TECHNICAL REPORT

Search for and characterization of lake sturgeon (*Acipenser fulvescens*) spawning grounds in the upstream portion of the Lachine Rapids, St. Lawrence River, in 2003

Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie

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Search for and characterization of lake sturgeon (*Acipenser fulvescens)* spawning grounds in the upstream portion of the Lachine Rapids, St. Lawrence River, in 2003

By
Michel La Haye
Sylvain Desloges
Chantal Côté
Ashley Rice
Stewart Philips "Junior"
John Deer
Benoît Giroux
Karen de Clerk
and
Pierre Dumont

Ministère des Ressources naturelles, de la Faune et des Parcs

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SUMMARY

The aboriginal people of the Kahnawake Indian Reserve have been practicing a subsistence fishery in the Lachine Rapids for many generations. Lake sturgeon (*Acipenser fulvescens*) is a species that is highly coveted by these fishers. This fishery has intensified over the years and has recently given rise to a trade in lake sturgeon outside the reserve. The lake sturgeon stock of the St. Lawrence River is overexploited and a new management plan reduced the commercial fishing harvest from 200 tonnes in 2000 to 80 tonnes in 2002. Catches by aboriginal fishers are not included in this quota and these fishers exert a portion of their fishing effort in the spring when spawners congregate at reproduction sites. Elsewhere in the St. Lawrence River, the lake sturgeon commercial and recreational fishery is prohibited from early November to mid-June.

The results of two studies carried out in the spring of 2001 and 2002 by the Société de la faune et des parcs du Québec (FAPAQ) and the Mohawk Council of Kahnawake, in cooperation with MAPAQ and the Secrétariat aux affaires autochtones, show that the upstream portion of the Lachine Rapids, opposite Kahanawake, is home to a vast lake sturgeon spawning ground which, by reason of its surface area and location, is of significant importance for the St. Lawrence River population. A third study was undertaken during the spring of 2003 to corroborate earlier observations and to continue the exploration of the rapids sector at the outlet of Lac Saint-Louis as a lake sturgeon reproduction area. Except for an expansion of the depth stratum covered, which increased from 0-5m to 0-7 m and the use of an underwater camera for the characterization of the substrate and the selection of the sectors, the methodology was the same as that used in 2002.

Lake sturgeon spawn was found in only one sector, namely that of the spawning ground identified in 2002. From May 23rd (46 eggs) to June 16th (3 eggs), 163 eggs were sampled using cement parpens at 23 of the 44 stations; from May 30th to June 19th, 108 eggs and five larvae were harvested during 2419 hours of drifting, spread out over 17 stations. During the spawning period, between May 22nd and June 18th, the temperature of green water in the river rose from 11.8 to 15 ºC. In 2003, the spawning activity zone shifted to the central portion and the outside edge of the spawning ground located in the spring of 2002. This shift may be due to the greater range of depths explored in 2003. The estimated area increased from 2.3 to 3.6 ha, at depths varying from 1.15 m near the shore to more than 6 m off-shore, under fast current conditions and on a substrate composed of rocks and big rocks serving as shelters, with fine to course gravel, free of periphyton and aquatic plants. These results clearly and unequivocally confirm the need to put an end to all forms of lake sturgeon harvesting in the Lachine Rapids during the spring period.

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PRODUCTION TEAM

Fieldwork:

Michel La Haye, M.Sc. Env. biologist (Enviro-Science inc.)
Sylvain Desloges, wildlife technician (FAPAQ)
Chantal Côté, B. Sc., biologist (FAPAQ)
Benoît Giroux, wildlife technician (FAPAQ)
Stewart Philips Jr, animal control (Mohawk Council of Kahnawake)
John Deer, animal control (Mohawk Council of Kahnawake)
Ashley Rice, animal control (Mohawk Council of Kahnawake)
Karen de Clerk, biology study (FAPAQ)

Project director:

Pierre Dumont, Ph. D. Env. Sc., Biologist (FAPAQ)

Fieldwork coordinators:

Michel La Haye
Sylvain Desloges

Preliminary analyses and sampling strategy:

Sylvain Desloges
Pierre Dumont
Michel La Haye

Analysis and writing:

Michel La Haye
Pierre Dumont

Mapping and reading:

Chantal Côté

Translation:

Mark McKenzie

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1. INTRODUCTION

The aboriginal people of the Kahnawake Indian Reserve have been practicing a subsistence fishery in the Lachine Rapids for many generations. Lake sturgeon (*Acipenser fulvescens*) has been and continues to be a species that is highly coveted by these fishers. Over the last few years, this fishery has intensified and given rise to a trade in lake sturgeon outside the reserve. The lake sturgeon stock of the St. Lawrence River is over-harvested and a new management plan, which entered into force in 2000, considerably reduced the commercial fishery harvesting potential, which went from 200 tonnes in 2000 to 80 tonnes in 2002 (Dumont et al. 2000). It has been kept at this level ever since. To control the trade in these catches, a tagging system of each fish kept by authorized commercial fishers was established. Only the holders of a commercial fishing licence issued by the ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) can be in the possession of these tags as part of individual quotas that are reviewed annually. The landings made by fishers of the aboriginal community of Kahnawake are not included in the quota system in effect and hence represent excess catches in relation to the quota in effect, the application of which seeks to reverse the decline in the stock.

Prior to the recent studies undertaken in this sector of the St. Lawrence River, several indicators pointed to the presence of one or more lake sturgeon spawning sites. Aboriginal fishers exert a significant part of their fishing effort in the spring. During that period, spawners are particularly vulnerable, as they move towards limited sites where they lose their natural distrust. Elsewhere in the St. Lawrence River, the lake sturgeon commercial and recreational fishery is prohibited from early mid-October to mid-June.

The results of the two studies conducted in the spring of 2001 and 2002 by the Société de la faune et des parcs du Québec (FAPAQ) and the Mohawk Council of Kahnawake, in cooperation with MAPAQ and the Secrétariat aux affaires autochtones (SAA), are unequivocal: the upstream portion of the Lachine Rapids, opposite Kahanawake, does indeed contain an important lake sturgeon spawning ground (La Haye et Clermont 2003; La Haye et al. 2003). On the basis of these results, a recommendation was made to prohibit all forms of lake sturgeon harvesting during the spring period. This restriction is generalized to all North American jurisdictions to ensure the perpetuation of sturgeon populations, including that of the St. Lawrence River. This recommendation was not followed in 2002, but seems to have been adhered to in 2003.

The results obtained in the spring of 2002 made it possible to confirm the presence of a spawning ground in the upstream portion of the Lachine Rapids, in a sector situated on the right shore 400 m downstream from Mercier Bridge. Given its large surface area and its location, this spawning ground could be of significant importance for the St. Lawrence River population. In 2002, the water found at this spawning ground was of good quality. The rocky substrate that makes up this sector is clean and free of fine sediments. This spawning ground is far from the shore.

In the St. Lawrence River and its tributaries, lake sturgeon spawning grounds are rare and the number of spawners present is likely in sharp decline (Dumont et al. 2000, Fortin et al. 2002). Less than a dozen spawning grounds are known and have been identified. The discovery of a new spawning ground, the first having a large surface area surveyed in the St. Lawrence River, is of capital importance for the survival of this stock.

A third study was undertaken in the spring of 2003. This study, which continues to rely on the involvement of the same partners, sought to corroborate the observations of 2002 on the new spawning ground and to continue, with greater precision, the exploration of the rapids sector at the outlet of Lac Saint-Louis as a lake sturgeon reproduction site. Except for the depth stratum covered and the use of an underwater camera for the stratification of the substrate, the methodology for this study was the same as that used in 2002.

Recent observations have shown that the lake sturgeon can spawn at great depths and not only in shallow rapids. Manny and Kennedy (2002) monitored sturgeon spawning in a territory stretching from the outlet of Lake Huron to Lake Erie, in the Saint-Clair and Detroit rivers, respectively upstream and downstream from Lake Saint-Clair. Three deep-water spawning sites are described in their study: Port Huron at the outlet of Lake Huron, Algonac in the northern part of the Saint-Clair River delta and Zug Island, just downstream from the City of Detroit. These sites have the following characteristics: they are located in deep water (between 9.1 and 12 m); the substrate is porous, having a variable particle size distribution, from fine to coarse gravel (3.0 – 64.9 mm); it is clean and free of periphyton or fine sediments. One of the members of the team (ML) visited these sites prior to the beginning of field work. He found that they are very much exposed to the current and with the exception of the Algonac site, that they are located on a slope. Except with respect to the great depths, these characteristics are similar to those of the spawning ground located in the spring of 2002 in the upstream portion of the Lachine Rapids.

The approach used in the spring of 2002 provided for the coverage of the 0 - 5 m depth stratum but in actual fact very few stations located below 3 m were sampled (La Haye et al. 2003). The stratification of the habitat adopted in the spring covers the 0 – 7 m stratum. The use of an underwater camera became necessary to facilitate the choice of stations based on the substrate.

The objectives of this study are:

- To check the use made of the spawning ground discovered in the spring of 2002 by extending the coverage up to 7 m in depth or more if possible;

- To identify the boundaries of the sturgeon spawning areas in the sector under study with greater precision;

- To compare the environmental characteristics of the various sectors sampled and/or used for spawning;

- To compare the results obtained with those of 2002 and, where applicable, with the deep-water spawning grounds described by Manny and Kennedy (2002).

2. MATERIAL AND METHODS

2.1. Delimitation of the study area

The study area covers only the upstream portion of the Lachine Rapids, from Dixie Island on the left shore to Kahnawake Church on the right. A distance of about 4 km separates this upstream limit from Mercier Bridge. The spawning ground located in 2002 constitutes the downstream limit on the south shore (Figure 1). The section sampled in 2003 is much smaller than in 2002. Moreover, the sectors located at the two tips of the study area were not sampled again since the flow conditions no longer corresponded to the pre-selection criteria, due to the fact that the river flow was much weaker than in the spring of 2003.

2.2. Sampling strategies and techniques for locating egg deposition

The 2002 sampling technique was used again in 2003. This technique is described in detail in La Haye et al. (2003). However, differences exist with respect to the stratification of the habitat and the observation of the substrate; these differences are described in detail in the following sections.

2.2.1. Stratification of the habitat according to the spawning potential

The detailed review of the physical characteristics of the study area was made during the previous campaign. The sectors offering a good lake sturgeon spawning potential were clearly identified during the work of 2002. Consequently, the pre-selection of the potential spawning sectors was quickly validated in the field, from May 9th to 15th, coinciding with the start of systematic monitoring. Two boats equipped with sonar covered the entire study area. These operations made it possible to delimit the zones to be covered with a few buoys (Figure 1).

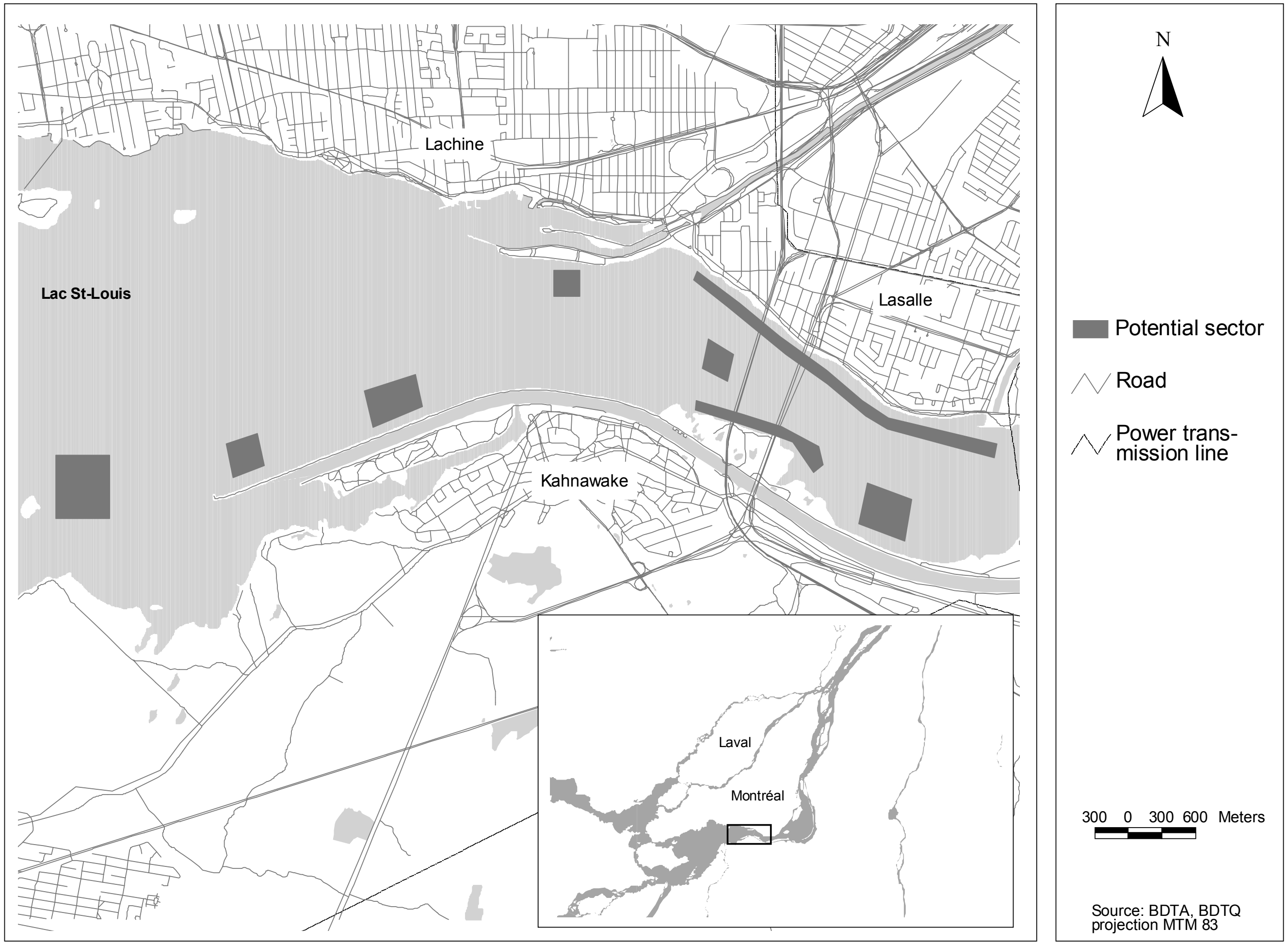


Figure 1. Potential sectors chosen based on the results of 2002 and following the preliminary filtering of available information, upstream portion of the Lachine Rapids, spring of 2003.

In the study area, the river bed mostly consists of solid rock covered with gravel and rocks in places. To increase the sampling power and to focus efforts on those sites having this type of substrate, the river bed was examined with an underwater camera. Indeed, the observations made in deep water spawning grounds described by Manny and Kennedy (2002) revealed the efficiency and precision of this type of equipment in open areas similar to the study area.

The substrate observation system is made up of an Aqua-Vu camera (Z-Series Underwater Viewing System) weighed down by a *downrigger* by means of a *camrigger* type attachment system (Photo 1). The entire set-up is connected to a monitor installed on the boat. This equipment was used on May 19th and 20th to describe the substrate of the various pre-selected sites and to complete the final selection of sites. To obtain an idea of the substrate as a whole of an interesting sector, several transects were made by allowing the boat to drift. The exposure to the current, the type of substrate, the absence of fine sediments, periphyton or macrophytes, and the presence of interstices between particles were the criteria used to guide the final choice. The presence of fine particles was detected by allowing the weight to drag along the river floor; this produced a cloud of dust that was easy to observe on the monitor.

Due to the weaker river flows in 2003, certain sites covered in 2002 had become stagnant or even dewatered areas. They were set aside. Upstream, the abandoned sectors are the following: 1st flat upstream and 2nd flat upstream, all of the stations located upstream from the iron bridge and close to the shore between this bridge and Mercier Bridge, the Iron Bridge site at the centre to the benefit of a new sector located closer to and under this bridge. Downstream from Mercier Bridge, the flats located near the north shore, and the 1st flat downstream and 2nd flat downstream sectors on the south shore (La Haye et al. 2003).

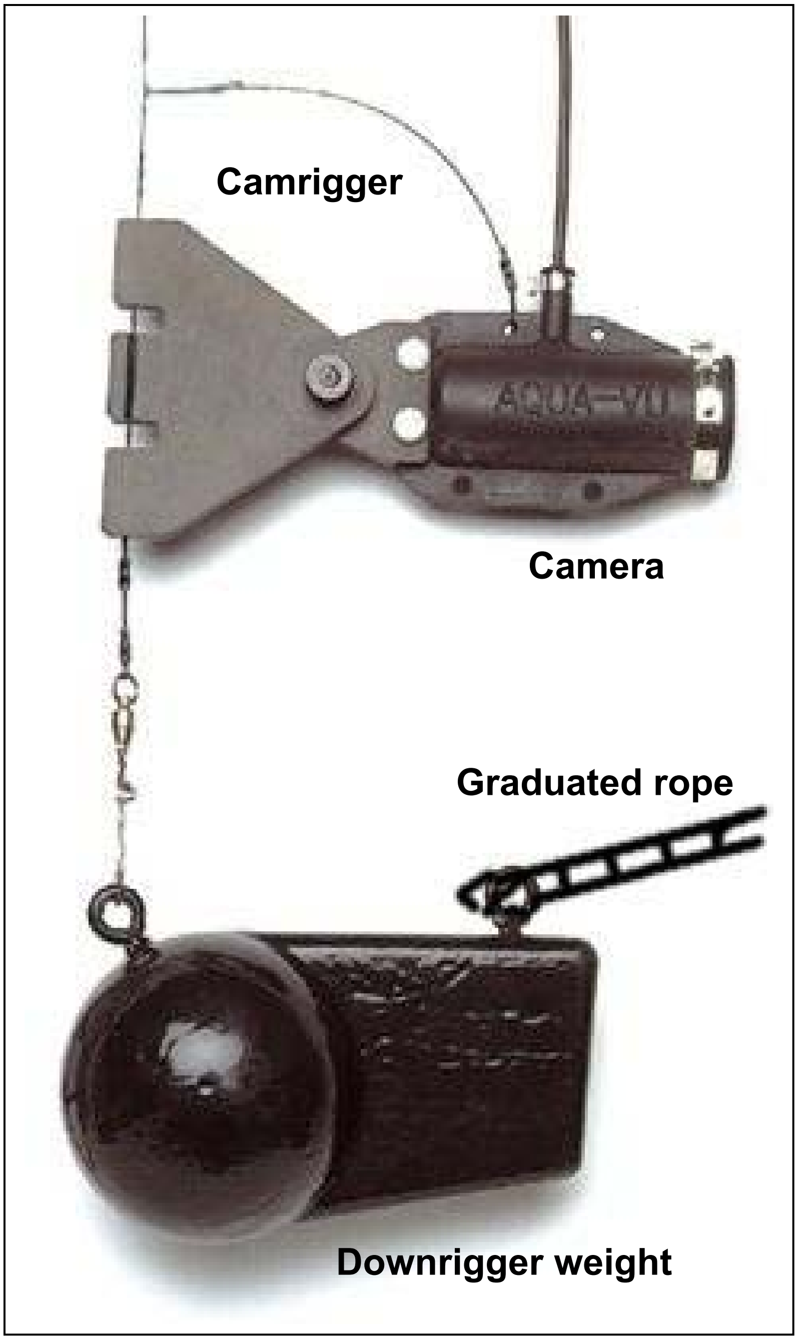


Photo 1. Aqua-Vu Underwater Viewing System (Z-Series Underwater Viewing System): camera and *downrigger* weight attached together by means of a *camrigger* and graduated rope for observing the substrate.

The surface area covered thus went from 2.6 to 1.8 km^2. The selection criteria finally applied in the field were as follows:

- depth stratum of 0 to 7 m and greater if possible,
- green, mixed or brown water habitat, with a hard substrate outside grass-beds,
- clean gravel, rock or pebble substrate,
- current stratum of 0.6 m/sec to 1.8 m/sec,
- absence of aquatic vegetation, periphyton or fine sediments.

The nine sectors chosen and covered during the study by means of various capture gears were named after a series of landmarks (Figure 2). In relation to the final selection of 2002, five new sectors were added: Rocky Point, between the north shore and the Dixie Island sector, Pointe Lachine, at the outlet of the Lachine Marina Dyke, Off Lachine, half-way along this dyke (formerly the North Shore Dyke but only near the shore), Centre of the Iron Bridge, moved downstream in relation to 2002 (formerly Upstream Iron Bridge), and Kahnawake opposite the church. In this latter sector, stations were added on the right shore, on both sides of the Mercier Bridge.

2.2.2. Period and rhythm of sampling using cement parpens

The putting in place of the parpens at the main sites of interest was rapid, both in time and space (from May 9th to 23rd). Unlike in the previous year, the initial set-up did not cause problems since the two work teams had learned to master the art of clearly defining the area to be covered while putting the parpens in place systematically. These teams were made up of three persons, two of whom took care of putting in place and raising the cement parpens, and the third of whom was responsible for operating the boat. Each team was able to install, lift, examine and clean some thirty filter sections per 7-hour work day.

The average time between the fertilization of the egg and the release of larvae in lake sturgeon is about six to seven days. After that period, the larvae bury themselves in the substrate and are no longer vulnerable to passive capture until they begin to drift, following the resorption of the vitelline sac. We therefore chose to apply a three-day rhythm of gear-lifting operations to reduce the risks of information loss.

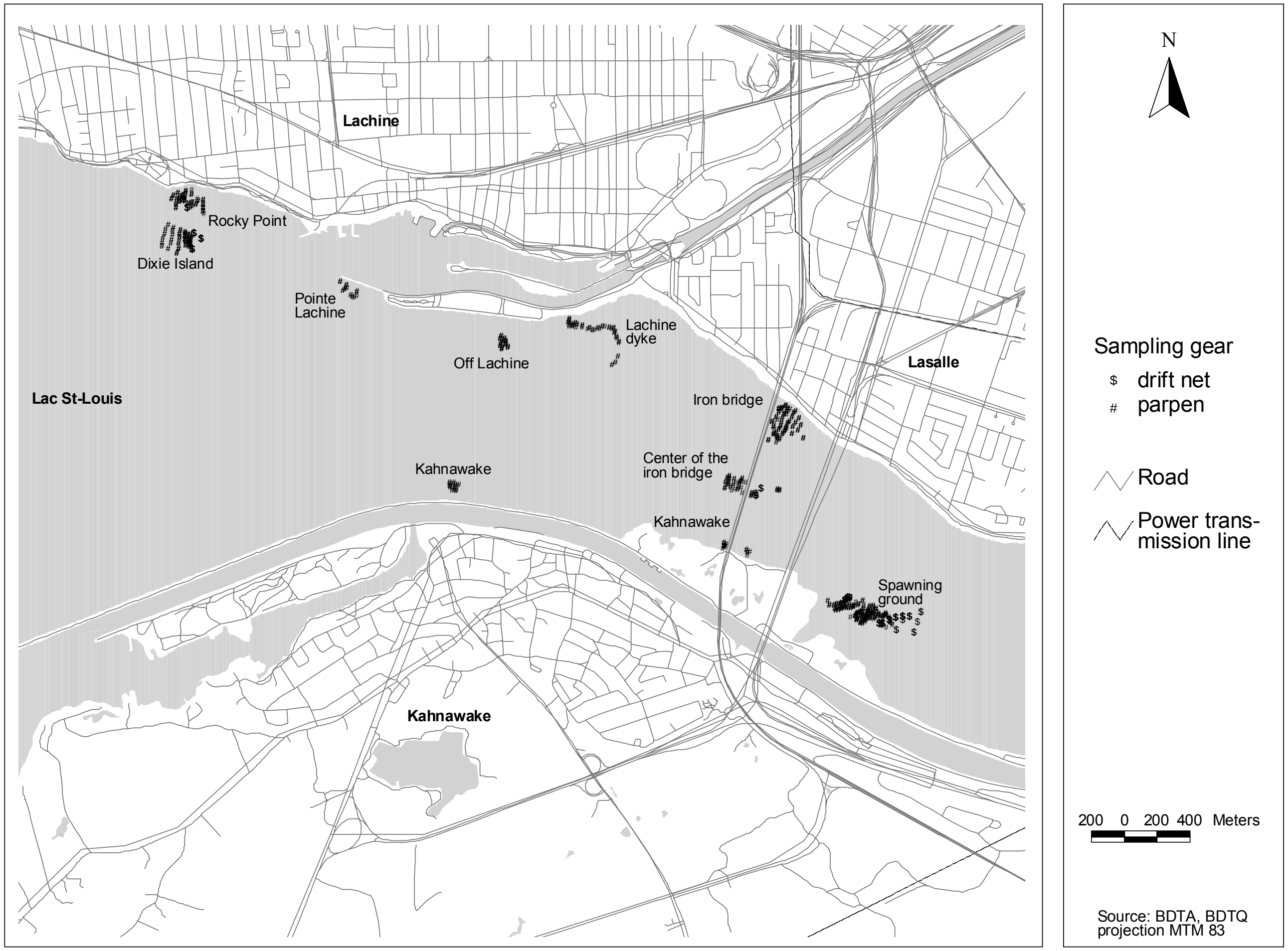


Figure 2. Sectors covered using parpens and drift nets during monitoring, upstream portion of the Lachine Rapids, spring of 2003. The detailed location of the stations appears in appendices 1 to 8.

For logistical reasons (damage to equipment, bad weather, etc.), this rhythm was extended to six days on a few occasions in less interesting sectors. The maximum number of cement parpens that could be put in place reached about 180 units (30 parpens/team-day X 2 teams X 3 days).

2.2.3. Sampling effort using parpens

The number of stations and the sampling effort per sector are reported in Table 1. The spatio-temporal progression of this effort in the study area is presented by means of three plates covering the entire sampling period, from May 9 to June 19, 2003 (Figure 3). In all, 202 different stations were monitored in nine sectors (Figure 2). According to the total surface area of each sector and its importance, the number of stations varied from 7 for Pointe Lachine to 44 for the spawning ground. The number of parpens was increased at the sites offering the best conditions for spawning in 2002 and 2003, such as Centre of the Iron Bridge and Iron Bridge. Finally, this approach was also applied to the Rocky Point and Dixie Island sectors where indicators of lake sturgeon spawning had been found in 2002, and which presented a less interesting flow than in 2003 (Table 1).

Table 1. Number of stations covered and gear-lifting operations performed in the nine sectors under study, upstream portion of the Lachine Rapids, spring of 2003.

Sector (Figure 2)	Maximum number of stations	Number of gear-lifting operations	Number of gear-lifting operations/station
Rocky Point	25	118	4.72
Dixie Island	32	139	4.34
Pointe Lachine	7	29	4.14
Off Lachine	9	44	4.89
Lachine Dyke	19	85	4.47
Kahnawake	11	45	4.09
Center of the Iron Bridge	20	67	3.35
Iron Bridge	35	197	5.63
Spawning ground	44	322	7.32
Total	202	1046	5.18

More than 1000 gear-lifting operations were performed during monitoring. With the exception of three sectors, the effort made is almost equal everywhere, varying between 4.09 raising operations per station in Kahnawake and 4.89 raising operations in the Off Lachine sector. Given the danger associated with working in fast moving water upstream from the pillars of the Iron Bridge, the work in this sector was suspended on windy days; the effort was only 3.35 raising operations/station. Finally, the effort was very intense at the spawning ground in order to corroborate the observations of 2002. This was the case in the Iron Bridge sector, which in 2003 offered environmental conditions that were very appropriate for lake sturgeon spawning.

The putting in place of the cement parpens was rapid and intensive at the start of the fieldwork. It began in the sectors situated on the north shore bathed by brown water from the Outaouais River, which warms up much faster than the water in the main course of the St. Lawrence River, originating from the Great Lakes. The following sectors were covered first between May 10th and 16th: Dixie Island, Rocky Point, Pointe Lachine, Off Lachine, Lachine Dyke and Iron Bridge (Figure 3, upper plate). The putting in place of parpens continued at the spawning ground on May 17th. Finally, the coverage of the Center of the Iron Bridge and Kahnawake sectors began on May 24th and 25th (Figure 3, central plate). The distribution of the sampling effort varied greatly during the fieldwork. Owing to the decline in the river’s level and to begin the monitoring of larval drift earlier, the sampling of eggs by means of parpens ended on May 28th at Rocky Point and on June 2nd in the Lachine Dyke and Off Lachine sectors. The following day, the Dixie Island and Pointe Lachine sectors were set aside. The gradual removal of the sampling stations began on June 8th in the Kahnawake and Iron Bridge sectors (Figure 3, lower plate). The parpens that covered the spawning ground were gradually removed from the water between June 12th and 16th.

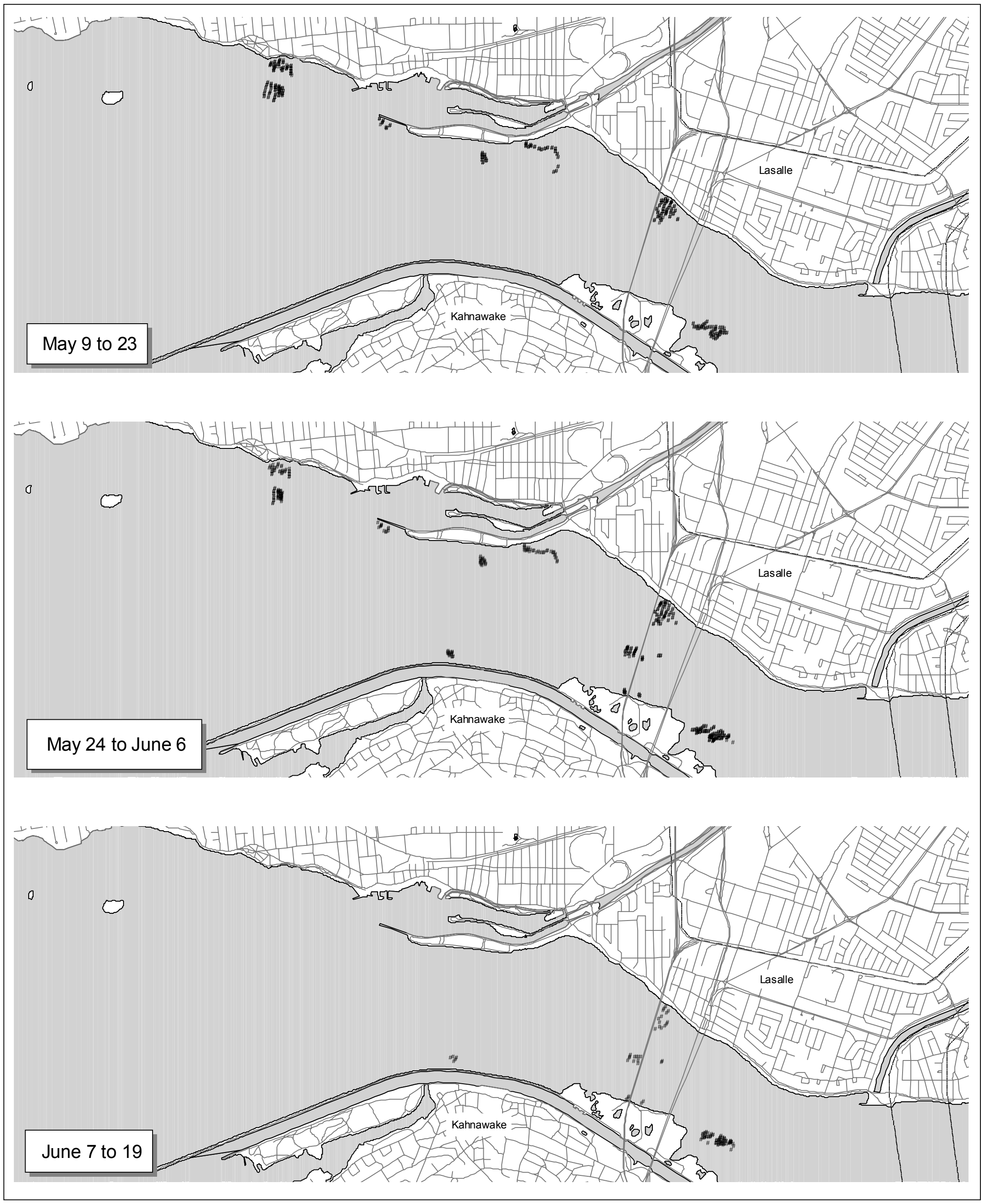


Figure 3. Spatio-temporal progression of the putting in place and removal of the parpens on the study area by period of 14, 13 and 12 days, between May 9 and June 19, 2003, upstream portion of the Lachine Rapids.

The spatial distribution of the stations in the nine sectors is represented on a series of individual large-scale plates (Appendices 1 to 8). The majority of the sectors were covered according to the pre-established sampling plan (section 2.2 in La Haye et al. 2003). A shoal covered with particles of variable size was sampled intensively in the Centre of the Iron Bridge sector where four lines of parpens were laid out on and downstream from this shoal (Appendix 1). A couple of parpens were added behind the pillar of an abandoned metal tower set back from this sector (Appendix 1).

The spawning ground was covered systematically when the conditions permitted. Certain stations located on the outside edge were spaced apart to permit safe boat maneuvers (Appendix 2), as the great depth of certain portions forced the teams to lay up to 50 m of rope to connect the parpen to its buoy. At Dixie Island and at Rocky Point, the coverage was intensive (Appendix 3). Camera observations made it possible to detect the presence of several strips of interesting substrata interrupted with sectors of barren solid rock. Sampling stations were placed behind the most interesting shoals on the big flat that begins at Dixie Island a few kilometers upstream and near the shore behind Rocky Point.

Sampling was more scattered in the Lachine Dyke sector: two lines of parpens covered a shoal near the shore and only one line, round in shape, stretched towards the centre of the river to cover a very extensive flat (Appendix 4). The interesting sites for spawning were distributed intermittently in the Kahnawake sector (Appendix 5). A small round-shaped shoal located in front of the church of this municipality was covered by means of two lines of parpens. A trio and a pair of parpens were added near the shore on both sides of the iron bridge to cover two small surfaces with gravel conducive to lake sturgeon spawning. The substrate is made up of solid rock covered by big rocks at places with fine particles being rare here. Sampling was more intensive on another small shoal half-way downstream from the Lachine Marina Dyke which was covered with two lines of relatively tightly arranged parpens (Appendix 6). The upstream point of the Lachine Marina Dyke contained a few scattered strips of fine to coarse gravel sampled by means of one or two parpens (Appendix 7). The last sector, Iron Bridge, was covered very intensively (distance of less than 20 to 30 m between the stations and the transects) as several observations made during the previous monitoring and at the start of the work of 2003 suggested the presence of very conducive sites. Five lines of tightly arranged parpens were laid out from the shore up to a quarter of the width of the river at this location (Appendix 8).

2.2.4. Sampling effort using drift nets

In 2003, the sampling effort using drift nets was much more sustained and extensive than in 2002, with four sectors having been covered. Five drift net stations (0.5 m in diameter, 1.5 m in length, nytex 500 µm, equipped with a removable bucket) were set up between June 5th and 10th to ensure a complete coverage of the sector of the spawning ground where lake sturgeon eggs had been sampled (Figure 2 and Appendix 2). Three stations were added towards the outside part of the spawning ground not covered by the parpens, and two others on June 10th upstream from the spawning ground. Certain stations that drifted during the work were renamed; they have two numbers in Table 2. Two stations placed downstream from the iron bridge covered the Centre of the Iron Bridge sector beginning on June 4th. Once again, one of the stations had drifted during monitoring and was renamed (Table 2). Three stations covered the downstream portion of the Dixie Island sector and two others, the Rocky Point sector (Figure 2 and Appendix 3). The location of these stations was selected based on the drift results of 2002 and the knowledge of one of the aboriginal collaborators (Stewart Philips Jr., animal control officer, Kahnawake, personal communication). Station 234 was moved further off-shore on June 6th following the further declines in the river's level; it too was renamed (no. 315).

The nets were laid in the afternoon and raised the next morning. The period for monitoring the drift of larvae varied a great deal between the sectors. It began much earlier, starting on May 30th, for the two sectors located on the north shore (Table 2).

Table 2. Effort (in hours), date of drift net installation and sampling period in four sectors of the study area, upstream portion of the Lachine Rapids, spring of 2003. (Location of the stations: see Figure 2 for the entire territory and in the order of presentation appendices 2, 3 and 1 for the four sectors)

Sector	**Station**	**May**	**June**											**Total**
		30	**3**	**4**	**5**	**6**	**10**	**11**	**12**	**13**	**17**	**18**	**19**	
Spawning ground	307/402				18	20	20	20	20	18	19	19	18	170
	308/403				18	20	20	20	20	18	19	19	18	170
	354/405						20	20	20	18		19	18	114
	355/404						20	20	20	18		19	18	114
	356/401						20	20	19	18	19	19	18	132
	375/406									18	19		18	55
	410										19	18		37
	371/407							20	20	18	18	19	18	113
	372/408							20	20	18	18	19	18	113
	Total				37	39	98	139	138	143	131	149	144	1018
Dixie Island	220	18	19	18	17	19	20	19	19	18	18	17		204
	230	18	19	18	17	19	20	19	19	18	18			186
	231	18	19	18	17	19	20	19	19	18				168
	232	18	19	18	17	19	20	19	19	18	19	17		204
	Total	72	74	72	70	78	82	77	76	72	56	35		763
Centre of the Iron Bridge	309/409				18	20	20	20	20	18	18	19	18	170
	353						20	20	20					60
	Total				18	20	40	40	39	18	18	19	18	230
Rocky Point	233	18	19	18	17	19	20	19	19	18	18	17		204
	234/315	18	19	18	18	19	20	19	19	18	18	17		204
	Total	36	37	36	35	39	41	39	38	36	37	35		408

Overall, the daily fishing effort was relatively constant, between 17 and 20 hours. The nets were gradually removed from the water beginning on June 18th.

2.3. Counting of eggs and larvae

The methods advocated in the spring of 2002 for counting eggs and larvae caught using parpens or drift nets were repeated without modification in the spring of 2003 (La Haye et al. 2003).

2.4. Characterization of egg deposition sites

The method advocated for the characterization of the spawning habitat described and developed by La Haye et Fortin (1990), La Haye et al. (1990) and La Haye et Clermont (in preparation) proved to be very hard to apply in 2002. This characterization makes it possible to highlight the preferential physical conditions of lake sturgeon during spawning. The variables that best express these conditions are the depth, the particle size distribution of the substrate (dominance and heterogeneity) and the speed of the current. Only one biological variable is taken into account, the number of eggs harvested in a standard size plot (1.25 m X 0.45 m) using a kick net. The technique is simple but not readily applicable beyond 2 m in depth as it requires that the substrate be disturbed in order to extract and count the buried eggs.

In 2002, a readily accessible lake sturgeon egg deposition site had been located. However, it was not possible to complete the characterization of this site owing to the adverse conditions encountered (high current speeds and water depths). The only parameters that could be measured here are the depth (sonar) and the speed of the current (PriceGurley current-meter). The characteristics of the substrate and the number of eggs could not be evaluated with sufficient precision. A new approach was developed in 2003 to circumvent these difficulties. This procedure was repeated with precision at the three transects downstream from the spawning ground by identifying the location using the buoys of the parpens (Appendix 2) and at a few stations of the other sectors (Appendices 1; 3; 4; 5; 6; 7 and 8). The parpens had been removed from the water at the time of the characterization and the boat was repositioned using the “GO TO” function of the GPS unit. We resorted to the camera to determine the dominance of the substrate at all these stations. A 2 m rope, graduated at every 10 cm, was attached to the weight under the camera (Photo 1). The size of the dominant particles was evaluated on the monitor at every 10 cm of rope. This procedure made it possible to obtain approximately 5 evaluations per station. The presence of periphyton and fine sediments was also noted. The speed of the current was measured using a ballasted General Oceanic current-meter-flow-meter (model 2035). According to the usual procedure, the flow speed of the water column above the station was evaluated using three measurements made at about 0.2, 0.6 and 0.8 times the depth when it exceeded 1.5 m, and at 0.6 time at less deep sites. The average speed on the column was then calculated according to the following equation:

V water column = (V 0.2 x (2 x V 0.6) x V 0.8) / 4

Finally, the number of eggs was evaluated based on the results obtained using parpens. Expressed in terms of the average per station, this number is the biological datum that best expresses the spatial preference of the spawners.

2.5. Other observations

The water temperature was noted on a daily basis in the main course of the St. Lawrence River and on several occasions on the left shore. Lake sturgeon may leap during the spawning period. The members of the team paid special attention to this behaviour. Finally, any anomaly or change in the environmental conditions was noted (turbid water, change in level, etc.).

2.6. Processing of data

The characterization of the various sectors covered is based on depth data, five evaluations of the dominant size of the substrate, the average speed of the water column, and the number of eggs harvested using parpens. The choice of this biological variable assumes that the effort was constant, which was generally the case.

As substrate data present values that can vary enormously within an observed plot, the geometric mean is the statistic that most faithfully expresses the dominant size of the substrate. Following this same reasoning, it is the variation coefficient that best expresses the heterogeneity of the plot of substrate examined. Fine particles were excluded from the descriptive statistics by station and by sector. These statistics were calculated using Excel 2000. For inter-site comparisons, the results were synthesized textually according to the four descriptors: depth, speed of the water column, dominance and heterogeneity of the substrate.

The value of the geometric mean calculated by station was transformed into standard particle category (Bovee 1986; Table 3). To express the dominance of the substrate of a station containing vegetation, the following rule was applied: when vegetation covered more than 50% of the station examined, the dominance of the substrate corresponded to class “v” of Table 3. The classes of depths, speeds and variation coefficients were chosen subjectively in order to facilitate visual comparisons between them by taking into account the dispersion and distribution of all of the data.

Table 3. Size distribution classes and values used for the characterization of the substrate, upstream portion of the Lachine Rapids, spring of 2003 (modified on the basis of Bovee 1986).

Codes of the classes	**Descriptions of the classes**	**Diameter of the classes (mm)**
s	Sand, clay, silt	< 1.0
sg	Coarse sand	1.0 – 2.9
gfm	Fine to average size gravel	3.0 – 16.9
gg	Coarse gravel	17.0 – 64.9
r	Rock	65.0 – 255.9
gr	Big rock	> 256.0
rp	Solid rock	---
v	Vascular plant, periphyton	---

An intra-site comparison was made for each habitat descriptor. The description and analysis of the physical characteristics of a spawning habitat often involve calculating the following two parameters: for each class, the number of stations with and without eggs, and the average number of eggs per station. We chose the average number of eggs within the context of this monitoring. In addition to providing a good way of analyzing sturgeon preferences regarding the habitats available on the spawning ground, this approach allows us to present the results graphically.

These data can be compared statistically. The average number of eggs per station per descriptor class is a non-parametric datum, the distribution of which is rarely normal. The statistical comparisons were made using Kruskal Wallis tests (Sall and Lehman 1996; Scherrer 1984).

2.7. Mapping

The geographical coordinates of all of the points of interest (fishing stations, spawning site, etc.) were obtained by means of a GPS (Furuno model GP36 DGPS Navigator) or by means of a portable GPS (Garmin GP12). All of the maps were created using ArcView version 3.1. The latitude and longitude coordinates were transformed manually into decimal coordinates using Excel, version 2000.

3. RESULTS

3.1. Location of lake sturgeon egg deposition sites

Lake sturgeon spawn was found in only one sector of the zone under study, that of the known spawning ground. One hundred and sixty-three eggs were harvested using parpens at 23 of the 44 stations (Appendix 2 for the numbers of the stations and Figure 4). The captures extended from May 23rd (46 eggs) to June 16th (3 eggs) (Table 4). In 2003, the spawning zone shifted towards the outside edge of the spawning ground located in 2002 (Figure 4). This shift may be due to the greater range of depths chosen in 2003. Despite a very tight coverage, no egg was harvested in the parpens placed upstream, towards the inside of the spawning ground.

The spawning activity was greatest between May 23rd and 27th, when the majority of eggs were collected. It was also during this period that the presence of sturgeons manifested itself most with the observation of one large individual near the spawning ground, two other average-size sturgeons, and several leaps on the spawning ground as well as on the Centre of the Iron Bridge and Downstream from Mercier Bridge sites between May 23rd and 27th. A final leap was observed on June 3rd near the Kahnawake sector.

Sturgeon spawn observations were also made on several occasions from June 6th to 19th in the drift nets placed downstream from the spawning ground (Table 4). One hundred and three eggs, including sixty-two on the last day, were caught during this period. Five larvae were collected on June 17th. Eggs and larvae were caught between June 10th and 19th at three of the four drift stations that covered the outside edge of the zone sampled by means of parpens 354, 355 and 375. A large number of eggs (47) were caught at station 375 at the end of the sampling period. This suggests that spawning activities took place on the edge of the zone covered by the parpens (probable spawning zone, Figure 4). Only five eggs were harvested in the two nets laid upstream from the spawning ground between June 11th and 19th. No sturgeon egg or larva was collected in the other sectors.

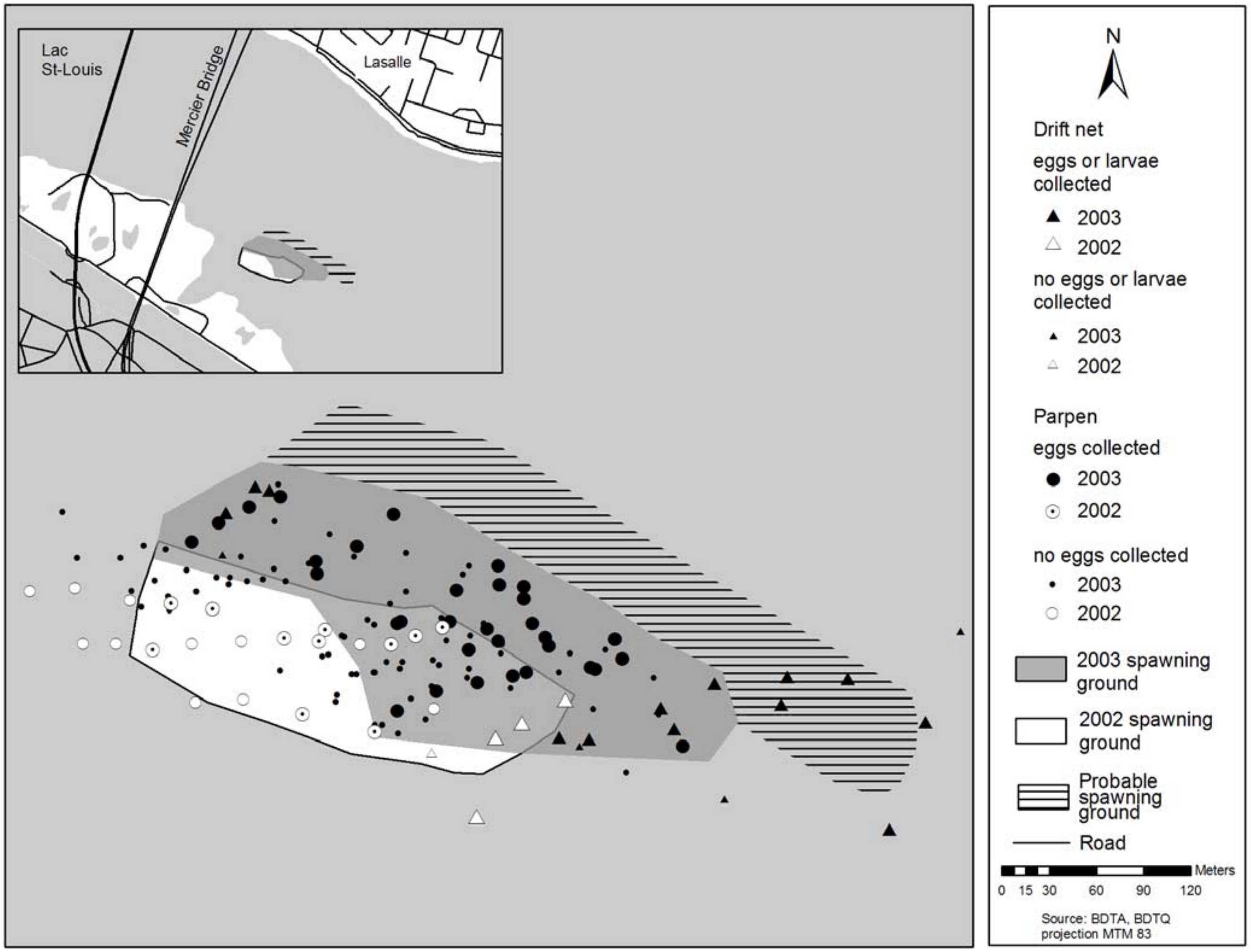


Figure 4. Location of the spawning zone used by lake sturgeons in 2002 and of the stations (parpens and drift nets) with presence of eggs or larvae in 2003 and probable spawning zone, upstream portion of the Lachine Rapids, spring of 2003.

Table 4. Number of lake sturgeon eggs harvested using parpens in the Spawning ground sector, upstream portion of the Lachine Rapids, spring of 2003. (See Appendix 2 for the location of the stations).

Date (June)	May 23	May 27	May 30	June 3	June 6	June 9	June 12	June 16	Total
Temp. ° C	11.8	12.8	13	12.5	12.9	15	14.5	15	
Station									
D2-5						1			1
D2-6		3							3
D2-7		1	1						2
D2-8		7	1						8
D3-10					2	2	5		9
D3-7		1						1	2
D3-8		1					1		2
D3-9		12							12
D4-4		2						1	3
D4-5								1	1
D4-6		10		1					11
D4-7	28	2		2			1		33
D4-8	16	8							24
D5-6		3			1	2			6
D5-7				1					1
D5-8	1	3		8		5			17
D5-9				1		1	1		3
D6-2		1							1
D6-4	1								1
D6-5		1							1
D6-6		3		2			1		6
D6-7		7					1		8
D6-8		2		1	2	2	1		8
Total	46	67	2	16	5	13	11	3	163

Table 5. Number of lake sturgeon eggs and larvae (L) harvested using a drift net in the Spawning ground sector, upstream portion of the Lachine Rapids, spring of 2003. (see Figure 4 and Appendix 2 for the location of the stations).

Sector	Station	May	June											Total
		30	3	4	5	6	10	11	12	13	17	18	19	
Spawning ground	307/402						2			1				3
	308/403					2	3	1	4	1	2L		2	13/2L
	354/405						6	2					10	18
	355/404							1	2				2	5
	356/401								1		2/1L			3/1L
	375/406									6	8/2L		47	61/2L
	410													
	371/407							2	1					3
	372/408									1			1	2
Total						2	11	6	8	9	10/5L		62	108/5L

3.2. Characterization of the spawning zone

The surface area of the spawning zone used went from 2.3 ha in 2002 to 3.6 ha in 2003 (namely about 385 m long by 140 m at its greatest width). The surface area of the potential spawning zone is 2.4 ha, for a total of 6 ha.

For logistical reasons, only the two-thirds downstream from the spawning zone used in 2003 were characterized (transects 4, 5 and 6; Appendix 2). The average number of eggs per station increases gradually between the 2.0-2.9 and 4.0-4.9 m depth classes where it reaches more than 6 eggs per station (Figure 5). It falls slightly in the last class (5.0-6.0 m). These differences are sufficiently marked to be significant (Kruskal Wallis test ; p = 0.0069). The depth of the spawning zone varies from 1.15 m towards the shore to 5.5 m moving off-shore (Figure 9). However, the spawning activities are concentrated in the central portion and on the outside edge of the spawning ground. The larval drift suggests that the potential spawning zone covers depths in excess of 6 m.

These preferences are even more marked for the average speed of the water column (Figure 6). Indeed, the average number of eggs per station increases slowly between the first four classes and culminates in the last class, with very high values.

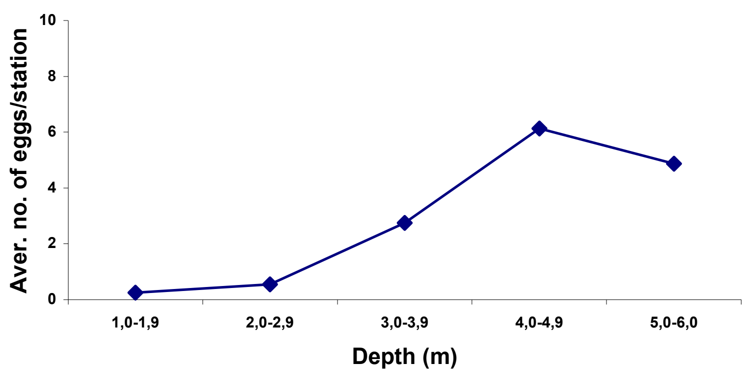


Figure 5. Average number of eggs collected by station according to the depth classes, upstream portion of the Lachine Rapids, spring of 2003.

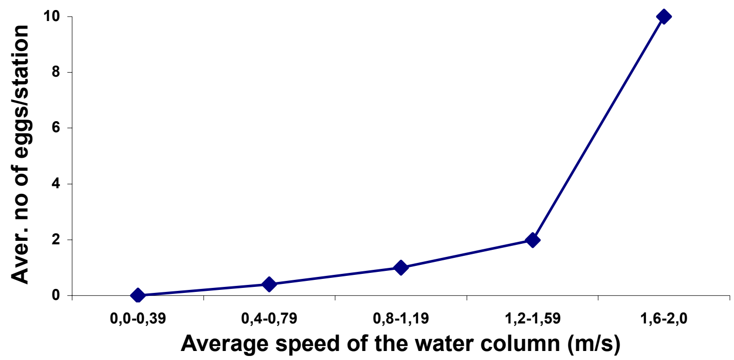


Figure 6. Average number of eggs collected by station according to the classes of average speed of the water column, upstream portion of the Lachine Rapids, spring of 2003.

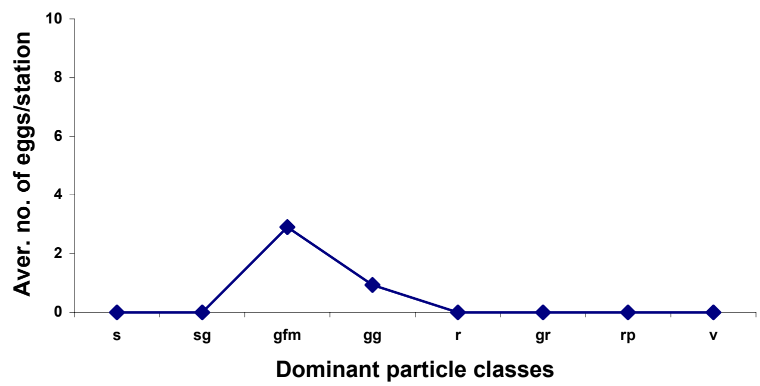


Figure 7. Average number of eggs collected by station according to the classes of dominant substrates (See Table 3 for the meaning of the codes), upstream portion of the Lachine Rapids, spring of 2003.

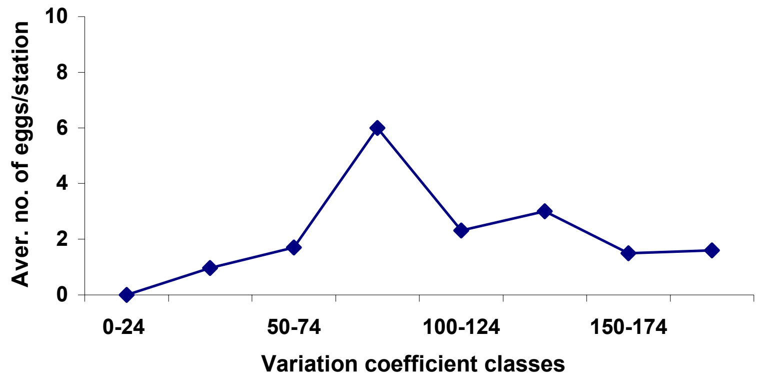


Figure 8. Average number of eggs collected by station according to the classes of the substrate variation coefficient, upstream portion of the Lachine Rapids, spring of 2003.

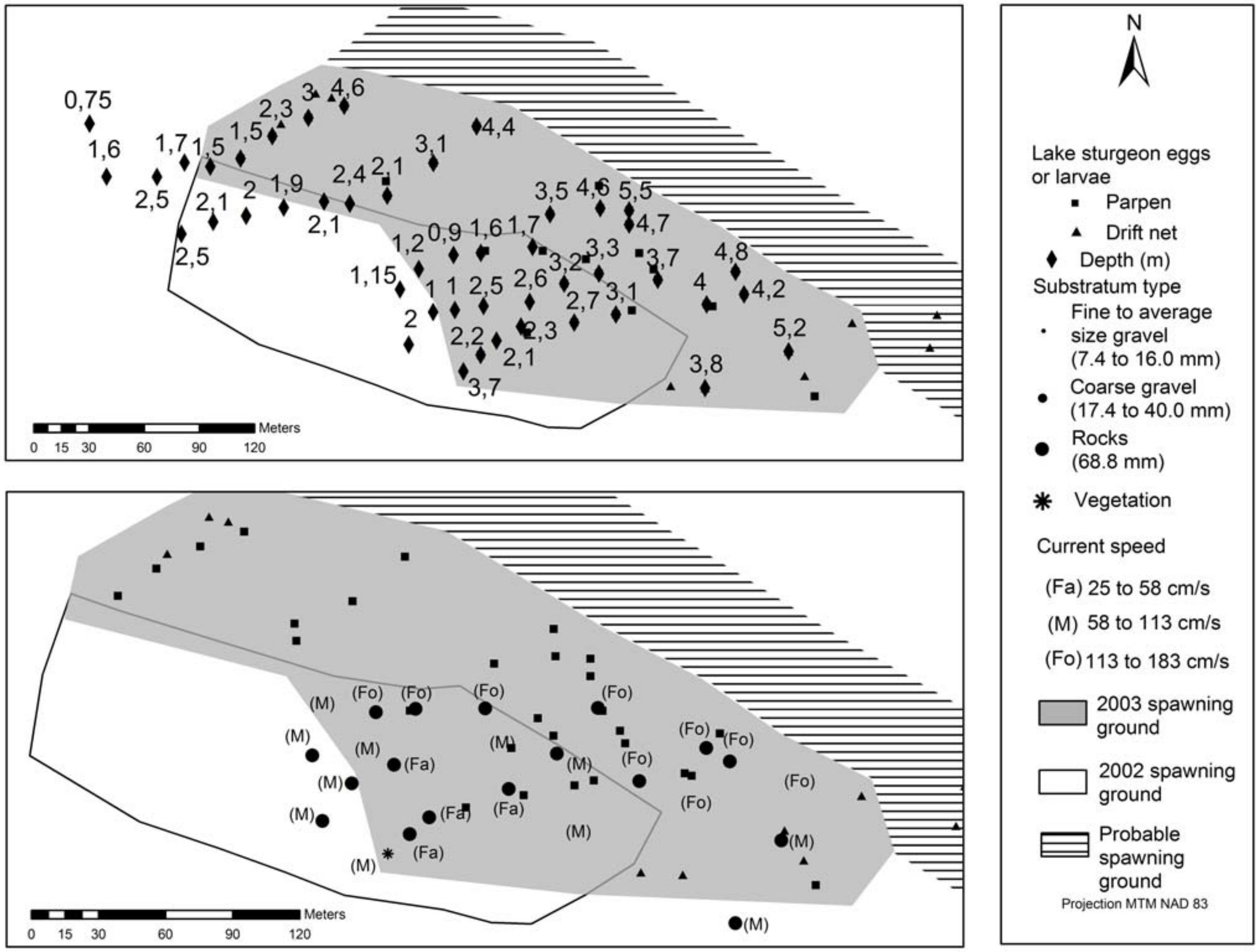


Figure 9. Location of the spawning zone used by lake sturgeons in 2002 and 2003. For the 2003 sampling: location of the probable zone and of the stations (parpens and drift nets) with the presence of eggs and larvae, and result of the characterization of the spawning ground, upstream portion of the Lachine Rapids, spring of 2003.

This difference is statistically significant (p=0.04). The average speed of the water column above the portion of the spawning ground that was characterized was classified in three major categories (Figure 9): low (Fa; 25 to 58 cm/s), average (M; 58 to 113 cm/s) and strong (Fo; 113 to 183 cm/s). The flow is average to weak on the inside edge and downstream from this zone. It is strong upstream and towards the outside edge. As mentioned, spawning occurred under rather rapid flow conditions from the centre towards the edge of the spawning ground. The speed of the current is generally faster near the surface (V0.2) and declines with increasing depth (V0.6 and V0.8) (Figure 9). It is more variable at the surface in the upstream portion of the zone characterized where a few large-size boulders cause turbulence. It appears to be fairly constant and streamlined in the remainder of this zone.

The substrate of the best spawning sites is made up of a mix of rocks and big rocks serving as shelter, with fine to coarse gravel. This gravel is found on strips that are 2 to 3 m long and about 50 cm wide. The strips are surrounded by coarse particles of different diameters. Several large boulders (> 2.0 m) are located on the upstream edge of the spawning zone and a few directly in this zone. At the time of spawning, the substrate was free of aquatic plants and periphyton. This arrangement of gravels and rocks is peculiar to the spawning ground identified and was not observed elsewhere on the study area. The two dominant particle size classes are fine to average gravels and coarse gravel (Figure 7). The greatest average number of eggs per station corresponds to a moderately varied substrate (Figure 8).

The presence of macrophytes was noted (Figure 9). It is associated with a shallow depth, less than 2.5 m and low to average current speeds. These conditions are those that prevailed in the inside portion of the zone characterized at the time of spawning. In the spring of 2003, spawners did not use this part of the spawning ground very much.

3.3. Environmental characteristics of the other sectors

Partial surveys done in the other sectors reveal marked differences in terms of the flow dynamics and the composition of the substrate. Generally, the flow is less rapid on the north shore than on the south shore. However, the current speeds measured in the Centre of the Iron Bridge sector are of the same order of magnitude as those observed above the spawning ground. The flow at the Iron Bridge site is fairly similar to that of the spawning ground in terms of speed but the presence of the bridge's towers creates numerous turbulence zones. The nature of the substrate is also similar, with strips of particles that are even finer at certain locations (fine to medium gravel) protected by boulders. In the other sectors, the substrate is dominated by very coarse particles and much finer particles but never by a mix of big stones and varied gravels like that observed at the spawning ground or in the Iron Bridge sector. Solid rock was observed in several locations in the Dixie Island sector.

The only site whose depths were near those of the spawning ground is Centre of the Iron Bridge where they vary between 2 and 6 m. The depth rarely exceeds 4 m elsewhere, except for the Off Lachine sector where it averages 5 m.

3.4. Temperature variations

The water that flows in the study area comes from two very distinct sources. Clear water from the Great Lakes, often called green water, feeds the main course of the St. Lawrence River up to one hundred metres from the north shore. The spawning zone is bathed by this water. Brown water, from the des Outaouais River, rich in tannins, flows in a narrow strip along the Island of Montréal. It partially mixes with green water at the Lachine Rapids. It covers the sectors situated along the north shore. The demarcation between these two types of water is very obvious on site. The green water tends to warm up later than the brown water in spring. As the chronology of spawning by the sturgeon depends on the water temperature, this parameter was measured regularly in the main course and near the north shore. During spawning, between May 22nd and June 18th, the temperature of the green water of the river increased by 3.2 ºC rising from 11.8 to 15 ºC (Figure 10). It was noticeably higher in the brown water, increasing from 13.2 ºC on May 22nd to 16 ºC at the end of the work (Figure 10).

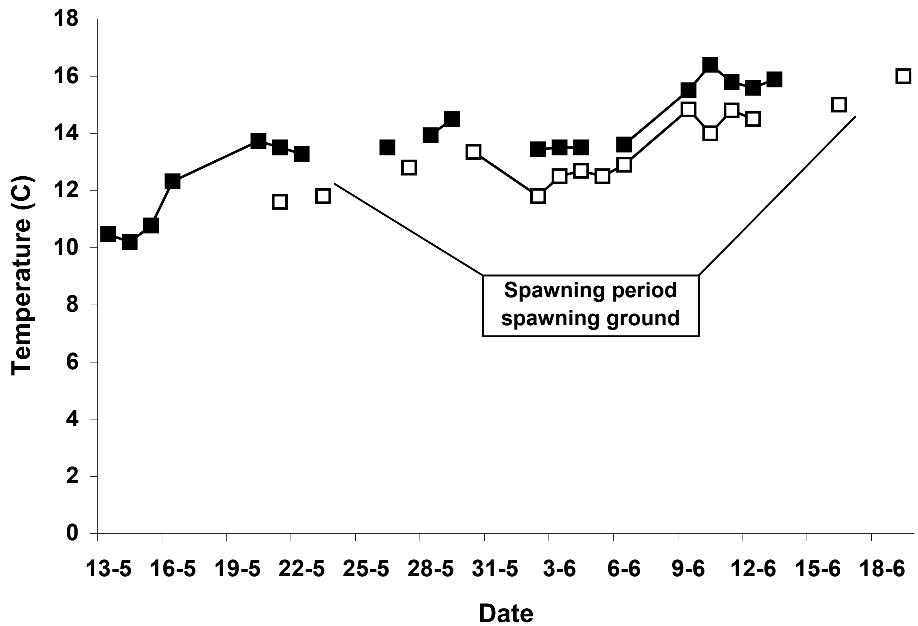


Figure 10. Temperature variations (ºC) in the main course of the St. Lawrence River (green water : □) and the northern part of the study area (brown water : ■), spring of 2003.

3.5. Capture of eggs and larvae of other fish species

Eggs of other fish taxa were collected (Table 5). A large quantity of redhorse (*Moxostoma sp*) eggs was sampled near the north shore, in the Iron Bridge sector (Figure 2; Appendix 8). Eggs of mooneye (*Hiodon tergisus*), walleye (*Stiszostedion sp.*) and percidae were also collected. Redhorse eggs were collected throughout the study area, except in the Rocky Point and Dixie Island sectors. The best catches were made between May 22nd and June 12th with significant abundance peaks on May 26th and 29th and June 3rd and 4th. More than 30 eggs were collected on these occasions across the entire territory.

Table 6. Number of eggs of other taxa harvested by means of parpens by sector, upstream portion of the Lachine Rapids, spring of 2003.

Sector	Percidae	Mooneye	Redhorse	Walleye
Rocky Point				
Dixie Island				
Pointe Lachine			7	
Off Lachine	2		10	
Lachine Dyke			13	1
Kahnawake			12	
Center Iron Bridge			6	
Iron Bridge	3	1	193	2
Spawning ground			77	
Total	5	1	318	3

4. DISCUSSION

The sampling strategy and methods used in 2003 made it possible to obtain precise results that confirm beyond a doubt the presence of an important spawning ground in the study area. These results corroborate those of 2002 as to its location and clearly show the relevance of the choice of greater depth strata for sampling. The spawning ground is still located about 400 m downstream from Mercier Bridge opposite a rocky point on the right shore. However, its dimensions are much greater than those observed in 2002. Oblong in shape, in 2003, it extended over 385 m crosswise to the direction of the current, as compared to 285 m in 2002, over a distance of about 140 m at its widest part. This difference may be linked to the increase in the depth stratum covered which went from 0-5 m to 0-7 m, or to a greater congregation of spawners. Whatever the case may be, the preferential spawning zone shifted towards the downstream outer portion of the spawning ground of 2002. Hence, the spawning ground remains attractive under various hydric conditions given that the level of the river was much lower (by about 75 cm) in 2003. This shift in the spawning zone shows the importance of this spawning ground for the St. Lawrence River population. In the St. Lawrence system, the use of several other known spawning grounds depends largely on the hydric conditions. During low-water years, certain spawning grounds, such as those of the Ouareau and l'Assomption rivers, become inaccessible or are over-used (La Haye et Clermont in preparation). This does not appear to be the case for the spawning ground discovered in the study area. As is the case for the Rivière des Prairies spawning ground, the largest known in the Québec network of the St. Lawrence River, it appears that the choice of preferential zones basically depends on the prevailing hydrological conditions (Fortin et al. 2002).

Aside from its accessibility under several hydric conditions, this spawning ground has several characteristics that are very suitable for the reproduction success of the lake sturgeon. It offers a good range of depths where good quality substrate is accessible and it is far from the shore. In addition, the rocky substrate found here is varied, clean and unobstructed. Water quality problems linked to the location of the outlet of the Kahnawake treatment plant, which was recently moved, may however compromise the survival of the spawn.

These characteristics are different from those surveyed to date in southwestern Québec with respect to the depth. Indeed, most of the known spawning grounds are located in rapids of various sizes where the water flow is basically torrential. The characteristics of the spawning ground discovered in the upstream portion of the Lachine Rapids are however similar to several other known spawning sites, in the St. Lawrence River or in major tributaries of the Great Lakes. Jennifer Hayes (biologist, New York State University, Syracuse, personal communication) collected eggs up to a depth of 7 m at the foot of the Moses-Saunders power dam (State of New York). As already mentioned, Manny and Kennedy (2002) discovered and briefly characterized three spawning sites used by the lake sturgeon in the St. Clair and Detroit Rivers, between Lake Huron and Lake Erie. The speeds measured at the Port Huron site were 0.98 m/s on average throughout the water column; at the Alganac site, they were 0.53 m/s everywhere and 0.33 m/s at the surface. They were 0.36 m/s at the bottom of the Zug Island site. In 2003, sturgeons showed a significant preference for sites exposed to high speeds that are close to those mentioned for the Port Huron spawning ground. According to Manny and Kennedy (2002), this spawning ground offers the best spawning conditions for lake sturgeon in both rivers. All of these sites had the following characteristics: they are located in deep water (between 9.1 and 12 m), the substrate is porous and made up of particles of variable size dominated by fine to coarse gravel (according to the classes mentioned in Table 3). The substrate was clean and free of periphyton or fine sediments at the time of spawning. All of these sites are well exposed to the current; their bed contains little or no asperities or depressions, and is concave in shape. In the case of Port Huron, the spawning ground is located on a slope. Except for the absence of asperities, these characteristics correspond to those observed on the portion of the spawning ground characterized in 2003 in the upstream portion of the Lachine Rapids.

Based on the observations reported by Jim Boase (biologist, USFWS, Alpena Michigan, personal communication), the presence of obstacles, such as the large boulders located on the upstream edge of the Mercier Bridge spawning ground, is another common point of these deep-water spawning sites. These boulders likely play an important role by providing spawning micro-habitats where sturgeons find a mix of substrate and velocity that suit them, without creating too much turbulence. These observations suggest that other spawning sites are present in the upstream portion of the Lachine Rapids at greater speeds and depths than those covered in 2002 and 2003. Additional surveys are therefore required. However, the cement parpen method will have to be refined given that close to 80 m of rope was necessary to hold the buoys on the surface in those stations located on the fringe of the zone covered in 2003. This entanglement of ropes makes boat maneuvers hazardous and difficult. The limitation of the current method is about 6 m for speeds exceeding 1.5 m/sec at the surface.

These observations and those made in 2002 on the spawning ground also suggest that in transparent water, sturgeons are hesitant about spawning at shallow depths. Similarly, in such water they systematically avoid shallow spawning habitats that are generally covered with vegetation or periphyton. This might explain the shift in the spawning zone between the two years of study since a good portion of the bed of the 2002 spawning ground was covered with macrophytes at the time of spawning in 2003.

More intensive sampling using drift nets yielded interesting results in 2003. This approach made it possible to extend the potential spawning zone off-shore, a milieu that is very hard to cover even using parpens, and to confirm spawning activities upstream from the spawning ground. However, few sturgeon larvae were caught despite a tight coverage of the spawning ground and the late period when the work ended. Given the unfolding of spawning in 2003, from May 23rd to the end of work on June 18th, and the ontogeny of the lake sturgeon, larvae could have been captured from the start of June.

The quality of spawning sites is high and a good proportion of the eggs likely develop here without problems. A methodological bias may explain this negative result. For example, large-size buoys had to be used to withstand the very strong currents in this sector of the Lachine Rapids. It is possible that the drift nets were raised from the bottom by the attraction of these buoys and did not cover the optimal larva capture zone.

One site in particular, the Iron Bridge sector, which is located in brown water, offered adequate physical characteristics for spawning by the lake sturgeon. The effort made in this sector was more sustained and intensive than in 2002, as several indicators pointed to the presence of a spawning ground (La Haye et al. 2003). However, no sturgeon egg was collected here. Yet it is in this sector that the yield in terms of the number of eggs per gear-lifting operation, all species combined, was the greatest, showing its appeal for spawning among fast current species. The lake sturgeon avoids turbulent water sectors and prefers a streamlined flow for spawning (Auer 1996 and La Haye 1996). The pillars of the bridge are an obstacle to the flow over the entire width of this sector, generating turbulence on a good proportion of its surface area.

At the time of the 2001 study, one of the two best net fishing zones of the aboriginal fishers was located downstream from a rocky point under Mercier Bridge (La Haye and Clermont 2003). This zone is located less than 100 m upstream from the spawning ground. The perception of the members of the 2001 team was that sturgeons appeared to prefer the right shore for moving about. The discovery of the spawning ground along this shore in the spring of 2002 and the observations of 2003 confirm this perception and once again show the species' vulnerability in the Lachine Rapids during the migration and reproduction period.

The capture of eggs of several other taxa shows that the parpen method could be used for other species under various conditions. However, this method does not appear to have been very effective in the Dixie Island and Rocky Point sectors, where the flow was very low in 2003.

5. CONCLUSION

The results obtained made it possible to confirm beyond a doubt the presence of a spawning ground in the upstream portion of the Lachine Rapids in the spring of 2002 and 2003. The discovery of a new lake sturgeon spawning ground in such a vast territory was not by chance; it was the result of an approach that was systematic and well structured, both in time and space. The stratification of the habitat in sectors having a high spawning potential and the increase in the scope of the depths covered did much to contribute to the study's success. At the start of the work in 2001, it would have been unthinkable to organize a sampling campaign using only field observations in such a vast territory. The experience of the team members, acquired in 2002, and the excellent spirit of cooperation that reigned among them made it possible to put the finishing touches on a very effective and inexpensive sampling method.

The work accomplished during the two years of study has been decisive for it allowed us to concentrate the fieldwork solely on the validation of the pre-sampling stratification, the delimitation of the sectors to be sampled and the search for spawning grounds. The increase in the depth stratum to be covered, chosen in light of recent results obtained in certain tributaries of the Great Lakes, has borne fruit since the surface area of the spawning ground went from 2.3 ha to 3.6 ha in 2003 solely on this basis.

The capture gear developed in the spring of 2002 for the search for egg deposition, a cement parpen covered with a section of air filter, continues to produce very satisfactory results in fast and deep water environments. This characteristic sets it apart from other capture gear (kick net, vortex pump, etc.) which is of little if any effectiveness under such circumstances. Inexpensive and easy to use in the field, between 30 and 40 parpens can be handled daily by a three-member team. In the absence of serious damage and under favourable weather conditions, each team can put in place and visit at least 100 units over a three-day period in a territory not exceeding 10 km in length. This sampling effort appears to be optimal and should be kept for subsequent monitoring operations. Finally, combined with the observation of the substrate using an underwater camera when pre-selecting the sites to be covered, this method allows researchers to achieve a precision and power that far exceed the efficiency of existing methods for sampling eggs in fast moving water.

The left shore of the territory is bathed by brown water from the Outaouais River. This water warms up faster than the green water from the Great Lakes. A time difference of close to two weeks was once again observed between the two water masses to reach sturgeon spawning temperatures (10 to 12 ºC in southern Québec). The chronology of sampling in the various sectors was adjusted to this time difference in 2003. As a result, the fact of not having identified a spawning ground in the portion of the study area bathed by brown water did not appear to have influenced the chronology of sampling. If, sturgeons spawned elsewhere in the Lachine Rapids than on the identified spawning ground, this activity was reduced or it occurred outside the study area.

The organization and daily planning of the work involved the participation of all team members. The success of this research, in a vast zone with difficult and varied hydrological conditions, is linked, among other things, to the presence of aboriginal collaborators throughout the surveys. It was with good reason that the organization of teams adopted in 2002 was kept in 2003.

Like the results obtained in the spring of 2001 and 2002, those of the spring of 2003 clearly and unequivocally confirm the need to put an end to every form of lake sturgeon harvesting in the Lachine Rapids in spring. Moreover, corrective action must be taken quickly to ensure that waste waters or partially treated waters of the plume from the new outlet of the Kahnawake treatment plant does not flow into the spawning ground, as has been the case since its start-up in the fall of 2002, thereby compromising the survival of sturgeon spawn and many other fish species that use this site to reproduce.

LIST OF REFERENCES

Auer, N. A. 1996. Response of spawning Lake Sturgeons to change in hydroelectric facility operation. Trans. Am. Fish. Soc. 125: 66-77.

Bovee, K. D. 1986. Development and evaluation of suitability criteria for use in the Instream Flow Incremental Methodology. Instream Flow Information Paper 21. Fish Wild. Serv. Biol. 86(7): 235 pp.

Dumont, P., Y. Mailhot, R. Dumas et P. Bilodeau. 2000. Plan de gestion de l'esturgeon jaune du fleuve Saint-Laurent 2000-2003. Société de la faune et des parcs du Québec, Direction de l'aménagement de la faune du Centre-Québec, de Lanaudière, de la Montérégie et de Montréal, 24 p.

Fortin, R., J. D'Amours et S. Thibodeau. 2002. Effets de l'aménagement d'un nouveau secteur de frayère sur l'utilisation du milieu en période de fraie et sur le succès de reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à la frayère de la rivière des Prairies. Rapport synthèse 1995-1999. Pour l'Unité Hydraulique et Environnement, Hydro-Québec et la Société de la faune et des Parcs du Québec, direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie. Département des Sciences biologiques, Université du Québec à Montréal. 130 p.

La Haye, M. 1996. Scénarios d'aménagement d'une frayère à esturgeon jaune dans le bief d'aval de la centrale Rivière-des-Prairies. Enviro-science pour le compte d'Hydro-Québec, Direction Maisonneuve, 21 pages.

La Haye, M. et S. Clermont. En préparation. Caractérisation des frayères à esturgeon jaune (*Acipenser fulvescens*) du bassin versant de la rivière l'Assomption dans un contexte de faisabilité d'aménagement. 36 p.

La Haye, M. and S. Clermont. 2003. Lake sturgeon (*Acipenser fulvescens*) experimental fishery and search for spawning grounds in the upstream portion of the Lachine Rapids in the spring of 2001. Study carried out by Enviro-science inc and Limno service on behalf of the Société de la Faune et des Parcs du Québec, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie. Longueuil, Technical report 16-11E, viii + 32 p.

La Haye, M., S. Desloges, C. Côté, J. Deer, S. Philips Jr., B. Giroux, S. Clermont and P. Dumont. 2003. Location of lake sturgeon (*Acipenser fulvescens)* spawning grounds in the upper part of the Lachine rapids. Study carried out on behalf of the Société de la faune et des parcs du Québec, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Technical Report 16-15E, ix + 43 p.

La Haye, M. et R. Fortin. 1990. Indice de la qualité de l'habitat de fraie et de l'habitat des jeunes de l'année de l'Esturgeon jaune dans la région de Montréal. Rapport de travaux. Département des sciences biologiques. Université du Québec à Montréal. 81 p.

La Haye, M., S. Guénette et P. Dumont. 1990. Utilisation de la frayère de la rivière Ouareau par l'Esturgeon jaune suite à l'éboulis survenu en mars 1990. Québec, Ministère du Loisir, de la Chasse et de la Pêche, Service de l'aménagement et de l'exploitation de la faune, Montréal, Rapp. trav. 06-07. vi + 30 p.

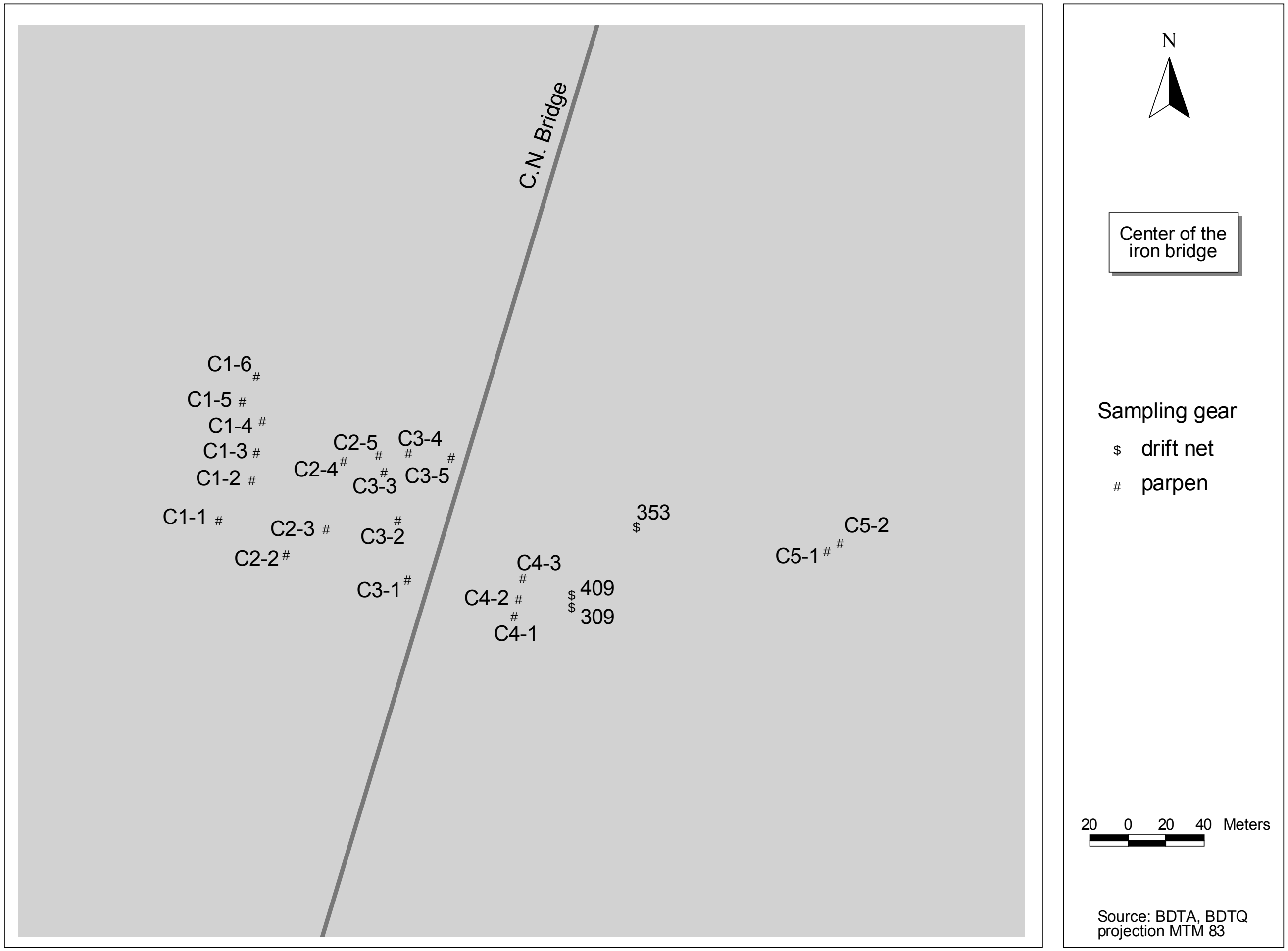
Manny, B.A. and G.W. Kennedy. 2002. Known lake sturgeon (*Acipenser fulvescens*) spawning habitat in the channel between lakes Huron and Erie in the Laurentian Great Lakes. J. Appl. Ichtyol. 18 (2002). 486 – 490.

Sall, J. and A. Lehman. 1996. Start Statistics. A Guide to Statistics and Data Analysis Using JMP and JMP IN Software. SAS Institute. Duxbury Press. 505 p.

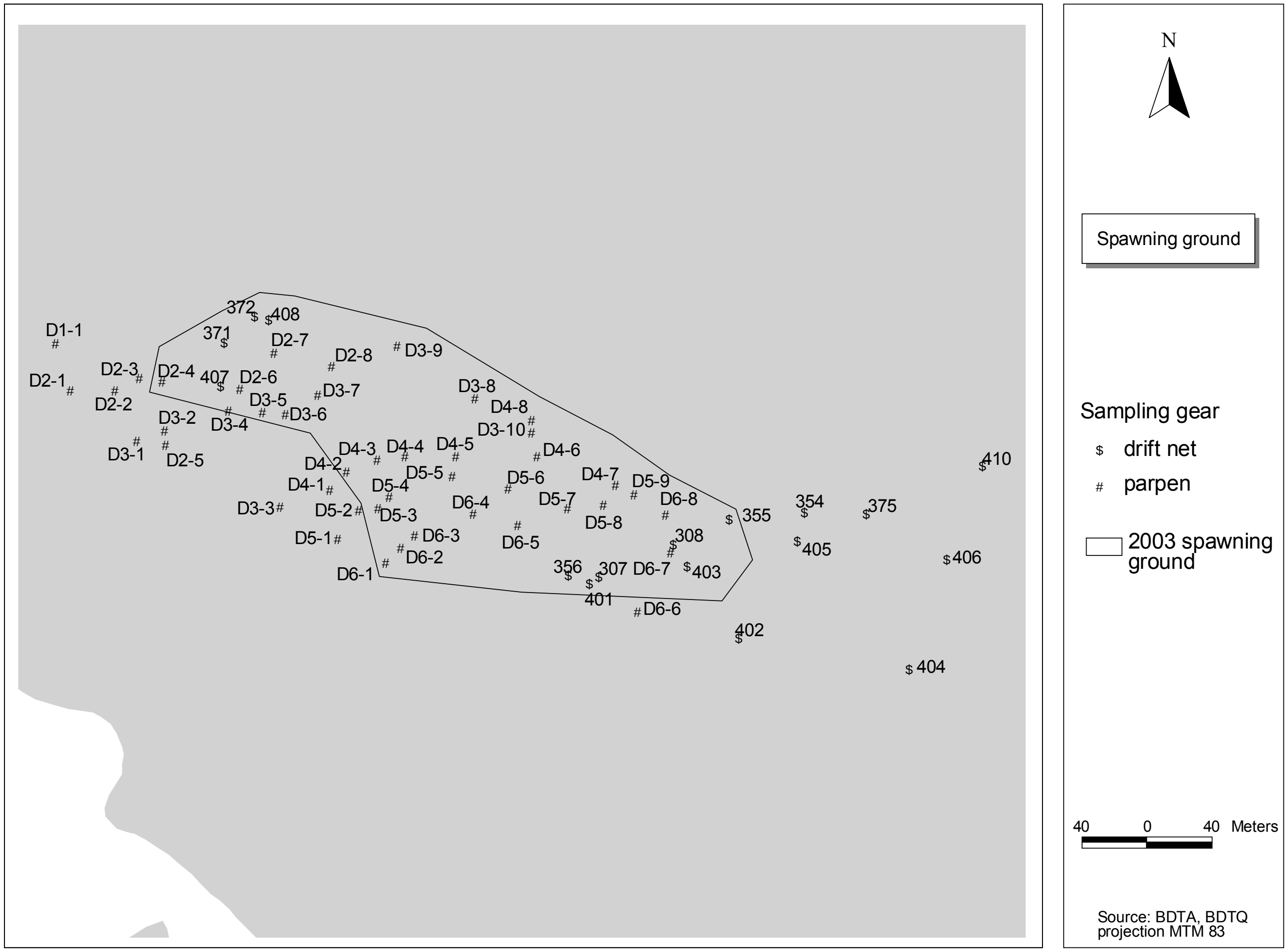
Scherrer, B. 1984. Biostatistique. Gaëtan Morin Éditeur. ISBN2-89105-093-2. 841 p.

APPENDICES

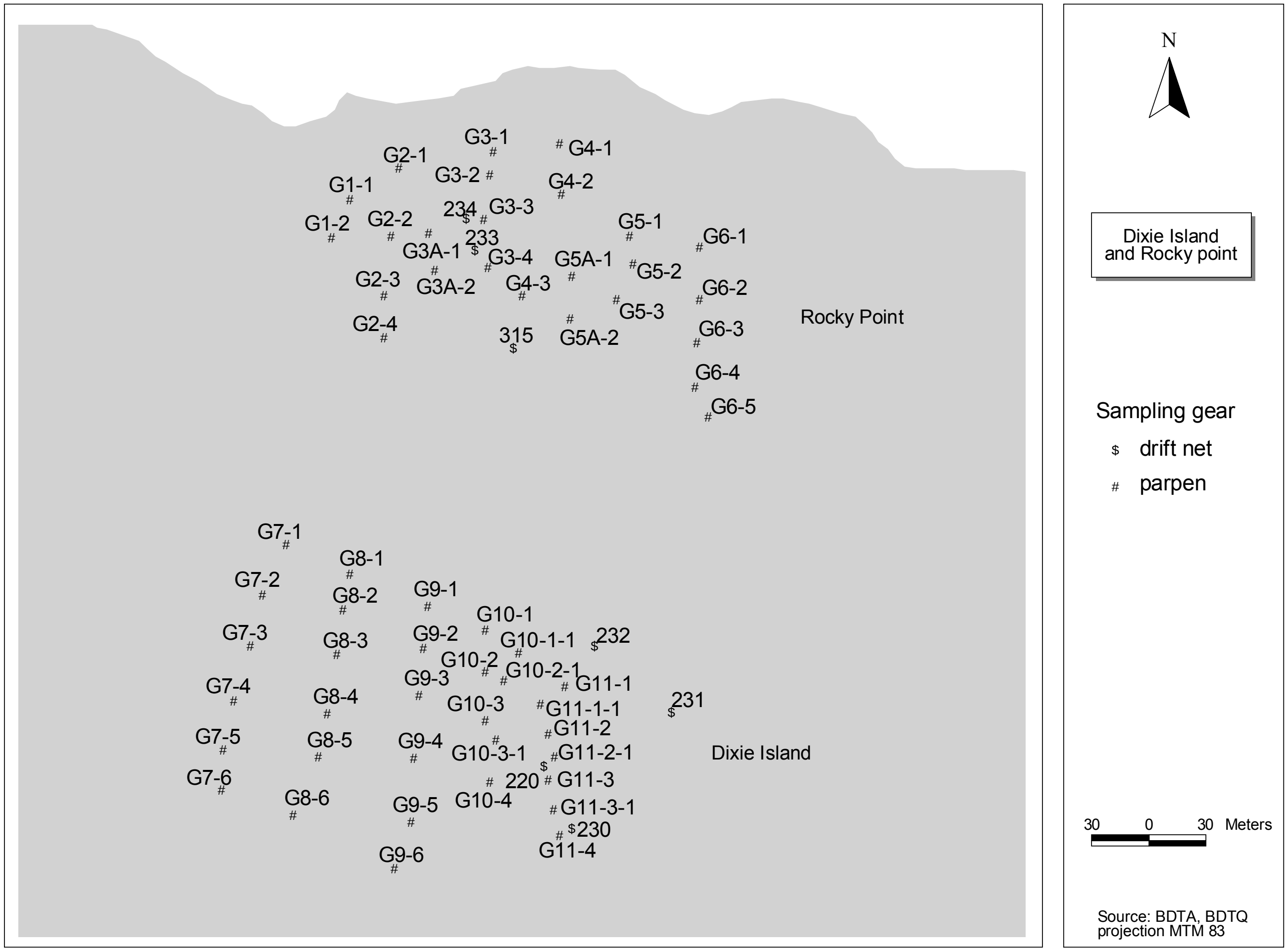
Appendix 1. Location of sampling stations in the Center of the Iron Bridge sector, spring of 2003.



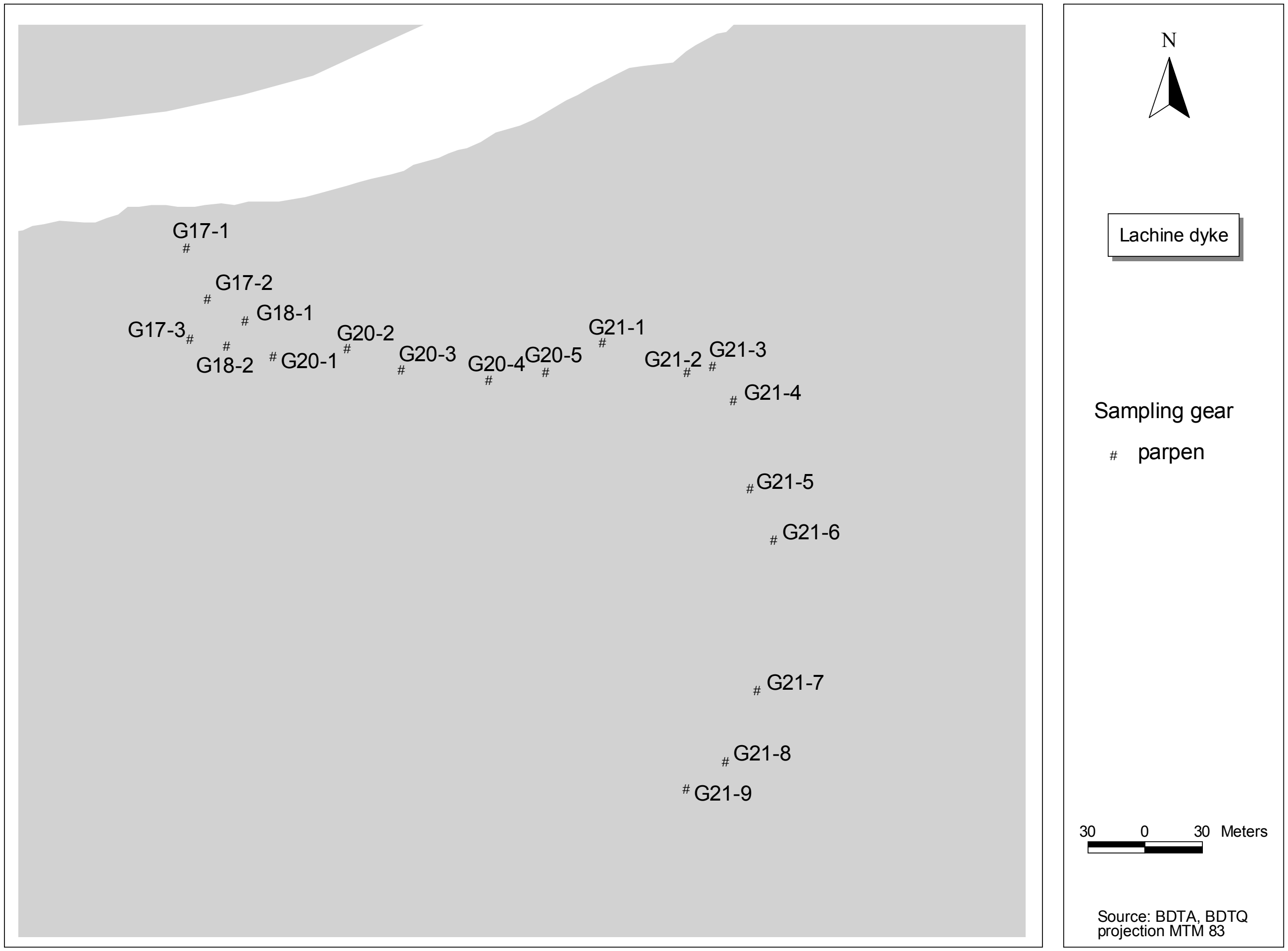
Appendix 2. Location of sampling stations in the Spawning ground sector, spring of 2003.



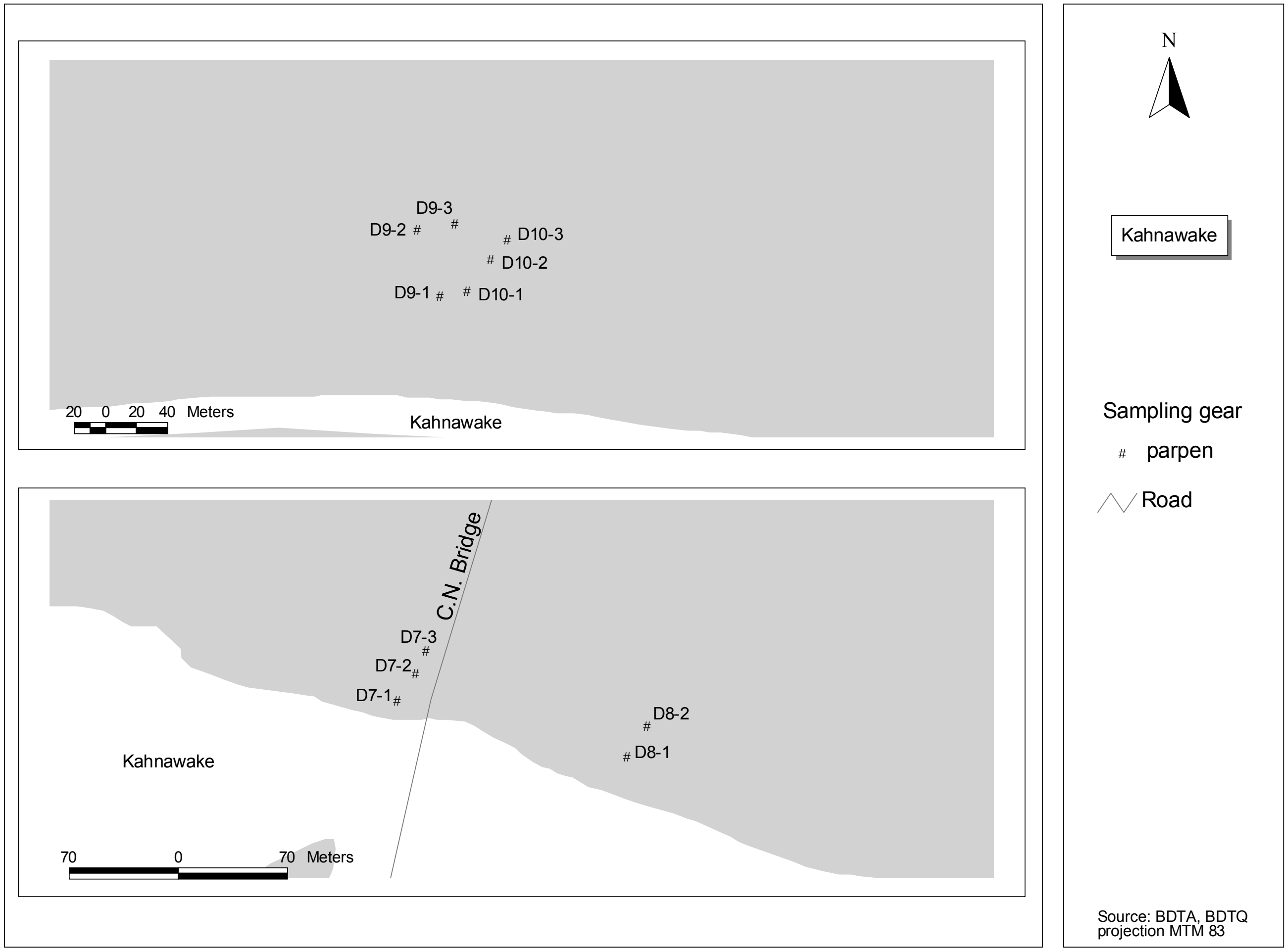
Appendix 3. Location of sampling stations in the Dixie Island and Rocky Point sectors, spring of 2003.



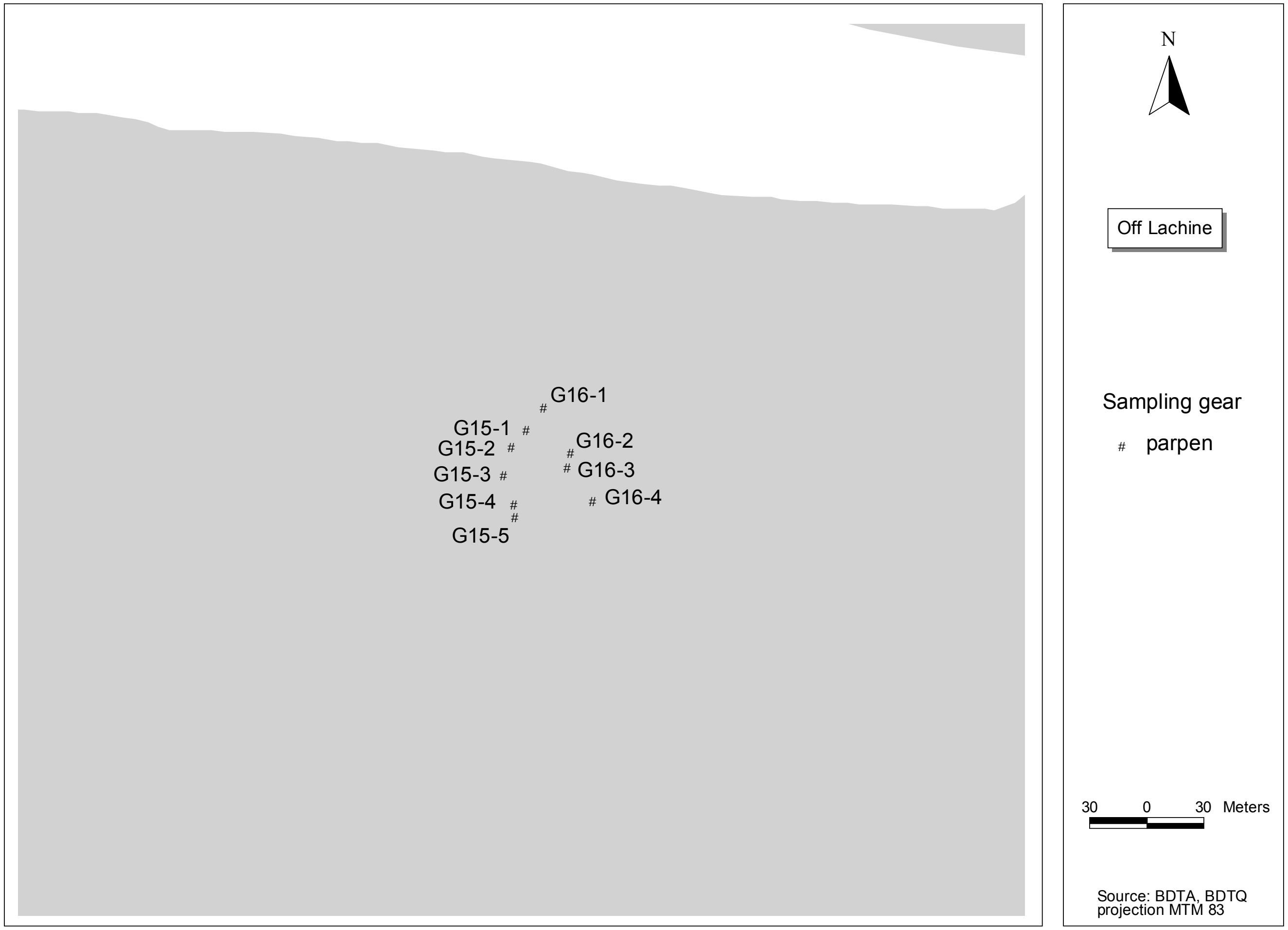
Appendix 4. Location of sampling stations in the Lachine Dyke sector, spring of 2003.



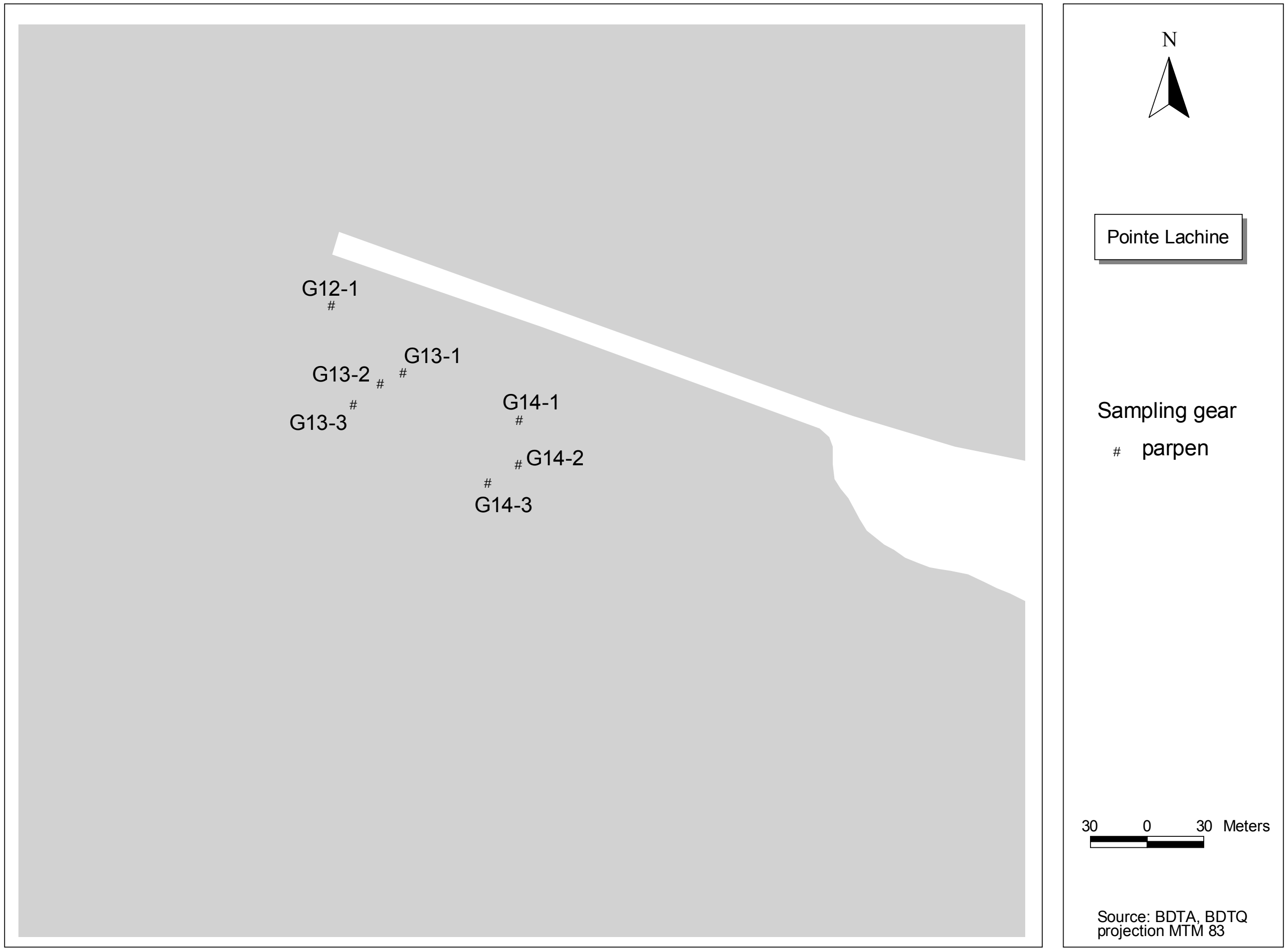
Appendix 5. Location of sampling stations in the Kahnawake sector, spring of 2003.



Appendix 6. Location of sampling stations in the Off Lachine sector, spring of 2003.



Appendix 7. Location of sampling stations in the Pointe Lachine sector, spring of 2003.



Appendix 8. Location of sampling stations in the Iron Bridge sector, spring of 2003.