Lac des Seize-Îles 2022 Report

Assessment of ecological/biological trends

Prepared for :

Municipalité Lac-des-Seize-Îles
Friends of the Lake, Lac-des-Seize-Îles

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Bill Clelland, representative of the “Friends of the Lake" was pivotal in the development and monitoring of this project. Bill selected the young volunteers, coordinated the meetings, made introductions, contacted and made arrangements with generous Lakers who provided a boat and temporary accommodation which simplified the work. Bill also participated in raising the necessary funds to cover the project.

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[1] CRE Laurentides, l’atlas des lacs. https://crelaurentides.org/atlas-des-lacs/

Definitions

Anoxia:
Anoxia is a lack of dissolved oxygen (in lake water). The state of anoxia could favour the release of the phosphorus contained in the sediments.

Anoxic:
In a state of anoxia.

Bank
More or less steep side of a lake or a watercourse. This includes the low water zone (part of the lake bed that can be submerged or dry depending on the conditions or time of year).

CFU
Colony-forming units. This is a bacterial count measurement. When bacteria replicate, they form colonies. In growth media, each colony of bacteria represents one bacteria from the original sample (usually of 100 mL).

Chrysophytes
Also known as golden algae, chrysophytes are microscopic planktonic algae. They are common in Quebec lakes and are part of phytoplankton. In large quantities, they confer to the water a strong fish-like smell. At Lac des Seize-Iles, strong proliferations of this type of microscopic algae can affect the transparency of the water and algae blooms are sometimes observed. In cold water conditions, chrysophytes are able to compete for uptake of dissolved phosphorus and other nutrients allowing them to dominate other algae.

Cyanobacteria
Also known as blue algae or blue-green algae. Cyanobacteria are microscopic planktonic algae. There are several species which are common in Quebec lakes as they are part of naturally occuring phytoplankton. They can become problematic if they are found in large quantities (in efflorescence or "bloom") since some species can produce cyanotoxins that can cause serious health problems. The high water temperature, the low current, climate changes but above all the phosphorus level contribute to the proliferation of this type of algae.

Epilimnion
The layer of water located at the surface (generally above 5 meters/16 feet at Lac des Seize-Iles) whose temperature is warmer in summer, and whose oxygen level is generally higher.

Eutrophication
Eutrophication is the enrichment of a body of water with nutrients, resulting in a series of changes, such as increased production of algae and plants, degradation of water quality and other changes considered undesirable and harmful by local residents.

Trophic level:
Scale for measuring the eutrophication of a lake

Eutrophic: from the Greek eu: “good, true” and trophein: “to nourish”. Describes a lake with high productivity in the biological sense. Usually shallow, with its water not very transparent, this type of lake is rich in nutrients often with deficits of dissolved oxygen in the hot season.

Mesotrophic: from the Greek mesos: "in the middle", Describes a lake moderately rich in nutrients. It is located between the oligotrophic (less rich) and eutrophic (richer) environments.

Oligotrophic: from the Greek oligo: “little”. Refers to an environment poor in nutrients, particularly deep and limpid lakes, which are poor in organic elements but rich in oxygen.

High water mark
This line is located at “the point on the shore of the lake where we go from a predominance of aquatic plants to a predominance of terrestrial plants.”’[2]

Hypolimnion
The layer of water located at depth (generally below 9 s / 30 feet at Lac des Seize-Iles) whose temperature is generally colder, and generally lower oxygen level.

Low water zone
The part of the bank located between the high water mark and the low water mark.

Macrophytes
A plant, especially an aquatic plant, large enough to be seen by the naked eye.

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2 https://www.environnement.gouv.qc.ca/eau/flrivlac/bandes-riv.htm

Plankton
All the microscopic organisms that live in the water column. It includes phytoplankton and zooplankton.

Phytoplankton
Microscopic algae. Phytoplankton includes algae such as chrysophytes, cyanobacteria and diatoms. They are small organisms, most of which are too small to be seen with the naked eye. If they are in sufficient quantity, they appear in the water as coloured areas. The majority are able to perform photosynthesis and like plants, they store carbon and release oxygen. On our planet, phytoplankton produce half of the oxygen consumed by living things.

Zooplankton
Microscopic organisms (some of which are small crustaceans). Zooplankton feed on phytoplankton and thus help to increase the transparency of the water. On the other hand, it should be noted that cyanobacteria are not their food of choice.

Riparian Strip
Part of the bank (or lakeshore) that needs to be kept in a wild state in order to limit the leaching of nutrients into the lake. In Quebec, this protective bank varies from 10 to 15 s in width depending on the average slope rate. The steeper the slope, the wider the riparian strip must be. The riparian strip minimum width is measured from the high water mark, inland.

RSVL
"Réseau de surveillance volontaire des lacs" or Voluntary lake monitoring network - a provincial program.

Shore (see also "bank")
Part of the terrestrial environment adjoining a lake or a watercourse. The shore ensures the transition between the aquatic environment and the terrestrial environment and allows the maintenance of a protective strip 10 or 15 s wide on the perimeter of the lakes and watercourses (riparian strip). The shore starts at the high water mark and progresses inland.

Thermocline
Also known as metalimnion. In deep lakes, this is the zone of rapid thermal transition between surface water (generally warmer and well oxygenated) and deep water (generally cooler and less oxygenated or anoxic). For wildlife, aquatic plants and plankton, the thermocline acts as a certain barrier, especially if it is associated with a sharp drop in oxygen (on either side of the thermocline). The area above the thermocline is called the epilimnion, and the area below is called the hypolimnion.

μg/L
Micrograms per litre is a nomenclature équivalent to "part per million" or ppm

Introduction and purpose of the project

Several studies of the physicochemical characteristics of the Lac des Seize-Iles have been carried out since the 1970s. In September 2019 the municipality, in collaboration with the "Friends of the Lake", showed interest in consolidating existing data and assessing the evolution of water quality specifically from a report issued by the firm Biofilia in 2012. As well, in order to determine a possible link with the presence in large quantities of golden planktonic algae (chrysophytes) which sometimes confers a fish-like odour to the water.

A team of representatives from the municipality, from "Friends of the Lake" group Lac des Seize-Îles, biologist Sylvain Miller and biochemist Anne Létourneau developed a program of physico-chemical analysis to be carried out during the summer of 2020 to 2022. Here are the milestones agreed to before the start of the project in 2020.

1. First, investigate and summarize the data collected over the years, particularly on Lac des Seize-Île. Existing data from the following documents was compiled:
    - 1.1. Environmental master plan report June 2012, by the firm Biofilia prepared for the municipality of Lac-des-Seize-Îles. In addition to the results of the physico-chemical characterization of the lakes of the municipality, it includes an environmental study with a description of the territory of the watershed around the municipality.
    - 1.2. Report of physico-chemical analysis by McGill University from the early 1970s.
    - 1.3. Report of the physico-chemical measurements carried out within the framework of the "Voluntary lake monitoring network" (RSVL).
    - 1.4. 1989 report; Specific report of the association for the protection of Lac des Seize-Iles concerning selected watershed and wetlands.

2. Secondly, during the summer of 2020, it was agreed to carry out analyzes to determine the evolution of significant physico-chemical parameters at several representative locations around the lake. It was also deemed appropriate to carry out bacteriological tests in order to better assess the importance of the impacts of vacationers on water quality. This in comparison to the study of Biofilia 2012.
3. It was also agreed that the Wonish, Grand-Héron and Baie des Sœurs lakes would be included in the 2020 sampling in order to provide a portrait of the evolution of phosphorus levels and water transparency, since these are important contributors to the watershed..
4. Concerning Lake Laurel, the main physico-chemical parameters (transparency and periphyton measurements) are taken and listed regularly within the framework of the RSVL (Réseau de Surveillance Volontaire des Lacs). In addition, since this lake is downstream from Lac des Seize-Îles, it has no impact on the latter. It was therefore decided that data from this lake should not be included in the report at this time.
5. In order to develop interest and expertise among lake residents to carry forward the monitoring experience to future years, it was agreed that 5 to 9 young volunteers would be put to contribution each year (from 2020 to 2022). These volunteers, selected by Bill Clelland in agreement with Friends of the Lake, participated in taking measurements of the thickness of the periphyton.
6. During the summer of 2020, there were health restrictions related to the pandemic which limited travel between regions. This meant that a much lower number of vacationers was present in the summer of 2020. Because of this, it was agreed that the physico-chemical parameter testing would

extend over three years in order to determine if less traffic could have a significant influence on the physico-chemical parameters.

7. It was also agreed to take additional ad hoc measures such as the evaluation of riparian protection strips, the evolution of aquatic plants and the temperature and dissolved oxygen profiles at different locations in the lake.
8. In the summer of 2022, a major fire completely destroyed a boathouse. A water sample taken approximately 20 s from the site (approximately 3 s outside the sedimentation barriers) was tested for phosphorus in order to determine if the fire may have had an impact on the quality of the water around the site (compared to regular testing around the lake). This data has been collected for information only.

Physico-chemical and biological parameters of Lac des Seize-Îles

Phosphorus

Description

Phytoplankton (microscopic algae) need several elements to thrive, including sunlight, nitrogen, phosphorus and potassium. All of these elements promote the growth of algae and plants, but since phosphorus is generally present in lower quantities, it is considered to be a limiting element to growth. It is therefore the amount of phosphorus in general that controls the presence and the amount of phytoplankton. The Ministry of the Environment and Fight against Climate Change (MELCC) considers that in oligotrophic lakes (clear water lakes) such as Lac des Seize-Iles, the total phosphorus measurements should not exceed 50% of baseline and remain inferior to 10 µg/L for aquatic life conservation (chronic effect or long term effect). In the watershed, phosphorus should not exceed 20 µg/L.

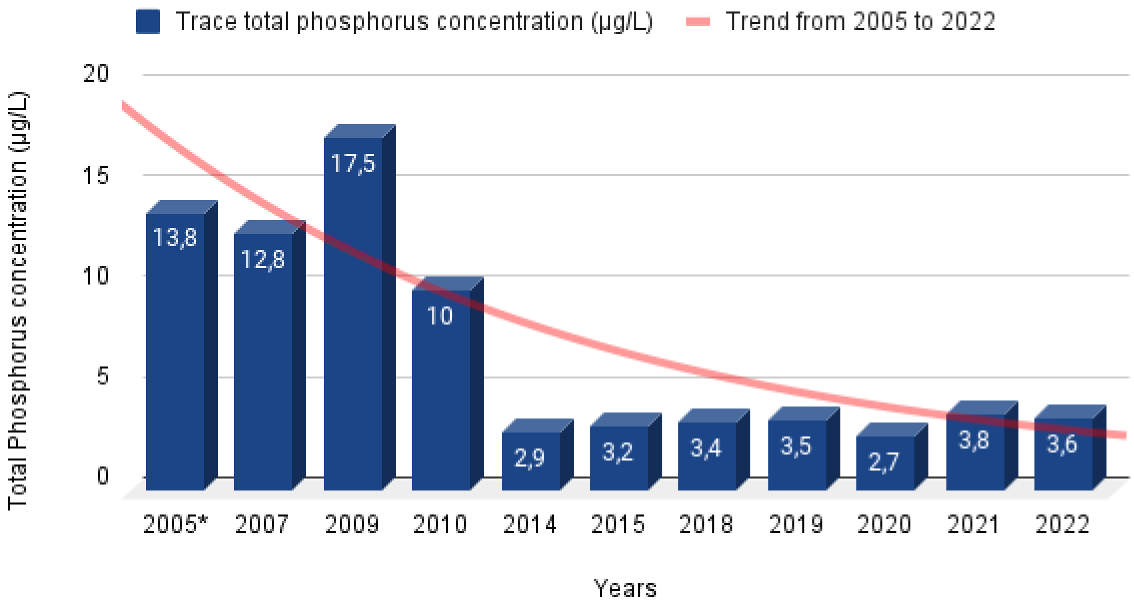
History

Surface phosphorus measurements were compiled between 2007 and 2011. These are listed in the latest report from the firm Biofilia. The precision of Biofilia's data (from 2005 to 2010) is different from that compiled by the RSVL (from 2014). The tests between 2005 and 2010 were carried out using the “total phosphorus” method which did not allow values to be measured below 10 µg/L (these were entered as less than or equal to 10 µg / mL). The RSVL values, on the other hand, were evaluated according to the “total trace phosphorus” method which is much more sensitive and much more precise. This makes comparisons difficult. We can see this difference in the phosphorus graph 2007 to 2010, where 20 samples revealed phosphorus levels below 10 µg/L, but recorded as 10 µg/L, while the latest reports from RSVL indicate phosphorus values ranging between 0.3 and 3.5 µg/L between 2014 and 2019. This may not be indicative of a real decrease. On the other hand, when one considers that there was a measurement of 13.8 µg/L of surface phosphorus taken by the UQAM in 2005, one might think that there was indeed a real drop in the level of phosphorus in surface waters. This decrease could be attributable to the efforts made during the 2000s on the revegetation of the shoreline, on the maintenance of septic systems of properties directly around the lake and on tighter standards with regard to the protection of watersheds. Stricter regulations and public awareness of the phosphates in detergents could also have had an effect.

Protocole

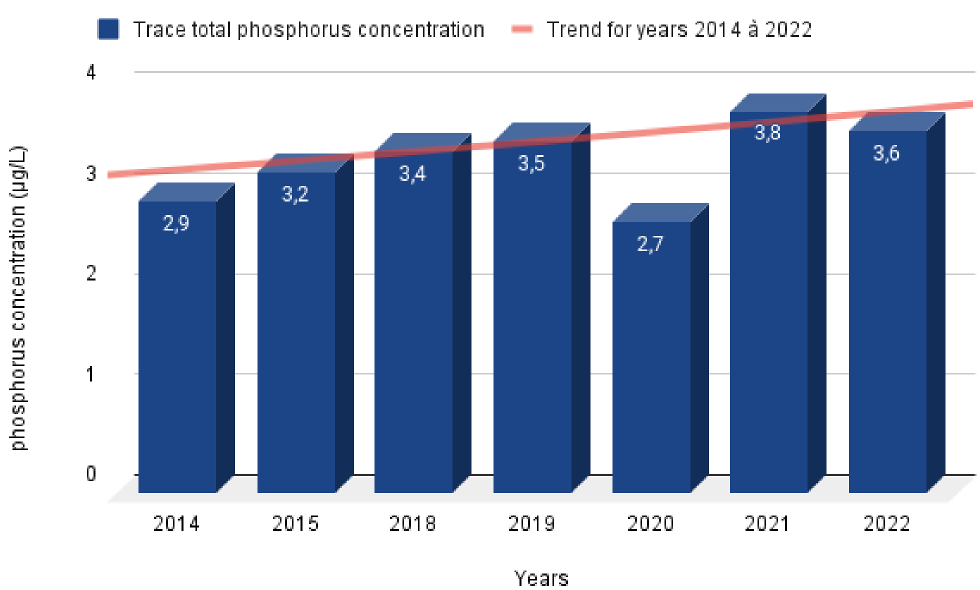
Sampling of surface water was done according to the method described in the RSVL protocol. The samples were transported using an appropriate cold-chain method and analyzed at the H2Lab laboratory in Sainte-Agathe. The phosphorus sampling sites were the same as those used for the RSVL testing.

Figure 1 : Trace total phosphorus concentration (µg/L) by year from 2005 to 2022



As can be seen in Figure 1 above, the total trace phosphorus at the surface of the lake for the years 2014 to 2022 appears to be lower than what was measured before 2010. The decreased level observed in 2020 could be a consequence of lower lake residence occupation due to the pandemic. In order to confirm whether the low residence occupation level in 2020 (restriction of trip COVID-19) had an effect on the apparent decrease in phosphorus, the tests were repeated in 2021 and 2022. The measurements taken between 2005 and 2010 are difficult to compare because of a difference in sensitivity and precision of the method . However, it is possible that the phosphorus level decreased during that period due to an effort to upgrade septic systems, as has been observed in several lakes in the Laurentians. However, this drop in phosphorus concentration should be accompanied by a decrease in chlorophyll a and an increase in transparency, which is not the case for Lac des Seize-Îles.

Figure 2 : Trace total phosphorus concentration (µg/L) by year from 2014 to 2022

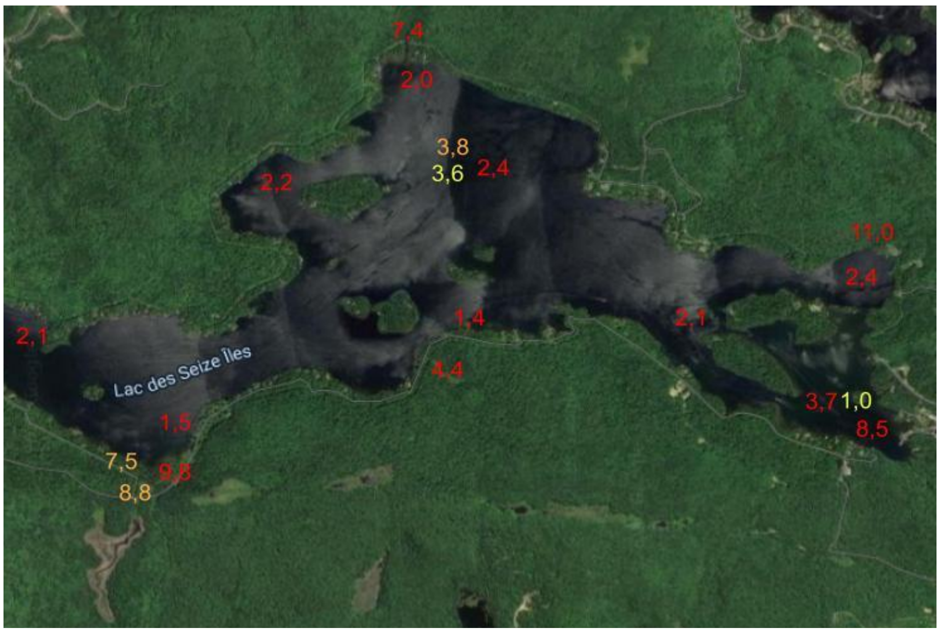


If we isolate the most recent data, we note a slight upward trend in the concentration of total trace phosphorus for Lac des Seize-Îles between 2014 and 2022. Year 2020 (sanitary restrictions due to Covid) stands out as the lowest since 2014.

Uniformity of phosphorus levels across the lake in 2020

To determine if the phosphorus levels were consistent across the lake, samples were taken from several surface locations for comparison. The following map (figure 3) shows the data obtained according to sample locations.

Figure 3: Phosphorus measurements in µg/L in 2020 (red), 2021 (orange) and 2022 (yellow)



The phosphorus concentrations varied little between samples taken throughout the entire lake (1.5 to 3.8 µg/L) with the exception of the bay near the outlet of the lake (3.7 and 8.5 µg/L), and in the main tributaries (7.2 to 11µg/L). Therefore, it can be assumed that the RSVL phosphorus measurements taken from the surface water above the deepest zone of the lake (zone number 10 as per appendix 1) allows fairly representative monitoring of the general water quality except at the southern end of the lake, and in the tributaries. It is not representative of what is found in the hypolimnion (mass of cold water under the thermocline) either. Samples taken near the thermocline at 4 different locations also revealed higher rates as shown in table 1 below. During a few dives, we also had observed a greater presence of algae.

Table1 : Total phosphorus in trace under the thermocline

	Aug 12 2020	Aug 12 2020	Aug 12 2020	Aug 12 2020	**Average**
Depth (m)	10	10	15	15	**12,5**
Zone number (As per map in appendix 1)	15	13	10	4	N/A
Total phosphorus in trace (µg/L)	11	7,3	5,8	8,8	**8,3**

The phosphorus content below the thermocline was found to be much higher than at the surface. Thermal stratification causes a change in the density of the water that prevents the warm water from the surface and the cold water below from mixing. Phytoplankton concentrate at the thermocline to take advantage of both light and the greater concentration of phosphorus located just below the thermocline. Water samples taken on August 12 under the thermocline clearly show the higher amount of phosphorus. Between 10 and 15 s, the concentration is on average 8.3 µg/L, which is almost 3 times greater than on the surface.

In the spring, before thermal stratification and in the fall during the autumn water mixing, surface water and water below the thermocline mix. We took samples during these times to get an idea of the average phosphorus value in the entire water column.

Table 2 : Total trace phosphorus on the surface (1) during mixing for zone 10

Date	13 may 2020	11 nov. 2020	24 april 2021	**Average**
Total Phosphorus trace (µg/L)	4,0	6,1	2,7	**4,3**

The 12 tributaries that were sampled in 2011 showed a phosphorus value ranging from 11 to 49 µg/L. As the flow of some tributaries is very low during the summer, samples were taken in the lake near the outlet rather than in the tributaries. We did not consider it important to measure phosphorus in all of these tributaries, but rather those with a sufficiently large flow to influence the quality of the lake water. As can be seen in the table, the phosphorus concentration is lower than in 2011, but again here it is probably a difference in the accuracy of the measurements of total phosphorus vs total trace phosphorus. The 2011 concentration varies between 4.4 and 11 µg/L. These values are higher than the concentrations present in the lake, which is usual for a tributary since it transports nutrients from the watershed.

Table 3 : Total trace phosphorus in tributaries (µg/L) in 2020 and 2021 compared to 2011

<table>
<tr><td rowspan="2">Date</td><td colspan="6">Tributary (see map in annex 1)</td></tr>
<tr><td>B</td><td colspan="2">C</td><td>F</td><td>I</td><td>K</td></tr>
<tr><td>15 August 2011</td><td>25</td><td colspan="2">17</td><td>11</td><td>27</td><td>17</td></tr>
<tr><td>26 July 2020*</td><td>7,2 (*30 août)</td><td colspan="2">9,8</td><td>4,4</td><td>11</td><td>7,4</td></tr>
<tr><td>8 August 2021</td><td></td><td>7,5</td><td>8,8</td><td></td><td></td><td></td></tr>
</table>

Although higher than in the lake, the phosphorus concentrations of the main tributaries do not exceed the ministry's standard of 20 µg/L therefore meeting the maximum concentration criteria for the conservation of aquatic life. Because of their high potential for phosphorus input, tributaries should be closely monitored and efforts should continue to minimize these effects (naturalization of riparian strips of streams and tributaries, management of septic systems).

In July 2022, a fire completely destroyed a boathouse. Approximately 3 days after the fire, a surface water sample was taken at three s outside the sedimentation barrier near the site. The phosphorus concentration of the sample was 6.7 µg/L. A water sample taken on the same day from the surface away from the site (site 10 on map in appendix 1) showed a concentration of only 5.1 µg/L of phosphorus. Although only one measurement was taken, the result supports the theory that a fire in the riparian strip may negatively impact the phosphorus level. Burnt material (wood) is an important source of minerals which contribute to the enrichment of lake water. This demonstrates the importance of avoiding fires in the riparian strip.

Dissolved oxygen

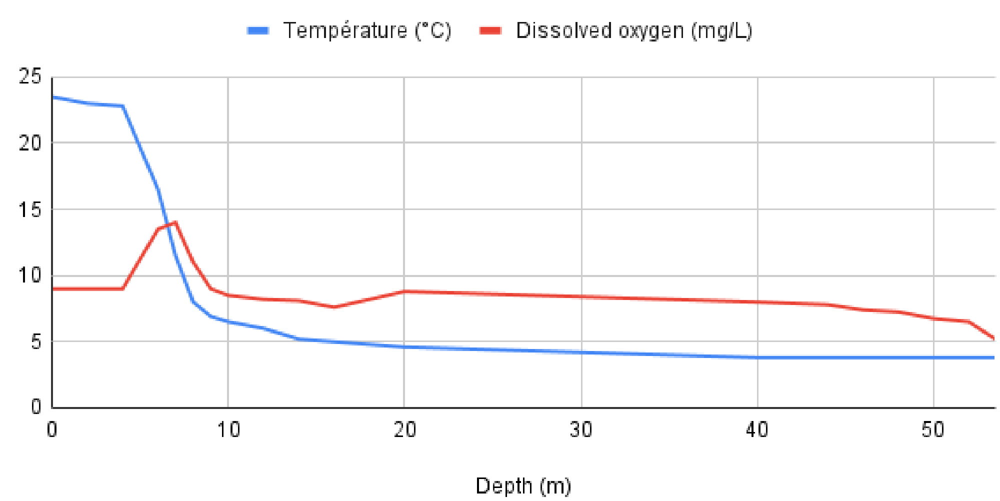
Description

Dissolved oxygen is a very important factor to consider in studying the physicochemical parameters of a lake as it indicates a lake's capacity to support aquatic life. Dissolved oxygen in the water comes from the atmosphere and from the photosynthesis of the aquatic plants. The only time when atmospheric oxygen is supplied to the entire water column is during mixing (fall and spring). Between these periods, due to thermal stratification, the oxygen below the thermocline is no longer renewed while it is consumed by the organisms that live there. This is how oxygen concentration decreases below the thermocline, especially in deeper lake wells. Under these conditions, aquatic life in the depths could be compromised if the level of consumption exceeds the level of available oxygen. The dissolved oxygen level must be above 4 mg / L to support aquatic life.

History

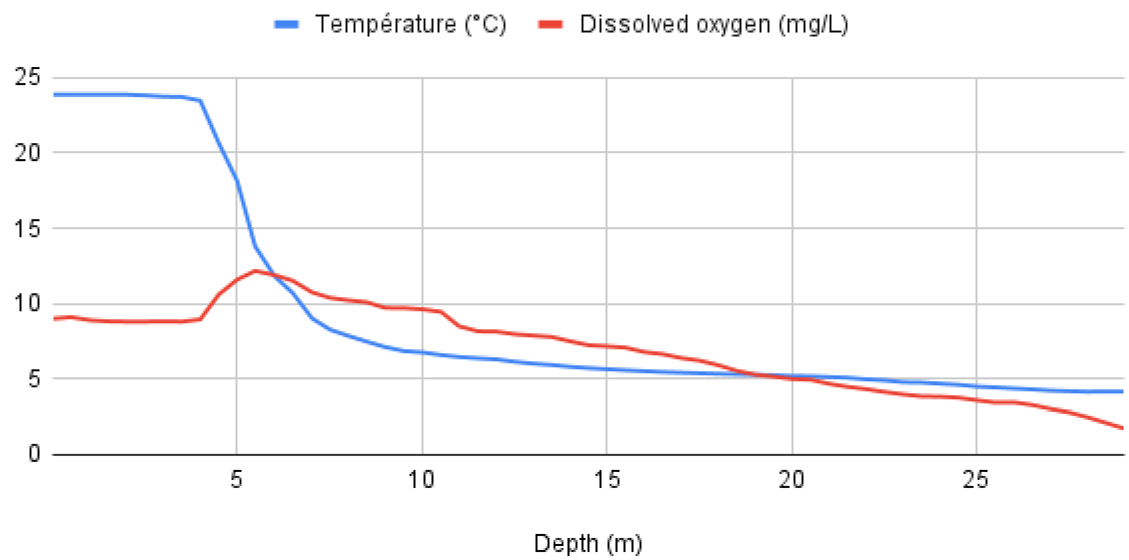
Three temperature and dissolved oxygen profiles were carried out between 2010 and 2019. Below is the oxygen profile recorded in August 2011 at the lake pit (Figure 4). There is an oxygen concentration that remains above 5 mg/L, even to a depth of 50 m. A relatively similar profile was also observed on August 5, 2010. Another profile taken on July 24, 2019 (UQAM) showed a dissolved oxygen concentration falling below 4 mg/L at a depth of 25 s (Figure 5).

Figure 4 : Dissolved oxygen (mg/L) and temperature (℃) profiles as per depth (m) in 2011



This situation could be an indicator of eutrophication. Since the oxygen at the bottom continues to be consumed by the organisms that live there during the summer without the possibility of renewal before the fall, it is possible that the bottom of the lake could end up in anoxia (lack of oxygen) before fall water mixing. In addition to putting the life of the organisms in danger of asphyxiation, such a lack of oxygen leads to the release of phosphorus from the sediments and increases the concentration of nutrients in the water column, thus encouraging the growth of algae. This could be one of the factors that can lead to a visually noticeable microalgal bloom. The more phosphorus in the water, the more algae there is, and together with the bacteria responsible for decomposition, the more dissolved oxygen is consumed in the water. These phenomena lead to the eutrophication of lakes and the increase of algae and aquatic plants.

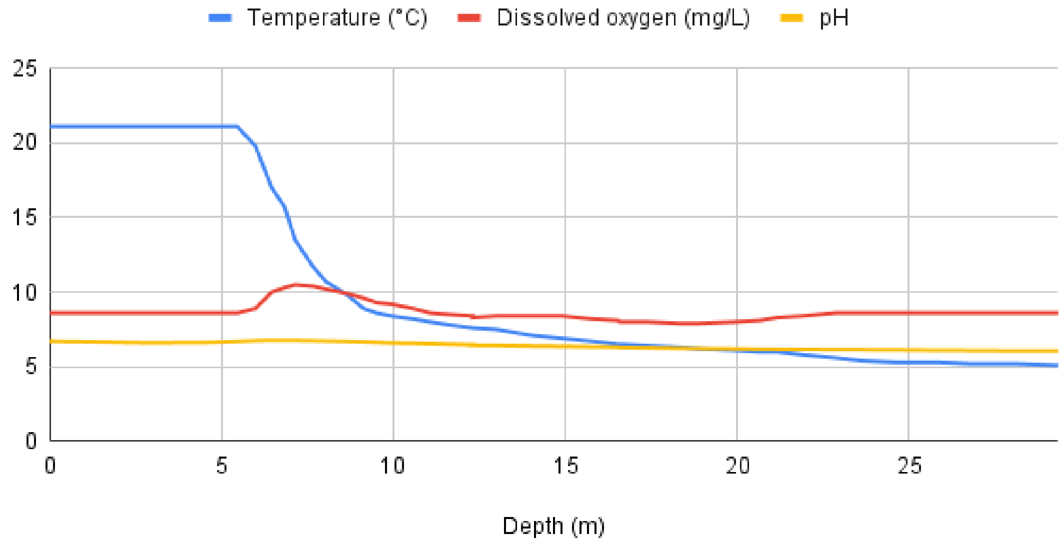
Figure 5 : Dissolved oxygen levels and temperature profiles carried out at site 10 (see map on appendix 1) on July 24, 2019



Protocol

As it is an important parameter to monitor, dissolved oxygen was measured on September 6, 2021 using a YSI PRO DSS multiparameter probe equipped with a 30- cable. The measurements were taken at the end of the summer, when the dissolved oxygen is theoretically at its lowest level (before the fall mixing).

Figure 6 : Temperature (℃), dissolved oxygen (mg/L) and pH profiles according to depth at site 10 (see map, appendix 1) on September 5, 2021.



As seen in Figure 6, the dissolved oxygen concentration (in red) remains above 4 mg/L at 30 s depth, suggesting that sufficient oxygen remains until mixing to support aquatic life.

Several other temperature and dissolved oxygen profiles were performed at different locations in the lake. The results can be found in appendix 2. At one site, in the bay at the outlet of the lake, we found an area poor in oxygen. In addition to bringing bad conditions for aquatic life, a lack of oxygen could be responsible for a release of phosphorus in the sediments. There could be a link between the low oxygen concentration and the higher phosphorus concentration in this part of the lake.

Chlorophyll *a*

Description

Chlorophyll *a* is a pigment present in all plants as it is essential to photosynthesis. The measure of chlorophyll *a* level is an indirect way to determine the amount (concentration) of microscopic algae. The number of these microscopic algae influences the transparency of the water and therefore the trophic level of the lake.

History

This parameter was measured 8 times from 2011 to 2019. Apart from a slight increase in 2015, the amount of algae remains stable. A result below 3 µg/L is typical of an oligotrophic lake.

Measurement of chlorophyll a between 2020 and 2022

A surface chlorophyll *a* measurement was made in the summer of 2020. The result showed a slight decrease compared to previous years. Two samples at 6 s depth were also taken as the presence of algae was seen as being more important at that depth. The chlorophyll *a* measurements obtained were 6.4 and 3.2 µg/L, therefore higher than at the surface (See table 4).

Table 4 : Chlorophyll *a* measurement at the surface compared to at 6 deep

	20 August 2020	28 July 2020	28 July 2020
Depth of sample taken	1 m	6 m	6 m
Sampling zone (see appendix 1)	10	8	15
Chlorophyll *a*	1,1 µg/L	6,5 µg/L	3,2 µg/L

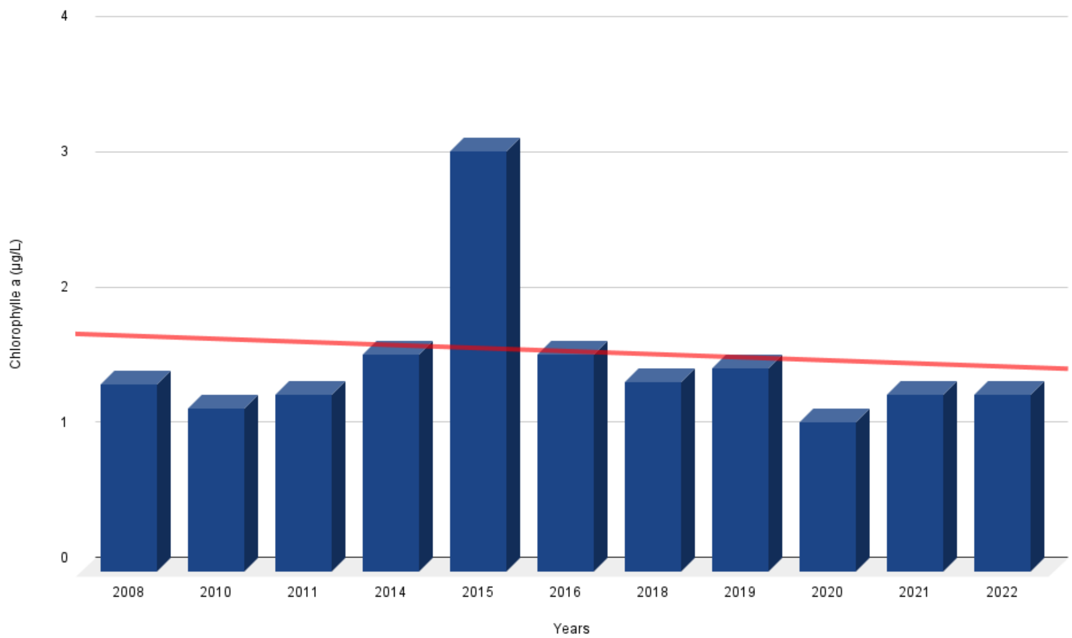
Chlorophyll *a* measurements taken at a depth of 6 s (near the thermocline) confirms the presence of a substantial amount of microscopic algae. This concentration of algae is easily detectable when diving as visibility decreases sharply at this depth. Samples were taken from different locations in the lake at the same depth (6 s). Microscopic identification revealed a predominance of cyanobacteria of the genus Aphanothece in the middle of the summer.

Although this type of cyanobacteria is rarely responsible for the production of toxins, we still proceeded to the analysis of total cyanotoxins given the high concentration of this type of algae. On the surface during a warm and sunny week in late July, there were also numerous colonies of cyanobacteria visible within the first of the water surface. The two types identified microscopically were anabaena and microcystis. We took a sample that was half water collected from scuba diving at 6 s and half surface water. The sample contained less than 0.02 µg/L of total cyanotoxins, which is far below the Quebec standard for drinking water quality, which is set at a maximum of 1.5 µg/L. The threshold for this toxin for recreational activities is set to less than 16 µg/L. In view of the presence of cyanobacteria, the lake water is suitable for recreational activities.

On the other hand, as the concentration of phosphorus seems to be slightly on the rise, this significant quantity of cyanobacteria is a factor to be monitored. Due to climate change, surface water tends to warm up, which favors this type of microscopic algae. The lake has an appreciable quantity and diversity of filter-feeding zooplankton which could reduce the concentrations of microscopic algae. On the other hand, these small organisms are less fond of feeding on cyanobacteria. If no effort is made to limit the presence of nutrients in the lake (including phosphorus), there could be a significant decrease in water transparency.

In 2021 and 2022, we averaged three surface measurements taken between July and September as per RSVL protocol. All the results from 2008 to 2022 are expressed in Figure 7.

Figure 7 : chlorophyll a concentration in µg/L at the site 10 (see appendix 1) from 2008 to 2022



The graph shows that the amount of microscopic algae appears to remain stable between 2008 and 2022. The highest value was observed in 2015, the year after a major landslide which may have had an impact. The lowest value was observed in 2020, the year when sanitary restrictions had an impact on lake attendance. However, all measurements are at or below 3 µg/L, which is typical of an oligotrophic lake.

DOC (dissolved organic carbon)

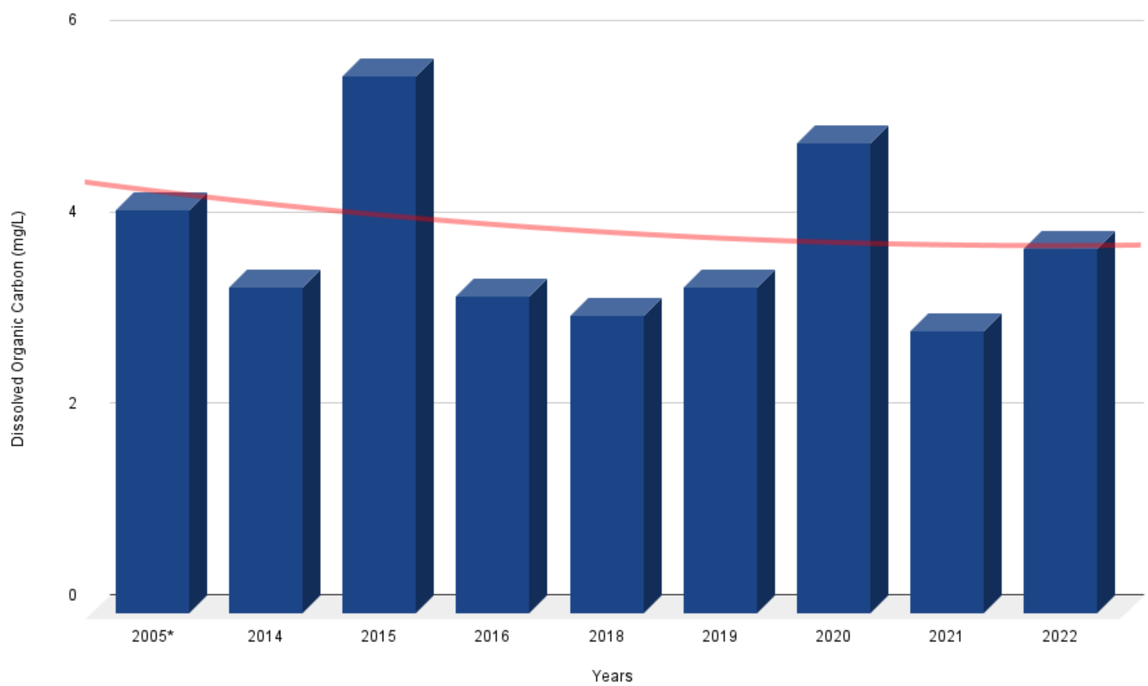
Description

Dissolved organic carbon is a measure of the amount of organic matter. This component gives water a more brownish tint. Much like tea leaves, which give their colouring to that of boiling water, water seeping from forests to the watersheds carry organic matter which colours lake water. Helping to better understand the natural health of a lake, DOC is an indicator of the colour of the water.

History

The amount of DOC was measured from 2014 to 2019. DOC increased slightly in 2015 and has fallen since. Only one measurement was taken in 2020 at site 10 (see appendix 1) of the lake and the average of three measurements made in 2021 and 2022 show an increase compared to the three previous samplings. COD values greater than 4 indicate that the colouring can have an impact on reducing the transparency of the lake water. Values below 4 would have little or no impact. The levels are very close to this value.

Figure 8 : Concentration of Dissolved Organic Carbon (DOC in mg/L) measured at site 10 (see appendix 1) between 2005 and 2022



The graph of fig. 8 shows the variation in DOC concentrations in the lake with a slight trend towards decreasing values. There are slightly higher concentrations in 2015 and 2020. These values are influenced by the frequency of rainfall (or dry spell followed by heavy rain). A high volume of precipitation carries more organic matter to the lake water by runoff.

Faecal coliform and E. Coli

Description

Tests for faecal coliform and E. coli bacteria were performed at ten stations throughout the lake and in some tributaries. Both tests tell us about the quality of the water, particularly for swimming in different areas of the lake. They could also be signs of defective or non-compliant septic systems. Tests for E. Coli and faecal coliform were performed twice. The results of these tests vary greatly depending on the weather conditions. During heavy rain, the amount of coliform tends to increase due to leaching. UV rays from direct sun tend to kill these bacteria. To get a result that represents maximum coliforms, samples need to be taken early in the morning, or during the day following heavy rain. Unlike phosphorus, samples are taken from shallow water near the banks. The presence of animals can also influence the amounts of coliforms in the water. Therefore the test is repeated twice. Results of less than 20 CFU / 100 mL indicate that the quality of the water for swimming is excellent, while between 20 and 100 it is classified as good. When values are above 200 CFU / 100 mL swimming is not recommended. Site # 10 (see appendix 1), located away from any building, was used as a control area, as it was unlikely to be contaminated by an outside source of coliforms. See appendix 1 for site localisation.

Résultats

Table 5 : Faecal coliforms and E. coli in surface water July 22-26 2020

Site number (see appendix 1)	E. Coli (UFC/100 mL)	Faecal Coliform (UFC/100 mL)	Average
2	<2	2	2
3 (beach)	2	5	3
5	<2	<2	<2
10	<2	<2	<2
11	<2	<2	<2
12	3	3	3
13	7	<2	4
14	5	5	5

E. coli Sample taken August 8 2020

Another set of E. coli samples was taken on August 8 at the site 3 (beach). The result was 15 CFU / 100 mL.

Table 6 : Faecal coliform and E. coli in affluents July 22 and 26, 2020

Site Identification (see appendix 1)	E.coli (UFC/100 mL)	Faecal Coliform (UFC/100 mL)	Average
Affluent B	38	8	23
Affluent C	27	13	20

Three more E.Coli tests were performed in August 2022 following a day of heavy rain to show worst case scenario. Table 7 shows the results which are higher than in 2020. Tributary B which crosses the village obtains the highest result and probably demonstrates the influence of the dwellings upstream. However, we observe that even in the worst conditions, the quality of the water remains below the standards established for the maintenance of aquatic activities such as swimming.

Table 7 : E. coli in two tributaries and at the outlet of the lake on August 10, 2022

Site	E.coli (UFC/100 mL)
Affluent B	74
Affluent K	28
Site 14	8

The results of the faecal coliform and e.coli values are also presented on the map below.

Figure 9 : Results for faecal coliform and E.coli counts (CFU/100 mL) in 2020 and 2022

The results indicated in figure 9 reflect that the quality of the water was good everywhere for swimming and recreational activities.

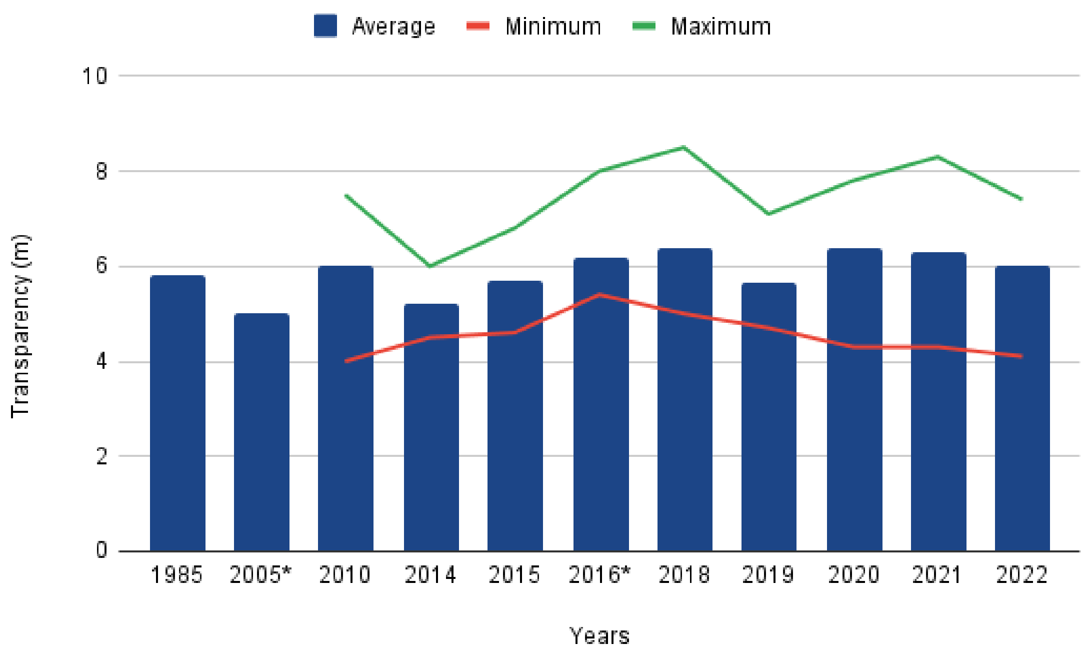
Transparency

Description

Transparency is the measure of the penetration of light into water. The submerged Secchi disc is visible until only 10% of the surface brightness remains. Suspended matter, DOC and the presence of plankton reduce the transparency of the water. Transparency has been measured by a volunteer at 4 stations at least 5 times between May and October each summer since 2014 as part of the RSVL or for this report. Standardisation is done when a new volunteer takes the measurements to ensure the uniform application of the protocol and similar results are obtained. The measurements presented in the following graph represent the average of the 4 stations for each year. In some years there have been fewer measurements (as was the case in 2005), which is why these results are marked with an asterisk. In the case of 2005, this is a single measurement made by UQAM during one of their visits to the lake.

Results

Figure 10 : Average, minimum and maximum measures of transparency in 1985 and 2022



Despite a slight decrease in 2014 and 2015, the transparency measure has remained essentially the same from 1985 to the present day. The transparency measurement seems to have been stable around 6 s. While diving, at three different points in the lake, we also noticed a thick layer of phytoplankton at this depth (6 s) which corresponded approximately to the depth of the thermocline. However, we note a downward trend between 2016 and 2022, the minimum measures of transparency are lower and lower (see figure 10 below).

Figure 11 : Average, minimum and maximum measures and trend for transparency from 2016 to 2022

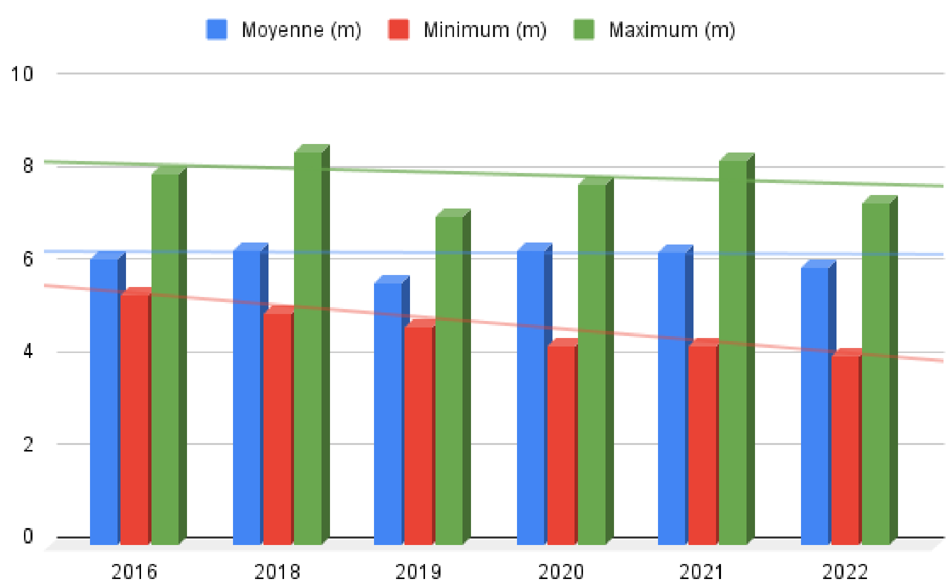
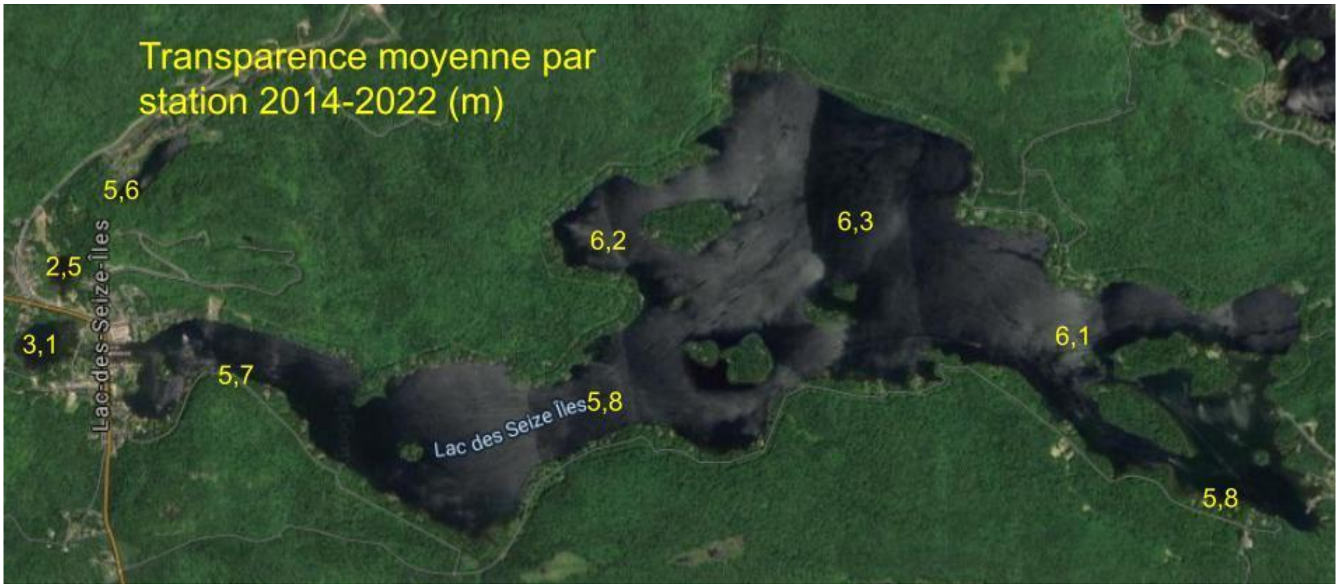


Figure 12 : Average of transparency measurements according to the different stations for the years 2014 to 2022



Note that the transparency varies between 5.7 and 6.3 depending on the different stations. The water of two small lakes (Lac du Grand-Héron and Baie des Soeurs) are tributaries of Lac des Seize-îles, but they are very different environments. Their transparency measurement results reflect this difference.

Table 8 below shows that the water is significantly more transparent in September than any other of the summer months. Transparency is at its lowest in July at 5.3 s and increases to 7.1 s in September. This phenomenon is normal and depends on factors such as the life cycle of phytoplankton, the amount of phosphorus, the depth of the thermocline and volume of rainfall. It should also be noted that the averages of transparency measurements were typically calculated with fewer data points in May, June and October than for other months.

Tableau 8 : Average of transparency measures for each month between 2020 and 2022

May	June	July	August	September	October
6,0 m	5,8 m	5,3 m	6,8 m	7,1 m	6,8 m

pH

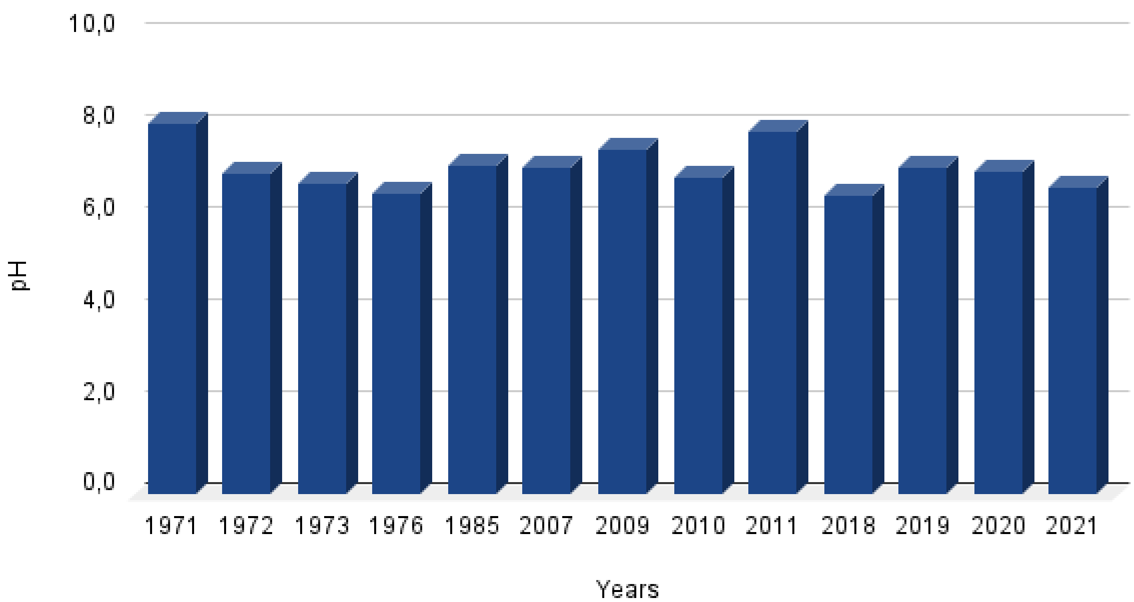
Description

PH is a measure of the acidity of water. Changes in pH have major consequences on the quality of life of aquatic flora and fauna. The pH should be between 6.5 and 8.5 to allow the species to reproduce and survive. The pH can vary with depth. On the surface, the consumption of carbon dioxide by phytoplankton can increase the pH value. Consumption of oxygen and the release of carbon dioxide by deep dwelling organisms in the absence of light can acidify the water which is typically more acidic as depth increases. There are other factors that can affect pH in freshwater, both natural and man-made. Natural changes can occur due to interactions with surrounding rock (carbonate forms or limestone for example). The pH value can also fluctuate with precipitations or wastewater discharges.

History

PH measurements have been taken several times since 1971. During the summer of 2020 the pH measurements have varied from 6.13 to 7.68 for an average of 7.03. In 2021, some measurements were taken on September 6 using the YSI PRODSS probe at three stations in depths varying from 0 to 30 s. The pH varied from 6.07 to 6.94. The average surface pH was 6.7. The pH profiles as a function of depth can be viewed in Appendix 2.

Figure 13 : Surface pH measurement between 1971 and 2021



Although the measurements vary from year to year, they appear to remain stable over time and remain within acceptable limits for the development of aquatic life (6.5 to 8.5).

Calcium

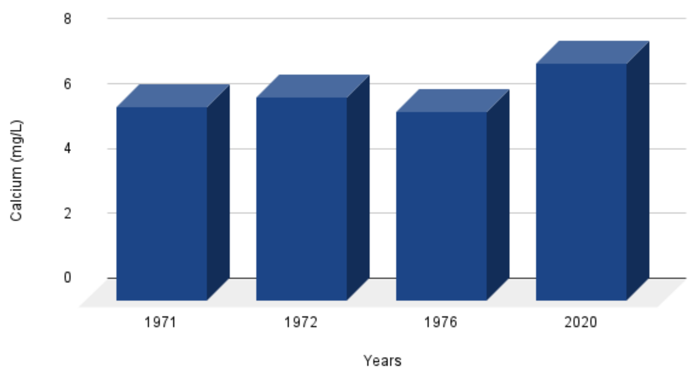
Description

Calcium is also an element for the growth of plants, for animals and for certain crustaceans that form zooplankton, the staple food of aquatic insects and small fish. The food chain of the lake is therefore strongly influenced by the presence of this mineral.

History

Calcium measurements were made in the 1970s. In 2020, we measured this parameter at three different points in the lake to see how it has changed. On July 26 2020, the surface calcium concentration varied between 6.38 and 7.91 mg/L. Those results represent an increase from measurements made in the 1970s.

Figure 14 : Average calcium concentration (mg/L) per year



One explanation for this difference could be the increased leaching of rocks. Most calcium in freshwater comes from the presence of calcium-containing rocks and minerals (including limestone, dolomite and gypsum) in lake bottom or in watersheds which leach (or dissolve). The application of road salt (de-icing and dust suppressants) can also increase the concentration of calcium.

Electrical conductivity

Description

Electrical conductivity is a measure of the amount of ions present in water. Pure water (H_20) does not conduct electricity. However, in the Laurentians, the natural conductivity of water is between 10 and 40 Us/cm.[3] It is the type of rock present and the application of road salt (de-icing and dust suppressants) in the watershed which increase the electrical conductivity of lake water. The conductivity is mostly due to the presence of charged particles that come from the separation of a neutral molecule when they dissolve in water (Na^+, Cl^- , Ca^{2+},CO_3^{2-}, HCO_3^-, etc.). The more charged ion particles present, the higher the electrical conductivity.

[3]CRE Laurentides, Vulnérabilité des lacs du Parc national du Mont-Tremblant à la colonisation par le myriophylle à épi, 2019
http://crelaurentides.org/wp-content/uploads/2021/09/Vulnerabilite_des_lacs_du_Parc_Mont-Tremblant.pdf

In summer, the concentration of CO_2 in the water is quite low. However, during photosynthesis, some plants such as watermilfoil and pondweed are able to use carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions as carbon source for their growth.

History

Electrical conductivity was measured at three locations on September 6, 2021 using the YSI ProDss probe. At a depth of one , the conductivity varies little from place to place. See appendix 2 for profiles of temperature, dissolved oxygen and conductivity through the water column.

Table 9 : Electrical conductivity, measured at one , at three stations in September 2021

Site #10 (Us/cm)	Site #13 (Us/cm)	Site #15 (Us/cm)	Moyenne (Us/cm)
52,6	52,6	52,8	52,7

According to an article by CRE Laurentide and Dr. Richard Carignan, the vulnerability of lakes to colonization by Eurasian watermilfoil is influenced by various factors. Using the conclusions of this study, it seems interesting to us to verify the vulnerability of Lac des Seize-Îles to the growth of Eurasian watermilfoil.

High transparency of water and nutrient-rich sediments would favor the proliferation of Eurasian watermilfoil. A calcium concentration that exceeds 6 mg/L also favors the growth of this plant. An electrical conductivity greater than 159 Us/cm would be another important factor.

Considering these four parameters, the lake would offer favorable conditions for the growth of Eurasian milfoil at least in the shallow bays with sediments. This is the case for Hammond Bay and Raymond Bay, among others. The transparency of the lake water is high since it corresponds to that of an oligotrophic lake. In 2020, the average calcium concentration was 7.34 mg/L. However, with a value of 53 Us/cm, we notice that Lac des Seize-Îles does not have a very high electrical conductivity. This may explain why in other parts of the lake, even if the plant is present, it does not tend to form beds as dense as in the sediment-rich bays.

The periphyton

Description

Periphyton refers to a complex community of microscopic organisms (algae, bacteria, protozoans and metazoans) and debris that accumulate on the surface of plants and objects (rocks, branches, dock pillars and others). It is found underwater in streams and lakes. The periphyton can take on different appearances, can be brown or green, and could feel slimy.

The presence and growth of periphyton can vary from year to year. This variability can be associated with yearly fluctuations in meteorological and hydrological conditions. To better reflect the situation, the characterization of the periphyton must therefore be carried out over more than one year. This helps determine the state of enrichment of the lake water. To highlight a change in the presence, appearance or abundance of periphyton, it is recommended to monitor at the same sites for three consecutive years, and to resume monitoring after a five-year break according to the same monitoring plan.

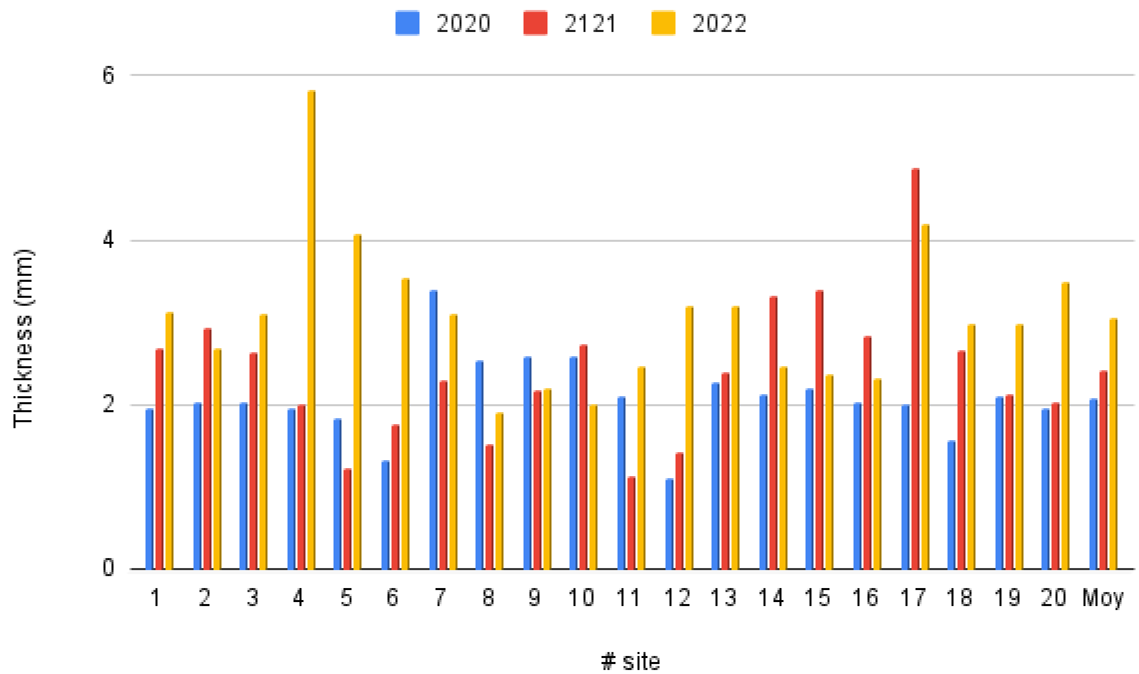
History

In Lac des Seize-Îles, periphyton measurements were taken in 2009. Ten measurements were performed at each of 21 sites. In the Biofilia report it is mentioned that these measurements on 21 sites (out of 61 areas defined) do not allow to draw clear conclusions about the effects of the enrichment of the lake water. In a procedure of the ministry, monitoring the periphyton must be performed over a period of three years and there must be at least 30 measurements on 20 sites for a lake of more than 2 km^2.

Results

As described in the protocol, measurements should be repeated for three consecutive years, followed by a period of five years before monitoring again. Despite the constraints of the pandemic in the summer of 2020, three teams of young scientists took charge of the periphyton measurements under our supervision. It was the same procedure for the next two years.

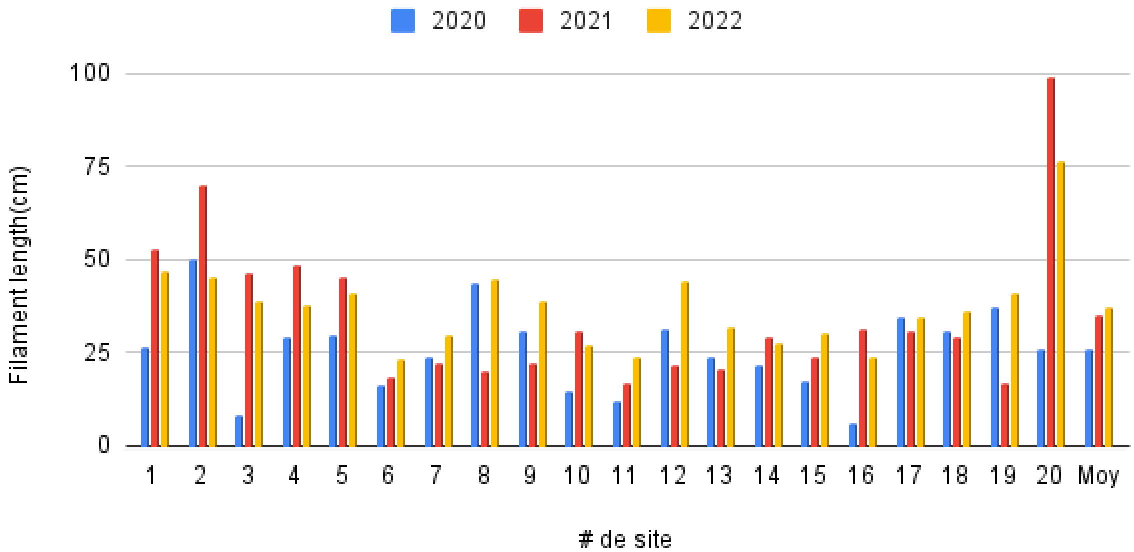
Figure 15 : Periphyton thickness variation for the 20 sites measured in the last three years



The measurement of periphyton carried out at 20 sites varied from 0 to 20 mm with an average of 2.1 mm in 2020, 2.4 mm and 2021 and 3.3 mm in 2022. In 2009 (Biofilia report), the measurements varied also from 0 to 20 mm with an average of 3.3 mm. According to these measurements, we cannot conclude a trend in the periphyton cover between 2009 and 2020-2022 period. The results appear to demonstrate stability in the level of eutrophication in the lake since 2009. However, care must be taken in analyzing these data. In the most recent protocol, the measurement of the periphyton carpet is now separated from that of the filaments. It is possible that this distinction was not made when measuring in 2009 and therefore could skew the results.

It is interesting to observe that the thickness of periphyton appears to increase as the level of activity increases on the lake from 2020 (pandemic restrictions) to 2022 (normal level of human activity). However, other factors that influence the growth of this community of organisms must be taken into account. The phosphorus level, the transparency of the water, the earlier spring, the abundance of precipitation are all factors that can influence this measurement. It is for this reason that it is not possible to draw clear conclusions after 3 years. Results from the next three consecutive years of measurement (in five years) will be more conclusive to show any trend.

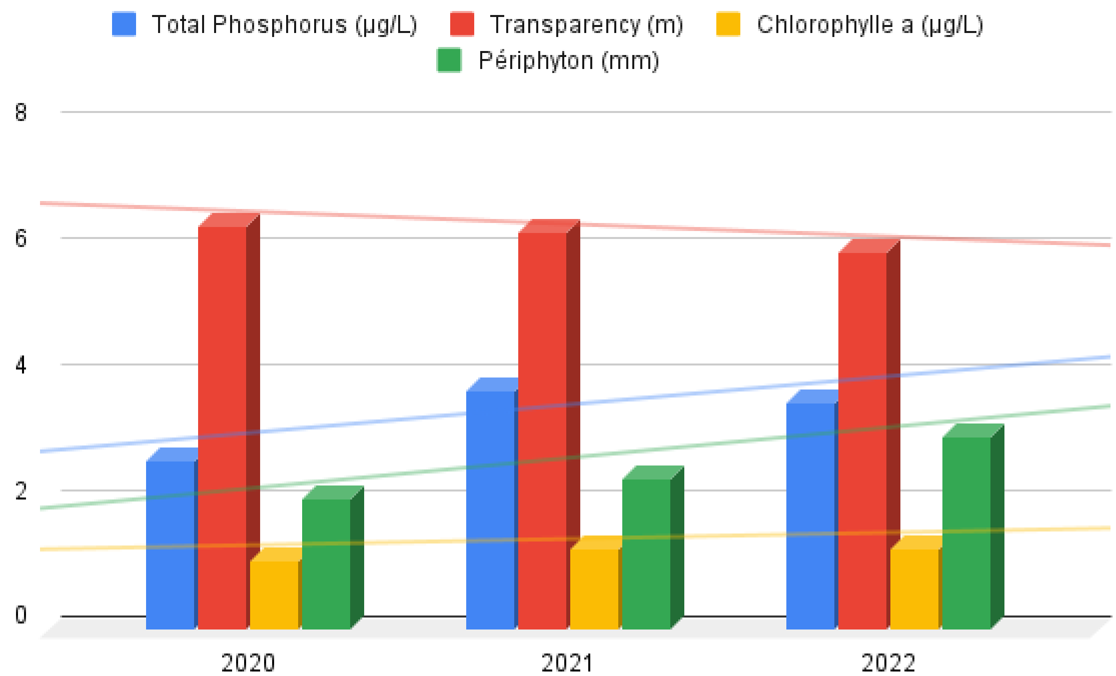
Figure 16 : Filament length variation for the 20 sites measured in the last three years



The length of the filaments vary from 0 to 18 cm. As for that of the periphyton, we observe that the average length of the filaments increased from 2020 to 2022.

Comparison using all parameters

Figure 17 : Concentration of phosphorus, chlorophyll a, transparency and thickness of periphyton as well as trend lines for summers 2020 to 2022.



The Covid 19 pandemic impacted the number of vacationers present on the lake. In 2020, several owners living abroad were unable to travel due to lockdowns. Gatherings were not allowed, which greatly limited the movements on the lake and the number of people present in each dwelling. In 2021, traffic and attendance on the lake increased but did not return to normal until the summer of 2022.

It is interesting to compare the results obtained during these three summers. In figure 15, we observe increases in the concentration of phosphorus, levels of chlorophyll a and the thickness of the periphyton. During the same period over 3 years, there is a decrease in transparency.

Obviously, to have a standard trend over 3 years as per protocol, one would have had to limit access to the lake during those years. Other factors that affect these parameters should also come into consideration such as the abundance of precipitation, the increase in water temperature and the number of hours of sunshine, for example.

However, it is interesting to note that with more visitors to the lake during a summer, more boats will make round trips to the village, more snowboarders or skiers will cause shoreline erosion and sediment drag and the water will be brewed. Septic systems will also be more stressed. This had definitely an impact on water quality.

Trophic Level Ranking

Definition

The trophic level is a tool used to classify lakes according to their degree of biological productivity. The grading scale classification varies from ultra-oligotrophic to hyper-eutrophic. Eutrophication is a natural process that results from accumulation of nutrients in lakes or other bodies of water. There is normally a gradual and very slow aging process towards eutrophication taking centuries. However, human activities can accelerate eutrophication by increasing the rate at which nutrients enter the water. Under extreme conditions, severe eutrophication can occur over only a few decades.

Figure 18 : Determination of the trophic level ranking of Lac des Seize-Îles in 2011 (Biofilia report)

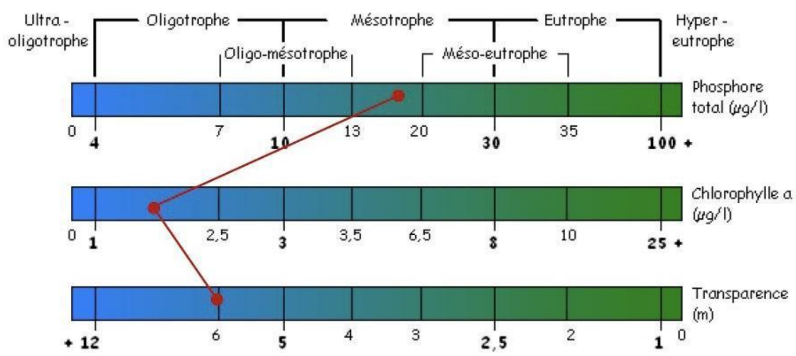
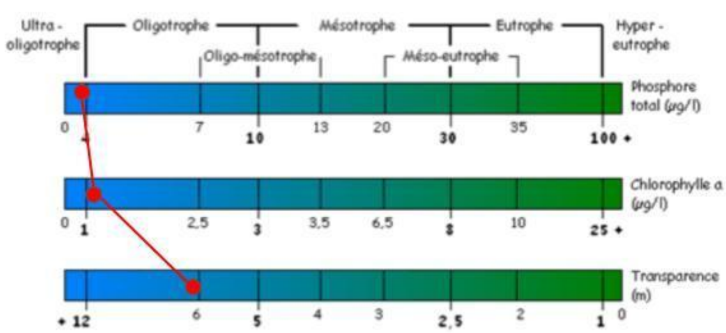


Figure 19 : Determination of the trophic level ranking of Lac des Seize-Îles based on results averages obtained from 2020 to 2022

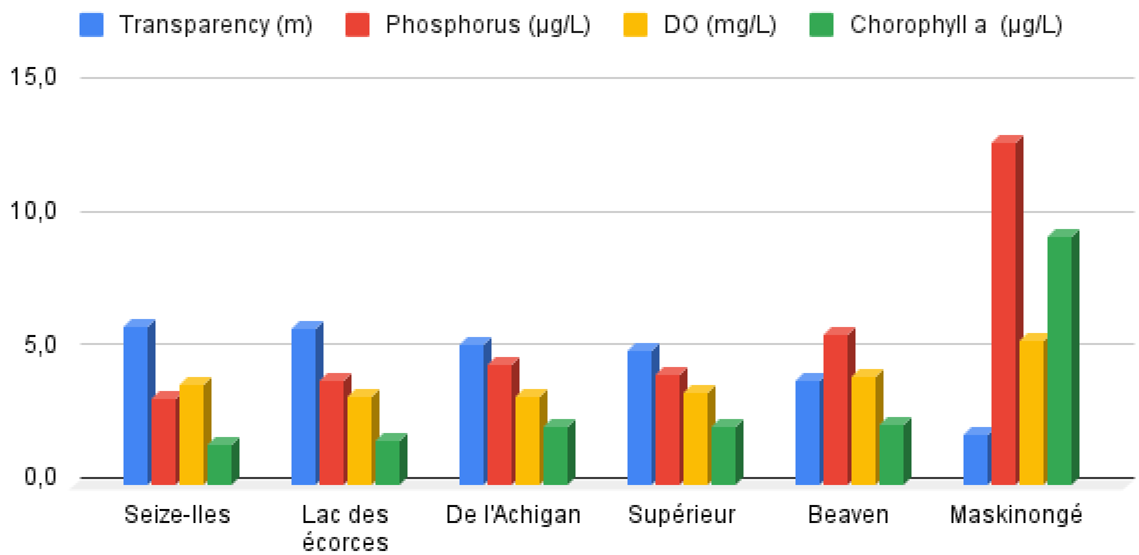


If we compare the two graphs from figure 18 and figure 19, we could conclude that Lac des Seize-Îles has remained in the oligotrophic level ranking. However, as mentioned previously, the phosphorus concentrations measured in 2011 are very high, making it difficult to compare to the situation of today.

Comparison of results for Lac des Seize-Îles with other lakes in the region

Figure 20 compares 6 lakes in the region, including one eutrophic lake, Lac Maskinongé in Mont-Tremblant. It can be seen that Lac des Seize-Îles has the highest transparency. The concentration of phosphorus and chlorophyll *a* are also the lowest of the six lakes, which is consistent with the transparency measurements.

Figures 20 : Comparison of the average transparency, DOC, phosphorus and chlorophyll *a* concentrations for the years 2010 to 2021 according to the results of RSVL[4]



As can be seen in Figure 21 below, Lac des Seize-îles has a big surface area and a relatively large average depth compared to the other lakes in the graph. The renewal time of its water is also high compared to other lakes. A long renewal time allows for the phosphorus that enters the lake to sediment. This limits its concentration in the water column and therefore limits the growth of phytoplankton. A value of 2.32 years represents a relatively long renewal time compared to other lakes in the Laurentians.

The drainage ratio represents the surface area of the watershed in relation to that of the lake. The greater this ratio, the greater the risk of phosphorus and DOCs being carried into the lake from affluents. In Figure 22 below, we see that Lac des Seize-Île has a drainage ratio of 11.21, which is equivalent to the other lakes used in the comparison. A value greater than 10 corresponds to a high ratio. Lac Beaven in Arundel has a drainage ratio of 111.70, which is 10 times greater.

[4]Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, RSVL, https://www.environnement.gouv.qc.ca/eau/rsvl/relais/index.asp

Figure 21 : Comparison of surface area, average depth and renewal time for 6 lakes in the region.

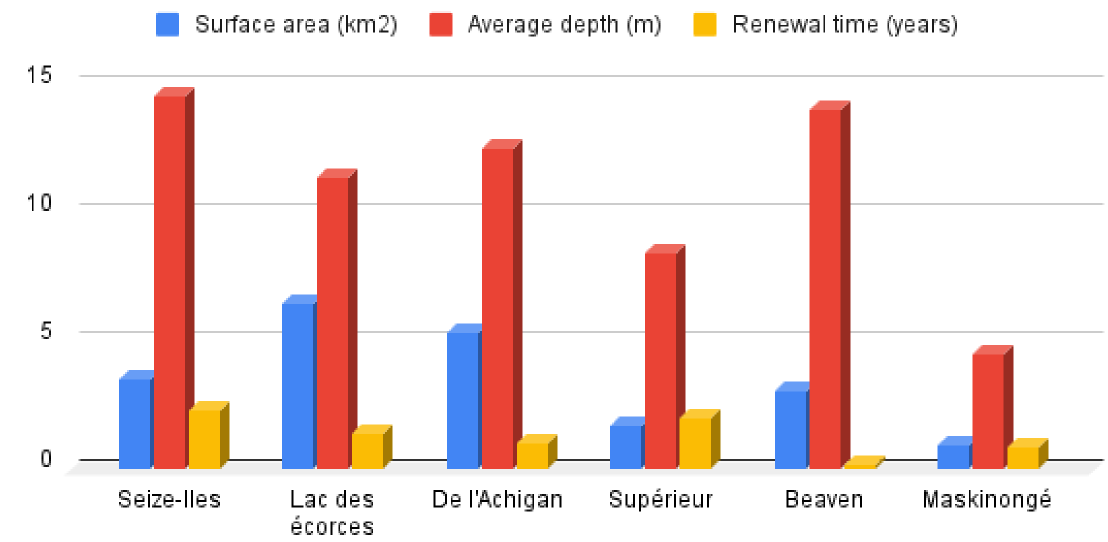
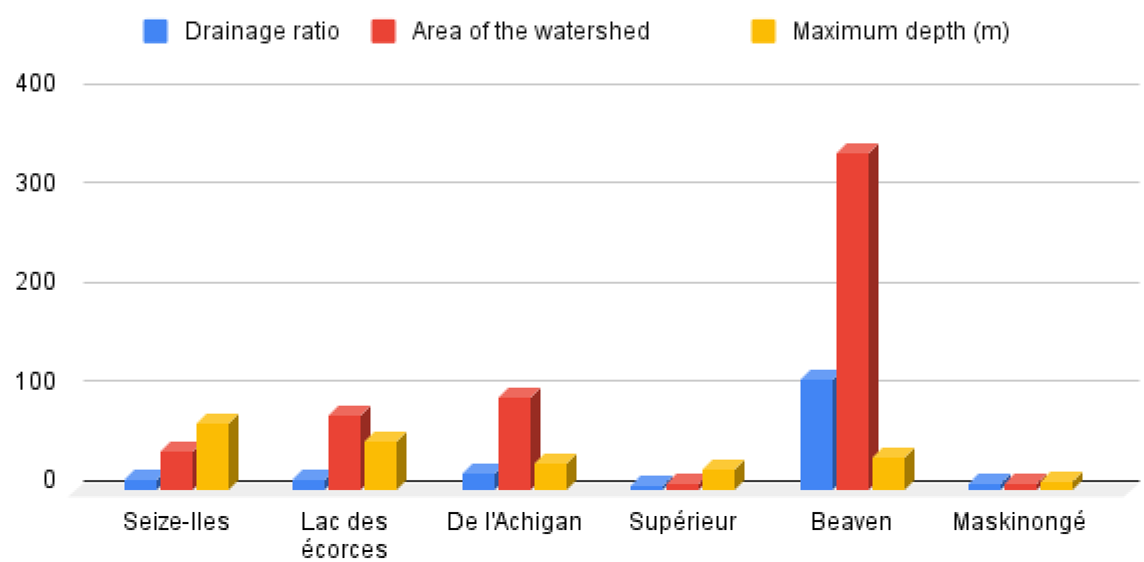


Figure 22 : Comparison of the drainage ratio, the area of the watershed and the maximum depth for 6 lakes in the region (Source: CRE Laurentide[5]).



Also in Figure 22, we see that Lac des Seize-Îles receives water from a large watershed, but in comparison, it is much smaller than that of Lac Beaven. Another advantage is that few agricultural activities occur near its watershed unlike Beaven Lake and Maskinongé.

[5] CRE Laurentides, l'atlas des lacs. https://crelaurentides.org/atlas-des-lacs/

Shoreline protection strip

The shoreline protection strip is a zone of vegetation between the aquatic environment and the terrestrial environment. Natural and left untouched, it fulfills multiple ecological functions in support of aquatic ecosystems and is essential to maintain the integrity of their biological communities. However, in many areas due to human intervention and activity (tourism, urbanization) it has lost its original character and has become highly dysfunctional. As a strict minimum, the shoreline protection strip must have a minimum width of 10 s and is measured from the high water mark (it must be at least 15 s if the slope is more than 30%).[6] It is made up of entirely natural indigenous plants represented by herbaceous ground cover, shrubs and trees.

Some Laurentian municipalities go further than this strict minimum requirement. For example, in its plan to counter climatic changes, for lakes Tremblant and Desmarais, the city of Mont-Tremblant requires a protection strip (outside the urban perimeter), of at least 20 m. This also includes subjecting wetlands which are not adjacent to a lake and water streams to a protection strip of at least 10 m.

According to the revised interpretation guide for the protection policy for shores, littoral zones and of the floodplains of Quebec, each living species requires a living environment that allows its survival and development. A diversified ecosystem with several species and biodiversity, is more stable and is less subject to the spread of diseases.

The shoreline is the bed of the stream or lake that extends from the high water mark to the center of the lake. The shallow part (12 feet depth of water or less) is where most aquatic organisms are found. It is also the richest and most diversified part of a lake ecosystem. With the plants on the shore, this is the place where we find the greatest biodiversity in the lake. We can even say that they are home to the majority of animals, from small crustaceans to mammals, that live in the lake. Many fish breed in this environment since their young will find shelter and food.

Shoreline plants also support a great diversity of small organisms (algae, bacteria, protists, and small crustaceans) which form the basis of a food chain. They also draw nutrients from the lake for their growth. Some can even absorb pollutants such as mercury and store it in their roots, purifying the lake water at the same time. They accelerate sedimentation and therefore improve water transparency. They also serve as wavebreakers helping reduce bank erosion.

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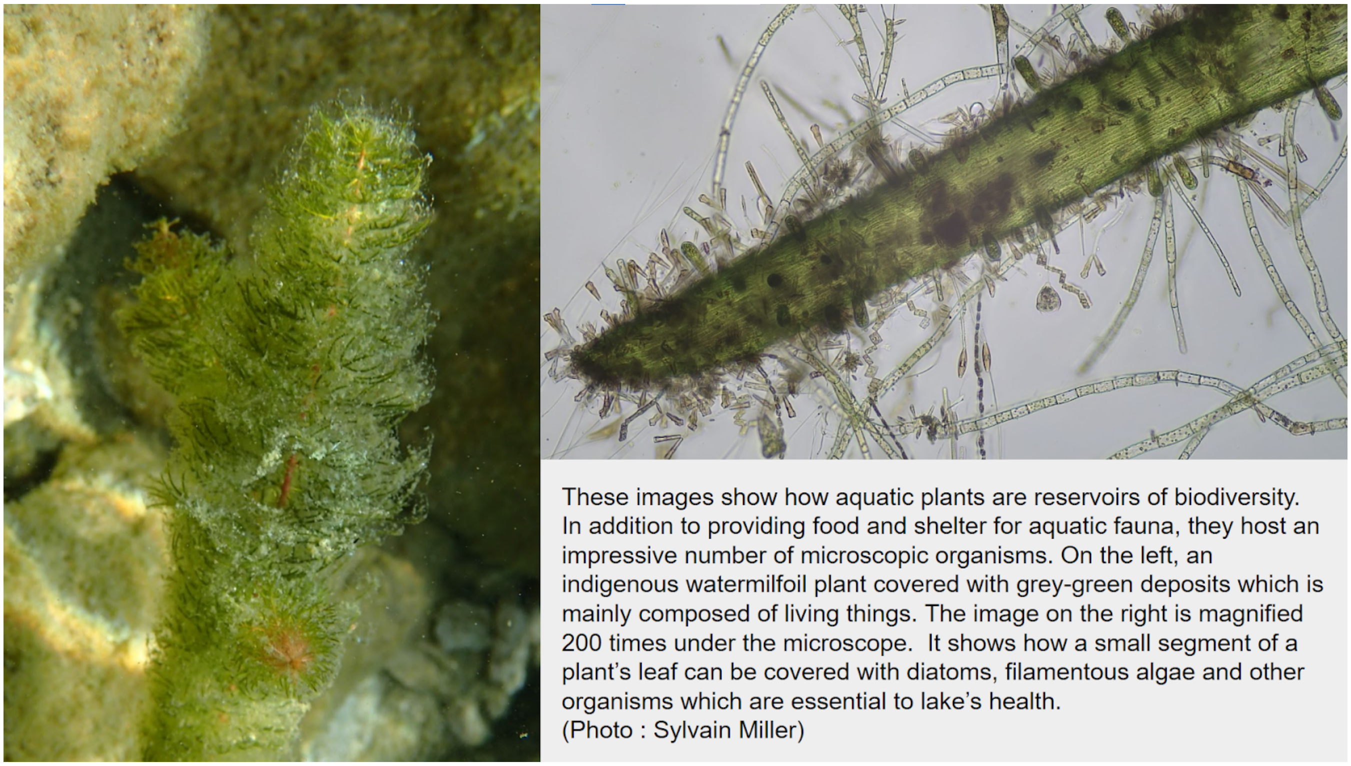
[6] Ministère de l'Environnement et de la Lutte contre les changements climatiques, RSVL, Document de soutien au protocole de caractérisation de la bande riveraine (2009), https://www.environnement.gouv.qc.ca/eau/rsvl/doc-soutien-bande-riv.pdf

Figure 23 : Role of coastal aquatic plants.



These images show how aquatic plants are reservoirs of biodiversity. In addition to providing food and shelter for aquatic fauna, they host an impressive number of microscopic organisms. On the left, an indigenous watermilfoil plant covered with grey-green deposits which is mainly composed of living things. The image on the right is magnified 200 times under the microscope. It shows how a small segment of a plant's leaf can be covered with diatoms, filamentous algae and other organisms which are essential to lake's health.
(Photo : Sylvain Miller)

Role of the shoreline

The shore is a very diversified environment because it is a transition zone between the terrestrial environment and the aquatic environment. This diversity is explained by the presence of different types of ecosystems in a restricted area that is the shore. It is also a fragile area since it is naturally exposed to the elements. It is even more vulnerable in the presence of human activity.

The shore and surrounding area is home to many mammals which use the lake as a source of drinking water.

To play its role effectively, the shore must be composed of three layers (herbaceous, shrubby and arboreal) of indigenous species. Herbaceous plants effectively protect the soil surface and retain small particles that are transported by runoff water. Trees and shrubs hold the soil deeper with their roots and dampen the effect of heavy rainfalls. Trees help cool the air and water in the shallow areas.

The plants that make up the riparian strip capture a large part of the nutrients and feed on them. By limiting nutrients, these plants limit phytoplankton growth and contribute to improving water transparency.

The plants limit the rapid runoff of rainwater to the lake by slowing it down, which allows best infiltration into the soil. At the same time, it limits the transport of sediments in the water (mineral and organic particles, pesticides, silt, clay and sand). Suspended in the water, these sediments clog the gills of fish and make them more susceptible to disease. Some substances transported in sediments such as pesticides, act as carcinogenic or endocrine disruptors and affect aquatic life.

Suspended sediments also affect the microscopic life of water by decreasing transparency. When sediment settles to the bottom of the water, it clogs gravel spawning grounds for fish. It also causes a drop in oxygen which affects aquatic life, especially the survival of small fry and bottom-dwelling invertebrates. When working near the banks, the installation of sedimentation barriers is crucial in order to limit the transport of sediment from the exposed soil to the water body.

Plant roots stabilize banks by limiting erosion and landslides caused by rain. Roots limit the impact of waves and other mechanical disturbances. The bacteria found in the soils of a healthy riparian strip allow transformation of nitrates into atmospheric nitrogen which reduces the supply of this nutrient to the lake water.

The shore of a lake is its most productive area from an ecological perspective. A natural riparian strip is a habitat that provides shelter and food for a large number of animals.

An increase in temperature would cause a drop in dissolved gasses such as oxygen since it better dissolves in cold water. However plants provide shade to the water in shallow shore areas, thus keeping water temperature cold and the growth of phytoplankton low.

Healthy vegetation in the shoreline also acts as a natural windbreak. This reduces the force of the wind and turbulence which is favorable to wildlife.

Tree trunks and plant stems also serve as shelter for aquatic fauna. The larger the natural shoreline strip, the more diverse the flora and fauna. A large surface allows the establishment of a greater diversity of plants which in turn will attract more animals.

A healthy shoreline protection strip forms preserves the natural character of a lake. To be effective and perform their various roles, **trees, shrubs and groundcover must not be cut or pruned**. According to the Policy for the Protection of Shores, Coastlines and Floodplains (PPRLPI), it may be permitted, by requesting the necessary authorizations, to prune the branches so as to form a window no more than 5 metres wide in the vegetation screen to provide a view of the lake as long as the slope is not less than 30% (abrupt slope allowing it to be performed at the top of a tree and not at the base). A slope less than 30% would mean removing branches at the tree base to improve the view. This would drastically reduce the efficacy of the natural shoreline strip as well as diminish the natural aspect of the lake for all users.[7]

Unless they are a threat to public safety or a vector of disease, dead trees should be left in place, especially on the shore, because they are widely used as shelter or as a perch by birds and small rodents. They therefore serve to increase biodiversity.

By tampering with the natural shoreline strip, we eliminate a rich habitat that will be replaced by a sterile environment detrimental to biodiversity. By removing the plant cover, we replace the natural habitat of several animal and plant species that often cannot adapt. The population density of these animals is

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[7] Québec Vert, Bandes riveraine, Plantation et entretien pour une restauration durable, http://banderiveraine.org/nous-joindre/

affected and the environment becomes less diverse. More tolerant undesirable species often take the place of the suppressed plants. When the natural environment is replaced by ornamental plants and lawns, these do not offer the same advantages as native plants. In addition, their maintenance often requires enrichment, fertilizers and sometimes pesticides which inevitably run off into the lake.

To renaturalize the shorelines, it is important to use native plants that reduce erosion. These should be of various species, ages and sizes to allow them to play their full role and attract wildlife. Lawn-type grass should be avoided since it leads to deterioration of water bodies and offers little or no attraction for wildlife except for a few species such as Canada geese.

It is also important to consider how the waters flow into the lake. If the flow of water is collected and drained at a specific location, through a path stripped of its vegetation, or through a grass area, the water will too rapidly reach the lake for the shoreline protection strip to play its role.

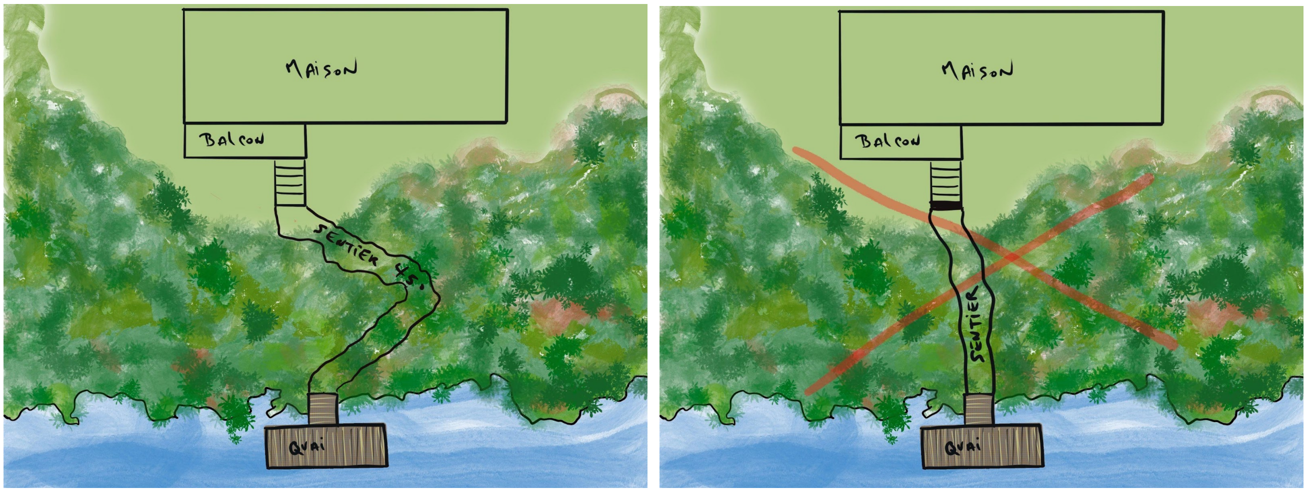
Access to the body of water

All lake residents want to have their own private access to the lake without sharing with their neighbors. For this reason, it is permitted to open a trail no more than 1.2 metres wide that leads to an opening to the lake of no more than 5 metres wide. But the access trails risk breaking the effectiveness of the shoreline protection strip. In order to cause as little disruption as possible, it is best to develop it taking into account the slope of the shoreline.

When the slope is less than 30%:
If the route of the access was perpendicular to the lake, it would provide a direct path allowing rainwater and snowmelt to reach the lake without being filtered by the shoreline protection strip. With time and frequent passages, there will be erosion of the slope. To mitigate this effect, it is preferable to form a horizontal angle (of a maximum of 60°) with the shoreline to reduce the effect of erosion (see figure 22).

For a slope greater than 30%:
It is best to build a staircase or a path at an angle to the shoreline. It is important to favor a winding path and avoid a straight line in order to minimize erosion (see figure 22). Natural vegetation must be preserved as much as possible by limiting the width of the path or stairway.

Figure 24 : Good configuration of an access trail in a shoreline protection strip and example of what to avoid.



After developing the access path, it is important to maintain plant cover over the entire surface of the access road, even seeding as needed. Access to water should not be built using concrete or other inert materials. Any access must not be used to launch large boats in the water. Only municipal boat ramps must be used for this purpose. The shoreline should not be used for storage. It is preferable to place small boats such as canoes and kayaks on raised supports or outside the shoreline protectionstrip.

Observations on the shoreline protection strips at Lac des Seize-Iles

Protocol

The method which was used for characterization of the shoreline protection strips is that of the RSVL.[8] The various lake properties were visited by kayak or boat and were separated by the approximate property lines. The factors looked at are the percentage of natural plants, ornamental plants and bare soil first. Grass lawn is considered an ornamental plant. We then noted if the slope was 30% inclination or more. If it was the case, the shoreline protection strip was to be 15 metres. Finally, the percentage of bare soil and the presence of retaining walls were evaluated.

For properties that had a significant portion of their shoreline in its natural state, the measurement was divided into two homogeneous zones, one presenting evidence of alteration and a separate zone in its natural state (see figure 25 below for illustration). For each zone a score was assigned according to the state of shoreline degradation over the first 10 metres (or 15 metres) assessed from the high water mark for the area used.

[8] RSVL, Document de soutien au Protocole de caractérisation de la bande riveraine (2009) https://crelaurentides.org/images/images_site/documents/troussedeslacs/Protocoles/document_soutien_br.pdf

Figure 25 : Example of undisturbed shoreline representing one homogenous zone.

The measurements were recorded in a table prepared for this purpose and subsequently, using Google map, we measured the length of the shore which we had associated to each of the following 4 grades: A (less than 25% degradation), B (between 25 and 50%), C (from 50 to 75%) and D (more than 75% degradation). Each score represents a percentage of shoreline degradation as per protocol. The compilation of the results therefore shows the proportion of the lake that is affected by a degradation of the shoreline strips as opposed to scoring each individual property. We also estimated the width of the access to the water which must remain below 5 metres wide.

The shorelines in the northern part of the lake were assessed in the summer of 2021. The results were grouped into three areas: Hammond Bay and the village, including the west coast and the east coast. The area covered is illustrated in the map in figure 28.

In the summer of 2022, we carried out the characterization of the southern part of the lake (see appendix 6). The southern part of the lake was divided into two sections, the west coast and the east coast. Islands have been included with the nearest coast. At the request of Friends of the lake, no images of the shorelines were taken in order to ensure that the results remained anonymous. However, taking photos would be an important tool for monitoring the trends in the improvement or degradation of the shoreline protection over the years.

Results

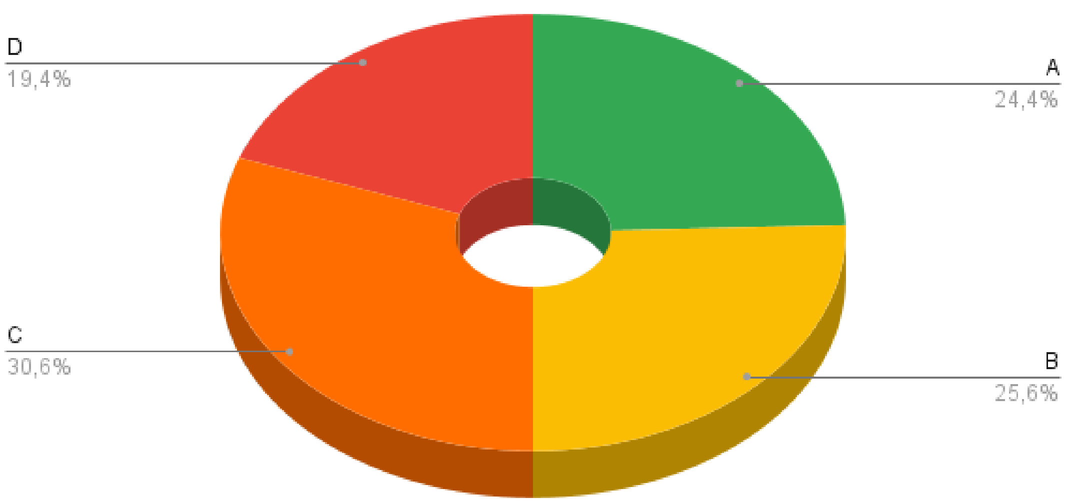
History

In the Biofilia report from 2012 it is mentioned that “according to the municipal database, even if the majority of riverside properties have infrastructure on the shore, 80% have natural vegetation or are being revegetated”. Our observation in 2021 and 2022 turned out to be different (see figure 25).

Figures 26, 27 and Appendix 6 show the results obtained for each part of the lake visited.

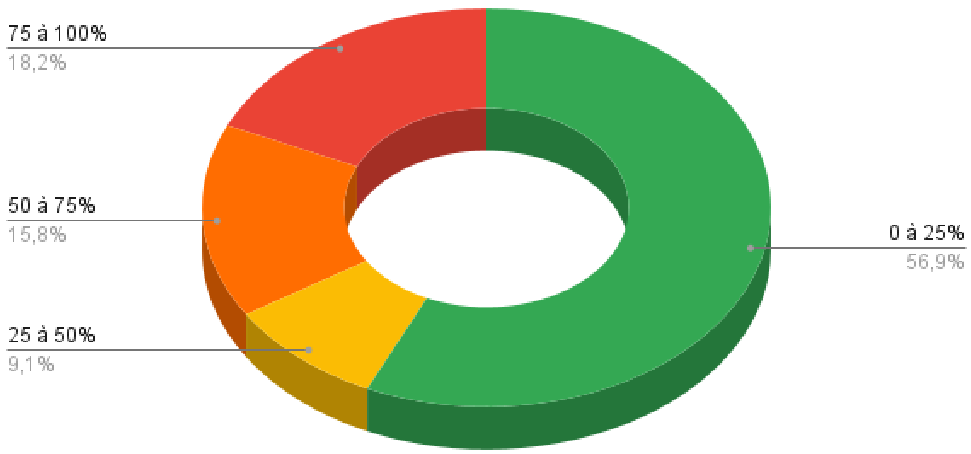
The general observation that we noted in 2021 and 2022 is that at least half of properties presented shoreline accesses and shoreline occupation needing improvement. There are many patches of lawn and developed land. As can be seen in Figure 24, only 24% of properties received an A rating for the good quality of their shorelines and 26% received a B grade. A large proportion (31%) received a C grade and 19% a D grade, which is 1 property in 5. Some properties were even found to be in derogation with municipal regulations.

Figure 26 :Percentages of properties obtaining each of the scores (A, B, C and D) for the quality of their shoreline as evaluated in 2021-2022.



When we apply the protocol, we consider the entire perimeter of the lake as a whole entity. When this is done, we find that only 57% of the shores are naturally preserved (compared to 80% in 2021) while 43% is degraded at various levels. This constitutes a large area which cannot be used by wildlife and which does not play its role of protecting the lake against eutrophication. A positive point for the lake is that a large portion is surrounded by vegetation in their natural state beyond the shoreline protection strip since there is no access road. This distribution of the quality of the shorelines (as protocol) can be seen in Figure 27 below.

Figure 27 : Percentage of degradation of shoreline protection strips for the entire lake as assessed in 2021-2022.



In general, we have noticed that the majority of owners have cut or pruned trees to have a view of the lake from the house without regard to the protection of shoreline strips. Moreover, the majority of the constructions are visible from the lake. These breaches in the forest cover reduce the protection of trees during heavy rains.

Another point that is specific to Lac des Seize-Îles is the presence of numerous boathouses. According to ministry policy, a maximum access of 5 metres can be practised in the vegetation to reach the shore. Considering that most properties have an access to their dock in addition to the one for the boathouse, the maximum opening of five metres on the lake is often largely exceeded. Also, there is often an additional path in the shoreline protection strip to access the boathouse from the dock area, which further jeopardises the effectiveness of protection.

A few flower pots and even two complete vegetable gardens were seen on the quays or in the shoreline. The presence of potting soil or compost near a body of water encourages the growth of algae and aquatic plants. The rich soil used to obtain beautiful flowers has the same effect on the growth of aquatic plants since it is a nutrient for both. During heavy rains, the flower pots and vegetable gardens are at high risk of overflowing with water. When this nutrient-enriched water ends up in the lake, the nutrients feed the algae and aquatic plants and help them spread.

In addition, some properties have deforested large areas to replant with ornamental non-indigenous varieties or grass. It was not exceptional to see people and workers using saws, clippers and weed-eaters in a portion of their shoreline which should have been kept undisturbed. We even saw someone removing rocks from underwater and throwing them in the shoreline.

We found it important to show the results for Hammond Bay and the village separately since it is necessary to consider the historical dimension of this area (and others similar). Several properties are built at the foot of a slope leaving very little land on the lakeside or at the back of it. Because of the terrain, it is difficult to grow an effective shoreline protection strip as buildings, docks and boathouses interfere with establishment of vegetation. Also, land affected by the 2014 landslide and/or the tsunami wave that followed, have not been naturalized. We took into consideration the village properties and road infrastructures. Looking at the satellite image taken from Google maps, it can be noticed that the width of the shoreline protection strip along the road and cycling path is insufficient. A small area near the parking lot has been re-naturalized but has not taken into consideration the three layers of vegetation (ground cover, shrubs and trees). Several properties have large lawn areas which should also be re-naturalized. Some changes would be difficult to make such as on the roadside, but any improvement even small would be an important step towards improving the water quality in this part of the lake.

Figure 28 : Map showing the land surveyed when we measured the score for quality of the shoreline protection strip of properties in Hammond Bay and the Village

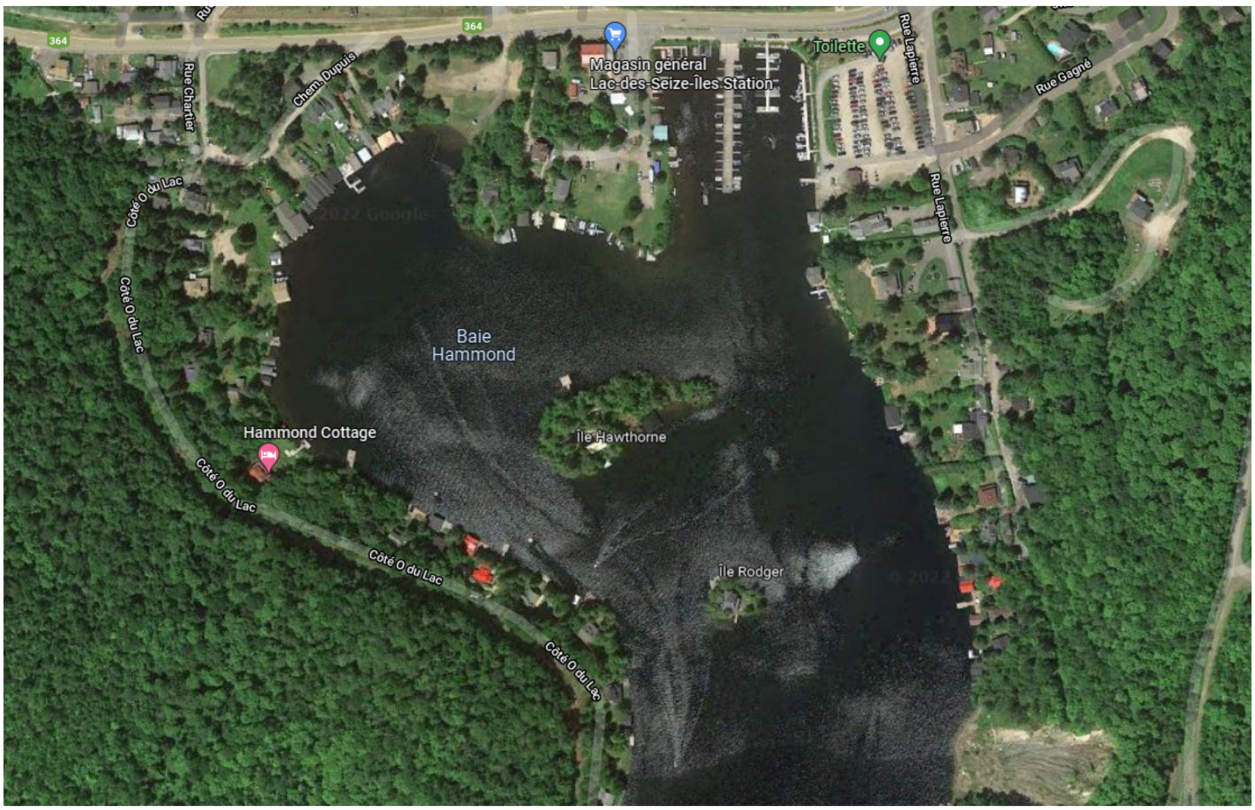
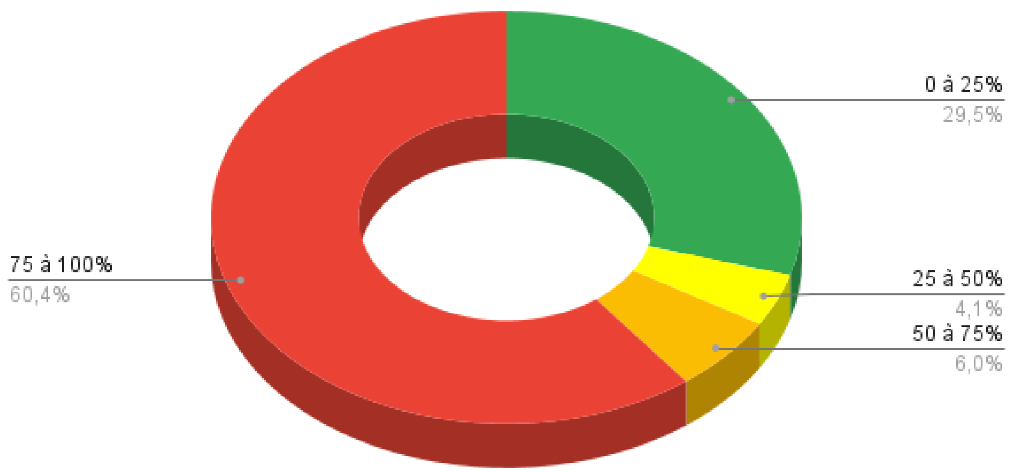


Figure 29 : Percentage of degradation of the shoreline protection strip of properties in Hammond Bay and village



In the Hammond Bay and village section, we observed that the vast majority of properties do not respect the minimum shoreline protection strip of 10 metres (for slope less than 30%) and 15 metres (for slope more than 30%). This represents 60% of shoreline degradation in that area. Some properties, such as municipal land, appear to be making some efforts to renaturalize the first 5 metres, but this is well below standard. Any effort of renaturalization must include the three layers of vegetation that are herbaceous plants, shrubs and trees. Certain portions of this area such as Hawthorne Island for example, have entirely natural vegetation and the shoreline protection strip appears in very good condition.

Macrophyte assessment

History

In the 2021 Biofilia report, there is a map indicating where the most important aquatic plant beds are present in the lake. A list indicating the dominant plant and the secondary species was attached to the report.

In this 2010 report, a total of 8.0 ha of aquatic plants had been identified. There were 31 Eurasian watermilfoil patches, covering 4.1 ha, (in Lac des Seize-Îles only), making it the most abundant species among the 14 species observed. The fragrant water lily, the European pondweed and the broad-leaved pondweed (Potamogeton amplifolius) are the other most frequent species which were observed in respectively 34, 20 and 16 plant patches.

Methodology

Using this information, we toured the lake by kayak or boat to find the plant beds mentioned on the map and identify others. On several occasions, we used the camera to take pictures underwater or used a drone to get aerial pictures. We noted important new plant patches. It was not possible for us to measure the occupied area, however, we were able to assess the general evolution of the plant beds compared to 2012. We used the 2012 Biofilia maps for comparison. The map of the Lac des Seizes-Iles was separated into four sections. The modifications were made using drawing software and the map pairs (form 2012 vs 2022) are presented in appendix 7.

Results

Roughly estimating surface areas, it was observed that the Eurasian watermilfoil presence has receded since 2012. Careful and systematic manual extraction of the plants including roots over the years has visibly reduced the watermilfoil dominance in certain areas. This is documented on the maps presented in appendix 7. The most striking difference can be seen in Hammond Bay where very large beds of Eurasian Milfoil were almost completely eradicated leaving only native plants. Another area where Eurasian Milfoil has receded notably due to manual extraction which occurred between 2018 and 2022 is the Shoal (rock mound near site #10 in appendix 1). Manual extraction work was also done in Raymond Bay and other areas on the lake. Overall on the maps, we noted 12 large beds of Eurasian watermilfoil and 4 smaller ones which have been considerably reduced or removed since 2012.

To better document the aquatic plant beds in order to compare them in future years, a link to a video of images taken between 2020 and 2022 is appended to this report.[9]

From the maps in appendix 7 we can observe that in Hammond Bay, plant beds #17 and #18 are completely transformed. There are only a few scattered stems of the Eurasian Milfoil present. Richardson's pondweed, Grass-leaved pondweed and Robbins pondweed remain. In some areas, the plants are very dense and in addition to the previous species, three other types of Pondweed are present. Plant bed #8 consists mainly of Canada waterweed. This species grows in particularly dense and tall patches which indicates that the sediments are very rich in nutrients in the bay.

Further south on the lake, the aquatic plant beds around Ile Cossette do not appear to have changed much. Eurasian watermilfoil is found in depths ranging from 6 to 10 feet. The plant does not form colonies as dense as was the case in Raymonds Bay. It grows along with Large-leaved Pondweed and Richardson's Pondweed.

In Raymond's Bay, two important beds, #12 and 13, of Eurasian watermilfoil were uprooted manually between August 2021 and August 2022. The difference (before removal and after removal) can also be seen in the video document (see link at bottom of page). The other aquatic plant beds in the bay appear fairly identical to what was observed in 2011.

On the west side of the lake (southern side), little has changed from what was observed in 2011 as indicated on the map. Beds #12 and #18 from 2011 were difficult to find in 2021/22 because the Eurasian Watermilfoil plants in these beds are now scattered.

At the southern end, plant bed #39 (from 2011) is very large but has a low density of plants. The number was changed to # 57 in 2022 because it was found to contain more Brasenia than Floating-leaved pondweed.

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[9] Sylvain Miller, Montage vidéo des herbiers du lac des Seize-Îles, https://youtu.be/Y1BLGmFThu8

Returning south near the shoal, we inspected the three aquatic plant beds labeled as #12 and we did not find the Eurasian watermilfoil which had been reported in 2021. In August 2022 however, we noted very healthy Richardson's Pondweed beds which were noticeably tall and dense (see bed #40 in appendix 7).

Around the shoal (near site #10 in appendix 1) at depths varying from 1.5 to 4 metres, the very rocky bottom was covered with Eurasian watermilfoil up to 2018, when we participated in manual uprooting and removal. The task was particularly difficult since the roots of the plants were solidly anchored between rocks of different sizes typical of the shoal. We were careful not to remove the three species of pondweed (Large-leaved, Grass-leaved and Leafy) which were not densely established. Canada Waterweed, Slender Naiad, Northeastern Bladderwort were also present and left in place. In very shallow areas, small Chara Algae plants are present. During our subsequent visits in 2019 and 2020, the watermilfoil had been almost completely removed. In 2022 only a few scattered plants of Eurasian milfoil remained while dominating species were Large-leaved pondweed, Grass-leaved pondweed and the Canadian waterweed.

At the foot of the bay, in beds #12, 16 and 18 reported in 2012, we did not find any Eurasian watermilfoil. Richardson's pondweed and Grass-leaved pondweed were sparsely scattered in two areas.

In conclusion, the consistent manual uprooting of Eurasian watermilfoil over a number of consecutive years gives convincing results for the lake. As for the other aquatic plant beds, there appears to be consistency in the quantity and type present in the lake. For Lac des Seize-Îles, 30 different species of submerged, floating or emerging aquatic plants have been identified. Waterlilies are present in 24 beds, Richardson's Pondweed in 24 beds and European Pondweed in 21 beds which make them the dominant species.

Baie des Soeurs

Phosphorus

History

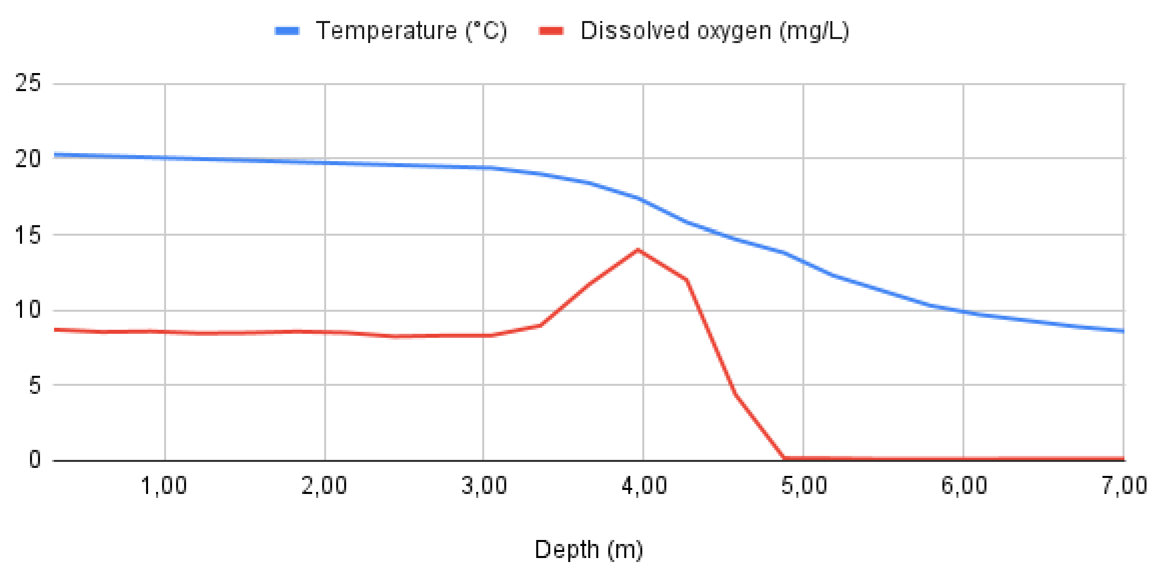
Several samples were analyzed for phosphorus content between 2007 and 2011. Results were often below 5 µg/L. The mean total dissolved phosphorus readings were 21 µg/L from 2007 to 2011.

2020 phosphorus results

We made two measurements of the phosphorus concentration at the surface for Baie des Soeurs in 2020 and one in 2021. The result in 2020 was 2.7 µg/L for the bay and 14 µg/L for the main tributary which comes from the lac du Grand-Heron. On August 8, 2021, the phosphorus level measured was 5.1 µg/L. The average phosphorus concentration for the two years in Baie des Soeurs would be 3.9 µg/L.

Dissolved Oxygen

Figure 30 : Temperature and dissolved oxygen profile at Baie des Soeurs on August 2, 2021



As seen in figure 30, the concentration of dissolved oxygen becomes null a little below 5 metres in depth. The bottom of this small lake is covered with a thick layer of black sediment. The condition of anoxia (lack of oxygen) is a sign that many microorganisms are breaking down the sediments and consuming all the oxygen present before the end of summer (before fall water mixing). This situation, however, is not new as Biofilia mentions similar results in their 2012 report.

Transparency

Three transparency measurements were made between July 22 and August 20, 2020 varying between 2.3 and 3.1 metres. In 2021 three measures were also taken between July 22 and August 15. The measurements varied between 2.9 and 3.7 metres for an annual average of 3.3 metres. The average transparency for 2020 and 2021 is 3.1 m, which is identical to the average of 3.1 m obtained between 2007 and 2011 by the firm Biofilia.

pH

The surface pH in July 2020 was 7.4. This measurement is comparable to the average pH of 7.2 measured between 2007 and 2011.

Figure 31 : Classification of the trophic level of the Baie des Soeurs 2011[10]

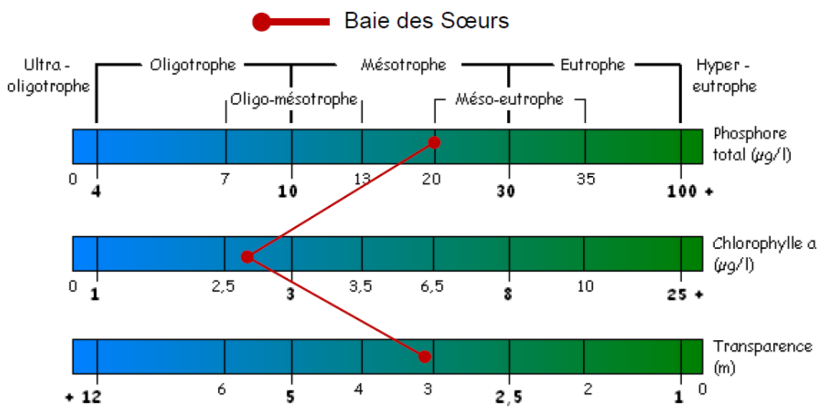
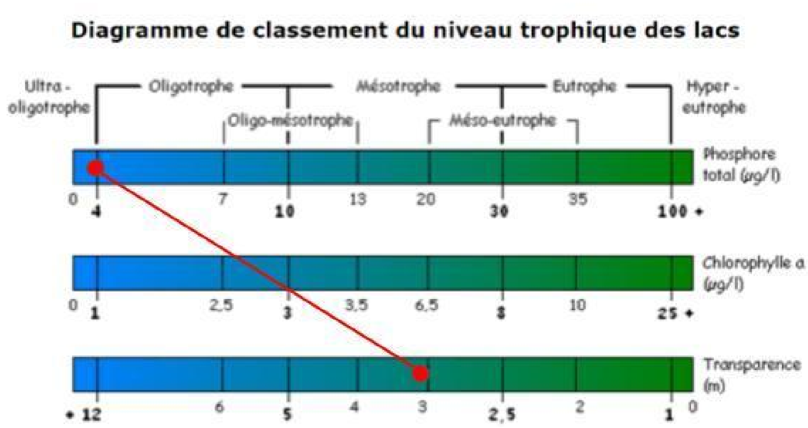


Figure 32 : Classification of the trophic level of the Baie des Soeurs 2021



[10] Rapport de Biofilia 2012

Evaluation of macrophytes

Baie des Soeurs is a small lake characterized, in its deeper part, by physicochemical parameters that place it in the mesotrophic stage. On the other hand, the large quantity of aquatic plants present, the low concentration of oxygen at the bottom, the low transparency of the water and the richness of plant biodiversity, are rather the characteristics of a eutrophic stage of a lake.

In 2011, on the map at the southern end, a lot of Eurasian watermilfoil appeared to be present. During our observations between 2020 and 2022, we noticed that bladderworts are the dominant submerged plants in this lake. Eurasian watermilfoil is still present there, but in competition with other aquatic plants and no longer the dominant species. This observation might be an indication that the lake is more shallow in some places.

An interesting phenomenon was observed on July 20 in Baie des Soeurs. Since the bottom is made up of a thick layer of sediment, the bacteria play their role as decomposers and form gasses which sometimes accumulate under a more impermeable layer. When a large amount of gas has been trapped, it pushes up the layer of sediment including the roots of the plants. Thus, on July 20, 2022, we were able to observe a mass of approximately 5 metres by 8 metres of sediment floating on the surface and revealing mainly large water lily rhizomes. We can observe images of the phenomenon in the video (43 seconds) on the seagrass beds of Baie des Soeurs and Passage des Grenouilles[11].

The underwater camera made it possible to notice that the submerged plant beds of this small lake are much more diversified than what was previously documented. As can be seen in the video document Baie des Soeurs and Passage des Grenouilles[10], the lakebed is completely covered with plants. We identified the following: common bladderwort, purple bladderwort, flat-leaved bladderwort, Eurasian watermilfoil, native watermilfoil, water beggarticks, robbins pondweed, floating-leaved pondweed, large-leaved pondweed, leafy pondweed, water bulrush, chara, fragrant water lily, Schreber's pondweed, variegated water lily, slender naiad, burreed, and arrowhead.

[11] Sylvain Miller et Anne Létourneau, Herbiers de la Baie des Soeurs, https://youtu.be/uxFMUsrQjPA

Lac Wonish

Phosphorus

At Lac Wonish, the Biofilia report indicates 9 µg/L of phosphorus in 2011. A measurement of 5.2 µg/L was taken on August 6, 2020, which constitutes a decrease compared to 2011. However, this is still a much higher value than what is found in the Lac des Seize-Iles.

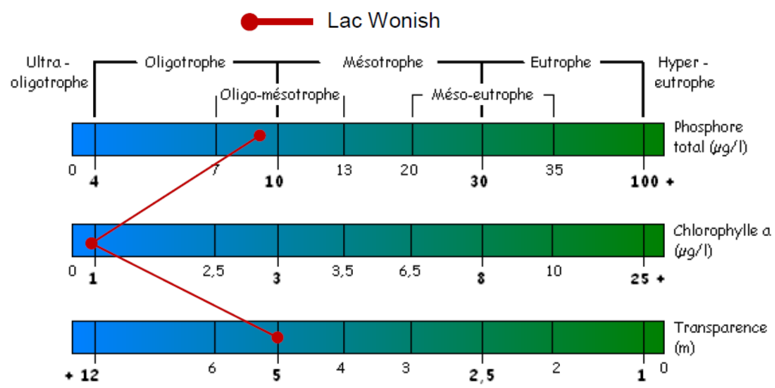
pH

The pH measured was 7.6 at the surface in 2020.

Transparency

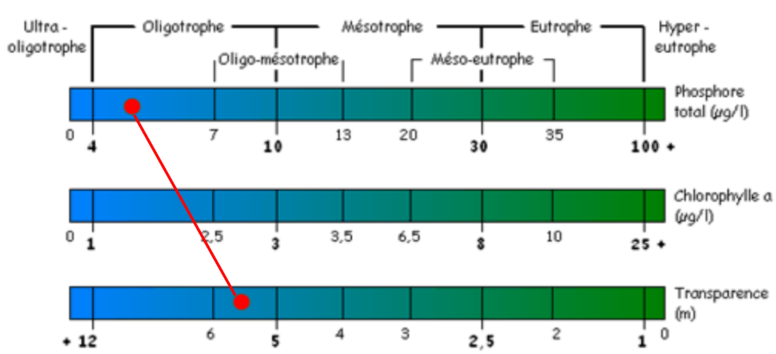
Transparency was 5.6 metres on August 6, 2020. This measure is comparable to that of 19 august 2011 which was 5.0 metres.

Figure 33 : Classification of trophic level of lac Wonish 2021



Source Biofilia 2012

Figure 34 : Classification of trophic level of lac Wonish 2020



Grand Héron lake

Phosphorus

In the Grand Héron lake, values varying between less than 10 µg/L and 16 µg/L were measured in 2007 and 2011. The phosphorus concentration measured during the summer of 2020 was very high compared to the other lakes with 11 µg/L.

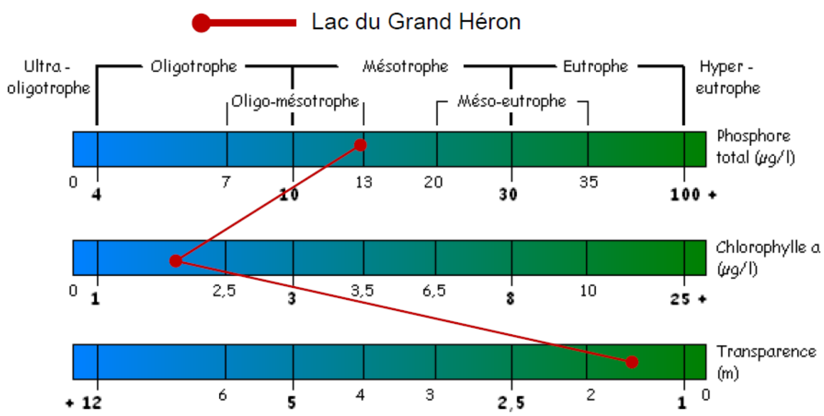
pH

In 2020, the pH of 7.5 at the surface decreases rapidly to reach 6.8 at 5 metres.

Transparency

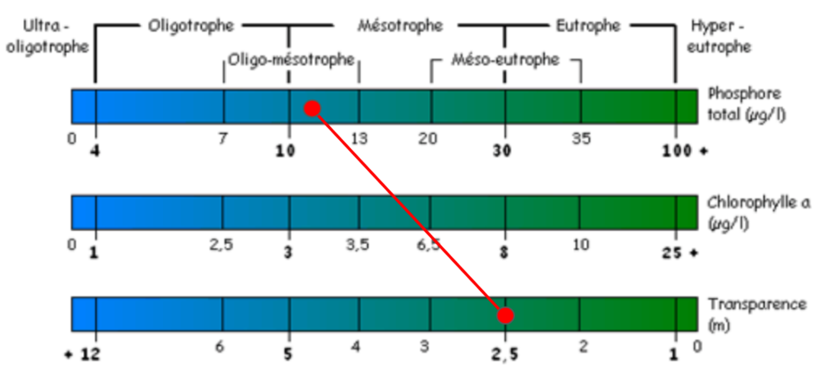
Transparency was 2.5 metres on August 5, 2020. This measure is a little better than the measure taken on August 15, 2011 which was 1.5 metres.

Figure 35 : Classification of trophic level of lac du Grand Héron en 2011



Source Biofilia 2012

Figure 36 : Classification of trophic level of lac du Grand Héron en 2020



Conclusion

As per the parameters studied between 2020 and 2022, Lac des Seize-Îles is in the oligotrophic class, typical of a lake not much enriched in nutrients. As per RSVL protocol, these parameters are measured at a single location on the surface of the water, above the deepest point of the lake. However, as was done by Biofilia between 2007 and 2011, we measured the phosphorus concentrations at several points, and in 2020 we found very little difference from one end of the lake to the other. The higher results were found in the large bay near the outlet of the lake.

As prescribed by the RSVL, we suggest continuing phosphorus measurements annually at 1 from the surface and above the deepest point of the lake. This will be useful to determine if there is a trend in the enrichment of the water. Following the results obtained, we would suggest taking three measurements per year at that single point to establish a trend. From time to time, two additional measurements, one in the spring and one in the fall during the mixing of the waters, would also give a good idea of the concentration of phosphorus throughout the water column.

The increase in phosphorus concentration, the thickness of the periphyton and the decrease in transparency from 2020 to 2022 are an indication that an increase in activities and traffic to the lake is having an impact on the health of the lake. In addition to these observations, we noted the presence of a large enough quantity of phytoplankton on the surface to be visible to the naked eye. In mid-summer, phytoplankton is mainly composed of cyanobacteria and there are also high concentrations near the thermocline. This should encourage caution and incentive to do everything possible to limit the input of nutrients into the lake.

Golden algae (chrysophytes) and blue-green algae (cyanobacteria) are part of phytoplankton. Chrysophytes favourably compete for uptake of dissolved phosphorus and other nutrients, allowing them to dominate other algae in early summer. As the water warms up, cyanobacteria become more abundant. The zooplankton which feeds on the phytoplankton helps the water transparency. On the other hand, cyanobacteria are not the favourite food of zooplankton, which tend to make these algae thrive when the nutrients are abundant. Therefore efforts to keep phosphorus as low as possible help keep phytoplankton levels low, and thus maintain good water transparency. Keeping nutrients from entering the lake and avoiding disturbing the sediments limit the growth of cyanobacteria and chrysophytes. These are the best ways of countering the effect of climate changes which increase surface water temperature and decrease in ice cover time.

The oxygen concentration at depth, measured in the summer of 2019 by UQAM had shown lower values than what had been measured in 2010-2011. Oxygen concentration measurements taken between 2021 and 2022 show that the bottom of the lake retains good oxygen concentrations throughout the summer, which is good news for the survival of lake trout. Low oxygen concentrations were measured in Nuns' Bay, which does not represent a change from 2012.

Although coliform tests are important for identifying possible sources of phosphorus, for technical reasons they are not reliable for accurately identifying septic systems deficiencies. It is important for municipal authorities to follow up on the maintenance and compliance of the facilities with each lakeshore owner as well as those bordering the watershed and inlets. The various biological tests show that the water quality is good for swimming in all parts of the lake which we tested.

Regarding the periphyton, the ministry recommends monitoring over three years and 30 measurements at 20 sites for a lake of more than 2 km^2. The periphyton measurements taken from 2020 to 2022 also showed an upward trend over three years. This would tend to demonstrate an increase in the growth of lake organisms according to lake traffic and occupancy. However, other factors could be responsible such as amount of rainfall, water temperature or period of ice cover .

Systematic surveys of the riparian strips show that the majority are in good condition and offer some protection against the input of sediments and nutrients caused by runoff water (which could enrich the lake). The lake still has large natural, undeveloped areas. On the territory occupied by the residents, several waterfront properties have grassed and landscaped areas with non-native plants requiring fertilizer, compost and watering for maintenance. This is especially visible in the area of Hammond Bay and the village where habitation density is greater. Some of them have slopes such that nutrients are likely to run off much more easily into the lake, especially in areas where riparian strips are not natural (stone/cement walls and rock embankments, absence of native vegetation , etc). This is also an area where there is evidence of erosion as it is a high motor boat traffic area.

In order to reduce phosphorus inputs, it would be beneficial to re-naturalize the first 10 s with the three types of native plants, namely ground covers (herbaceous plants), shrubs and trees. This observation also applies to all the properties around the lake. We have little control over climate change, but at Lac des Seize-Îles, the health of the lake would benefit from improving the riparian protection strips.

Shallow areas in several places in the lake are well identified. In Hammond Bay, among others, reduced speed zones have been set up. However, they are not always respected. It would be important to continue raising awareness because the mixing of sediments in these shallow areas leads to the release of the phosphorus present in the sediments.

Certain other observed practices should be prescribed or supervised. For example:

- Fires near the riparian strip. The ash is responsible for a significant supply of phosphorus which is likely to end up in the lake over the seasons. Fires should not be permitted within 15 s of the shore.
- Pots containing potting soil or compost for vegetables or flowers should also be installed as far from the riparian strip as possible since these are rich in nutrients which risk being (such as the phosphorus contained in the ash) eventually washed away. into the lake by rainwater. One solution could be to provide the flower pots with a container that can collect drainage water. However, it is necessary to watch that they do not overflow during heavy rains or during the absence of the owner.
- Outdoor showers should be used without soap. Even biodegradable soap is rich in nutrients that can cause water enrichment.
- The compost bin should be placed as far as possible from the riparian strip since it too is an important source of nutrients.
- The practice of water sports in sensitive areas can also be an important source of phosphorus release. Two important studies have been done on the subject. Their conclusion reports that the waves caused by "wakeboat" or "surf" or "tow" type boats have a significant effect on the mixing of sediments and the recirculation of the phosphorus they contain, even up to several s depth. It is recommended to regulate this activity at a distance of more than 300 s from the banks in deep areas, and to supervise them in order to avoid the degradation of the banks and the recirculation of

phosphorus. This recommendation also applies to boats travelling near the shoals that are numerous in Lac des Seize-Iles.

- In addition to causing the release of phosphorus from the sediments, the passages and turbulence of all types of motorboats also encourage the dispersal of Eurasian watermilfoil by cuttings. Ideally, motor boat traffic should be limited to corridors in places where this plant is present in high density. As the plant is dwindling, important herbaria should be identified and marked.

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15. Québec Vert, Bandes riveraine, Plantation et entretien pour une restauration durable, http://banderiveraine.org/nous-joindre/

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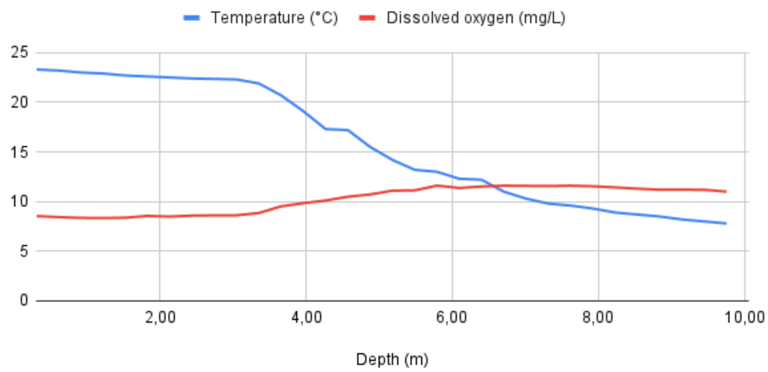
Appendix 1: Numbering of sites sampled between 2020 and 2022

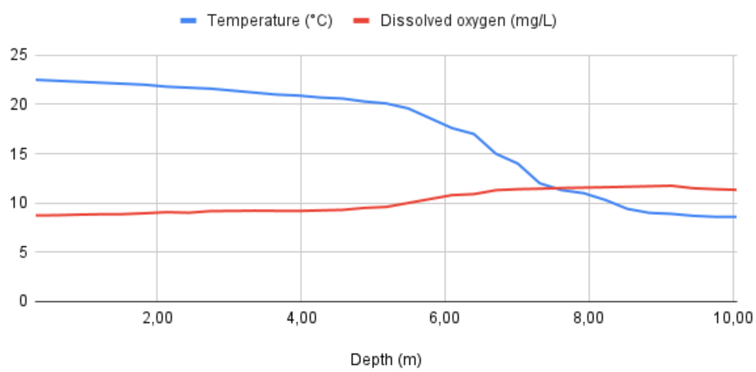
Appendix 2 : Temperature and oxygen profile at Lac des Seize-Îles in 2021 and 2022

Profile of temperature and dissolved oxygen as a function of depth, carried out with a YSI DO200 probe

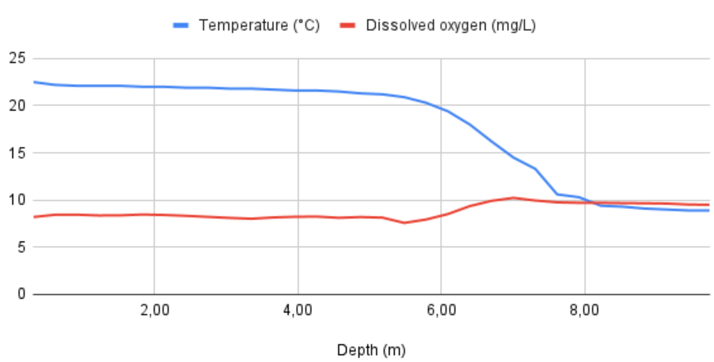
Lake's deepest point (Site #10) June 13, 2021



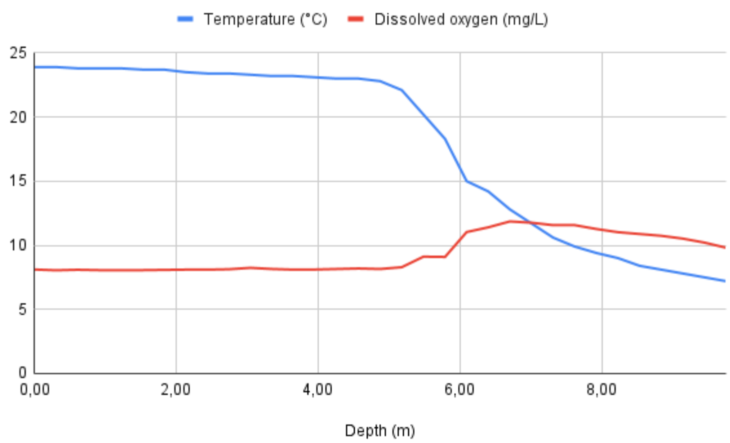
Lake's deepest point (Site #10) July 12, 2021



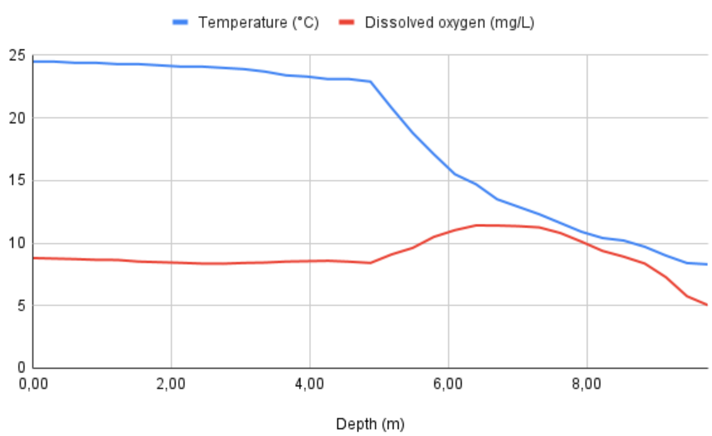
Baie Black (Site #13) August 6, 2021



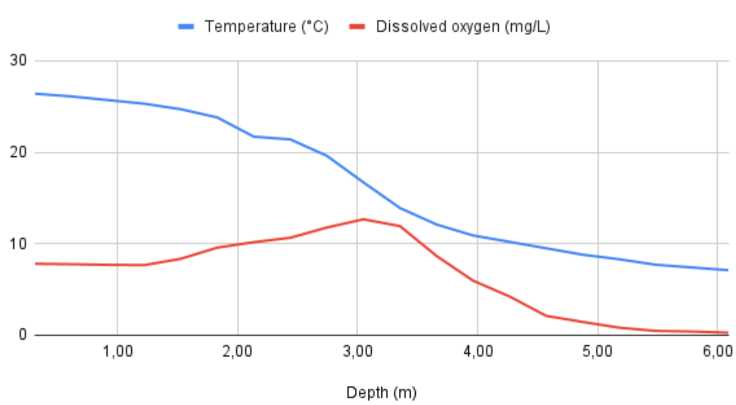
Lake's deepest point (Site #10) 6 August 2022



Lake's outlet (Site 15) 6 August 2022

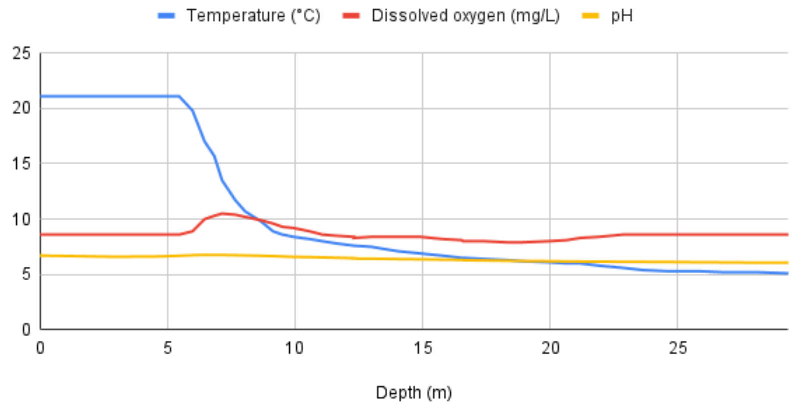


Baie des Soeurs (site #1) July 22, 2022

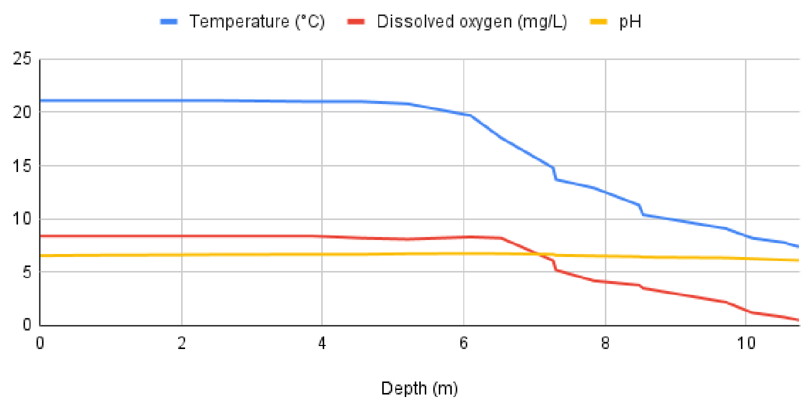


Profile of temperature, pH and dissolved oxygen as a function of depth, performed with a YSI PRO DSS probe

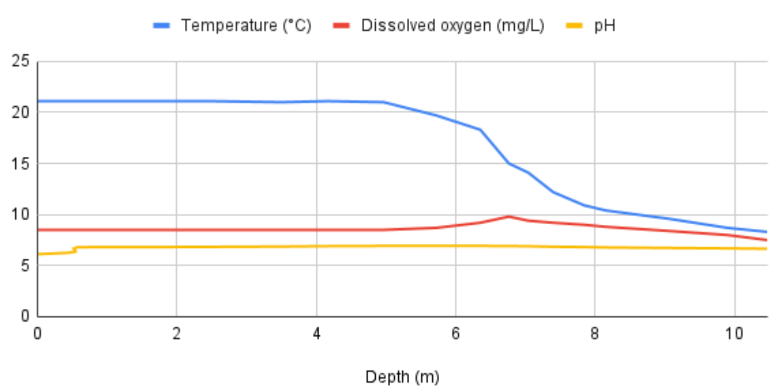
Lake's deepest point (Site #10) September 6, 2021



Lake's outlet (Site 15) September 6, 2021

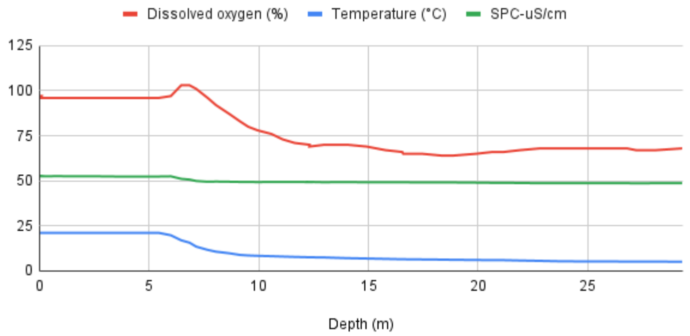


Baie Black (Site #13) September 6, 2021

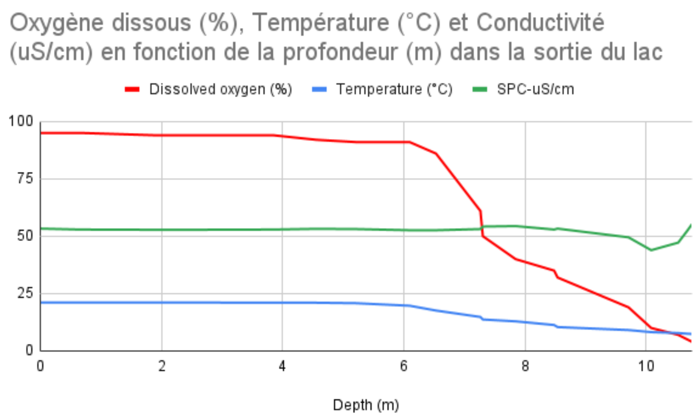


Profile of temperature, dissolved oxygen and conductivity as a function of depth, performed with a YSI PRO DSS probe

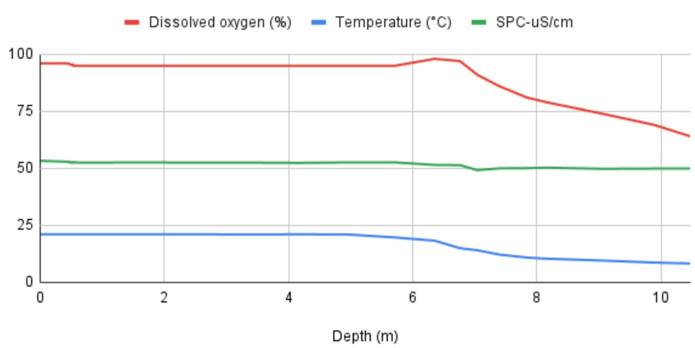
Lake's deepest point (Site #10) September 6, 2021



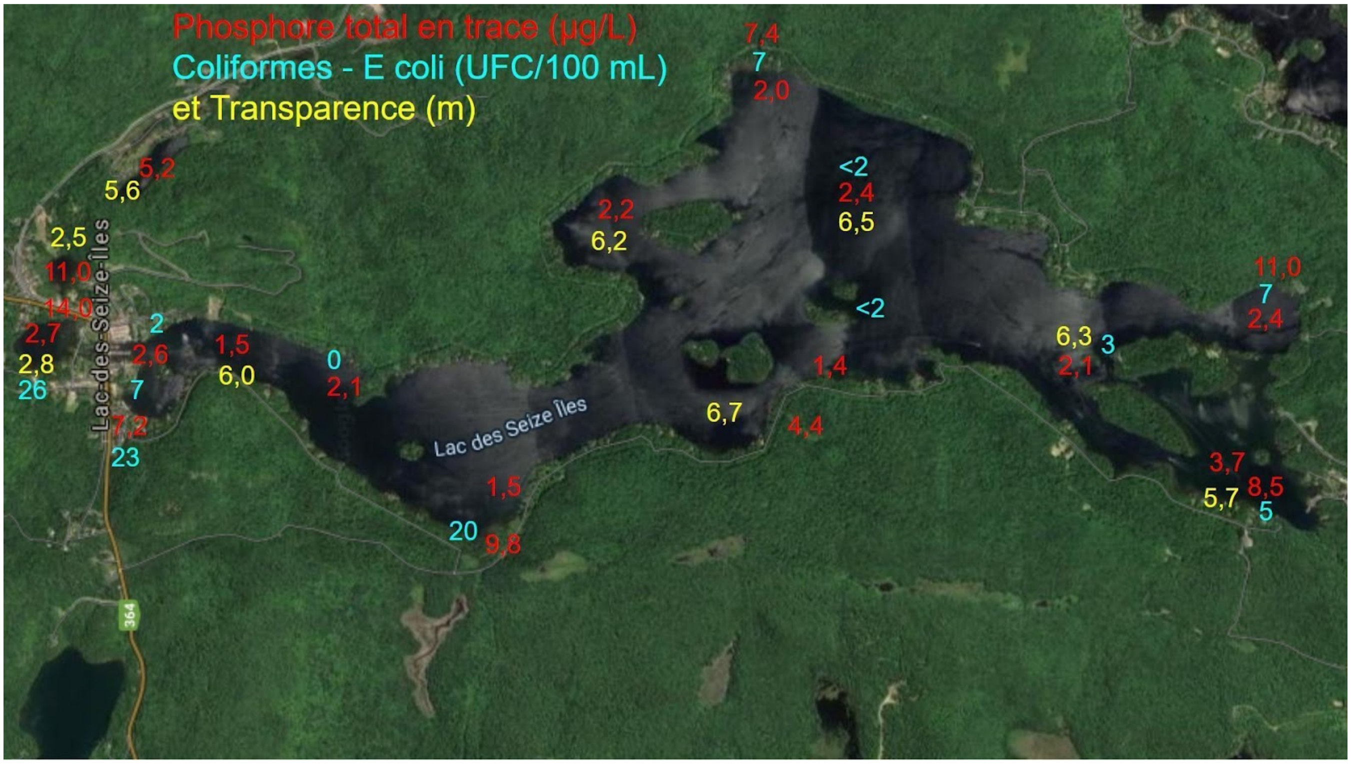
Lake's outlet (Site 15) September 6, 2021



Baie Black (Site #13) September 6, 2021

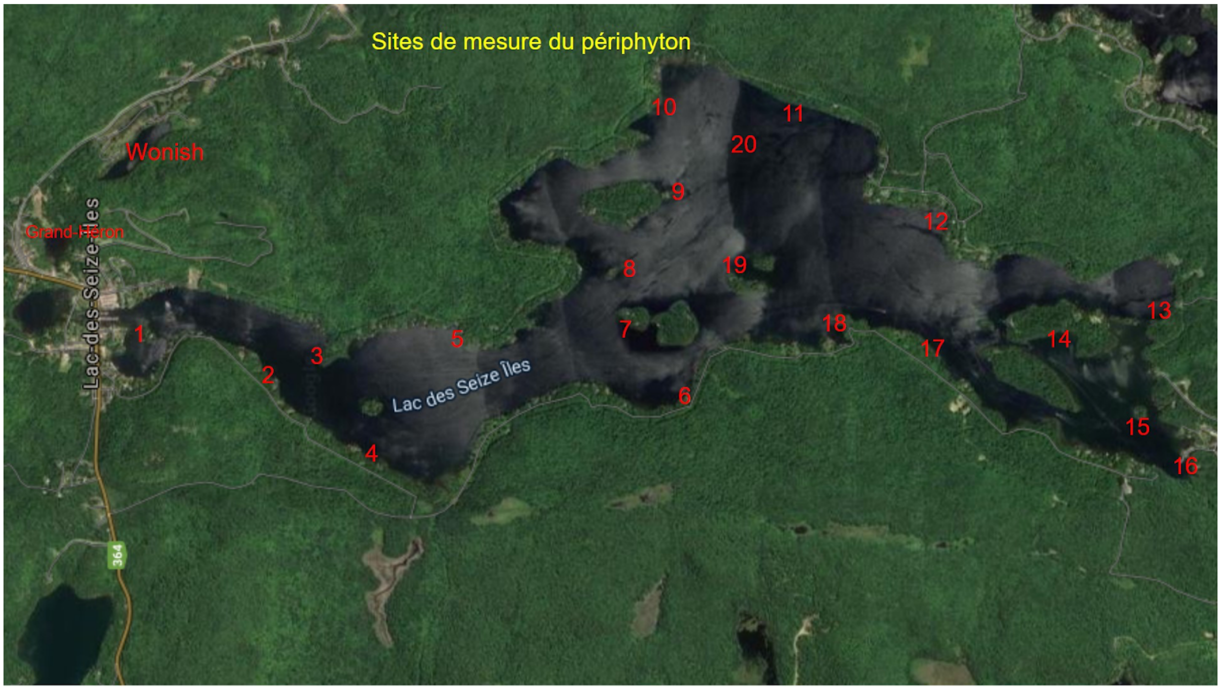


Appendix 3 : Summary of results by sampling sites



Appendix 4 : Summary of Periphyton Measurements

Periphyton measurement sites for the years 2020 to 2022



The geographical coordinates of each measurement site can be found in the spreadsheet sent to the RSVL each year.

Extract of periphyton measurements for the year 2020

Site #1										Average
2	1	2	3	3	2	1	2	2	1	2
1	1	2	5	1	4	1	1	1	2	2
2	2	2	3	2	3	1	4	1	1	2
Site # 2									Average Site #1	1,967mm
1	2	1	3	3	2	1	5	2	1	2
1	2	1	3	2	3	1	3	2	1	2
1	3	2	2	3	1	1	5	1	2	2
Site#3									Average Site #2	2,033mm

N.B. The measurements and observations can be found in the spreadsheet of the ministry. This was sent to the RSVL by the municipality.

Appendix 5 : Characterization of riparian protection strips

Data table used for characterisation of riparian protection strips

Natural Area or Address	% Natural Cover	Ornamental Vegetation	Inert Materials	Slope 30% or more	Bare ground %	Retaining wall s	Commentaires

Appendix 6 : Results for the characterization of riparian protection strips by section of the lake.

Figure 37 : North part of the lake for the characterization of the riparian protection strips. What is considered the East bank is highlighted in Yellow and the West bank is highlighted in Red.

Figure 38 : Percentage of degradation of the riparian strip for the northern part of the lake, coast of the western shore (in yellow in Figure 1)

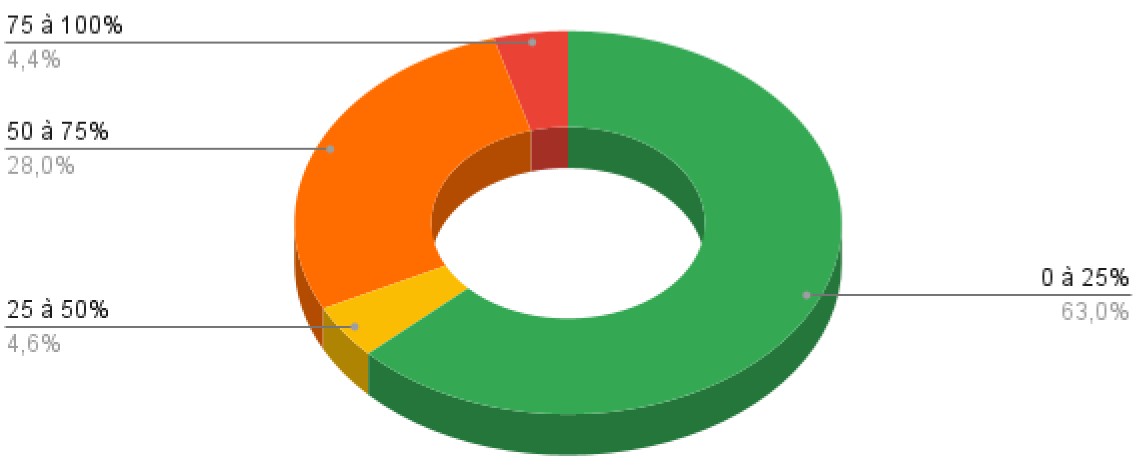


Figure 39 : Percentage of degradation of the riparian strip for the northern part of the lake, coast of the eastern shore (in red in Figure 1)

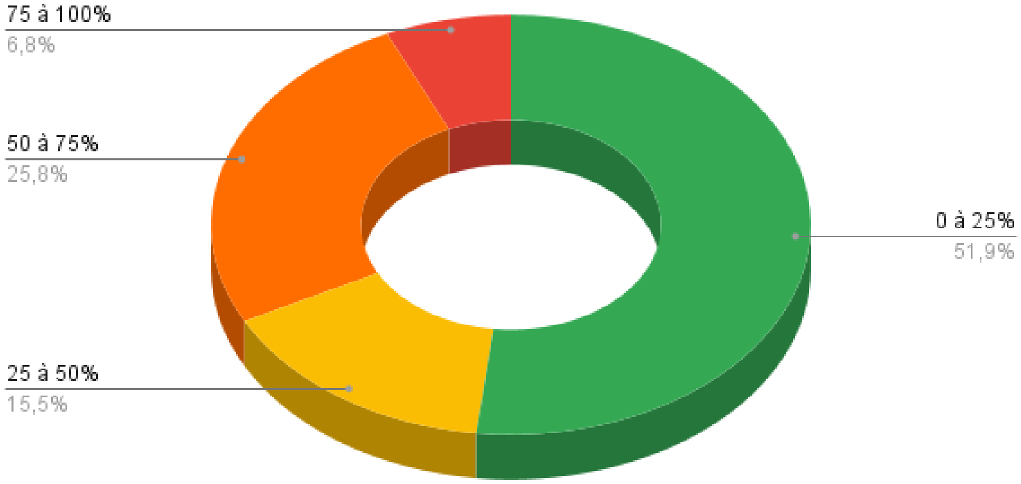


Figure 40 : Southern part of the lake for the characterization of the riparian protection strips. What has been integrated into the coast of the East bank is underlined in Yellow and what has been integrated into the coast of the West bank is underlined in red.

Figure 41 : Percentage of degradation of the riparian protection strip Southern part of the lake, coasts of the western shore of the lake, including the islands (in yellow in Figure 4).

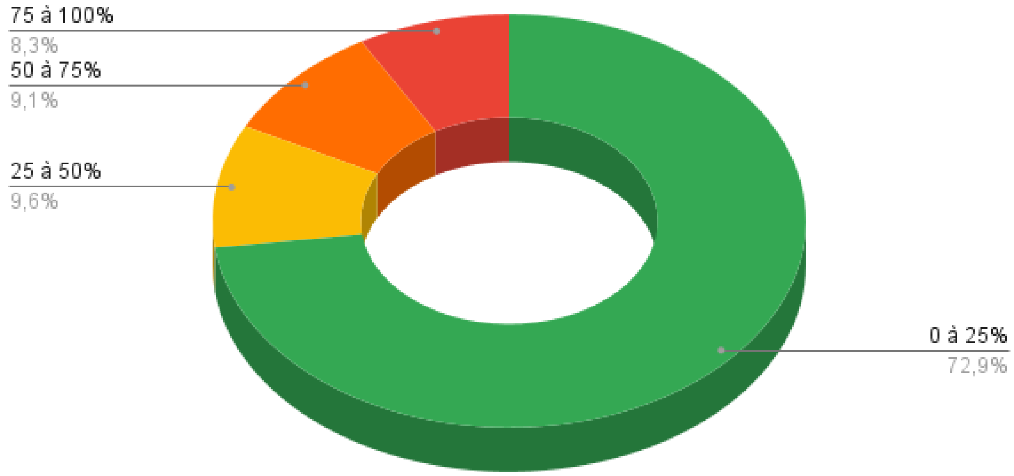
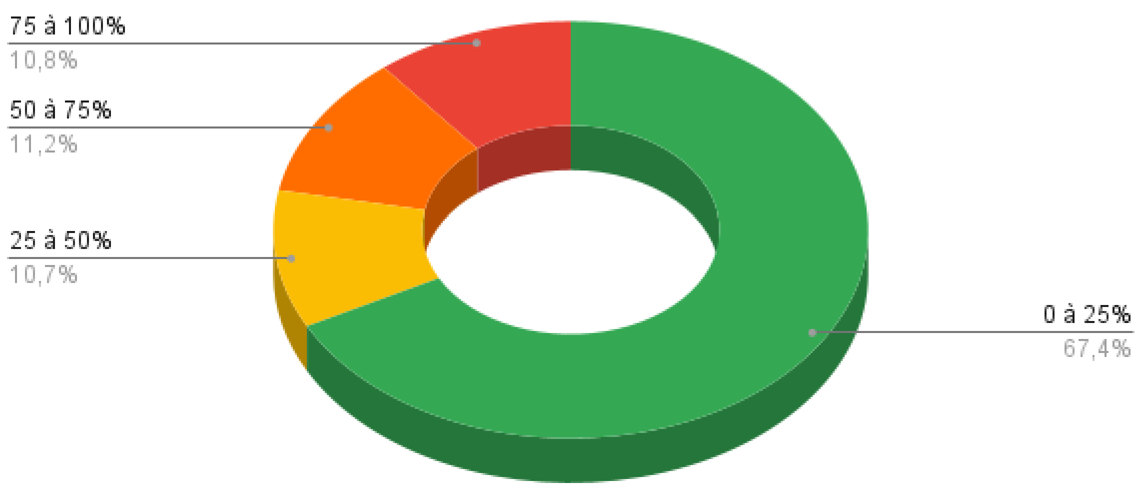
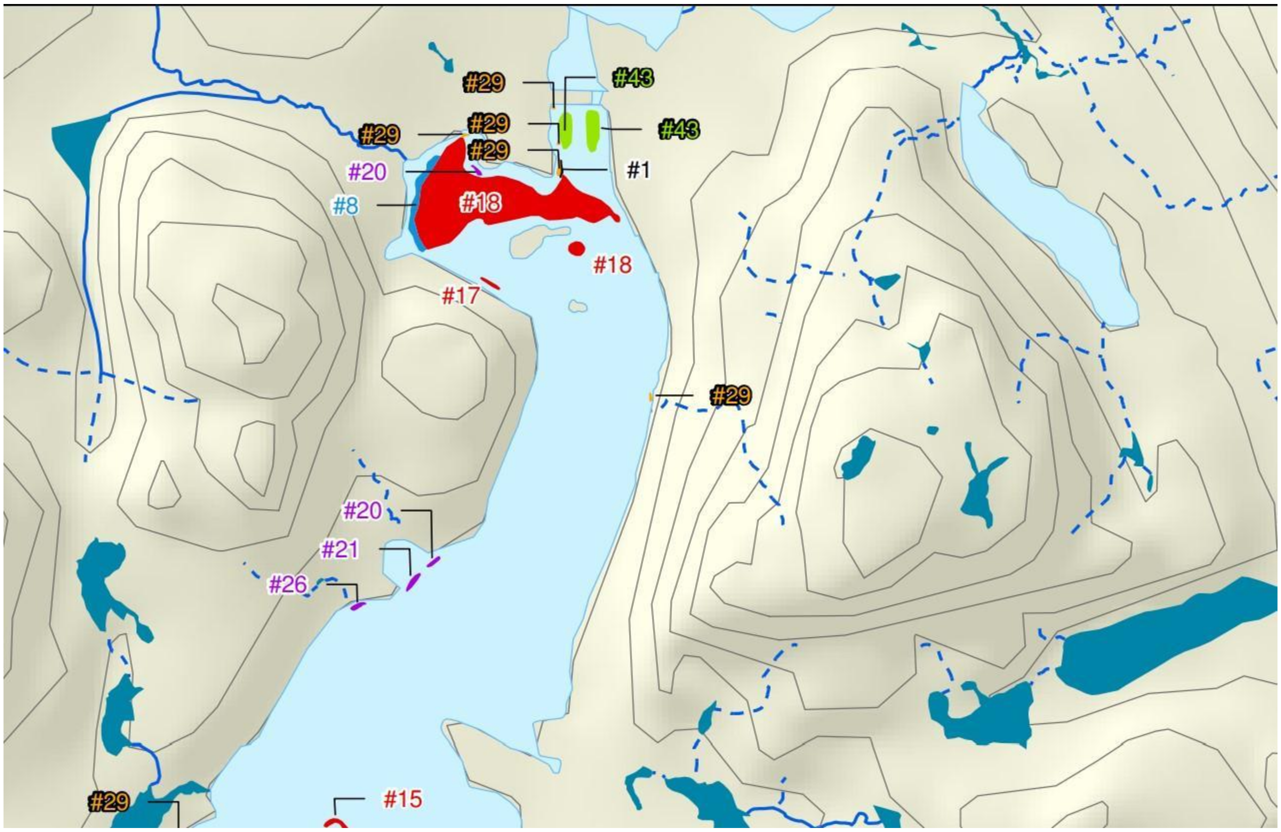


Figure 42 : Percentage of degradation of the riparian protection strip on the southern part of the lake, coasts on the eastern shore of the lake, including the islands (in red in Figure 4).

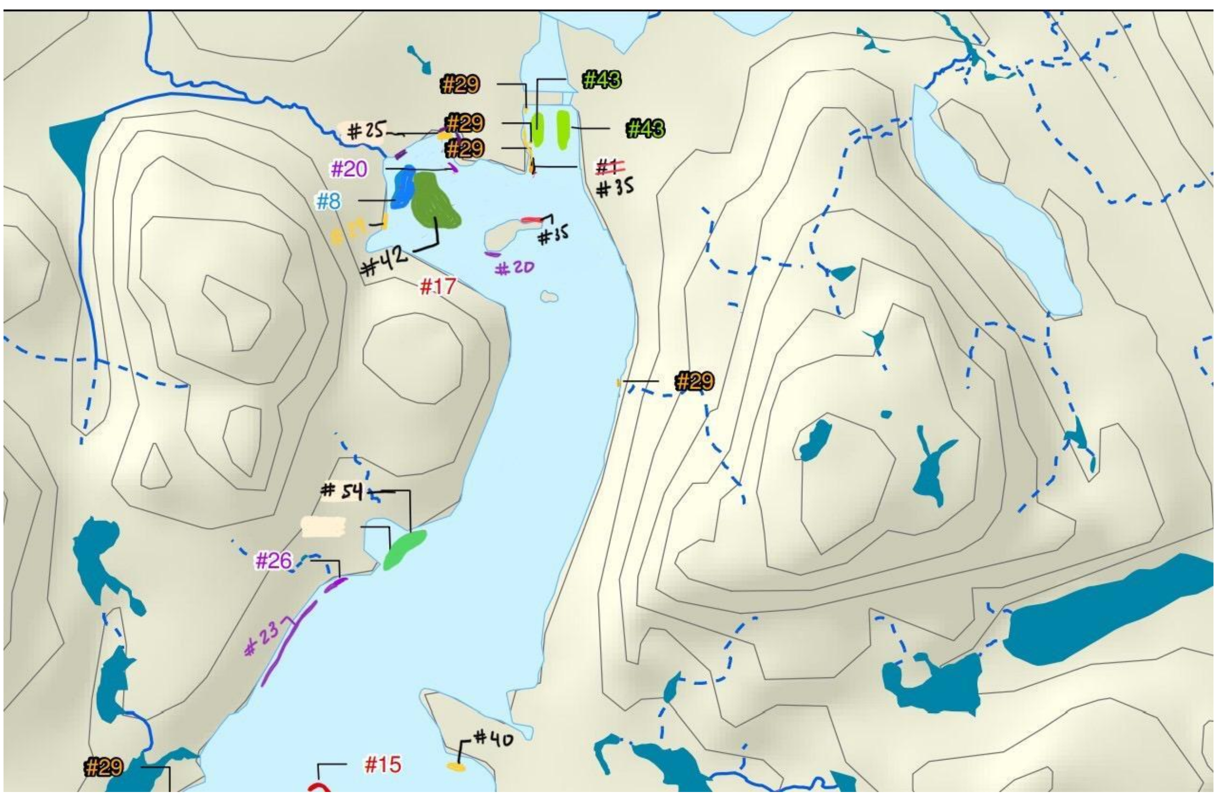


Appendix 7 : Map of aquatic plant beds

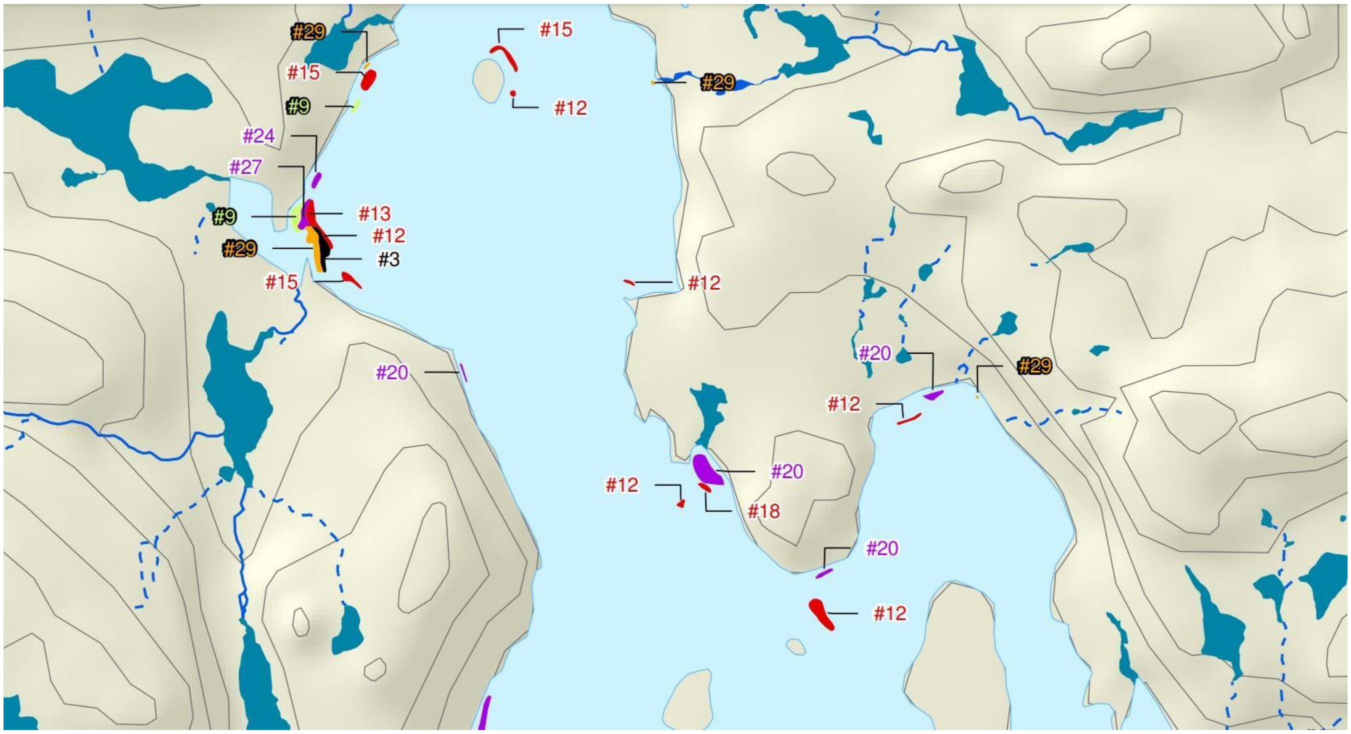
Map 1 : Aquatic plant beds in the northern part of the lake in 2011



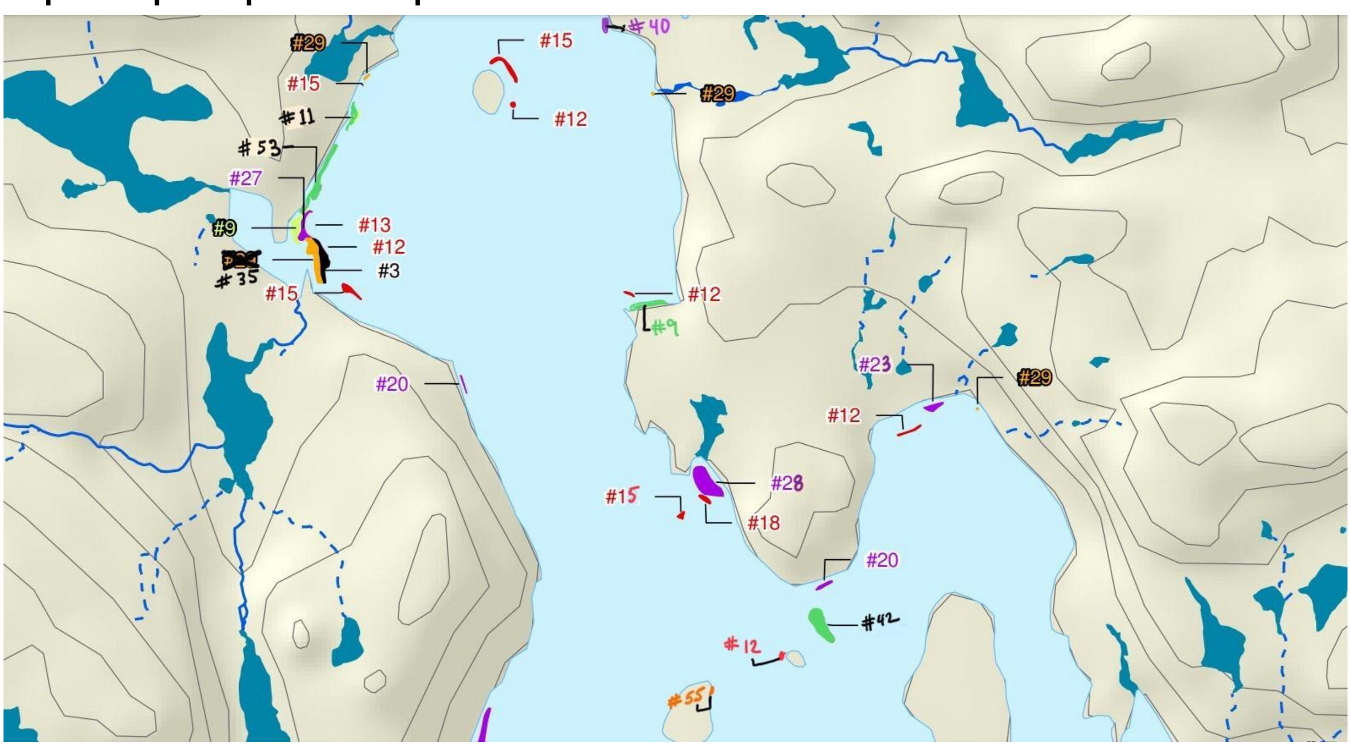
Map 2 : Aquatic plant beds in the northern part of the lake in 2022



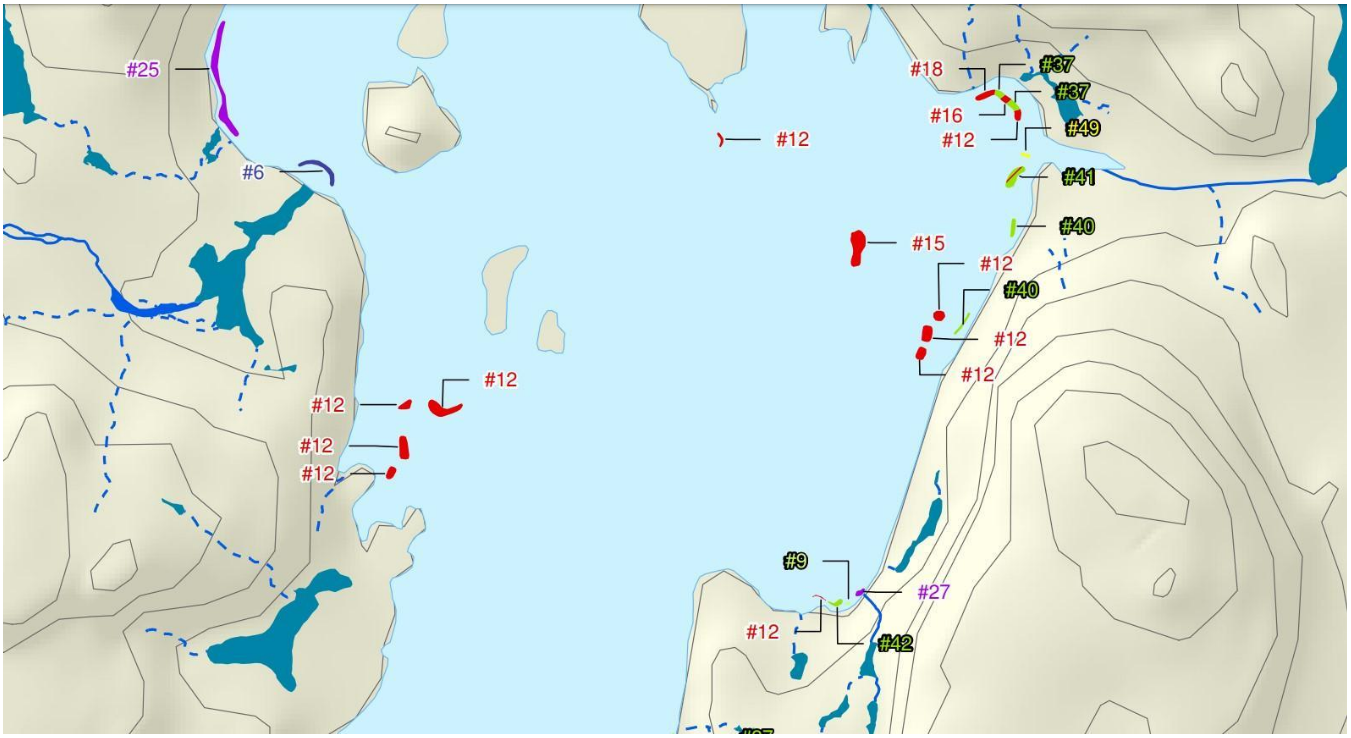
Map 3 : Aquatic plant beds part 2 in 2011



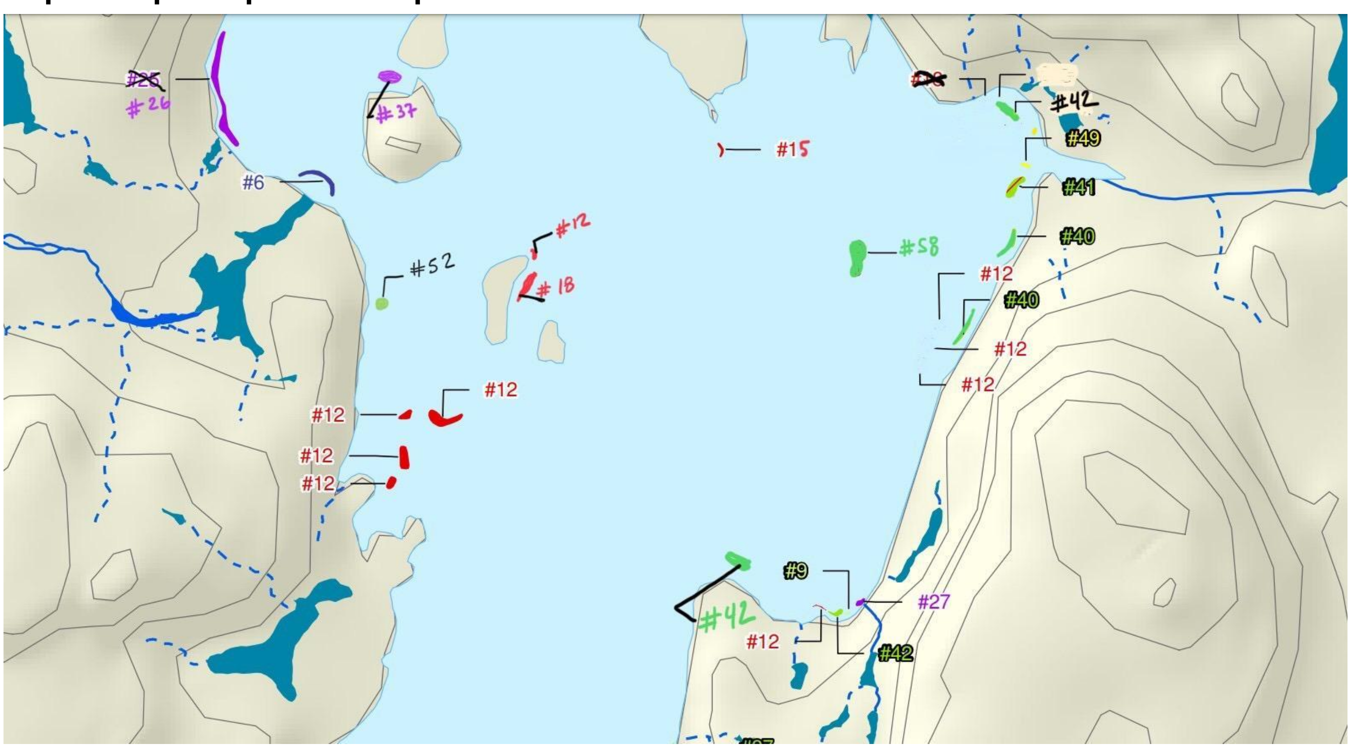
Map 4 : Aquatic plant beds part 2 in 2022



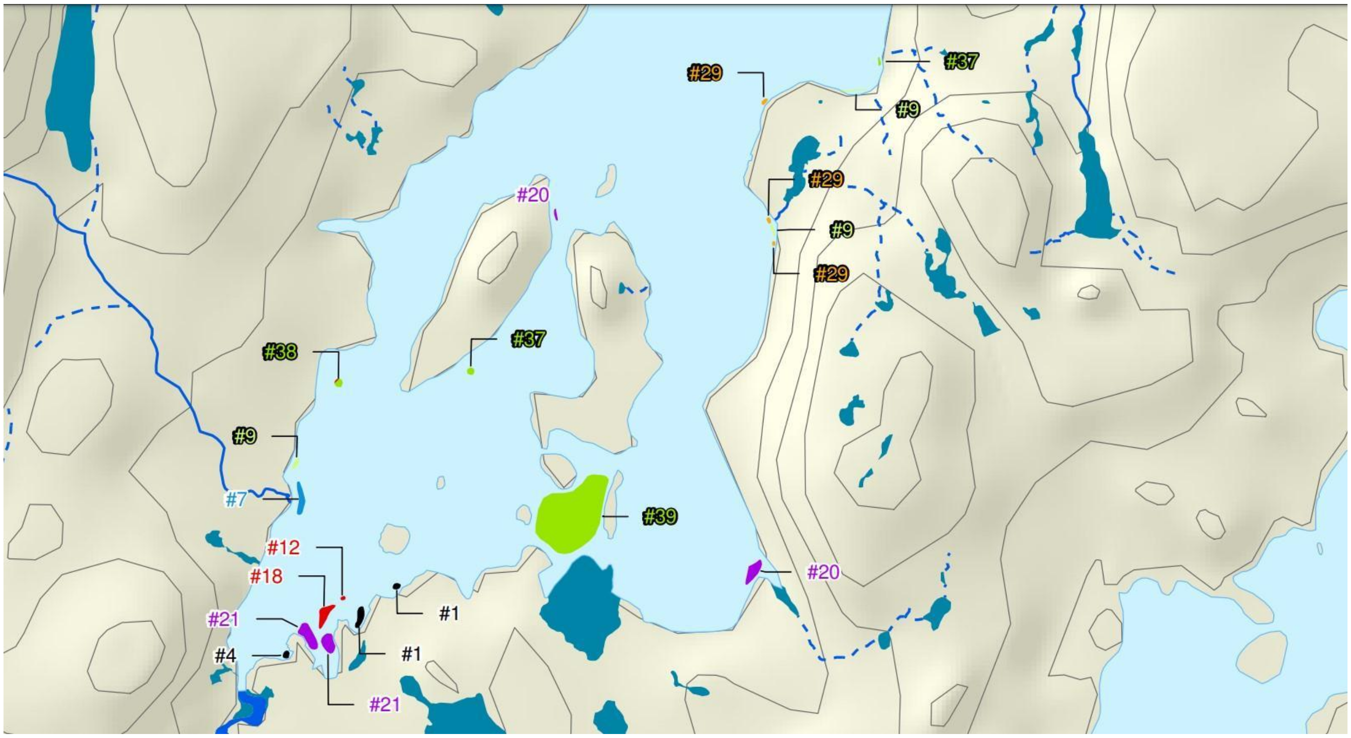
Map 5 : Aquatic plant beds part 3 in 2011



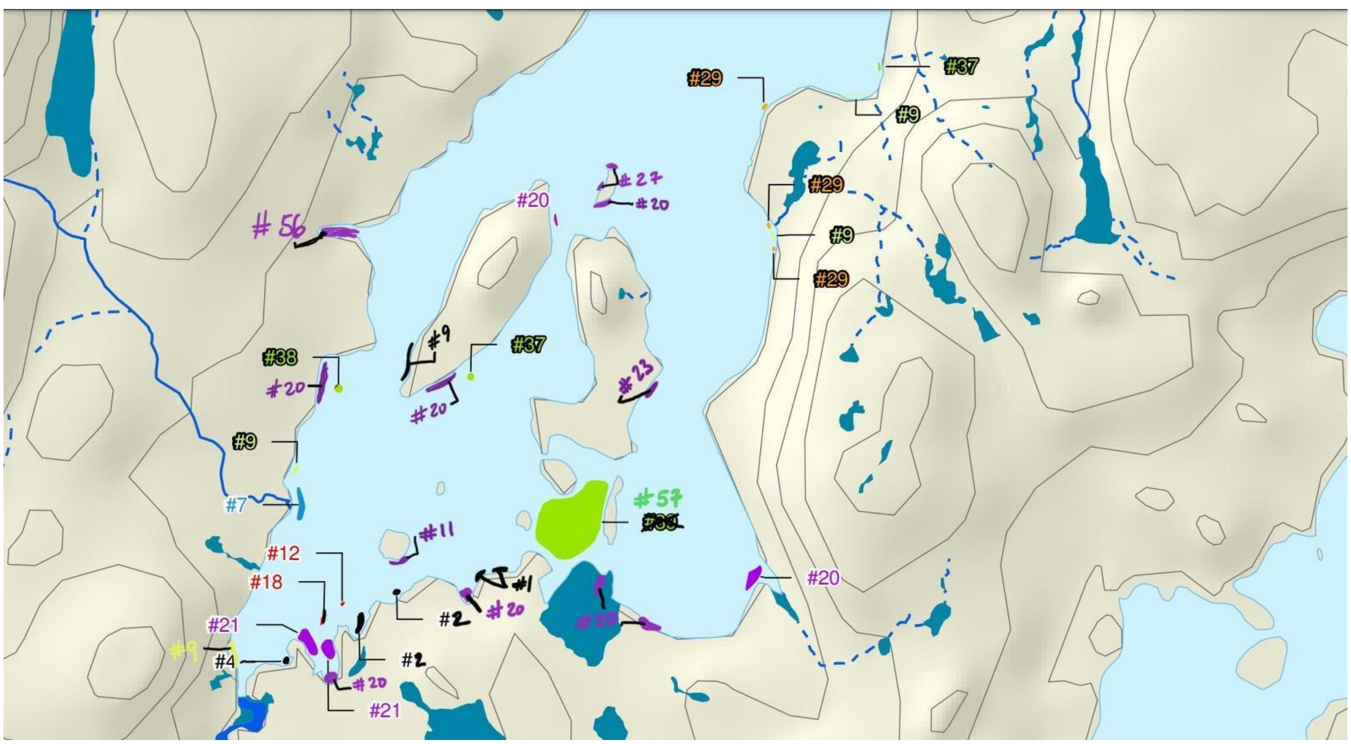
Map 6 : Aquatic plant beds part 3 in 2022



Map 7 : Aquatic plant beds part 4 in 2011



Map 8 : Aquatic plant beds part 4 in 2022



Appendix 8 : Compositions of listed aquatic plant beds

Table 10 : Dominant and secondary species making up each of the aquatic plant beds of Lac des Seize-Îles and Baie des Soeurs[12]

	Dominating specie	1st companion specie	2nd companion specie
#1	Brasenia schreberi		
#2	Brasenia schreberi	Eriocaulon aquaticum	
#3	Brasenia schreberi	Nymphaea odorata	Potamogeton amplifolius
#4	Brasenia schreberi	Pontedaria cordata	
#5	Brasenia schreberi	Potamogeton sp	
#6	Chara		
#7	Elodae canadensis	Potamogeton amplifolius	
#8	Elodae canadensis	Potamogeton robbinsii	
#9	Eriocaulon aquaticum		
#10	Eriocaulon aquaticum	Brasenia schreberi	
#11	Eriocaulon aquaticum	Nymphaea odorata	
#12	Myriophyllum spicatum		
#13	Myriophyllum spicatum	Elodae canadensis	Potamogeton amplifolius
#14	Myriophyllum spicatum	Nymphaea odorata	Brasenia schreberi
#15	Myriophyllum spicatum	Potamogeton amplifolius	
#16	Myriophyllum spicatum	Potamogeton amplifolius	Elodae canadensis
#17	Myriophyllum spicatum	Potamogeton gramineus	
#18	Myriophyllum spicatum	Potamogeton richardsonii	
#19	Myriophyllum spicatum	Potamogeton sp	
#20	Nymphaea odorata		
#21	Nymphaea odorata	Brasenia schreberi	
#22	Nymphaea odorata	Brasenia schreberi	Myriophyllum spicatum

[12] Taken and modified from Biofilia 2012 report

#23	Nymphaea odorata	Eriocaulon aquaticum	
#24	Nymphaea odorata	Eriocaulon aquaticum	Brasenia schreberi
#25	Nymphaea odorata	Pontedaria cordata	
#26	Nymphaea odorata	Pontedaria cordata	Potamogeton richardsonii
#27	Nymphaea odorata	Potamogeton amplifolius	
#28	Nymphaea odorata	Potamogeton sp	
#29	Pontedaria cordata		
#30	Pontedaria cordata	Myriophyllum spicatum	Potamogeton sp
#31	Pontedaria cordata	Nymphaea odorata	
#32	Pontedaria cordata	Nymphaea odorata	Brasenia schreberi
#33	Pontedaria cordata	Nymphaea odorata	Eriocaulon aquaticum
#34	Pontedaria cordata	Nymphaea odorata	Sparganium fluctuans
#35	Pontedaria cordata	Sparganium fluctuans	
#36	Pontedaria cordata	Typha latifolia	
#37	Potamogeton amplifolius		
#38	Potamogeton amplifolius	Myriophyllum spicatum	
#39	Potamogeton natans		
#40	Potamogeton richardsonii		
#41	Potamogeton richardsonii	Myriophyllum spicatum	Potamogeton amplifolius
#42	Potamogeton richardsonii	Potamogeton gramineus	
#43	Potamogeton robbinsii	Chara	Scirpus subterminalis
#44	Potamogeton sp		
#45	Potamogeton sp	Brasenia schreberi	Myriophyllum spicatum
#46	Potamogeton sp	Myriophyllum spicatum	
#47	Potamogeton sp	Nymphaea odorata	
#48	Scirpus subterminalis		

#49	Sparganium fluctuans		
#50	Typha latifolia		
#51	Typha latifolia	Pontedaria cordata	
#52	Potamogeton richardsonii	Potamogeton robbinsii	Myriophyllum spicatum
#53	Eriocaulon aquaticum	Nymphaea odorata	Pontedaria cordata
#54	Nymphaea odorata	Brasenia schreberi	Potamogeton richardsonii
#55	Lobelia dortmanna		
#56	Nymphaea odorata	Potamogeton sp.	Utricularia sp.
#57	Brasenia schreberi	Potamogeton natans	
#58	Potamogeton gramineus	Potamogeton amplifolius	Potamogeton sp.
#59	Eleocharis sp.		
#60	Utricularia sp.	Pontedaria cordata	Potamogeton amplifolius

An online video also allows you to see images of the main plant beds.

For lac des Seize-Îles
https://youtu.be/Y1BLGmFThu8

For Baie des Soeurs and Passage des Grenouilles
https://youtu.be/uxFMUsrQjPA

Appendix 9 : Identification of plankton from 2020 to 2022

The signs added next to a species or genus indicate the presence of a significant quantity. ++ indicates a very large amount, and +++ indicates dominance of the species.

Vertical: the net was lowered under the surface of the water to 12 s of depth and quickly retrieved vertically.

Horizontal: the net is pulled at the surface of the water at low speed over a distance of 30 s.

Images are available upon request for identification (sylvain.miller@hotmail.ca).

2020

November 8 Lac des Seize-îles, vertical 50 µm Site #10 secchi 7,1 m
45°53'44.1"N 74°27'39.2"W

Cladocères : Sida crystallina, Daphnies++ (Daphnia mendotea, Catawba et longiremis), bosmina longirostris+, holopedium+
Copépodes : Cyclopoides+, calanoides+ et nauplius
Rotifères : Conochilus unicornis, Kellicottia, keratella cochlearis, Asplancha, polyarthra
Algues :
Cyanobactéries : Aphanothece, aphanocapsa, anabaena
Chrysophytes : Dinobryon++, Synura, Chrysosphaerella, Uroglena, sur les diatomées, mallomonas
Diatomées : Synedra, Tabellaria+++, Asterionella+++
Chlorophyceae (vertes) : staurastrum
Dinoflagellés : Peridinium
Cryptomonad
Ciliés sur asterionella

Surface deposit (anabaena)

September 26 Lac des Seize-iles, vertical 80 µm Site #10
45°53'44.1"N 74°27'39.2"W
Cladocères : Sida crystallina++, Daphnies+ (Daphnia mendotea), bosmina longirostris, Diaphanosoma birgei, holopedium+, Leptodora
Copépodes : Cyclopoides+, calanoides+ et nauplius
Rotifères : Conochilus unicornis, Kellicottia, keratella, Asplancha, Collotheca pelagica, polyarthra
Algues : Cyanobactéries : Anabaena+ (avec ciliés), Aphanothece+, Aphanocapsa++
Chrysophytes : Dinobryon++, Synura+, Chrysosphaerella+, Uroglena, sur les diatomées

Diatomées : Synedra, Tabellaria+++, Asterionella+++
Chlorophyceae (vertes) : i4723
Dinoflagellés : Ceratium

August 20 Lac des Seize-iles, Baie des Soeurs, vertical 80 µm Site #1
45°55'34.1"N 74°28'06.8"W
Bloom Chrysosphaerella
Insectes : Chaoborus
Cladocères : Daphnies++ (Daphnia mendotea et parvula?), Diaphanosoma birgei
Copépodes : Cyclopoides+, calanoides + et nauplius (peu nombreux)
Rotifères : Keratella crassa, Kellicottia bostoniensis, polyarthra, filinia
Algues :
Cyanobactéries : Anabaena (avec ciliés), Woronichinia,Gloeotrichia, Microcystis
Chrysophytes : Chrysosphaerella+++, Dinobryon++, Uroglena, mallomonas,
Diatomées : Asterionella
Chlorophyceae (vertes) : Staurastrum
Dinoflagellés : Ceratium++

August 12 Lac des Seize-iles, vertical 50 µm Site #8
45°54'04.0"N 74°27'57.5"W
Cladocères : Daphnies (Daphnia mendotea), Sida crystallina, bosmina longirostris, Diaphanosoma birgei, holopedium, Leptodora
Copépodes : Cyclopoides+, calanoides + et nauplius
Rotifères : Conochilus unicornis, Collotheca pelagica, Ascomorpha ecaudis, polyarthra
Algues dominantes :
Cyanobactéries : Anabaena (avec ciliés)++, Aphanothece++, Gloeotrichia, Woronichinia (i2700)
Chrysophytes : Dinobryon+, , Chrysosphaerella, mallomonas,Uroglena, Chrysophytes (i2698),
Chlorophycées (verte) : (i2638), Staurastrum, Botryococcus
Diatomées : Tabellaria, Synedra, Asterionella, Dinoflagellés : Ceratium
Cryptomonad+

Baie Black 45°52'46.3"N 74°28'01.9"W
Semblable mais moins de cyanobactéries
Synura++, Uroglena++

7 Août Lac Wonish Filet à plancton **50µm** descente et remonté verticale 10h30
45°55'19.6"N 74°27'33.3"W
Cladocère: Daphnia longirémis et (laevis ou dubia), Bosmina, Holopedium, Diaphanosoma
Copépodes : Cyclo++ et calanoide++ 2 espèces (Epischura nordenskiøldi), nauplius
Rotifères : Keratella, Synchaeta, i2355, i2430, gastropus sp.
Algue :
Chrysophytes : Dinobryon+++, Uroglena, Chrysosphaerella, Mallomonas, Synura,
Dinoflagellés : Ceratium
Diatomées : Asterionella + chrysophytes, Tabellaria

7 Août Lac du grand Héron Filet à plancton **50µm** descente et remonté verticale 11h30
45°55'30.8"N 74°27'51.4"W

Insectes : Chaoborus
Cladocères: Bosmina, Daphnia ambigua et rosea ?
Copépodes : Cyclo et calanoide, nauplius
Rotifères : Keratella crassa, Kellicottia bostoniensis
Algue :
Chrysophytes : Dinobryon++, Uroglena, Mallomonas, Uroglenopsis
Dinoflagellés : Ceratium++, (péridinium?)
Cyanobactéries : Woronichinia
Chlorophycées : Desmides

28 Juillet Lac des Seize-îles, verticale Site #15 50 µm
45°52'52.5"N 74°28'31.7"W

Insecte : Chaoborus
Cladocères : Sida crystallina, holopedium, Diaphanosoma birgei, bosmina longirostris, Daphnies (Daphnia pulicaria et mendotea),
Copépodes : Cyclopoides++, calanoides ++ et nauplius
Rotifères : Conochilus unicornis, Kellicottia longispina, keratella, polyarthra
Algues dominantes :
Chrysophytes : Synura++, Uroglena, mallomonas
Cyanobactéries : Anabaena (avec ciliés), Aphanothece ++
Dinoflagellés : Ceratium
Cryptomonad
Chlorophycés : Staurastrum, Nephrocytium (i1817), Verte (i1823),
Diatomées : Asterionella + Chrysophytes, Diatomées centriques

26 Juillet Lac des Seize-îles, verticale Site #4 50 µm
45°55'10.6"N 74°28'06.8"W
Cladocères : Daphnies (Daphnia mendotae),sida crystallina, Diaphanosoma birgei, holopedium, bosmina longirostris
Copépodes : Cyclopoides, calanoides et nauplius
Rotifères : Conochilus unicornis, Kellicottia longispina, keratella, Conochhiloides
Algues dominantes :
Cyanobactéries : Aphanothece ++, Anabaena (avec ciliés), Microcystis,
Chrysophytes : Synura, Uroglena, Uroglenopsis, Sphaerocystis (i1672), Dinobryon, mallomonas
Chlorophyceae : Staurastrum, botryococcus
Diatomées : Tabellaria
Dinoflagellés : Ceratium

25 Juillet Lac des Seize-îles, Échantillon pris en plongée à 16 pieds puis filtré
45°53'15.2"N 74°28'16.4"W
Cladocères : Daphnies
Copépodes : Cyclopoides

Rotifères : Keratella, Kellicottia longispina, Polyarthra
Algues dominantes :
Cyanobactéries : Aphanothece +++, Anabaena (avec ciliés), Rhabdoderma
Chrysophytes : Uroglena

21 Juillet Lac des Seize-îles, verticale 15h30 50 µm
45°53'15.2"N 74°28'16.4"W
Cladocères : Daphnies (Daphnia mendotae),sida crystallina, Diaphanosoma birgei, holopedium, bosmina longirostris
Copépodes : Cyclopoides, calanoides et nauplius
Rotifères : Conochilus unicornis, Kellicottia longispina, keratella, Conochhiloides
Algues dominantes :
Cyanobactéries : Anabaena (avec ciliés), Microcystis
Chrysophytes : Uroglena, Sphaerocystis (i1672), Dinobryon, mallomonas
Diatomées : Tabellaria,
Dinoflagellés : Ceratium,
Chlorophyceae : Botryococcus

12 Juillet Lac des Seize-îles, verticale 18h00 50 mm 4 points

Acarien
Cladocères : Daphnies (Daphnia mendotae et pulicaria),sida crystallina, holopedium, bosmina longirostris
Copépodes : Cyclopoïdes (Cyclops scutifer), calanoides 2 espèces (Epischura nordenskiøldi) et nauplius
Rotifères : Conochilus unicornis, Kellicottia longispina, Gastropus stylifer, Ascomorpha ecaudis, Collotheca pelagica, Conochhiloides, polyarthra,
Algues dominantes :
Cyanobactéries : Microcystis, Anabaena (avec ciliés), Woronichinia, Rhabdoderma
Chrysophytes : Uroglena, Synura (colonies défaites) i1478, Sphaerocystis (i1459), Dinobryon, Synura, Mallomonas
Diatomées : Tabellaria
Dinoflagellés : Ceratium
Chlorophyceae : verte i 1450 400x, botryococcus, i9191 200 x, Micrasteria
Cryptomonad

16 Juin Lac des Seize-Îles, verticale 18h00 50 mm 45°55'20.9"N 74°28'05.7"W

Cladocères : Daphnies (Daphnia mendotae et pulicaria),sida crystalline, holopedium, bosmina longirostris, leptodora
Copépodes : Cyclopoïdes (Cyclops scutifer), calanoides et nauplius
Rotifères : Conochilus unicornis, polyarthra, Gastropus stylifer
Algues dominantes :
Chrysophytes : Uroglena, Dinobryon, Synura, Mallomonas,

Diatomées : Asterionella, Tabellaria,
Cyanobactéries : Anabaena (avec ciliés), Microcystis,
Dinoflagellés : Ceratium,
Chlorophytes : verte i 9194 200x, botryococcus, i9191 200 x
Cryptomonad

13 Juin Lac des Seize-iles, du quai 9h30 80 mm 45°55'20.9"N 74°28'05.7"W

Dominants : Bosmina, cyclopoïde
Cladocères : Daphnies (Daphnia mendotae), bosmina longirostris, Holopedium, polyphemus
Copépodes : Cyclopoïdes (Cyclops scutifer), calanoides et nauplius
Rotifères : Conochilus unicornis, kellicottia, (keratella crassa), Trichocerca sp.
Ciliés : frontonia
Algues dominantes :
Chrysophytes : Uroglena, Dinobryon, Synura,
Diatomées : Asterionella, Tabellaria,
Cyanobactéries : Anabaena (avec ciliés), Microcystis
Dinoflagellés : Ceratium

2021

6 Septembre Lac des Seize-îles, Filet à plancton **50µm vertical** 10h00 Eau 21°C, Secchi 6,5m, 45°55'19.0"N 74°28'18.7"W (img000-028)

Cladocères : Daphnies (Daphnia Mendotea, Catawba), Sida crystallina, Holopedium
Copépodes : Cyclopoïdes, calanoides 2 espèces (Epischura nordenskiøldi) et nauplius
Rotifères : Kellicottia longispina, Polyarthra sp., Keratella sp,
Algues :
Cyanobactéries : Anabaena avec ciliés+, Aphanothèce+++, microcystis
Chrysophytes : Mallomonas+, Dinobryon
Diatomées : Asterionella, Synedra
Chlorophyceae (vertes) : Gloeocystis, Staurastrum
Dinoflagellés :

11 Août Lac des Seize-îles, verticale 50 µm 17h00
45°53'52.0"N 74°27'53.1"W

Cladocères : Daphnies (Daphnia Catawba, Mendotea+), Holopedium, bosmina longirostris, Sida crystallina, Diaphanosoma
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Conochilus hippocrepis, Keratella, Kellicottia
Algues :
Cyanobactéries : Anabaena avec ciliés++, Aphanothece+++, Gloeotrichia
Chrysophytes : Mallomonas, Synedra, Dinobryon, Amibes sur tabellaria
Diatomées : Centriques, Synedra, Tabellaria
Chlorophyceae (vertes) : Gloeocystis, Staurastrum, Crucigenia, botryococcus

Dinoflagellés :

29 Juillet Lac des Seize-îles, Baie black, verticale 50 µm 10h00
45°52'44.4"N 74°28'02.5"W

Cladocères : Daphnies (Daphnia Catawba, Mendotea), Holopedium, bosmina longirostris, Sida crystallina
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Conochilus hippocrepis, Polyarthra
Algues :
Cyanobactéries : Anabaena avec ciliés, Aphanothece++
Chrysophytes :
Diatomées :
Chlorophyceae (vertes) :
Dinoflagellés :

29 Juillet Lac des Seize-îles, Baie Hammond, verticale et trainé 50 µm
45°55'18.7"N 74°28'17.4"W

Arrachage de myriophylle la veille (beaucoup de sédiments en suspension)
Cladocères : Daphnies (Daphnia mendotea), Bosmina+++
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Polyarthra++, Synchaeta
Algues :
Chlorophyceae (vertes) : Sphaerocystis+, Staurastrum
Chrysophytes : Chrysosphaerella++, Dinobryon, Mallomonas, Uroglenopsis, amiboïde sur chlorophycée
Diatomées : Tabellaria, Synedra, centrique
Dinoflagellés : Ceratium
Cyanobactéries : Anabaena + ciliés, Aphanothèce
Planaire

22 Juillet Lac des Seize-iles, Baie des Soeurs, verticale et trainé 50 µm Site #1
45°55'34.1"N 74°28'06.8"W
Bloom Dinobryon
Cladocères : Daphnies++ (Daphnia mendotea et parvula?), Diaphanosoma birgei, Ceriodaphnia
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Keratella crassa, Gastropus hyptopus, Kellicottia, polyarthra
Algues :
Chrysophytes : Chrysosphaerella++, Dinobryon++++, Mallomonas
Diatomées : Asterionella,
Dinoflagellés : Ceratium, Peridinium

22 Juillet Lac des Seize-îles, verticale 50 µm Site #10, 14h00
45°53'28.3"N 74°27'58.9"W

Cladocères : Daphnies+ (Daphnia Catawba, Mendotea), Holopedium, bosmina longirostris, Sida crystallina
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Kellicottia longispina, Conochilus longicornis, Polyarthra
Algues :
Cyanobactéries : Anabaena avec ciliés, Aphanothece++, Microcystis
Chrysophytes : Mallomonas, Dinobryon
Diatomées : Asterionella, sphérique, Synedra
Chlorophyceae (vertes) : Chlorococcum ?, Sphaerocystis, Crucigenia
Dinoflagellés : Ceratium
Cryptomonad : Présentes

12 Juillet Lac des Seize-îles, verticale 50 µm Site #10, 14h00, Secchi 7,5 m
45°53'28.3"N 74°27'58.9"W

Cladocères : Daphnies+ (Daphnia Catawba, Mendotea), Holopedium++, bosmina longirostris, Sida crystallina
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Kellicottia longispina, Conochilus longicornis+, Polyarthra, Collotheca mutabilis
Algues :
Cyanobactéries : Anabaena avec ciliés, Aphanothece
Chrysophytes : Mallomonas
Diatomées : Tabellaria, Asterionella, sphérique+, Synedra
Chlorophyceae (vertes) : Chlorococcum ?, Sphaerocystis, Staurastrum, Crucigenia
Dinoflagellés : Ceratium
Cryptomonad : Présentes

13 Juin Lac des Seize-îles, verticale 50 µm Site #10, 14h00, Secchi 7,5 m
45°53'44.1"N 74°27'39.2"W

Cladocères : Daphnies+ (Daphnia longiremis? et Catawba, Mendotea, Holopedium++, bosmina longirostris,
Copépodes : Cyclopoides+, calanoides et nauplius
Rotifères : Kellicottia longispina, Conochilus longicornis, Polyarthra,
Algues :
Cyanobactéries : Anabaena (rare petites colonies)
Chrysophytes : Dinobryon, Uroglena, Chrysophytes sur diatomées (Epipyxis)
Diatomées : Tabellaria, Asterionella+++ , sphérique+++, Synedra
Chlorophyceae (vertes) : Botryococcus, Staurastrum, pediastrum
Dinoflagellés : Ceratium
Cryptomonad : Présentes

24 Mai Lac des Seize-îles, verticale 50 µm Site #10, 11h30, Secchi 6,5 m, 5,5 m site #15
45°53'44.1"N 74°27'39.2"W

Cladocères : Daphnies+ (Daphnia longiremis? et pulicaria/Catawba (hybride?), bosmina longirostris, holopedium

Copépodes : Cyclopoides+, calanoides et nauplius
Rotifères : Kellicottia longispina, keratella cochlearis, Asplancha sp.
Algues :
Cyanobactéries : Anabaena (rare petites colonies)
Chrysophytes : Dinobryon, Chrysospaera, Mallomonas, Uroglena
Diatomées : Tabellaria, Asterionella+++ , sphérique, Synedra
Chlorophyceae (vertes) : Botryococcus, Staurastrum
Dinoflagellés : Peridinium+, Ceratium
Cryptomonad : Présentes
Pollen

24 Avril Lac des Seize-îles, verticale 50 µm Site #10, 15h00, Secchi 6,0 m 45°53'44.1"N 74°27'39.2"W

Cladocères : Daphnies+ (Daphnia longiremis et pulicaria/Catawba (hybride?), bosmina longirostris+, holopedium (2 larves)
Copépodes : Cyclopoides+++, calanoides+ et nauplius
Rotifères : Kellicottia longispina, Conochilus unicornis, keratella cochlearis, Asplancha sp.
Algues :
Cyanobactéries : Anabaena (rare petites colonies)
Chrysophytes : Chrysosphaerella, Dinobryon, Synura, Mallomonas
Diatomées : Tabellaria, Asterionella+++
Chlorophyceae (vertes) : Sphaerocystis
Dinoflagellés : Peridinium+
Cryptomonad

2022

15 Septembre Lac des Seize-îles, Filet à plancton **50µm vertical** 15h30 Eau 20°C 45°53'42.6"N 74°27'28.5"W

Cladocères : Daphnies (Daphnia Mendotea, Catawba), Sida crystallina, Holopedium gibberum, Bosmina longirostris), Diaphanosoma birgei
Copépodes : Cyclopoïdes, calanoides 2 espèces (Epischura nordenskiøldi) et nauplius
Rotifères : Conochilus, Kellicottia longispina, Keratella sp, Gastropus stylifer
Algues :
Cyanobactéries : Anabaena+, Aphanothèce+, Aphanocapsa+
Chrysophytes : Synura+++, Dinobryon, Chrysosphaerella
Diatomées : Asterionella
Chlorophyceae (vertes) : Crucigenia
Dinoflagellés : absents

7 Août Lac des Seize-îles, 12h30, verticale 50 µm Pointe de l'église 45°54'51.9"N 74°28'24.1"W

Cladocères : Sida crystallina++, Daphnies+ (Daphnia mendotea et pulicaria), Holopedium gibberum, Bosmina longirostris, Diaphanosoma birgei

Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Chonochillus, Keratella sp., Kellicottia, polyarthra, Gastropus stylifer
Algues :
Chrysophytes : Synura+++, Uroglena, Mallomonas
Diatomées : Asterionella, Tabellaria, Centrique
Dinoflagellés :
Chlorophytes : Crucigenia, Sphaerocystis, Staurastrum, Botryococcus
Cyanobactéries : Anabaena, Aphanothece+++, Aphanocapsa, Rhabdoderma
Cryptomonad : Présentes

22 Juillet Lac des Seize-îles, Baie des Soeurs, 14h00, verticale 50 µm Site #1
45°55'34.1"N 74°28'06.8"W

Cladocères : Daphnies+ (Daphnia mendotea et parvula?), Diaphanosoma birgei
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Keratella sp., Kellicottia
Algues :
Chrysophytes : Chrysosphaerella+++, Dinobryon++
Diatomées : Asterionella, épiphytes sur copépode
Dinoflagellés : Ceratium+++, Peridinium

6 Juillet Lac des Seize-îles, verticale 50 µm Site #10, 11h00
45°53'28.3"N 74°27'58.9"W

Cladocères : Daphnies+ (Daphnia Catawba, Mendotea), Holopedium++, bosmina longirostris, Sida crystallina
Copépodes : Cyclopoïdes, calanoides et nauplius
Rotifères : Kellicottia longispina, Conochilus unicornis, Polyarthra+, Gastropus Stylifer+,
Algues :
Cyanobactéries : Aphanothece, aphanocapsa
Chrysophytes : Uroglena+++, synura++, Mallomonas
Diatomées : Tabellaria, Asterionella avec amiboides, sphérique+
Chlorophyceae (vertes) : Chlorococcum ?, Sphaerocystis, Staurastrum
Dinoflagellés : Ceratium
Cryptomonad : NON

Appendix 10 : Video sequences related to this report

An online video also allows you to see images of the main plant beds.

For lac des Seize-Îles
https://youtu.be/Y1BLGmFThu8

For Baie des Soeurs and Passage des Grenouilles
https://youtu.be/uxFMUsrQjPA

We have created a visual report with images taken at the lake between June 2017 and November 2020. Almost all the images were taken at Lac des Seize-Îles or from samples taken from the lake. Certain sequences may be relevant to illustrate observations discussed in this report.

The video is available on YouTube by following this link: https://youtu.be/NugCxFBoECg

The following visual records can be found:

Emerging plants : 1 minute to 2 min 16
A major tributary : 2 min 50
Periphyton measurement : 7 min 45
Submerged Plants : 9 min 06
Phytoplankton at the thermocline : 10 min 25
Plankton in general: 10 min 55
Zooplankton : 11 min 25
Chrysophytes (phytoplankton): 13 min 25
Cyanobacteria (phytoplankton): 14 min : 23