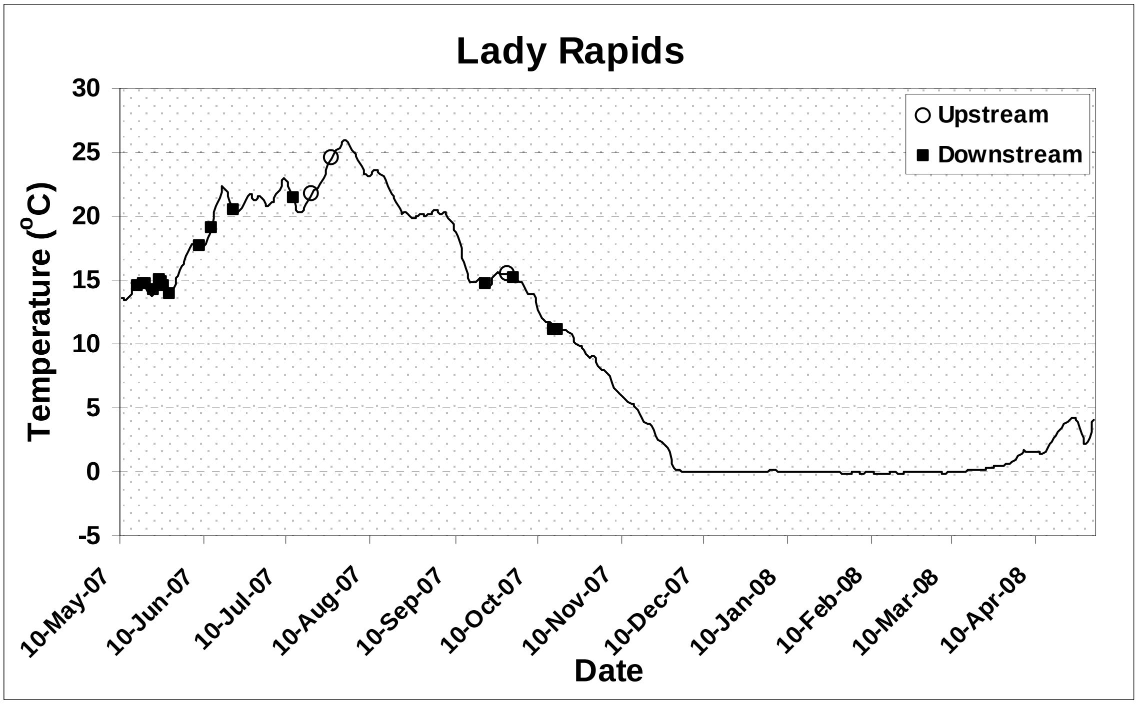
Quetico Rapids	4592	Upstream	May 25, 2008 08:15	May 25, 2008 22:50		464
	4741	Upstream	May 30, 2008 15:21	May 31, 2008 07:33		439
	49644	Upstream	Jun. 21, 2008 05:27	Jun. 21, 2008 19:46		404
	4592	Upstream	Jun. 21, 2008 09:04	Jun. 22, 2008 01:58		403
	49634	Upstream	Jun. 30, 2008 09:01	Jun. 30, 2008 21:35		373
	49630	Upstream	Jul. 06, 2008 03:57	Jul. 06, 2008 11:01		321
	49632	Upstream	Jul. 06, 2008 14:45	Jul. 07, 2008 21:58		315
	4741	Upstream	Jul. 07, 2008 15:45	Jul. 07, 2008 18:41		315
	49633	Upstream	Jul. 08, 2008 16:23	Jul. 08, 2008 20:47		302
	4595	Upstream	Jul. 11, 2008 12:19	Jul. 24, 2008 09:44		220
	49632	Upstream	Jul. 20, 2008 20:30	Jul. 27, 2008 19:56		202
	49637	Upstream	Jul. 22, 2008 16:34	Jul. 23, 2008 08:24		226
	49634	Upstream	Oct. 13, 2008 06:56	Oct. 13, 2008 23:42		96
	49632	Upstream	Oct. 19, 2008 07:04	Oct. 20, 2008 07:00		107
Lady Rapids	4745	Downstream	May 16, 2007 14:29	-	14.5	52
	4739	Downstream	May 16, 2008 15:46	-	14.5	52
	4740	Downstream	May 16, 2007 21:52	May 22, 2007 18:34	14.5	52
	4747	Downstream	May 18, 2007 21:17	-	14.7	53
	4744	Downstream	May 19, 2007 20:19	Jul. 16, 2007 13:45	14.6	54
	4748	Downstream	May 22, 2007 01:46	May 22, 2007 20:51	14.2	55
	4741	Downstream	May 24, 2007 14:49	May 30, 2007 03:55	15.0	56
	4588	Downstream	May 25, 2007 23:50	May 26, 2007 05:36	14.9	56
	4750	Downstream	May 26, 2007 00:12	May 26, 2007 03:29	14.6	58
	4589	Downstream	May 28, 2007 02:51	May 28, 2007 00:25	14.0	59
	4749	Downstream	May 28, 2007 06:57	May 28, 2007 21:00	14.0	59
	4743	Downstream	May 28, 2007 23:40	May 29, 2007 16:22	14.0	59
	4591	Downstream	Jun. 08, 2007 03:46	Jun. 08, 2007 11:48	17.7	71
	4602	Downstream	Jun. 08, 2007 06:48	June 8, 20007 21:35	17.7	71
	4594	Downstream	Jun. 12, 2007 18:05	Jun. 13, 2007 07:04	19.1	83
	4590	Downstream	Jun. 20, 2007 02:24	Jun. 21, 2007 06:55	20.5	103
	4742	Downstream	Jul. 12, 2007 01:05	Jul. 12, 2007 10:06	21.4	106
	4752	Downstream	Sept. 21, 2007 00:16	Sept. 21, 2007 10:11	14.7	44
	4751	Downstream	Oct. 01, 2007 23:48	Oct. 2, 2007 21:00	15.2	106
	4744	Downstream	Oct. 16, 2007 14:45	Oct. 16, 2007 23:19	11.2	283

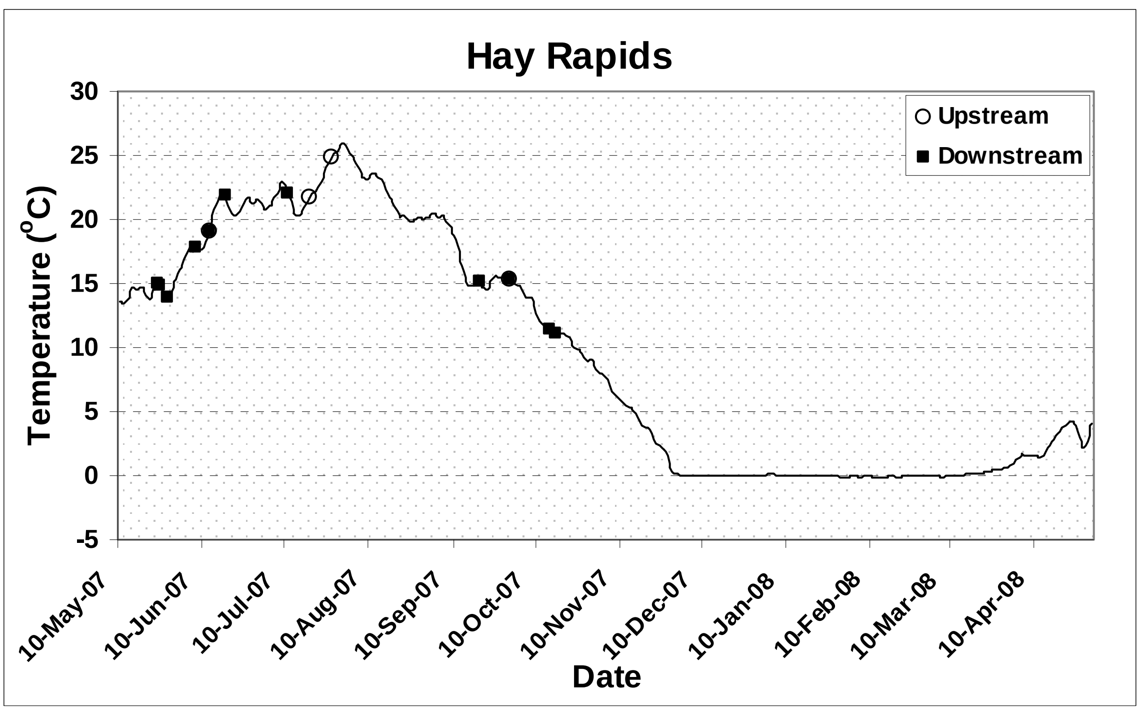
Lady Rapids	4593	Downstream	Oct. 17, 2007 13:51	Oct. 18, 2007 03:46	11.0	293
	4601	Downstream	May 25, 2008 13:45	May 31, 2008 13:00		464
	4602	Downstream	Jun. 08, 2008 06:06	Jun. 08, 2008 21:27		402
	4742	Downstream	Aug. 17, 2008 22:39	Aug. 18, 2008 06:00		115
	4744	Upstream	Jul. 16, 2007 22:16	Jul. 19, 2007 09:09	21.8	94
	4741	Upstream	Jul. 25, 2007 08:58	Jul. 26, 2007 20:43	24.5	81
	4602	Upstream	Sept. 29, 2007 12:29	Sept. 29, 2007 22:58	15.4	92
	49644	Upstream	Jun. 09, 2008 02:56	Jun. 11, 2008 21:37		407
	49634	Upstream	Jun. 14, 2008 20:19	Jun. 23, 2008 15:35		400
	49630	Upstream	Jun. 22, 2008 00:39	Jun. 24, 2008 15:06		396
	49633	Upstream	Jun. 24, 2008 00:28	Jun. 25, 2008 23:01		391
	49632	Upstream	Jun. 28, 2008 11:54	Jul. 02, 2008 18:45		358
	49637	Upstream	Jul. 14, 2008 00:38	Jul. 18, 2008 18:01		253
	49635	Upstream	Jul. 14, 2008 10:55	Jul. 17, 2008 04:57		260
	4742	Upstream	Jul. 17, 2008 03:02	Jul. 21, 2008 00:07		238
	4744	Upstream	Jul. 28, 2008 11:07	Jul. 29, 2008 19:54		191
	49640	Upstream	Jul. 29, 2008 00:42	Aug. 04, 2008 05:34		163
	4588	Upstream	Aug. 01, 2008 02:39	Aug. 02, 2008 23:57		173
	4740	Upstream	Aug. 01, 2008 03:40	Aug. 02, 2008 09:19		173
	49642	Upstream	Aug. 09, 2008 23:37	Aug. 10, 2008 20:00		139
	49643	Upstream	Aug. 14, 2008 11:30	Aug. 15, 2008 02:38		122
	4739	Upstream	Sept. 3, 2008 17:13	Sept. 4, 2008 19:39		74
	4752	Upstream	-	Sept. 28, 2008 19:59		69
	49653	Upstream	-	Sept. 27, 2008 01:41		67

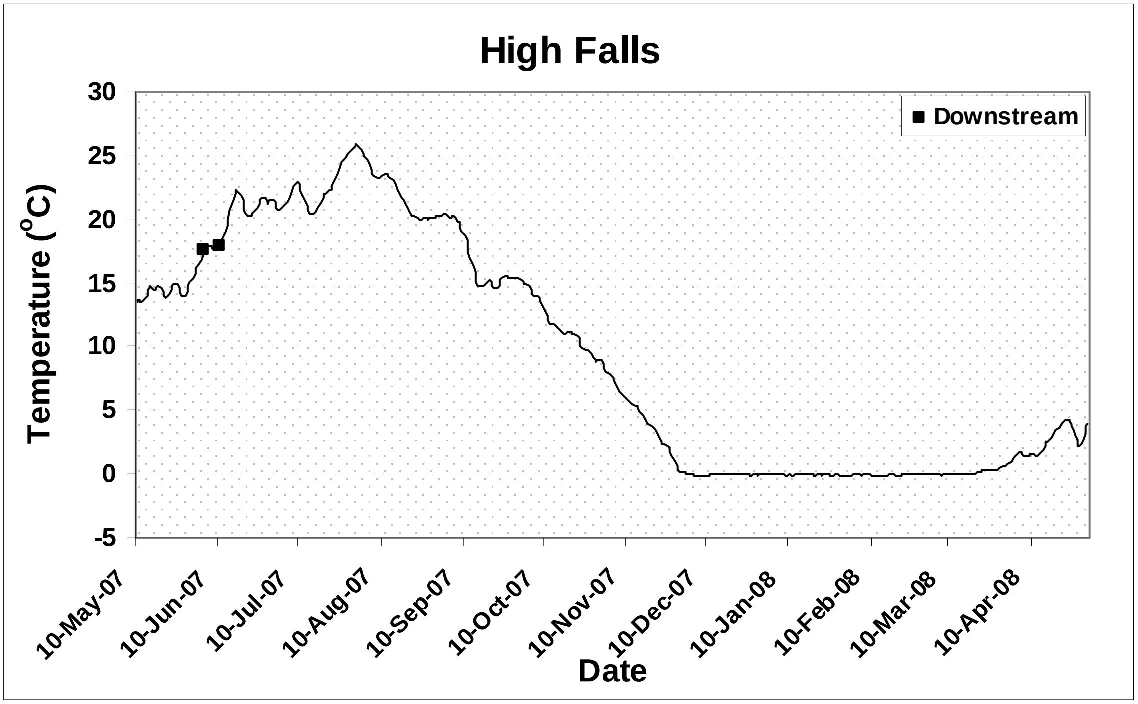
Appendix V: Mean daily water temperature recorded at Lady Rapids in Namakan River, Ontario from May, 2007 to May, 2008.

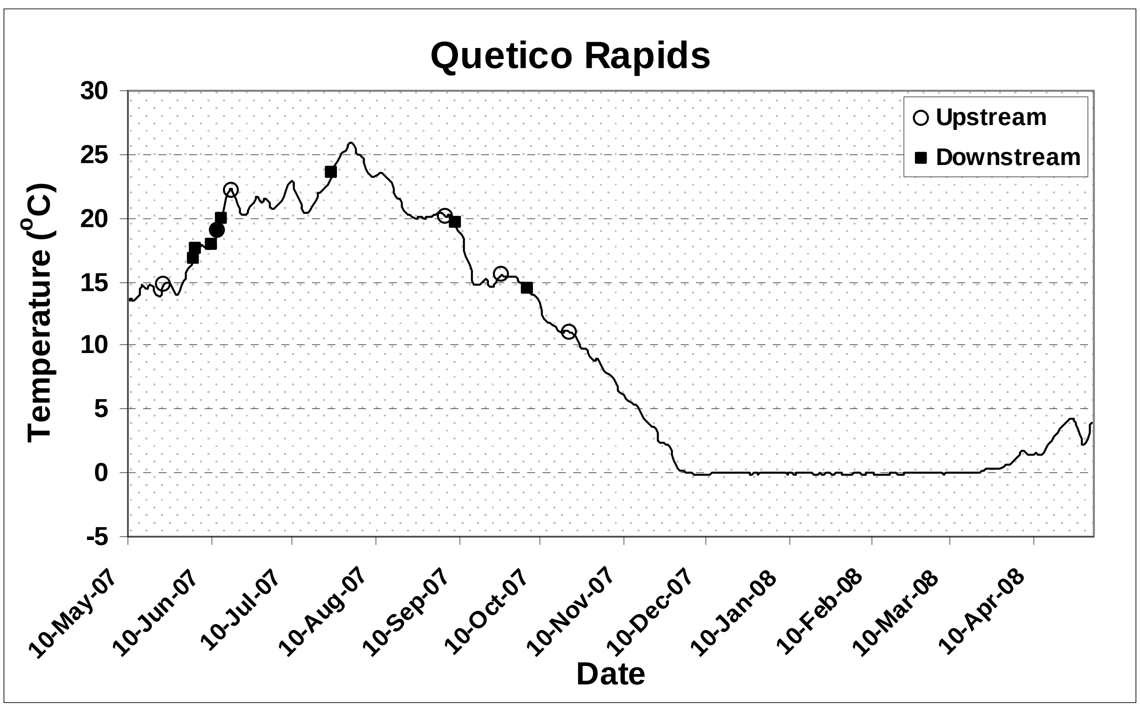


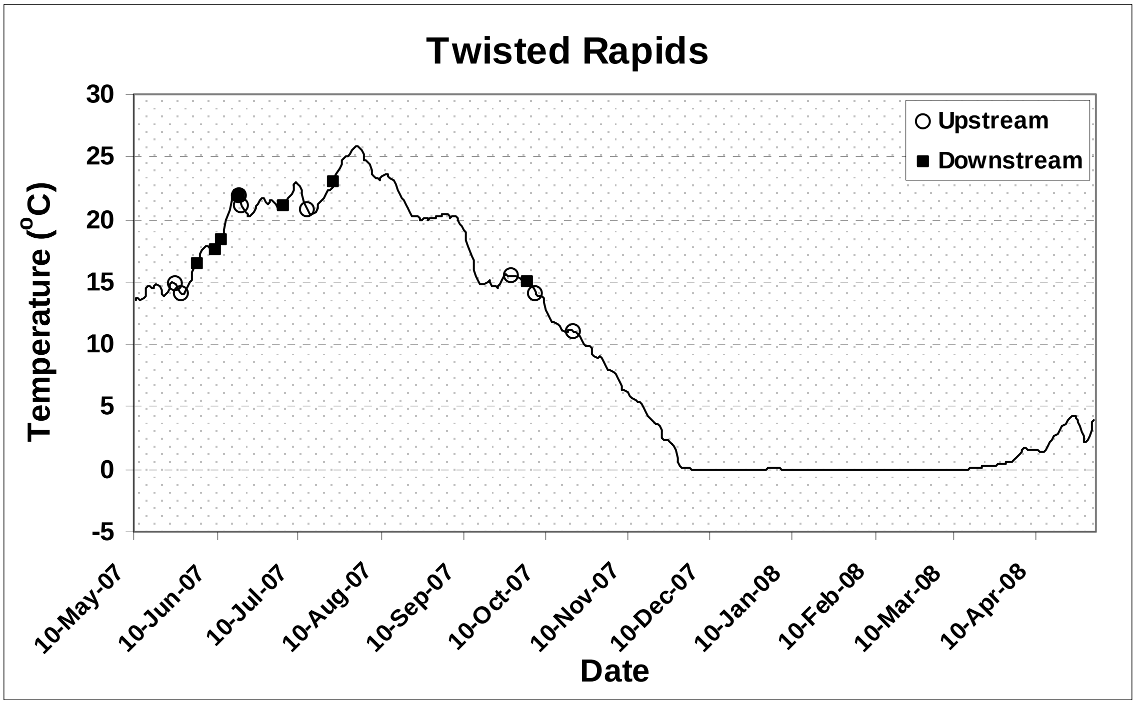
Appendix VI: Movement of lake sturgeon through selected shallow rapids/falls in relation to daily water temperatures in the Namakan River, Ontario.



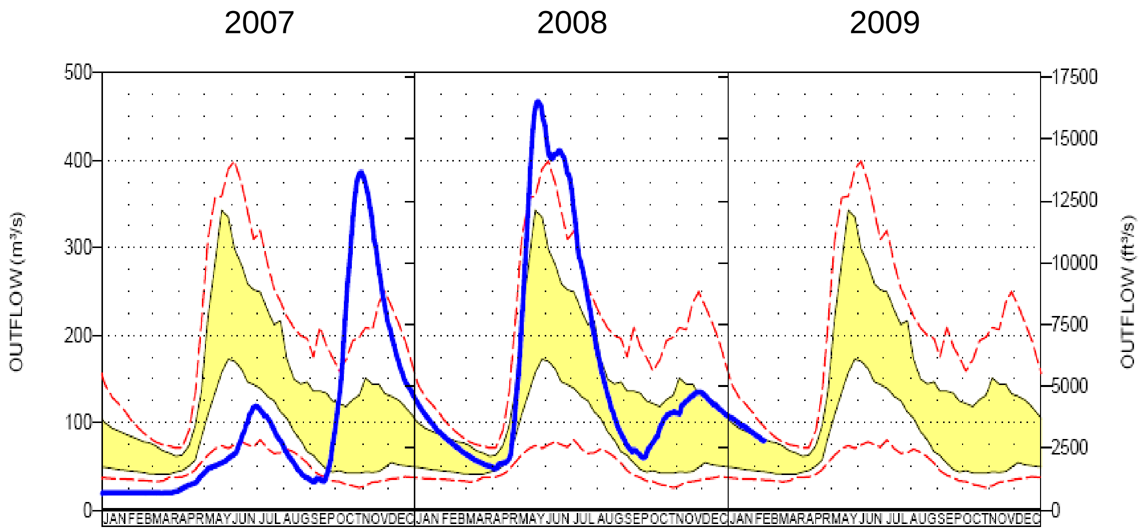



High Falls
30
25
20
15
10
5
0
-5
Temperature (°C)
Downstream
10-May-07
10-Jun-07
10-Jul-07
10-Aug-07
10-Sep-07
10-Oct-07
10-Nov-07
10-Dec-07
10-Jan-08
10-Feb-08
10-Mar-08
10-Apr-08
Date

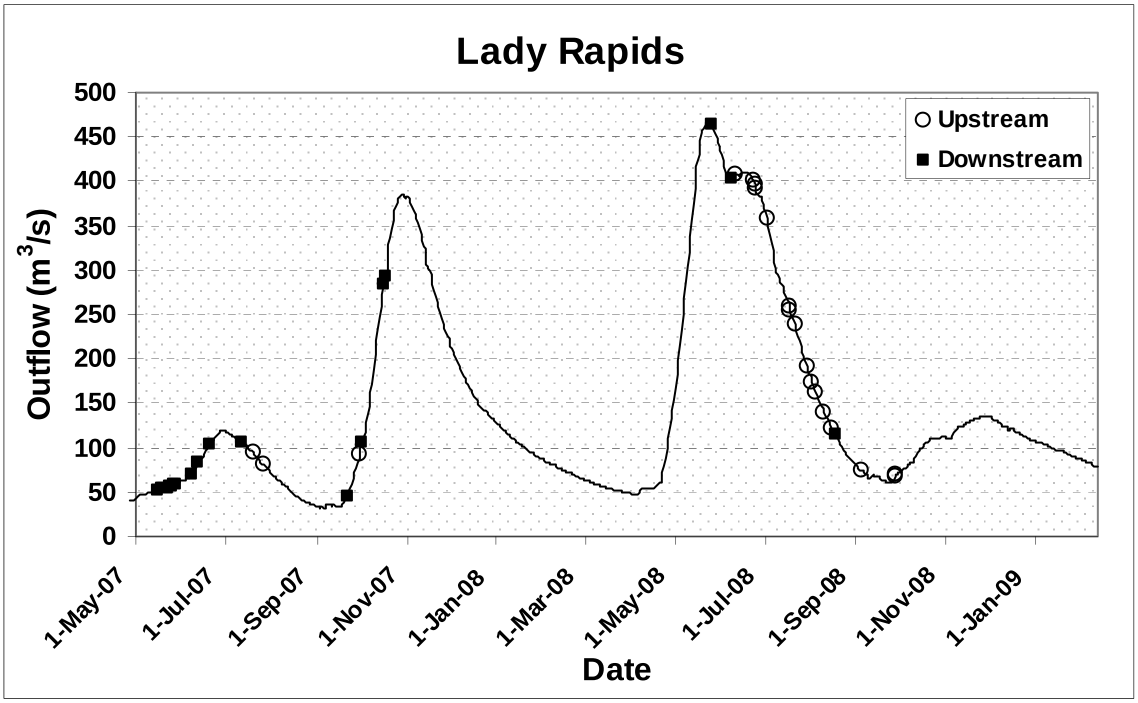

Quetico Rapids
30
25
20
15
10
5
0
-5
Temperature (°C)
Upstream
Downstream
10-May-07
10-Jun-07
10-Jul-07
10-Aug-07
10-Sep-07
10-Oct-07
10-Nov-07
10-Dec-07
10-Jan-08
10-Feb-08
10-Mar-08
10-Apr-08
Date

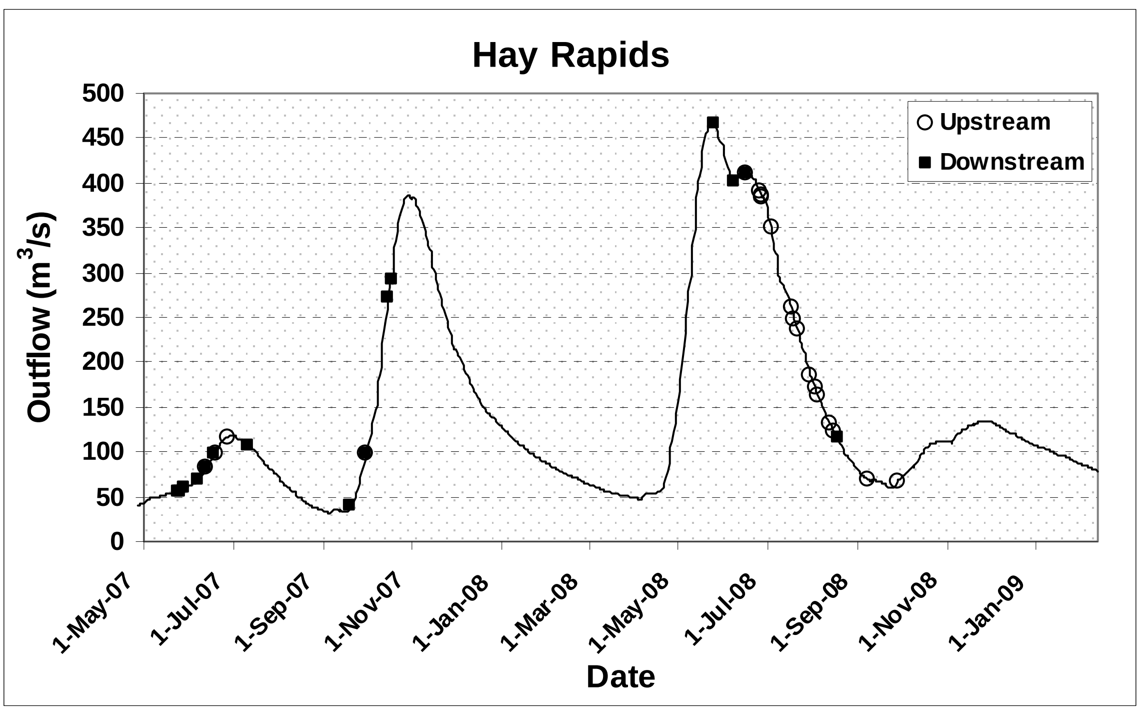

Twisted Rapids
Upstream
Downstream
Temperature (°C)
30
25
20
15
10
5
0
-5
10-May-07
10-Jun-07
10-Jul-07
10-Aug-07
10-Sep-07
10-Oct-07
10-Nov-07
10-Dec-07
10-Jan-08
10-Feb-08
10-Mar-08
10-Apr-08
Date

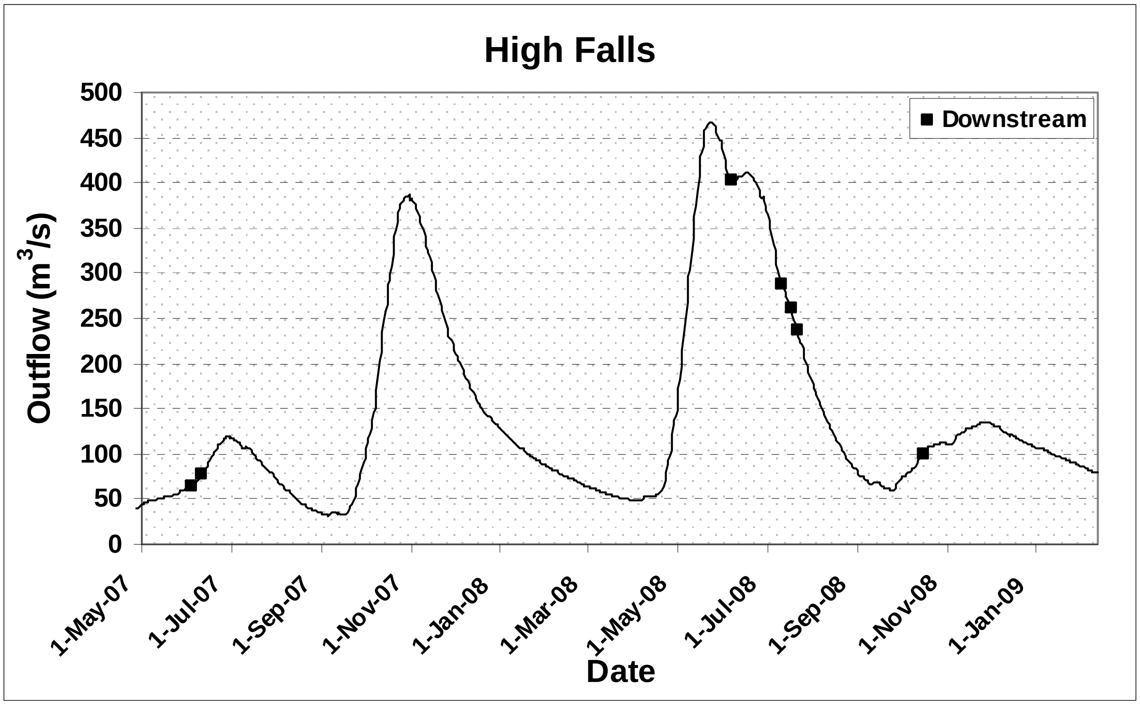
Appendix VII: Estimated water flow in Namakan River, Ontario from January, 2007 to January, 2009. Data reported as the daily mean outflow from Lac La Croix including 10%, 25%, 75% and 90% percentile flows.

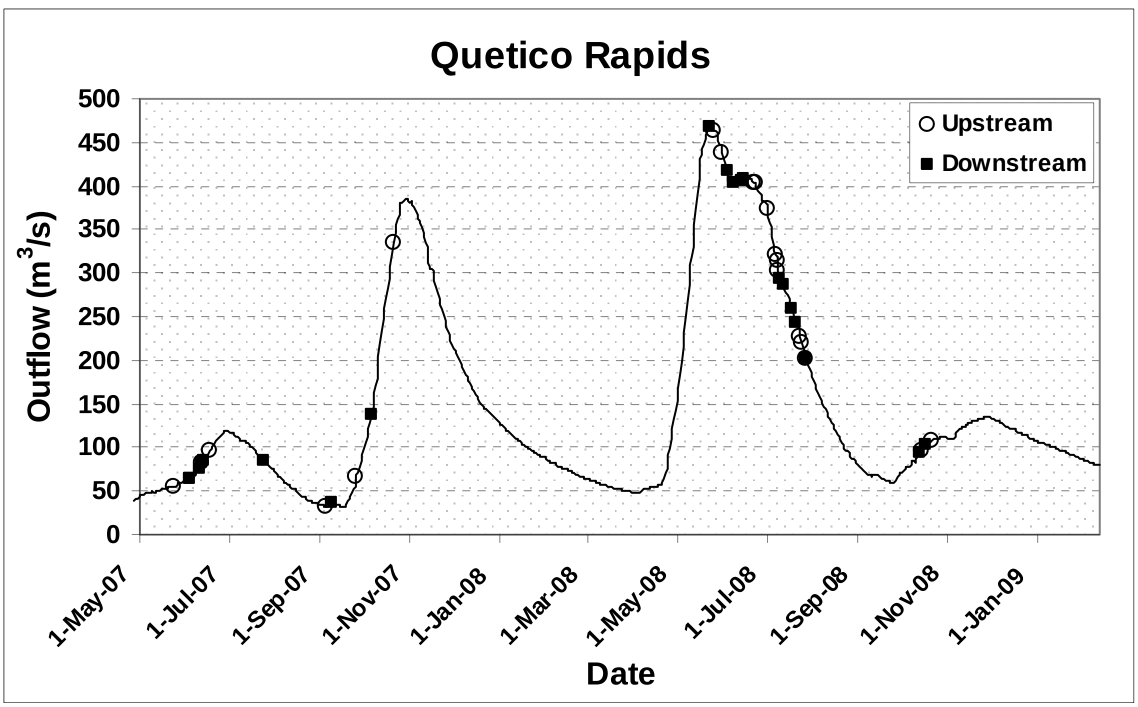


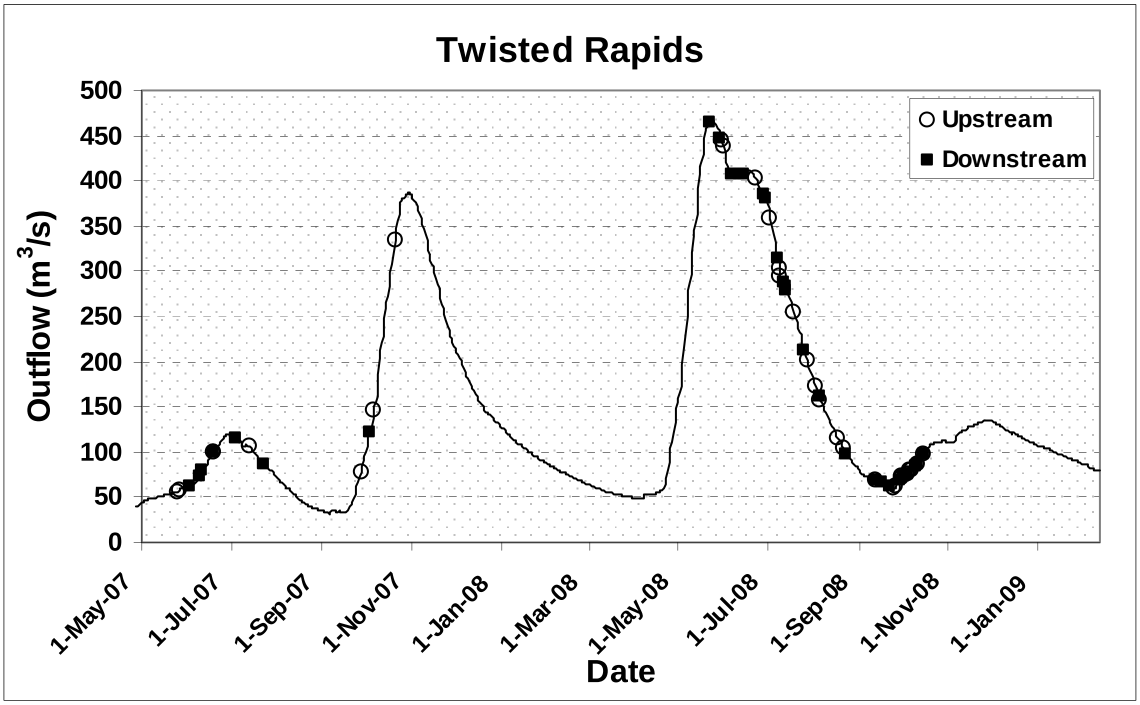
Appendix VIII: Movement of lake sturgeon through selected shallow rapids/falls in relation to daily water flows in the Namakan River, Ontario.

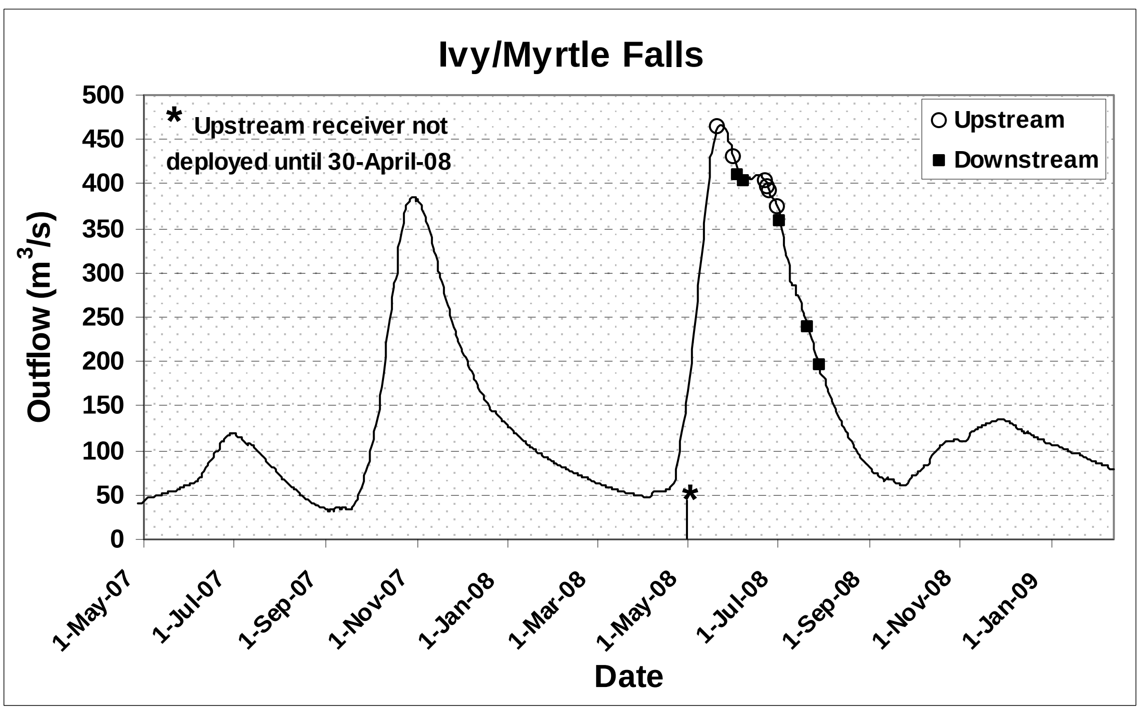





High Falls
Downstream
Outflow (m3/s)
Date
500
450
400
350
300
250
200
150
100
50
0
1-May-07
1-Jul-07
1-Sep-07
1-Nov-07
1-Jan-08
1-Mar-08
1-May-08
1-Jul-08
1-Sep-08
1-Nov-08
1-Jan-09


Quetico Rapids
Upstream
Downstream
Outflow (m3/s)
Date
500
450
400
350
300
250
200
150
100
50
0
1-May-07
1-Jul-07
1-Sep-07
1-Nov-07
1-Jan-08
1-Mar-08
1-May-08
1-Jul-08
1-Sep-08
1-Nov-08
1-Jan-09


Twisted Rapids
Outflow (m3/s)
500
450
400
350
300
250
200
150
100
50
0
Upstream
Downstream
1-May-07
1-Jul-07
1-Sep-07
1-Nov-07
1-Jan-08
1-Mar-08
1-May-08
1-Jul-08
1-Sep-08
1-Nov-08
1-Jan-09
Date


Ivy/Myrtle Falls
* Upstream receiver not
deployed until 30-April-08
Outflow (m3/s)
500
450
400
350
300
250
200
150
100
50
0
Upstream
Downstream
*
1-May-07
1-Jul-07
1-Sep-07
1-Nov-07
1-Jan-08
1-Mar-08
1-May-08
1-Jul-08
1-Sep-08
1-Nov-08
1-Jan-09
Date