Final Summary Report:

AN ASSESSMENT OF LAKE SCUGOG OFFSHORE WATER QUALITY AND ECOLOGICAL CONDITION (2017-2019)

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PREAMBLE

This report intentionally presents a high-level summary of findings related to the Ontario Trillium Fund Project's offshore study. It was written to showcase results aimed at informing future lake management and stewardship activities. More detailed findings from this study will be presented in peer-reviewed journal publications that will be shared with the Scugog Lake Stewards upon publication.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Lake Scugog is a productive ecosystem, from both an ecological and socioeconomic perspective. In recent years, the walleye population has been in decline to the point of a walleye sport-fishery moratorium issued in 2016. There are likely multiple factors contributing to this decline, but given the major data gaps in our understanding of Lake Scugog's health, this OTF Grow-Grant project focused on collecting water quality and habitat condition data at sites near current and past walleye spawning grounds. Although an array of water quality and biological data was collected, we were particularly interested in the role that nutrients (phosphorus and nitrogen), water clarity, temperature, and oxygen conditions had on aquatic weed beds and macroinvertebrate communities.

Over the course of the study, there was a notable shift from native macroinvertebrate and macrophyte species to invasive species. Specifically, there was an increase in the non-native mollusk *Dreissena polymorpha* (Zebra Mussel) and the non-native macrophyte *Nitellopsis obtusa* (Starry Stonewort). The historically dominant invasive aquatic plant *Myriophyllum spicatum* (Eurasian Watermilfoil) was replaced by the invasive macrophyte Starry Stonewort over the course of the study. Interestingly, Eurasian Watermilfoil was found to be associated with a more diverse macrophyte community, whereas Starry Stonewort had a negative relationship with macrophyte community richness (i.e., number of species). Periodic blooms of the cyanobacterium *Microcystis* occurred over the course of the study, and were found to be associated with both Starry Stonewort and Zebra Mussel abundance. Overall, phosphorus concentrations were high (eutrophic) over the course of this study, and in addition to other factors, phosphorus was a likely driver of algal blooms.

The main ecological threats to clearly emerge in the analysis of water quality and biological data from Lake Scugog include: (1) Starry Stonewort has taken over as the dominant invasive macrophyte species; (2) Eutrophication of Lake Scugog is worsening, based on phosphorus concentrations and algal bloom events; and (3) High chloride concentrations are associated with the most urban areas around the lake, and several sites have average concentrations exceeding chronic toxicity guidelines. Therefore, priorities for lake stewardship should focus on managing invasive species and phosphorus inputs into Lake Scugog, as well as mitigating the effects of urban development.

BACKGROUND

Lake Scugog is a large shallow lake located in southern Ontario within the municipal boundaries of the Township of Scugog, Township of Brock, and the City of Kawartha Lakes. Lake Scugog is a regulated reservoir, which was created after the construction of a grist mill and dam on the Scugog River in the early 1800s. Prior to the lake's creation, the surrounding area was a network of grasslands and marshes (Weir, 1927). Lake Scugog has an average depth of 1.4 m and a surface area of 68 km^2 (Kawartha Conservation, 2010). The deepest part of the lake (7.6 m) is located in the eastern arm (Kawartha Conservation, 2010). The depth and volume of Lake Scugog is maintained by a dam on the Scugog River near Lindsay, Ontario. Due to its shallow depth and long fetch, Lake Scugog does not usually exhibit thermal stratification like other temperate lakes, and therefore is considered to be polymictic (Kawartha Conservation, 2010).

Since Lake Scugog's creation, it has been a macrophyte-dominated (i.e., aquatic plants and macroalgae) ecosystem (Irwin, 1984). Submerged macrophytes are aquatic plants and large filamentous algae that grow primarily below the water surface. Similar to other macrophyte-dominated ecosystems, the high abundance of aquatic macrophytes has likely controlled phytoplankton growth due to shading and competition for nutrients (Sand-Jensen & Borum, 1991). Additionally, the macrophyte community creates a heterogeneous habitat for a diversity of aquatic life including periphyton (Blindow et al., 1993; van den Berg et al., 1998), micro- and macroinvertebrates, and fish diversity (Meschiatti et al., 2000).

Aquatic plants also influence the cycling of nutrients by stabilizing sediments with their roots and leaves. Physically controlling lake sediments has an important role in altering nutrient release by reducing wave action (Meerhoff et al., 2003; de Neiff et al., 1994). The metabolic activity of submerged macrophytes can influence oxygen concentrations, inorganic carbon, pH, and alkalinity, which can have profound and lasting effects on overall aquatic ecosystem health (Mack et al., 2000; Caraco & Cole, 2002).

Although Lake Scugog has long been considered a "weedy" lake, which can be a navigation nuisance for small motorized watercraft and swimmers alike, the benefit is that it has historically been a very productive ecosystem supporting a wide variety of wildlife and a sport fishery. As a result, the regional economy accrues an estimated $10 - 15 million dollars annually in the form of tourism and recreational activities supported by the lake (Kawartha Conservation, 2010). In recent years, however, Lake Scugog has faced increasing threats to ecosystem health by multiple stressors, including climate change, land-use activities (i.e., agriculture and urbanization), and invasive species. The proximity and connection of Lake Scugog to the Great Lakes makes it particularly vulnerable to the introduction of invasive species via the movement of watercraft in the Trent-Severn system.

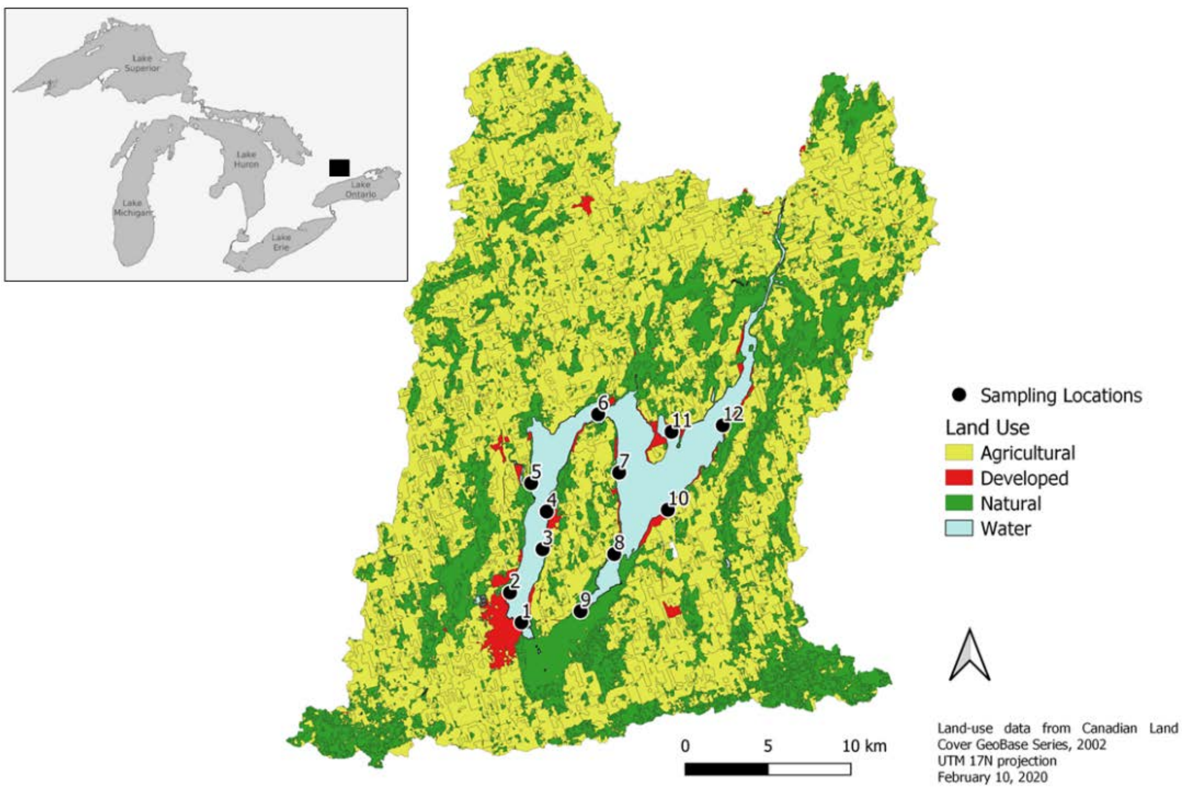

Figure 1. Location of study sites, and watershed land-use composition. This figure was adapted from Harrow-Lyle and Kirkwood (2020).

When water quality is poor in an aquatic ecosystem, it can usually cause the disappearance of sensitive native species, and promote the dominance of pollution tolerant and invasive species. Excess nutrients (primarily phosphorus and nitrogen) can support excessive weed and algae growth, and contribute to algae blooms. Current threats to healthy walleye populations in general include degraded water quality and climate change, but habitat condition for walleye in Lake Scugog is largely unknown. In this study, we focused on characterizing water quality and aquatic weed beds situated near walleye spawning grounds to assess habitat condition. We hypothesize that an over-abundance of invasive species such as Starry Stonewort would diminish the diversity and heterogeneity of aquatic weed beds, which in turn would decrease prey diversity and abundance, as well as impede walleye foraging.

STUDY OBJECTIVES

The overall research goals of this study include:

1. Document and evaluate overall water quality condition in Lake Scugog near historic walleye spawning grounds.
2. Document the distribution of the new invasive species Starry Stonewort in Lake Scugog and its relationship with other aquatic organisms including macrophytes, macroinvertebrates, and phytoplankton.
3. Determine the water quality and habitat conditions that promote Starry Stonewort growth in Lake Scugog.

METHODS

Each year, 2016-2019, monthly samples were taken from May-September at twelve sites in Lake Scugog (Figure 1). During each sampling trip, environmental parameters were measured including: depth, Secchi depth, temperature, conductivity, pH, and dissolved oxygen concentrations. In addition to field observations, water samples were collected to analyze chlorophyll α, total phosphorus concentration, total nitrogen concentrations, and chloride concentrations. Please refer to Table 1 for a description of each water quality parameter.

Table 1. Description of chemical and physical water quality parameters examined in this study.

Water Quality Indicator	**Common Land-use Source(s)**	**Significance**
Chloride (Cl)	De-icing road salt, dust suppressants, fertilizer	Indicates urban land-use, can be detrimental to certain aquatic species.
Conductivity	Erosion and release of mobile elements from the landscape (e.g., salts)	Represents total amount of dissolved ions in water; used to infer land-use activities, but hardwater lakes have naturally high conductivity due to local limestone source
pH	N/A	Represents the total hydrogen ions in lake water; indicates how acidic or alkaline the lake water is, which can affect the types of organisms that can live in the lake
Total Phosphorus (TP)	Manure, fertilizer, septic system, sewage inputs	High levels can result in excessive weed and algae growth.
Total Nitrogen (TN)	Manure, fertilizer, septic system, sewage inputs	An important nutrient for plant and algae growth.
Chlorophyll *a* (Chl *a*)	N/A	Represents the amount of phytoplankton algae growing in the water. High levels usually indicate high nutrient levels.
Depth (m)	N/A	Measures the depth of the water column from surface to lake bottom; controls the kinds of macrophytes that can grow at a given site.
Secchi Depth (m)	N/A	Estimates water clarity; affected by particle concentration in the water column. Light availability to aquatic organisms can be inferred by Secchi Depth.
Water Temperature	Influenced by air temperature and stormwater run-off; run-off water warmer in urban areas	As water becomes warmer, it can limit the presence and growth of some plant and animal species, can be important for some fish life cycles (e.g. egg hatching), support blue green algae blooms.

All processing was done within 24 h of collection. All water processing was performed at the Ontario Tech University lab, with the exception of the nitrogen suite analysis, which was performed by an accredited lab (SGS Canada, Lakefield, Ontario). Frozen lake water samples were shipped to SGS for determination of ammonia/ammonium, nitrate/nitrite, and total Kjeldahl nitrogen. Total nitrogen was determined by summation of nitrogen species. Phosphorus was measured using a modified ascorbic acid method and chloride was measured with an ion-selective electrode device.

Macrophyte samples were collected using a lake rake method, similar to what is described in Ginn (2011). Plant tissues were washed and identified to species within the laboratory. Macroinvertebrates were collected from the macrophyte mass samples and were identified using microscopy. Data was analyzed using the open sourced statistical software R.

STUDY FINDINGS

Over the course of this study, depth remained relatively consistent across the study locations (Figure 2). Depth is an important metric when conducting studies on macrophyte communities, as many macrophytes are vascular and require a root system attached to the sediments. However, depth also can greatly impact the establishment and growth of macrophyte species by changing light conditions and biochemical requirements such as nutrients (phosphorus and nitrogen) and oxygen concentrations. Interestingly, temperature also remained relatively consistent across the four years of sampling (Figure 2). Although Lake Scugog is a shallow lake and assumed to frequently mix over the course of the ice-free season, there was periodic thermal stratification, especially in the deeper eastern arm of the lake.

The west basin of Lake Scugog has more urbanized areas, which can be observed with the distribution of chloride concentrations throughout this study (Figure 2). Sites 1-5 had a higher degree of variability for chloride detected. Generally, as the season progressed (May – September) chloride concentrations decrease. The highest concentrations detected were found during early sampling months, suggesting road salt application as the likely source. Increasing chloride concentrations are a concern because of known toxicity to freshwater organisms (28-day chronic toxicity for chloride = $120 \text{ mg} \cdot L^{-1}$). High chloride can also shift communities to tolerant taxa like the cyanobacterium *Microcystis*.

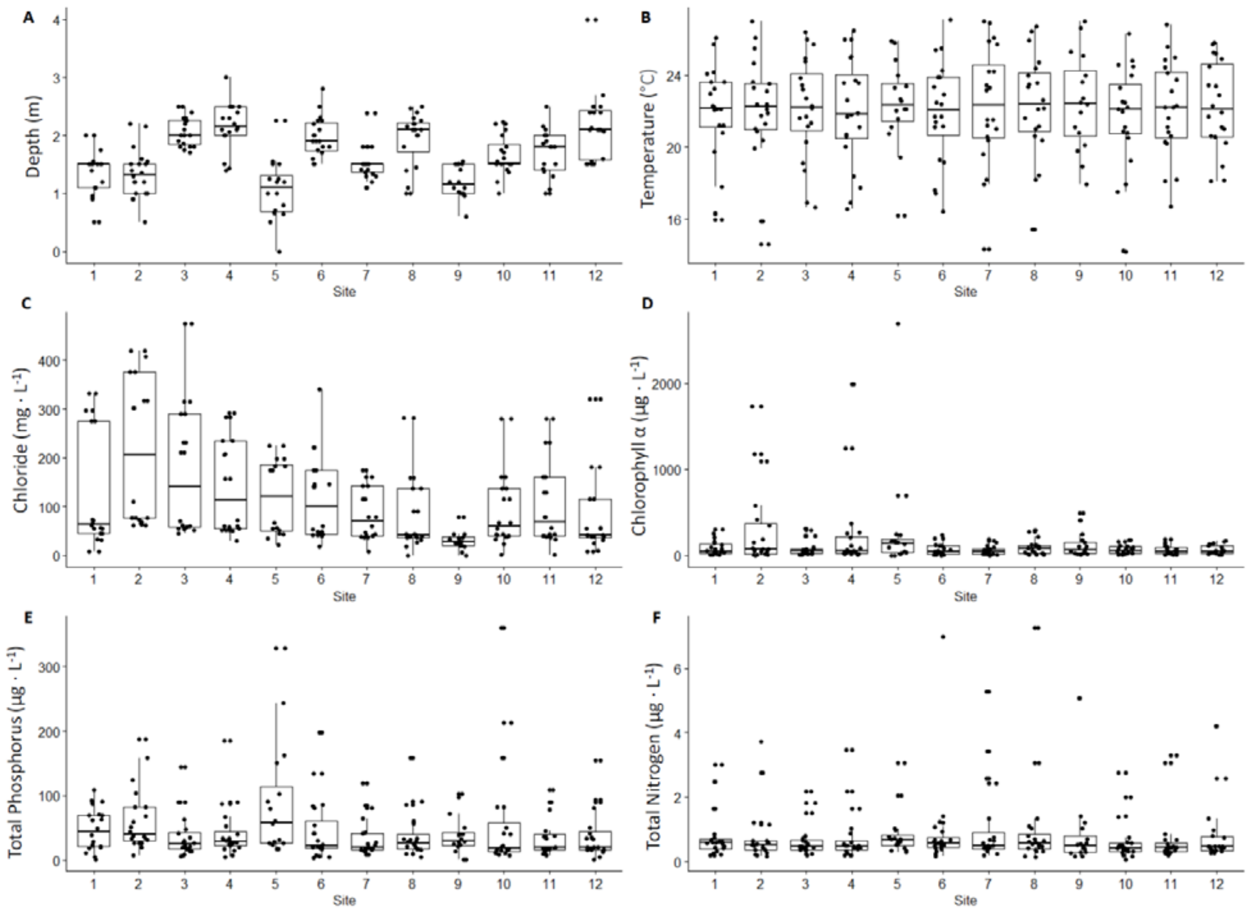

Figure 2. Boxplots show the data distribution for six of the water quality parameters investigated throughout this study.

Chlorophyll α, which is an estimate of phytoplankton abundance, was also generally higher in the west basin than east basin (Figure 2). There were 13 instances of very high chlorophyll over the course of the study, and these signify algal bloom events. Two bloom events captured were composed of filamentous algae, where the mats were so dense they stalled out the boat during sampling. The remaining eleven instances were when *Microcystis* blooms occurred.

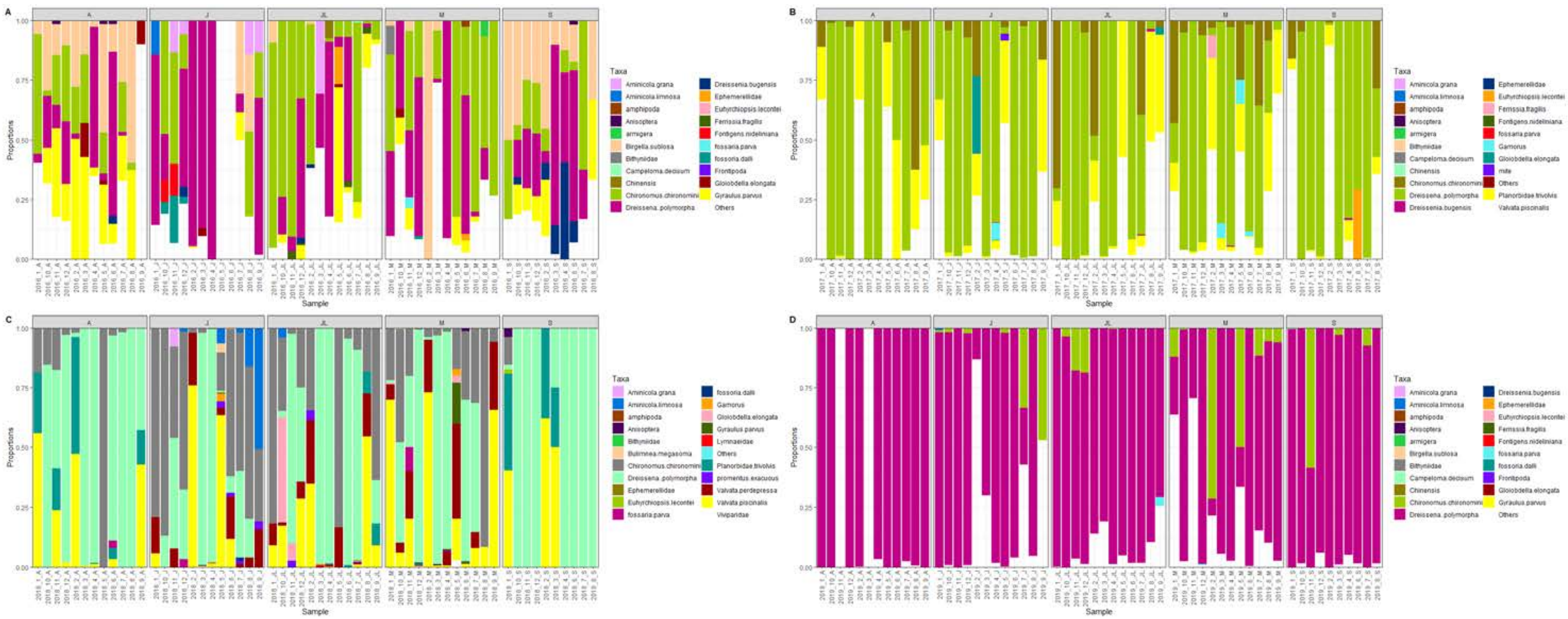

Figure 3. Macroinvertebrate community composition over the four-year study period. **A** = 2016, **B** = 2017, **C** = 2018, and **D** = 2019.

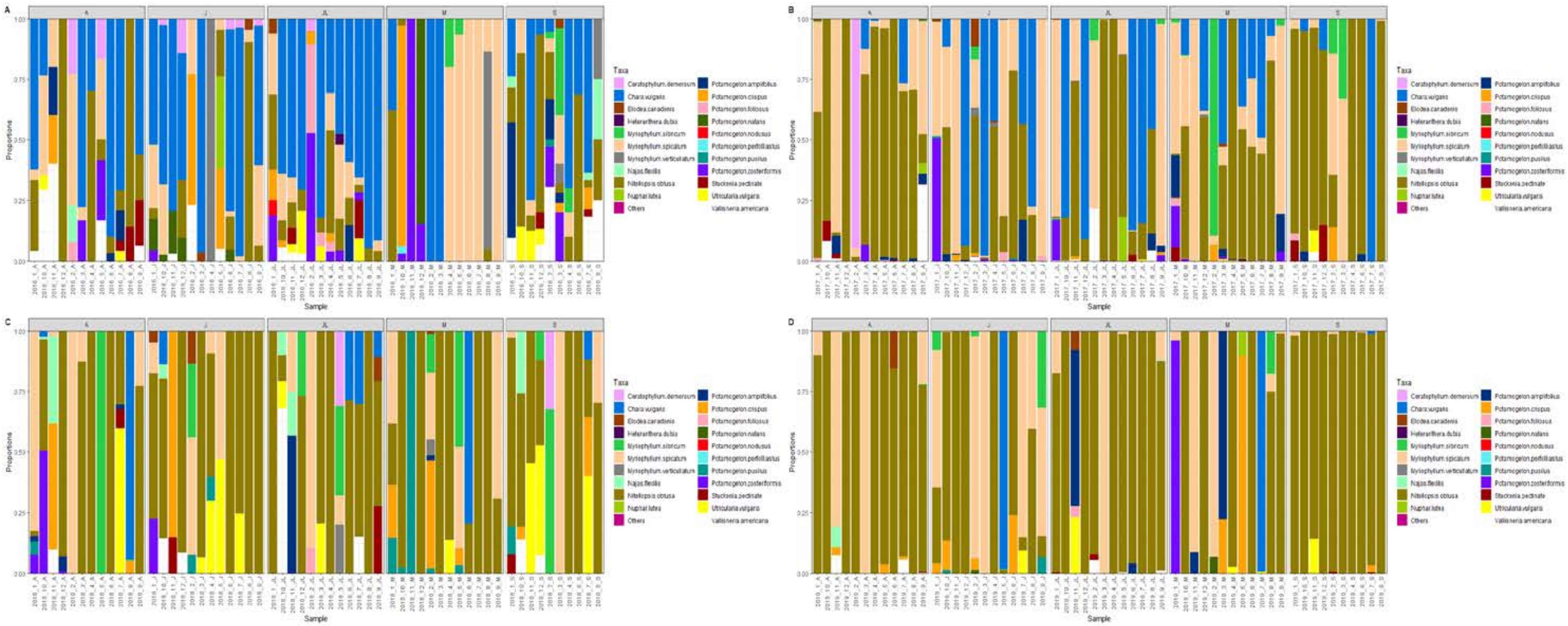

Figure 4. Macrophyte community composition over the four-year study period. **A** = 2016, **B** = 2017, **C** = 2018, and **D** = 2019.

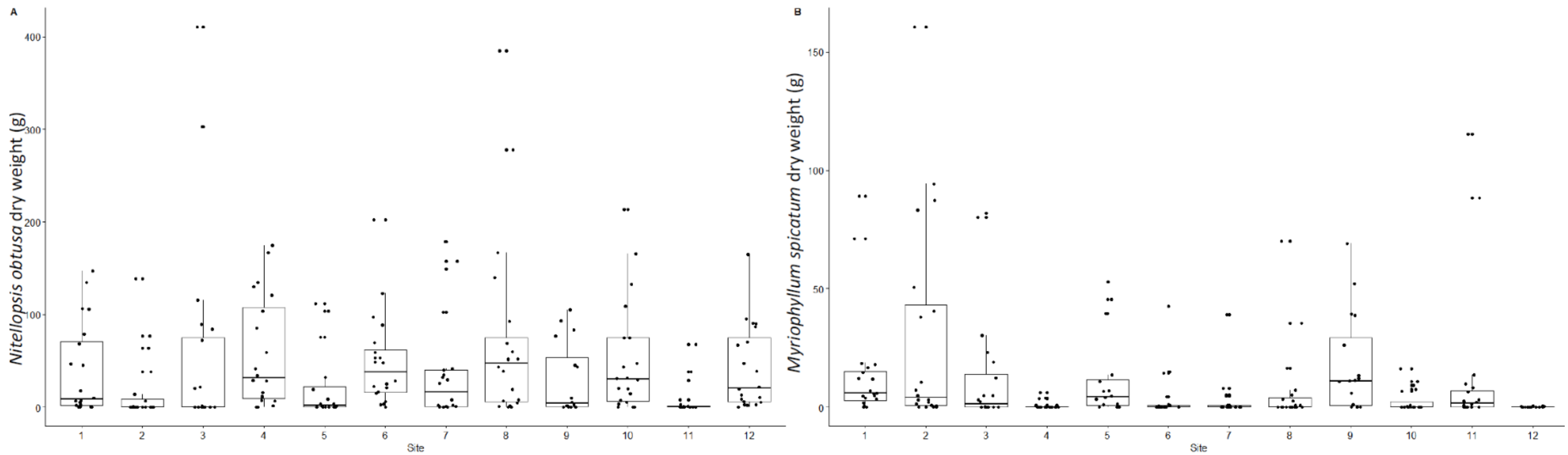

Figure 5. Abundance of *Nitellopsis obtusa* (Starry Stonewort) and *Myriophyllum spicatum* (Eurasian Watermilfoil) by site throughout the sampling period (2016-2019)

Phosphorus and nitrogen are essential macronutrients for phytoplankton, macroalgae, and aquatic plants. However, total phosphorus concentrations throughout this study were consistently over the 30 $\mu g \cdot L^{-1}$ threshold, which signifies eutrophic conditions (Figure 2). Eutrophic ecosystems often have degraded water quality due to human activities and tend to support invasive species. Further investigation is required to determine what the sources of phosphorus are in the lake, but it is likely that legacy phosphorus in the sediments is being released when oxygen is low in the sediments (i.e., anoxia). In contrast, total nitrogen concentrations were variable over the study with no notable trends (Figure 2). All data points that were above the normal distribution of total nitrogen occurred during the 2016 sampling period, which was the drought year. Unlike phosphorus, nitrogen does not seem to be a key driver of algal blooms or macrophyte growth.

The macroinvertebrate community in Lake Scugog over the past four years revealed a shift from a primarily diverse community of native species to one dominated by invasive species (Figure 3). Over the course of the study, 44 macroinvertebrate taxa were identified. In 2016, the most prevalent macroinvertebrates were *Chironomus chironomini* and *Birgella subglobosus.* In contrast, the dominant macroinvertebrates in 2019 were Zebra Mussel (*Dreissena polymorpha*) and *Chironomus chironomini*. *Chironomus chironomini* is an indicator taxon for oxygen concentrations. Generally, *Chironomus chironomini* are an indicator of low oxygen concentrations in an ecosystem. In highly productive ecosystems, such as Lake Scugog, the depletion of oxygen near the bottom of the lake where there is lots of organic material being decomposed, is common. However, there appears to have been a shift in the macroinvertebrate community, where *Chironomus chironomini* are found more frequently with the new invasive macrophyte Starry Stonewort. This result supports the notion that Starry Stonewort, like other charophytes, may be driving low-oxygen concentrations in the bottom waters of the lake.

There were 21 macrophyte species encountered over the course of the study (Figure 4). In 2016, the native *Chara vulgaris* was the dominant species throughout the study year. There were intermittent instances of Eurasian Watermilfoil being prevalent during the 2016 field season. Over the intervening period, the dominant macrophytes shifted to Starry Stonewort and Eurasian Watermilfoil by 2019 (Figure 4 and 5). Interestingly, an overall negative association was detected between these two invasive macrophytes (Figure 6). This is particularly noteworthy given that Eurasian Watermilfoil is considered to be the most aggressive invasive macrophyte introduced into North American lakes.

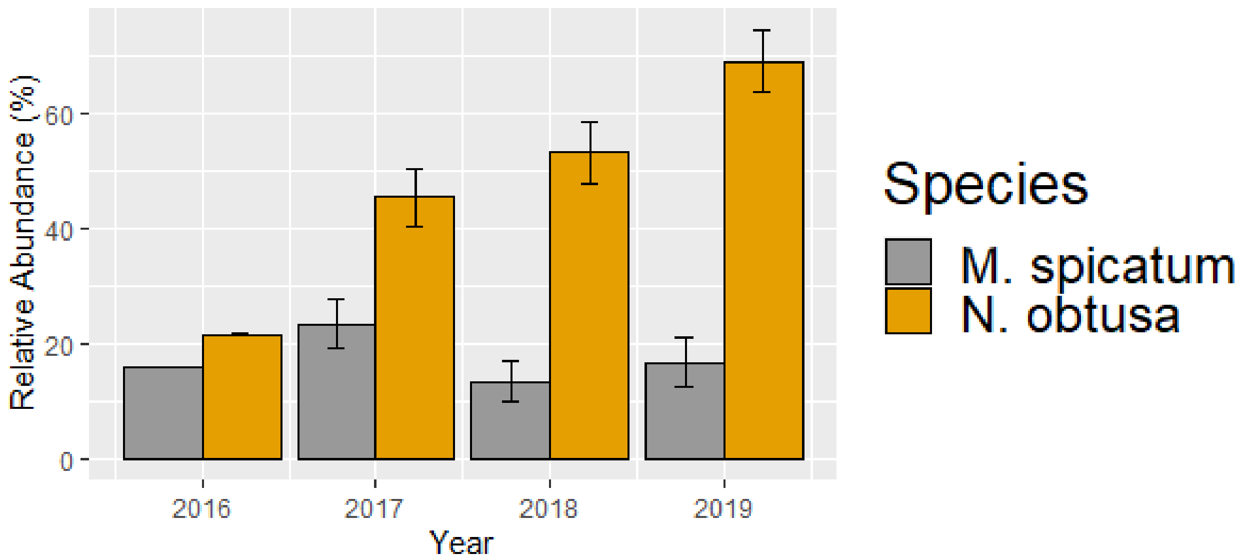

Figure 6. Comparison of *Myriophyllum spicatum* (Eurasian Watermilfoil) and *Nitellopsis obtusa* (Starry Stonewort) mean abundance in Lake Scugog over the four-year study period. Error bars represent standard error.

Serendipitously, in the first year of lake-wide monitoring (2016), wide-spread phytoplankton blooms erupted in the lake for apparently the first time in recent memory. Up to this point, there had been no historical reports of phytoplankton blooms in Lake Scugog, which was not particularly unusual for a shallow, polymictic, and macrophyte-dominated lake. Generally, blooms do not occur in these types of systems due to competition for available light and nutrients. However, microscopic analyses determined that the dominant taxon in the phytoplankton community was the potentially toxin-producing genus *Microcystis.* These phytoplankton blooms that were first detected in 2016 persisted and worsened over the course of the four-year study period.

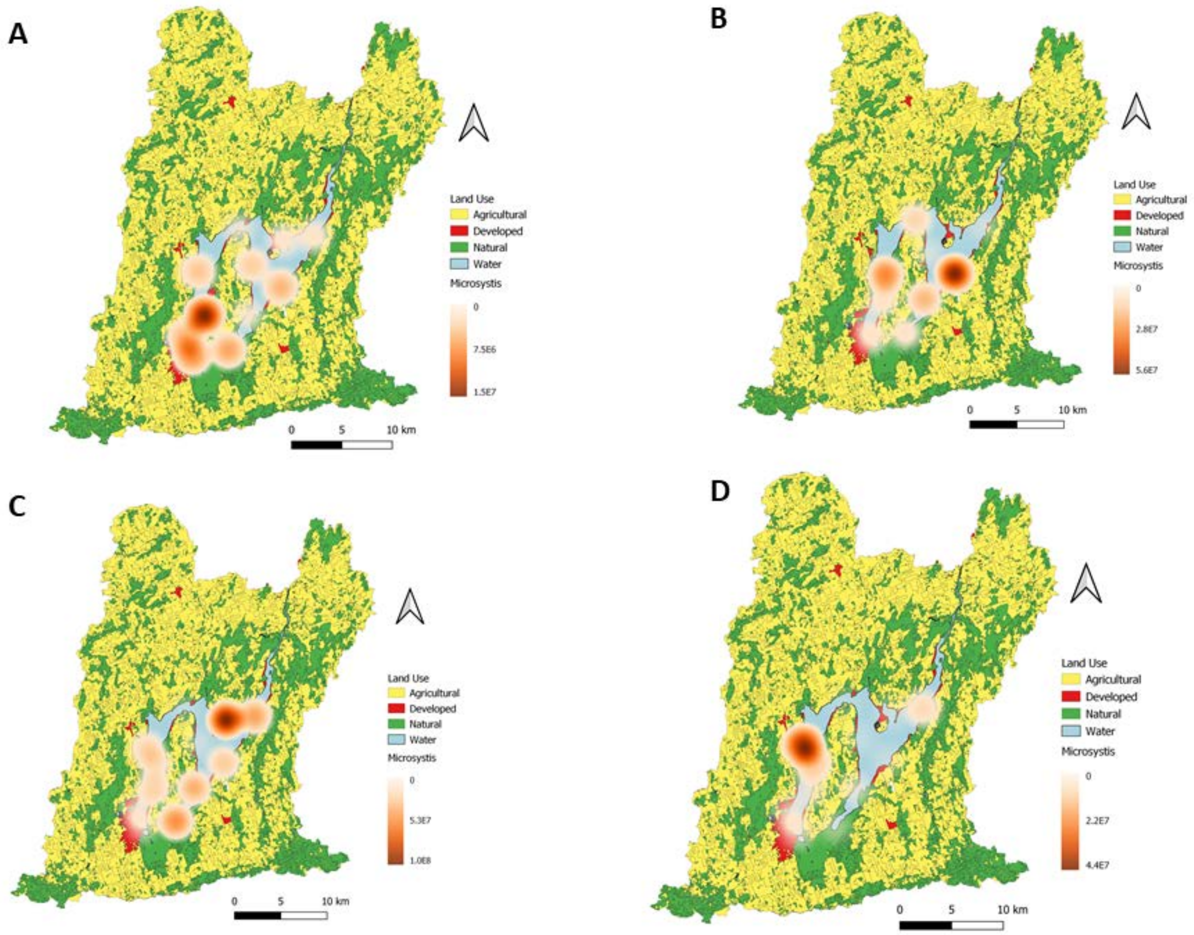

Figure 7. Normalized *Microcystis* biomass over the course of the study (2016-2019). The more intense the red dot, the higher the density of *Microcystis* at a given site. **A** = 2016, **B** = 2017, **C** = 2018, and **D** = 2019.

Interestingly, when *Microcystis* biomass is normalized relative to each year of study, locations where these blooms were most intense were identified (Figure 7). In general, these blooms occurred in the west basin of the lake, where there is more urban development, including Port Perry, but also, where Starry Stonewort was dominant. *Microcystis* is an opportunistic microorganism most associated with increased nutrients (primarily phosphorus). Phytoplankton blooms are not always caused by nutrient pollution, and are not necessarily detrimental to an ecosystem if they are transient. However, increased frequency and magnitude of phytoplankton blooms can have negative impacts on macrophyte communities by blocking light for photosynthesis and causing anoxia when the bloom material dies and decomposes. When water becomes anoxic, this is detrimental to all organisms requiring oxygen, such as fish and macroinvertebrates.

Species richness (the number of species in a given community) is an important biodiversity metric. It has been shown in terrestrial and aquatic ecosystems that ecosystem function and resilience generally increase with increased ecosystem biodiversity. With higher degrees of species richness, ecosystems can be relatively stable, while a reduction in species richness can be an indicator of negative habitat impacts (such as reduced water quality or the introduction of invasive species). Investigation into water quality effects revealed that chloride concentration, conductivity, site depth, temperature, Secchi depth, and total phosphorus concentrations had a negative relationship with macrophyte community richness.

Although phosphorus is a required macronutrient for macrophyte growth, too much phosphorus can cause excess growth of both algae and macrophytes. When conditions are optimal, high amounts of phosphorus in the water column can cause algal blooms, which can shade submerged macrophytes. Several macrophyte species are also sensitive to high nutrient concentrations, and disappeared from the community assemblage at sites with high phosphorus. Species that have the capability to precipitate excess phosphorus or act as nutrient sinks, like Muskgrass and Starry Stonewort, are typically the only macrophytes present in these instances.

Interestingly, there was a weak positive relationship observed between Eurasian Watermilfoil abundance and macrophyte species richness (Figure 8). This indicates that Eurasian Watermilfoil does not negatively impact the number of other macrophyte species. In contrast, the new invasive macrophyte, Starry Stonewort, had a notable negative relationship with macrophyte species richness. This seems to indicate that compared to the other non-native invasive species like Eurasian Watermilfoil, Starry Stonewort has a far greater negative affect on the macrophyte community.

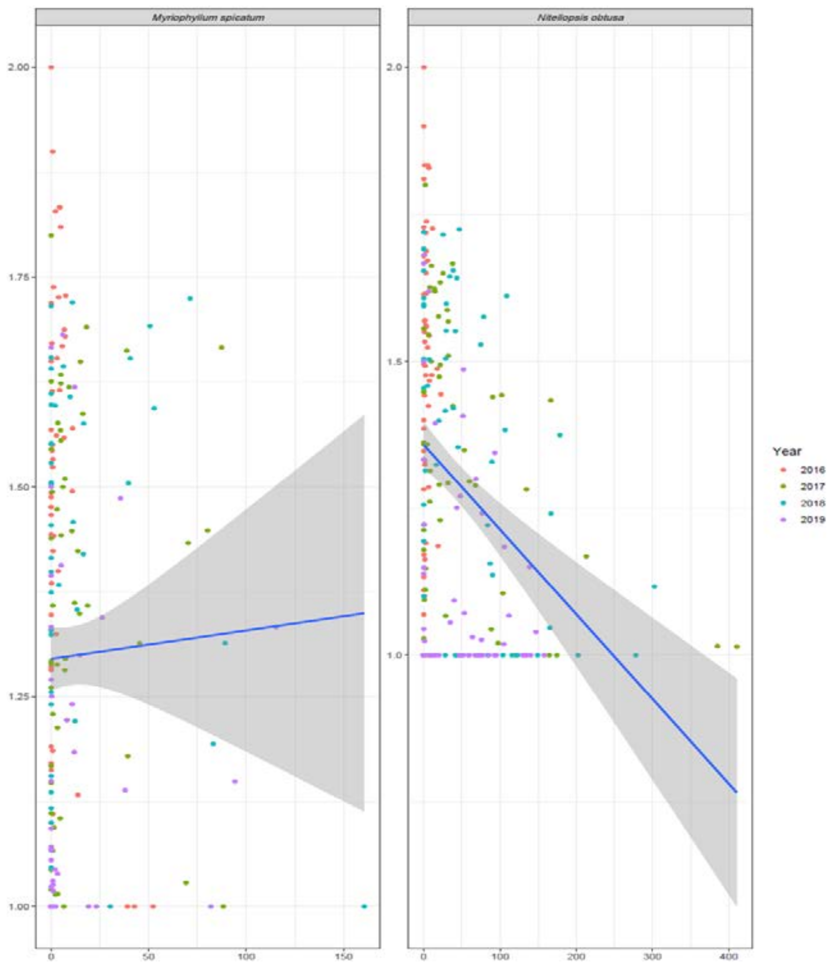

Figure 8. Relationship between macrophyte community richness and Eurasian Watermilfoil (left panel) and Starry Stonewort (right panel).

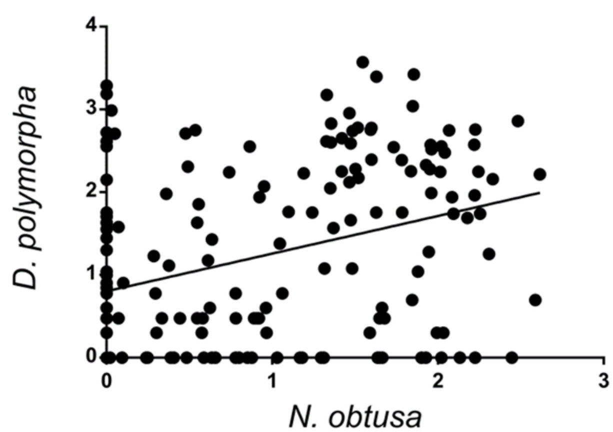

Figure 9. Relationship between the invasive species Starry Stonewort (*N. obtusa*) and Zebra Mussel (*D. polymorpha*) in Lake Scugog.

With the increasing prevalence of Zebra Mussels and *Microcystis* blooms occurring in conjunction with Starry Stonewort invasion of Lake Scugog, further analyses were done to assess the relationships between all of these problematic taxa. A statistically significant positive relationship between Starry Stonewort and Zebra Mussels was identified (Figure 9). Generally, when there was a higher density of Starry Stonewort, there would be higher counts of Zebra Mussels. This could be due to the hard-calcareous encrustation that Starry Stonewort has which provides an excellent substrate for Zebra Mussel attachement.

Furthermore, a positive relationship was also found between Starry Stonewort and *Microcystis* (Figure 10). There could be direct and indirect interactions between Starry Stonewort and *Microcystis* that support a synergistic relationship. A direct interaction could be allelopathy (i.e., where Starry Stonewort exudes substances that inhibit other algae, but do not harm *Microcystis*). An indirect interaction could relate to Starry Stonewort providing ample habitat space for Zebra Mussels, which have been documented to support *Microcystis* blooms via selective filter feeding. Sites where there was an intense *Microcystis* bloom often had > 80% relative abundance of Starry Stonewort, and high counts of Zebra Mussels.

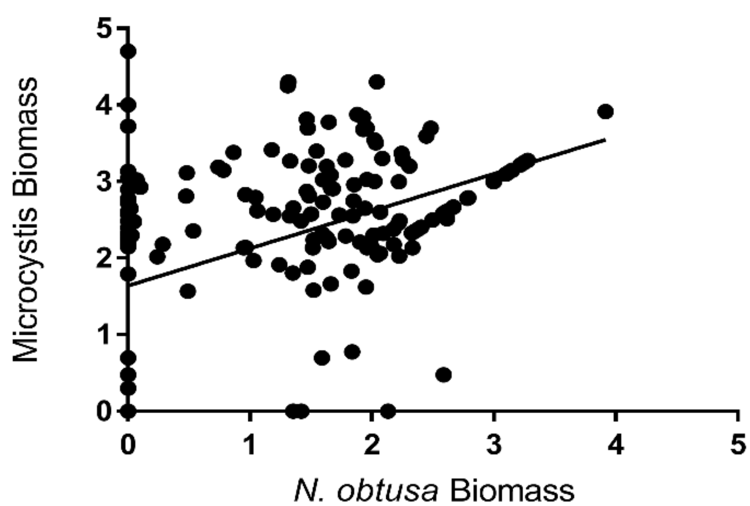

Figure 10. Relationship between the bloom-forming blue-green alga *Microcystis* and the invasive macrophyte Starry Stonewort (*N. obtusa*) in Lake Scugog.

The synergistic interactions between the two invasive taxa, Starry Stonewort and Zebra Mussels may reflect an "invasional meltdown". Invasional meltdown is a phenomenon first described by Simberloff and Von Holle (1999) that states negative effects in an ecosystem from one invasive species are exacerbated and compounded by an additional invasive species. With Starry Stonewort effectively decreasing species richness across the macrophyte community and supporting the population increase of the invasive Zebra Mussel, it is apparent that community dynamics and nutrient cycles have been disrupted.

Understanding biological communities and ecosystem level events are often very complex. As such, an advanced statistical model was created to understand the dynamics of *Microcystis* blooms within Lake Scugog that were observed throughout this study. This model demonstrated that not only are environmental parameters such as precipitation, water temperature, chloride concentrations, site depth, and phosphorus concentrations contributing to the *Microcystis* blooms, but there were biological influences as well; namely Starry Stonewort and Zebra Mussels. This analysis has been published in a peer-reviewed scientific journal article, which has already been shared with the Scugog Lake Stewards (See **Appendix 1.)**

CONCLUSIONS

Over the course of the 4-year study, it became apparent that Lake Scugog was becoming more degraded with respect to water quality conditions, as well as over-taken by two key invasive species: Starry Stonewort and Zebra Mussels. Compared to reported phosphorus trends in the Lake Scugog Management Plan (Kawartha Conservation 2010), phosphorus has clearly increased since then. There are likely multiple sources of phosphorus to the lake, but given that province-wide trends show declining phosphorus inputs from tributaries, the key sources of phosphorus in Lake Scugog are likely from growing shoreline and urban development, as well as internal loading. Septic systems and fertilizer application on lawns and gardens are the major sources of nutrients from shoreline properties and subdivisions. A lake as productive as Lake Scugog, with periodic algal blooms, probably experiences transient anoxia in the sediments, which can be an important driver of legacy phosphorus release. Although Lake Scugog is considered to be polymictic, which would normally combat anoxia, it is possible that the dense beds of Starry Stonewort help to stabilize the sediments and support periodic anoxia to occur.

Even with the troubling developments of elevated phosphorus, chloride, algal blooms and invasive species, the silver lining is that degraded water quality and invasive species were largely spatially explicit – meaning that they were most problematic at certain “hot spot” areas in the lake. It is fair to say that the west arm experiences more water quality degradation and algal blooms than the east arm. The Port Perry Bay area is the most degraded section of the lake, with the highest chloride levels, periodic algal blooms, and prevalence of Starry Stonewort. If stewardship activities are to be prioritized, they should focus on the Port Perry Bay area since water from the bay eventually makes its way through the western arm to the Scugog River. The Lake Scugog Enhancement Project will be key to improving water quality conditions in Port Perry Bay.

Now that the Scugog Lake Stewards have a comprehensive baseline dataset from this OTF study, it will be worthwhile to build and sustain a community-science monitoring program to continue documenting lake water quality and habitat condition. This data will be vital to not only assessing lake health over time, but the effectiveness of stewardship and restoration activities as well.

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Appendix 1.

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ARTICLE

The invasive macrophyte *Nitellopsis obtusa* may facilitate the invasive mussel *Dreissena polymorpha* and *Microcystis* blooms in a large, shallow lake

Tyler Harrow-Lyle and Andrea E. Kirkwood

Abstract: This study was conducted in Lake Scugog, a large, shallow reservoir in Ontario, Canada. Historically, Lake Scugog has been a macrophyte-dominated ecosystem with a productive fishery. In recent years, periodic *Microcystis* blooms have erupted coinciding with the discovery of the non-native macroalga *Nitellopsis obtusa* in the lake. From 2016 to 2018, we conducted field surveys to assess the physical, chemical, and biological conditions across 12 sites spanning the lake. All study species (*N. obtusa*, *Dreissena polymorpha*, and *Microcystis* spp.) increased from 2016 to 2018. To determine potential biotic and abiotic drivers of *Microcystis* blooms, we used a structural equation modelling (SEM) approach. The SEM (r^2 = 0.27, $p < 0.05$) revealed several positive (precipitation, chloride, depth, and *N. obtusa*) and negative (total nitrogen) explanatory variables for *Microcystis* biomass. The only statistically significant biotic driver was *N. obtusa*, which was a positive explanatory variable for both *D. polymorpha* and *Microcystis*. Future work will test the efficacy of the SEM model across Ontario lakes to confirm the facilitative role of *N. obtusa* on *D. polymorpha* and *Microcystis* populations.

Résumé : La présente étude a été réalisée dans le lac Scugog, un grand réservoir peu profond en Ontario (Canada). Par le passé, ce lac était un écosystème dans lequel dominaient les macrophytes et il soutenait une pêche productive. Ces dernières années, des proliférations périodiques de *Microcystis* ont eu lieu, coïncidant avec la découverte de la macroalgue non indigène *Nitellopsis obtusa* dans le lac. De 2016 à 2018, nous avons effectué des relevés sur le terrain dans le but d'évaluer les conditions physiques, chimiques et biologiques dans 12 sites à la grandeur du lac. L'abondance de toutes les espèces étudiées (*N. obtusa*, *Dreissena polymorpha* et *Microcystis* spp.) a augmenté durant cette période. Afin de déterminer les facteurs biotiques et abiotiques qui pourraient favoriser les proliférations de *Microcystis*, nous avons utilisé une approche de modélisation d'équations structurelles (MES). La MES (r^2 = 0,27, p < 0,05) a fait ressortir plusieurs variables explicatives positives (précipitations, chlorure, profondeur et *N. obtusa*) et négative (azote total) associées à la biomasse de *Microcystis*. Le seul facteur biotique statistiquement significatif est *N. obtusa*, une variable explicative positive tant pour *D. polymorpha* que *Microcystis*. Des travaux futurs évalueront l'efficacité du modèle SEM dans d'autres lacs de l'Ontario afin de confirmer l'effet de facilitation de *N. obtusa* sur les populations de *D. polymorpha* et *Microcystis*. [Traduit par la Rédaction]

Introduction

Aquatic invasive species in Canadian inland waters are an increasing problem that pose major socio-ecological impacts. The invasive mussel *Dreissena polymorpha* is no exception and was first discovered in the Laurentian Great Lakes in 1988 (Hebert et al. 1989). *Dreissena polymorpha* has been shown to have negative effects on ecosystem biodiversity and function, including biofouling (Clark 1952; Greenshields and Ridley 1957; Morton 1969; Afanas'yev and Protasov 1998), displacement of native species (Sebestyen 1938; Arter 1989), and alteration of nutrient dynamics (Stańczykowska et al. 1976; Stańczykowska 1977; Stańczykowska and Planter 1985). Another non-native invasive species from Eurasia is *Nitellopsis obtusa* (also known as starry stonewort). *Nitellopsis obtusa* is a freshwater macroalga first introduced to the Laurentian Great Lakes basin in the 1970s, when it was discovered in the St. Lawrence River (Sleith et al. 2015). By the 1980s, *N. obtusa* was documented in Lake Ontario and Lake St. Clair (Schloesser et al. 1986; Midwood et al. 2016).

Over the intervening decades, *D. polymorpha* has successfully invaded inland lakes in Ontario such as Lake Simcoe and the Trent–Severn Waterway (TSW). It was confirmed in 1991 that *D. polymorpha* had invaded Lake Scugog, a large headwater reservoir in the TSW (Hincks and Mackie 1997). In fact, Lake Scugog's water chemistry was determined to be ideal for dreissenid mussel invasion, but the prevalence of soft substrate throughout the lake has likely kept numbers in check. This assumption is based on anecdotal reports by the Scugog Lake Stewards (SLS), which describe *D. polymorpha* as known to be present, but not at nuisance levels.

No published reports have documented the spread of *N. obtusa* to inland lakes in the Great Lakes basin. By the mid-2000s, conspicuous stands became apparent in Michigan and New York lakes (Larkin et al. 2018). On the Canadian side, there has been mounting anecdotal reports of *N. obtusa* in Ontario inland lakes connected to the TSW, including Lake Simcoe (Lake Simcoe Region Conservation Authority 2015). The scarcity of data on *N. obtusa* spread and establishment in North America is likely due to both a lack of awareness of this non-native taxon, as well as frequent misidentification (Larkin et al. 2018). There is growing consensus, however, that it has become the dominant aquatic macrophyte in

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