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A Multi-Disciplinary Approach to Plastic Pollution from Environmental Sampling to Surveying: Quality Assurance, Freshwater Contamination, and Popular Opinions

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Abstract

Plastic pollution is a global problem impacting every environmental compartment, from the air in Mount Everest to urban freshwater supplies. The scope and magnitude of the plastic problem requires an interdisciplinary approach that addresses human and environmental dimensions. I look to inform circular economy approaches through three phases of research: 1) individual waste generation and perceptions of waste and plastic issues; 2) methods and quality control evaluation for quantification of freshwater microplastics; and 3) temporal and spatial variation in plastic particle dynamics over a 3-year period in an urban lake compared with a rural lake in Central New York.

In phase 1 (Chapter 2), I consider the non-perishable waste generation and environmental perceptions of participants in a social media campaign, Futuristic February. Participants in this campaign were directed to collect their non-perishable waste in February 2020. The aim of this work was to evaluate general perceptions of the survey participants on common areas of misinformation regarding waste and plastics, as well as to obtain general information regarding individual waste generation. Participant's perceptions of plastic and waste issues were compared to popular search results on Google and Google Scholar in a mini-review. Participants were most uncertain on topics related to bioplastics and biodegradable plastics. The majority of participants (86%) agreed that there were trash islands in the ocean gyres. The mini-review results showed that uncertainty differed by group (Google, Google Scholar, and participants) and topic, rather than any consistent pattern among participants and search platform.

In Phase 2 (Chapter 3) I focus on quantifying environmental impacts of plastic pollution in temperate freshwaters. Methods for collection and quantification of plastic particles in the environment are non-standardized and often incomparable across studies. In this chapter I consider the use of point sampling (grab, bucket, and pump methods) and areal sampling (net) methods for microplastic sampling in fresh surface waters. I used a strict quality control correction using a limit of detection (LOD) and limit of quantification (LOQ) approach to account for background contamination. Point sampling methods were less likely to exceed the LOD compared to net sampling, though results differed depending on the location chosen for sampling and if visible floatable plastic pollution was present. Net sampling likely underrepresented smaller particles but collected a higher diversity with respect to color and morphology and exceeded the LOD in every sample, providing a more reliable method for monitoring microplastics.

Lastly, in Phase 3 (Chapter 4) I applied the refined net method identified in Phase 2 to monitor both urban and rural lake surface waters for microplastics in central New York over a 3-year period (2019-2021). The goals of this monitoring campaign were to: identify patterns with respect to source and location, and discuss potential impacts of seasonal stratification on microplastic circulation in dimictic lakes. Plastic particle concentrations were higher in Onondaga Lake (urban) compared to Skaneateles Lake (rural), likely owing to higher potential inputs for plastic pollution from CSOs, urban runoff, and wastewater effluent inputs. The shorter residence time and smaller number of large inflows impacted by urbanization to Onondaga Lake resulted in a higher temporal variation. Chemical characterization of particles revealed patterns of particle types that can further inform sources and losses of particles for improved regional floatables management.

Lastly, I offer areas for future research and priority policy action based on these three phases of work in Chapter 5.

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by

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Chapter 1: Introduction to the Plastic Problem

Plastics are both a modern marvel and a pervasive contaminant. Plastic provides inexpensive, cheap, durable, and efficient materials for packaging, construction, and many other applications. Their widespread usage has invoked a Plastic Age of our society, with a remarkable increase in plastic production in recent years (Borrelle et al., 2020; Thompson et al., 2009b, 2009a). Since the beginning of large-scale plastic production in the 1950s until 2015, an estimated 8,300 million metric tons (Mt) of virgin plastics had been produced, of which 30% were still in use (Geyer et al., 2017). An increase in plastic production has coincided with its increasing mismanagement. Global plastic released into aquatic ecosystems could reach 90 million metric tons by 2030 if plastic management and production continues on its current trajectory (Borrelle et al., 2020). Law et al. (2020) found that the United States was the largest generator of plastic waste, with 0.83 million metric tons of litter estimated in 2016. Current efforts to quell the threat of plastic pollution include current proceedings in the United Nations to develop a Global Plastics Treaty (United Nations Environmental Programme, 2022).

Waste management in the United States has recently struggled as a result of decreasing demand for recyclables following the 2017 Chinese import ban of most plastic waste (Brooks et al., 2018). The recycling industry following this ban is operating at a net loss, with widespread implications for global waste management. Locally, in 2020, the Onondaga County Resource Recovery Agency (OCRRA) in Central New York was set to lose $2 million USD and was considering other options with potential economic and environmental ramifications, including adding hauling fees or incinerating recyclables (Coin, 2020). Additionally, not all plastic is recycled, with past trends indicating only 9%

of plastics being recycled, 12% incinerated, and the remaining 79% accumulating in landfills or the environment (Geyer et al., 2017). A report by Greenpeace (Greenpeace, 2022) placed the 2021 recycling rate of plastics in the United States (US) at 5%. If current waste trends continue, there will be a globally estimated 12,000 Mt of plastic waste collectively in landfills and the environment (Geyer et al., 2017).

Strategies to manage plastic waste include ocean and beach clean-ups, plastic bag bans and media campaigns targeting plastic as an unsustainable material, among others. However, these management strategies do not always correct the underlying issue and, in some cases, lack a full accounting of the life cycle of plastic. An increased awareness of single-use plastic has prompted use of bioplastics, which are not always compostable or not able to be composted due to a lack of proper industrial composting facilities. For example, “biodegradable” tea bags, which persist in outdoor soil for 12 months (Mateos–Cárdenas, 2022). A general shift in consumerism toward “green” products has prompted the use of other packaging materials, like glass, in lieu of plastic. However, glass is heavier and may be more carbon intensive to transport than plastic and is not typically recycled in the US unless it is source-separated, which impacts its overall carbon footprint (Pasqualino et al., 2011). Moreso, the sustainability of plastic, both conventional and bio-based, and proposed alternatives is subject to greenwashing, or the misleading of consumers on environmental claims related to products (Dangelico and Vocalelli, 2017). The availability of reliable information for consumers to make sustainable decisions concerning the use of plastics further contributes to the plastic problem.

The shift toward approaches of a circular economy is essential to reduce resource and plastic usage. The circular economy is an alternative to our linear (take-make-dispose) economy in which materials are kept in use and reuse , rather than disposal after single use (Cordier and Uehara, 2019). Approaches for a plastic circular economy include:

- Limiting the production and generation of single-use plastics;
- Designing materials for reusability and recyclability;
- Shifting plastic production to alternative, non-fossil fuel, feedstocks;
- Increasing the capture of mismanaged waste through expanded waste management; and
- Mitigating plastic pollution in the environment (Mihai et al., 2022).

Source reduction requires the implementation of policies and incentives for behavioral change that address single-use and highly littered plastic items, which may contribute to plastic pollution.

Increases in plastic waste coupled with poor disposal of plastic products contribute to the formation and transport of macro- (> 5 mm) and micro-plastics (length 1 μm - 5 mm) into the environment. Microplastics are diverse in shape (Figure 1.1), size, and material (Rochman et al., 2019), making effective monitoring and mitigation a challenge.

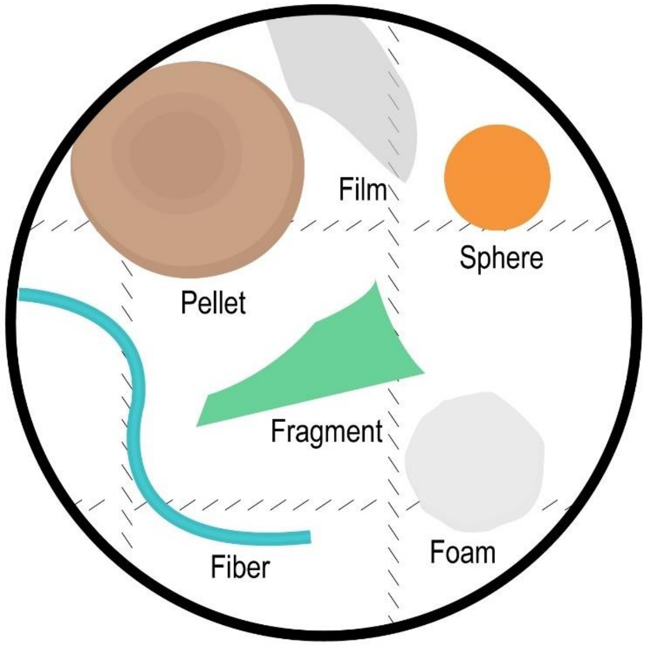

Figure 1.1: Major morphology (shape) types in microplastic classification.

Microplastics can occur as primary microplastics, which are manufactured at a size less than 5 mm, or as secondary microplastics, which are formed by the degradation of larger plastics. Primary microplastics include plastic pellets, or nurdles, that originate from manufacturing plants (Horton and Dixon, 2018), as well as microbeads and glitter. While there has been an increasing focus on policies addressing microbead pollution by banning their usage in rinse-off cosmetics (Xanthos and Walker, 2017), few policies address the usage of plastic particles in other abrasives or cleaning supplies (Browne et al., 2011).

Microplastics are ubiquitous; occurring in marine (Cole et al., 2011), freshwater (Eerkes-Medrano et al., 2015), and terrestrial ecosystems (Horton et al., 2017), , air (Brahney et al., 2020; De Falco et al., 2020), and snow (Bergmann et al., 2019; Napper et al., 2020) consumer products (Mason et al., 2018). Despite growing concerns over mismanaged waste and microplastics, which have been exacerbated by an increase in single use plastic waste during the COVID-19 pandemic (Prata et al., 2020), research gaps remain on the approaches to study the prevalence, behavior, fate and processing of microplastics in freshwaters. Mitigation of freshwater plastic pollution sources requires monitoring on a regional or watershed-scale to determine the likely sources and pathways for microplastics in the environment.

In 2015, 70% of freshwater used for irrigation and public supply came from surface water bodies, which may act as a pathway for both environmental and human exposure to microplastics from agricultural use or ingestion. Additional risks and harm have been established for biota that interact with plastics in the environment. Macroplastics can result in entanglement or ingestion by biota, resulting in harm or death (Isangedighi et al., 2020). There is limited understanding of the health impacts of environmentally relevant microplastic exposure in freshwater ecosystems and in humans (Bucci et al., 2020), but ingestion has been linked to reduced reproduction, growth, and fitness of marine invertebrates (Horton et al., 2017). Human exposure to microplastics can occur by ingestion and/or inhalation, causing inflammation and other effects (Wright and Kelly, 2017), but human risk has not been adequately assessed due to a lack of data (VKM et al., 2019).

Impacts on human and ecosystem health are limited by current estimates of microplastic abundance, morphology, and size distribution to evaluate environmentally relevant mixtures and exposure. These risks pervade through time due to the persistence and storage of plastics in freshwater ecosystems (Emmerik and Schwarz, 2020). Therefore, reliable monitoring of freshwaters is essential to assess the effectiveness of mitigation strategies for plastic pollution source controls, determine the full extent of contamination, and understand possible exposure and effects to human and environmental health. Quantification of microplastics in freshwaters has increased in the literature with time (Blettler et al., 2018), but is still under-investigated compared to the marine environment. In addition, due to regional influences on microplastic presence, such as type and severity of contamination, further monitoring and particularly increasing the geographic scope of monitoring is necessary to develop and assess effective mitigation strategies.

In this dissertation I seek to inform circular economy approaches from an interdisciplinary perspective through three phases of research:

- In the first phase (Chapter 2) I consider waste generation and plastic and waste perceptions by the individual. In this chapter, waste production of an environmentally oriented population is characterized and understanding of perceptions of waste and plastics issues are sought. Furthermore, participant views are compared with views presented in popular media (Google) and scientific articles (Google Scholar).
- In the second phase (Chapter 3) I evaluate methods to reliably quantify freshwater microplastics. I compare plastic particle capture and diversity achieved by different sampling methodologies in fresh surface waters in an urban and rural lake in Central New York. I also discuss how improvements in quality control could impact concentration values. In addition, I summarize the quality assurance and quality control (QA/QC) associated with water sampling and

analysis and discuss the results of a spike test spanning the full diversity of microplastic morphologies.

- In the third phase (Chapter 4) I apply the most reliable method identified in chapter 3, net sampling and appropriate QA/QC protocols, to determine concentrations and types of plastic particles in Onondaga and Skaneateles lakes from 3 years of sampling from 2019 to 2021. I also discuss potential impacts of fall lake turnover on plastic particle concentrations November 2020 and 2021.
- Finally, I summarize the conclusions from this dissertation research (Chapter 5) and make recommendations for future study.

Chapter 2: Uncertainties About Waste Using a Global Online Survey and Review Approach: Environmentalist Perceptions, Waste Composition and Views from Media and Science

From Laura A. T. Markley[1]*, Maja Grünzner[2] and Tony R. Walker [3] (In Review)

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1. Introduction

The overproduction of waste has resulted in increasing pollution to the environment. Waste generation has been associated with negative ecological and human health impacts due to the storage, treatment, or burning of waste (Giusti, 2009) as well as the contribution of waste to plastic pollution. It is estimated that 19-23 million metric tons (Mt) of plastic waste were released into aquatic environments in 2016, with an anticipated future increase of 53 Mt annually by 2030 associated with increases in plastic production, consumption and improper waste disposal (Borrelle et al., 2020). Waste reduction, in addition to reintegrating and recycling materials, is essential for the protection of human and environmental health. Achieving lasting change in global waste management requires informed decision making and policy aimed at affecting human behavior.

Plastic pollution, as either macro- (>5 mm) or microplastics (<5 mm), can have both a physical and chemical impact or no effect on organisms and their associated environment (Rochman et al., 2019). Plastic pollution can be ingested by organisms or entangle them, resulting in suffocation, death, or potential changes in feeding habits (Gall and Thompson, 2015). Plastics have been detected in a wide range of environments and matrices (Allen et al., 2019; Free et al., 2014; Nelms et al., 2021; Ostle et al., 2019; Rillig and Lehmann, 2020), including food and drink (Cox et al., 2019), aquatic (Munno et al., 2021) and terrestrial (Eriksen et al., 2021) organisms, and have only just begun to be studied in humans (Ragusa et al., 2021; Schwabl et al., 2019). In recent years, plastic pollution has become a large topic of conversation in popular media (Völker et al., 2020). With this increase in popularity, misconceptions and myths, such as that of the "Great Pacific Garbage Patch" (Henderson and Green, 2020), have become pervasive. Prior work on this topic has noted differences in how risk associated with plastic pollution is communicated in scientific vs. media articles (Völker et al., 2020), and who may have a different understanding of the current knowledge gaps and uncertainties associated with plastics in the environment. Even within the scientific literature, there have been topical debates on the misperceptions of single-use plastic (Miller, 2020; Walker and McKay, 2021) and the priority of climate *vs.* ocean pollution environmental threats (Avery-Gomm et al., 2019; Stafford and Jones, 2019). The perception and misconceptions about plastic waste and plastic require study to drive informed decision making and motivate change. Furthermore, waste reduction can be informed by better characterization of individual waste generation and composition.

Globally, municipal solid waste (MSW) generation exceeds approximately 1,814 million metric tons per year (Karak et al., 2012; Kaza et al., 2018). Waste generation has been linked to demographic factors such as income (Bandara et al., 2007; Hoornweg and Bhada, 2012), population density (Johnstone and Labonne, 2004), and degree of urbanization (Hoornweg and Bhada, 2012; Johnstone and Labonne, 2004) and number of household members (Bandara et al., 2007). Waste composition is also an important factor in determining methods of waste disposal and reduction. Bandara et al. (2007) found that waste composition in Moratuwa, Sri Lanka was predominantly biodegradable organics, or compostables, but other studies have noted variations in composition with location and income (Hoornweg and Bhada, 2012; Ozcan et al., 2016). In terms of global

MSW composition, food and greens have a negative relationship with the income level of a country, while non-perishable forms of waste, such as paper and cardboard, rubber and leather, and plastic increase for high-income countries (Kaza et al., 2018). Action toward waste reduction should be implemented on the household level following changes in policy, but levels of individual waste production and perceptions must first be understood and quantified.

Perception of the environment, waste, and plastic pollution are all important factors impacting waste minimization, such as reduction and reuse. A U.K. case study of household waste management found that predictors of reduction and reuse included environmental values, knowledge, and concerned-based variables, whereas recycling is considered normative behavior (Barr, 2007). While social norms influence recycling behavior, personal norms have a stronger influence with waste prevention (Barr et al., 2001; Bortoleto et al., 2012). Barr et al. (2001) found that waste reduction in Exeter, England was more likely in older females with a knowledge of policy, whereas reuse was dictated by perception of task difficulty and whether the individual had knowledge and values which motivated their actions(Barr et al., 2001).

An individual's environmental behavior is not only influenced by their values toward the environment, but is dictated by the indirect relationship between their environmental conscience, awareness of environmental problems, social responsibility, and perception of task difficulty (Kollmuss and Agyeman, 2002). Pro-environmental consciousness consists of knowledge, values, attitude, and emotion toward the environment (Kollmuss and Agyeman, 2002). A model by Bortoleto et al. (2012) found that individuals with a stronger environmental consciousness were more aware of environmental issues and felt a greater sense of responsibility for their waste production (Bortoleto et al., 2012). This sense of responsibility influenced their behavior to reduce their waste and their perception of task difficulty, which has been supported by other studies. A study conducted in Ghana considered prevalent attitudes and behaviors towards single-use plastics, noting a distinct group called “avoiders.” The avoiders possessed behaviors that reduced usage of single-use plastic and were more likely to avoid or pay extra to avoid single-use plastics (Adam et al., 2021). Similarly, a survey in Canada found the majority of respondents (93.7%) were motivated to reduce their personal single-use plastic packaging footprint with respect to food packaging, primarily due to environmental concerns (Walker et al., 2021).

A common way to measure environmental attitudes, in the form of broader environmental worldviews, is the New Environmental/Ecological Paradigm (NEP) (Dunlap, 2008). This measure can be used to determine the prevailing environmental attitudes in a population and explore how these attitudes may relate to the behaviors or views on certain topics, such as waste and plastic pollution.

1.1 The present research

Importantly, a large focus on waste generation and plastic pollution reduction is on end-of-pipeline measures, such as clean-ups, waste burning, and recycling, to name a few. These solutions are partly limited by the availability of data on waste production, behaviors, and perceptions. To add to the social lens of the waste discussion, in this work I provide a quantitative assessment of a social media challenge aimed at increasing consumer awareness of their non-perishable waste generation. This social media challenge, Futuristic February, directs participants to collect their non-perishable waste for a portion or the entire month of February. In this paper I explored the survey data collected from participants in Futuristic February in 2020, with a focus on their: waste composition, perceptions toward waste and plastic pollution issues, and environmental worldview using the NEP scale (Dunlap et al., 2000, p. 200). In addition, I conducted a mini-review of common statements about waste which are sources of uncertainty or misinformation. The mini-review consisted of top search results in popular media (Google) and scholarly articles (Google Scholar). The goal of the mini-review was to determine how the different groups (popular media, scholarly articles, and our surveyed population) aligned, but also whether popular media and the scientific community are expressing the certainty around these topics differently. This analysis focused on the following research questions:

i) What are the environmental attitudes of Futuristic February participants?

ii) What is the primary composition and weight of non-perishable waste produced by Futuristic February participants?

iii) How do Futuristic February participants perceive waste and plastic pollution issues?

iv) How are waste and plastic pollution issues portrayed in popular media and scholarly articles?

2. Materials and Methods

2.1. Participants

At the end of February 2020, an online survey through Qualtrics was distributed to participants in Futuristic February. The survey was distributed to known participants in Futuristic February through the creator of the event's Instagram (sustainableduo), in addition to those who were subscribed to newsletters from the Futuristic February campaign.

I received 111 responses to the survey, 62 of which were 100% complete submissions from either participating groups (households, work) (n=12) or individuals (n=50). However, for coherent analysis I chose to explore only individual responses for this analysis (Table 2.1). Of the 50 respondents, 25 submitted usable data on non-perishable trash weight due to challenges with either obtaining a measurement or disposing of their waste prior to survey completion.

Table 2.1: Summary of survey respondents demographic information (n=50).

Demographic Category	**Percentage**
Gender	
Female	92%
Male	6%
Other	2%
Age	
18-20	8%
21-29	60%
30-39	26%
40-49	4%
50-59	2%
Income Range	

$100,001 or over	8%
$80,001 - $100,000	2%
$60,001 - $80,000	8%
$40,001 - $60,000	20%
$20,001 - $40,000	32%
Under $20,000	30%
Education	
Doctorate	4%
Master's Degree	12%
Bachelor's degree	44%
Specialist Degree	4%
Vocational Training	0%
Associate Degree	8%
Some college but no degree	18%
High school degree or equivalent (e.g., GED)	10%
Race/Ethnicity	
Asian	4%
Black/African	2%
Caucasian	82%
Croatian	2%
Hispanic/Latinx	8%
Mixed White/Latino	2%
Employment Status	
Disabled, not able to work	4%
Employed, working 1-39 hours per week	24%
Employed, working 40+ hours per week	42%
Graduate Student	10%
Other	4%
Undergraduate Student	16%
Country	
United States	70%
Canada	10%
Germany	4%
Australia	2%
Croatia	2%

England	2%
Finland	2%
Singapore	2%
South Africa	2%
Switzerland	2%
The Netherlands	2%

2.2. Measures

2.2.1 Demographic information

Participants indicated their age, gender, income range, education, race/ethnicity, employment status, and country of residence (Table 2.1).

2.2.2 NEP scale

I included the NEP scale to capture participants' environmental attitudes. Using 15 items and five subscales, the NEP scale measures to what extent people belief that: 1) the Earth's resources are limited (limits to growth); 2) humans have the right to change and control the natural environment (human domination over nature); 3) humans influence the balance of nature (balance of nature) 4); humans are not excluded from the restraints of nature (human exemptionalism); 5) an ecocrisis is possible and caused by humans negative impact on the natural environment (risk of an ecocrisis) (Dunlap et al., 2000).

2.2.3 Non-perishable waste generation and composition

Participants were asked to select the most commonly occurring waste materials (by number of objects) among 5 categories (plastic, cardboard and paper, aluminum/steel, glass, or other), which had accompanying images to guide selection. Following this, respondents answered an open-ended question on the most common type of waste within this category.

2.2.4 Perception of waste and plastic pollution issues

I asked survey respondents to complete an 11-item series on frequent statements of misinformation or uncertainty pertaining to waste on a 5-point Likert scale. These statements spanned topics ranging from ocean trash gyre “islands” to recyclability of plastic.

2.2.5 Mini-Review of popular media and scholarly articles

I investigated differences in perception of each of the survey statements in a mini-review of 160 media and journal articles. The goal of this analysis was to determine if there is a gap between how these statements are expressed in scientific literature, popular media, and the views expressed in the surveyed population. In this analysis I attempted to simulate how a participant might search for information on these statement topics on two widely used search engines, one widely used by the scientific community (Google Scholar) and one with a broader readership (Google). I determined the degree of uncertainty of each statement on a 3-point Likert scale based on recent literature on each topic published until the end of February 2020 and compared this to recent popular media using the same search terms. Key search terms from each statement were queried through Google Scholar and Google. In either case, the first 10 resulting items from each search were scanned for relevance to the statement using keyword searches (Table 2.2).

Table 2.2: Waste and plastic pollution issue statements and, when applicable, their relevant search terms used in the scholar and google mini-review. Note that statements 5, 6, and 10 were not included in the mini-review.

Statement	Search term 1:	Search term 2:
1. Bioplastics are all biodegradable.	bioplastics biodegradable	
2. Biodegradable plastics are able to break down in the environment.	biodegradable plastics break down environment	
3. Glass is infinitely recycled in recycling facilities.	glass infinite recycling	glass recycling
4. Ocean trash gyres, locations in the ocean where large quantities of trash are concentrated by currents, have trash islands that can be seen from space.	ocean garbage patch visible from space	ocean garbage patch visible from space
5. Reducing our trash / garbage prevention is the best way to reduce our overall environmental footprint.	N/A	
6. Plastic pollution is the greatest threat to our environment.	N/A	
7. Glass or paper are better alternatives to plastic.	plastic alternatives glass	plastic alternatives paper
8. All plastics are equally recyclable.	plastic types recyclability	
9. Single-use items are better if they can be composted.	single use composting environmental impact	
10. Waste (in the form of trash/garbage) is the greatest threat to our oceans.	N/A	
11. Microplastic particles (broken up pieces of larger plastic or smaller plastic like microbeads) are toxic to humans and animals.	microplastics toxic animals	microplastics toxic humans

Based on the content resulting from the keyword search and the general conclusions provided by the article or text, the statement was assigned as “Agree,” “Unsure,” or

“Disagree.” “Unsure” was chosen when the result returned either conflicting statements or expressed a degree of uncertainty, such as a need for further research on the topic or applicability of an answer to a specific set of conditions. If the statement topic was not addressed as either option, then the next search result was scanned until a total of 10 results were found. In some cases, this required changing the search term to locate more relevant articles. For statements that required investigation of two separate affirmative conditions, such as Statement 7 and 11, search results were split in half between each condition, with 5 results for each. Three statements (Statement 5, 6, and 10) were excluded from this analysis because they were too broad or required a more in-depth investigation than this analysis provided.

2.3. Procedure

Participants gave their informed consent prior to participation. Additional information on adherence to ethical standards for human research can be found in Appendix A-1. The survey was distributed to participants at the end of the Futuristic February campaign and collected basic demographic information, quantitative and qualitative data on their non-perishable waste, their perception of waste and plastic pollution issues, and their ecological worldview using the NEP scale.

Following basic demographic questions, survey respondents were asked about: non-perishable waste weight and composition, perception and knowledge of waste and plastic pollution issues, and their perception of the relationship between humans and the environment. The survey and its format can be found in Appendix A-2. Furthermore, I conducted a mini-review within Google and Google Scholar to compare participants' perception about waste and plastic pollution with common narratives in media and current scientific findings.

2.4. Data analysis

Data analysis was performed in Microsoft Excel and R Statistical Software (R Core Team, 2022) using the likert (v.1.3.5; Bryer and Speerschneider, 2016), psych (v.2.2.9; Revelle, 2022), and tidyverse (Wickham et al., 2019) packages. Open-ended responses to the most commonly occurring trash item within their chosen category were grouped into 14 categories based on commonly mentioned trash items arising from written responses (Table A.2). Comparison between the mini-review results and grouped participant results was done on a 3-point Likert scale. Participant results were assigned to “Agree” if they were either “Strongly Agree” or “Mildly Agree” and results were assigned to “Disagree” if they were either “Strongly Disagree” or “Mildly Disagree.” However, this adjustment to a 3-point Likert scale was only for comparison with the mini-review and is left on the 5-point scale otherwise.

3. Results

3.1. New ecological paradigm (NEP) scale

Respondents ecological worldview was high (*M*=4.32, *SD*=0.88) and the internal reliability of the 15 NEP scale items in the study was acceptable (Cronbacks alpha=0.68) and mirrored the average Cronbach's alpha among NEP studies worldwide (Hawcroft and Milfont, 2010). A summary of the NEP results across the different facets from highest to lowest can be found below in Table 2.3. On average, ‘risk of an ecocrisis’, 'human domination over nature' and 'balance of nature' have the highest scores with lowest spreads whereas 'human exemptionalism' and 'limits to growth' have the lowest score with bigger spreads, indicating that our respondents strongly believe in the risk of an ecocrisis, mildly agree that humans dominate over nature and that this impacts nature, mildly agree that humans are not exempt from natures constraints, and that nature has limits of growth.

Table 2.3: Ecological Worldview Facets among Futuristic February participants (n=50).

NEP Facets	Mean	SD
Risk of an ecocrisis (5, 10, 15)	4.71	0.65
Human domination over nature (2, 7, 12)	4.44	0.91
Balance of nature (3, 8, 13)	4.28	0.94
Human exemptionalism (4, 9, 14)	3.97	1.17
Limits to growth (1, 6, 11)	3.65	1.40
Total	**4.32**	**0.88**

Note. The numbers in parenthesis indicate the NEP item . SD = Standard Deviation.

Survey responses to the presented NEP items show that almost all answers are skewed, meaning that most participants strongly agreed or strongly disagreed (Figure 2.1). All agreed that 'humans are severely abusing the environment' and the greater majority expressed that humans are 'subject of the laws of nature' (98%), that our interaction with nature 'causes disastrous consequences' (98%) and if it continues like that, we 'will soon experience a major ecological catastrophe' (98%). Moreover, most participants did not believe that 'humans were meant to rule over the rest of nature' (94%), that we will eventually learn enough about it to 'be able to control it' (74%) and that the ecological crisis had been 'greatly exaggerated' (88%). However, 30% of the respondents were unsure about 'human ingenuity will ensure that we do not make the Earth unlivable' but overall leaning more towards disagreeing with that statement (42%). A detailed overview of the means and standard deviations for each statement can be found in the Appendix in Table A.1.

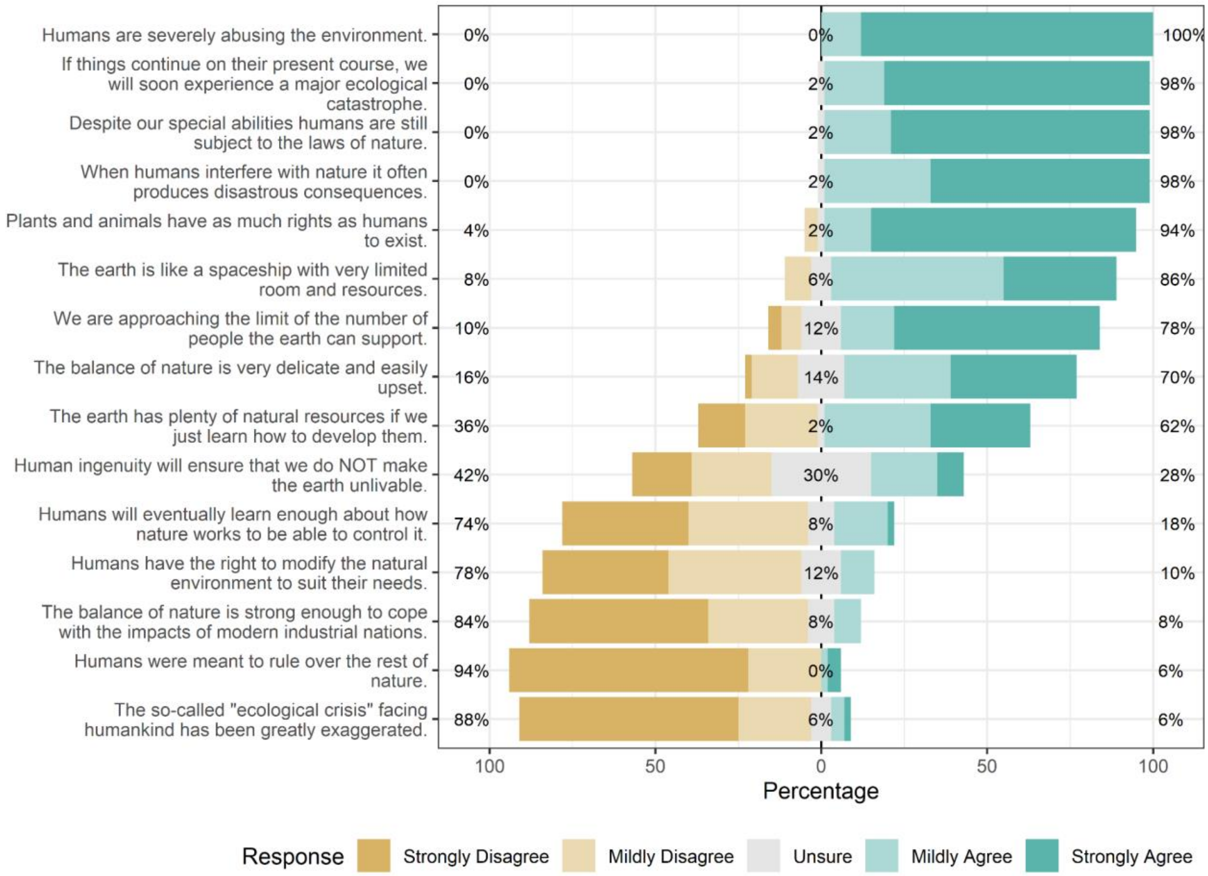


Figure 2.1: New Environmental Paradigm (NEP) scale results in percentage of agreement. Note that agreement with the odd numbered items and disagreement with the even numbered items display a pro ecological worldview response. Odd numbered items (indicated with *) were re-coded for the descriptive statistics.

3.2. Non-perishable waste generation and composition

Non-perishable waste generation was low among respondents (*M*=0.157 kg per person per day, *SD* = 0.199 kg per person per day, n=25) and trash composition was variable. Non-perishable trash weight varied by orders of magnitude, with the minimum trash accumulation per day weighing approximately 0.061 kg/day and the highest at 2.069 kg/day. The most commonly occurring waste for each participant by visual inspection was cardboard and paper (66%), followed by plastic (18%), aluminum and steel (10%), and glass (6%) (Figure 2.2). The top 5 most common trash types within all categories included: food packaging, mail, beverage container, boxes, and takeout boxes.

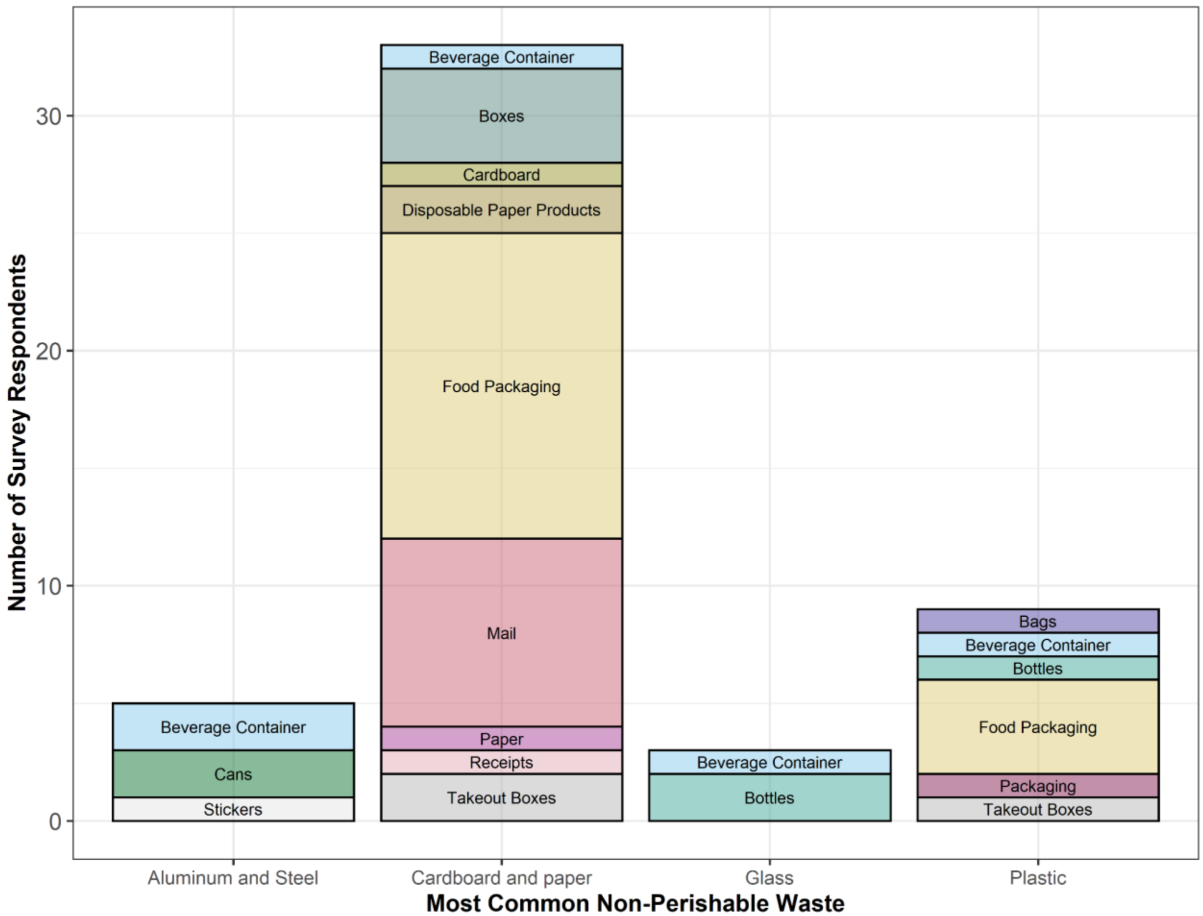


Figure 2.2: Stacked bar chart showing the fraction of responses (n=50) for the most commonly occurring non-perishable waste (by number of objects, based on visual estimate) from the participant's non-perishable waste. Each stacked bar shows the relative contribution of the most frequently occurring waste from within that category. Cardboard and paper was the most common category, while food packaging was the most common trash type across categories.

3.3. Perception of waste and plastic pollution issues

Survey responses (n=50) to the provided statements had varying levels of agreement and uncertainty based on responses on a Likert scale. Responses indicate that the two statements related to bioplastics had the greatest percentage of unsure or uncertain responses (44% and 30%), followed by statements on glass recycling (24%) and ocean trash gyres (12%) (Figure 2.3). Only three statements had no unsure responses, with the statement on microplastic toxicity obtaining 100% mildly or strongly agreed responses. However, 6 of the 11 statements received over 80% agree responses. In contrast, the statement “All plastics are equally recyclable” had 98% mildly or strongly disagree responses, which is 44% higher than the next highest rated statement.

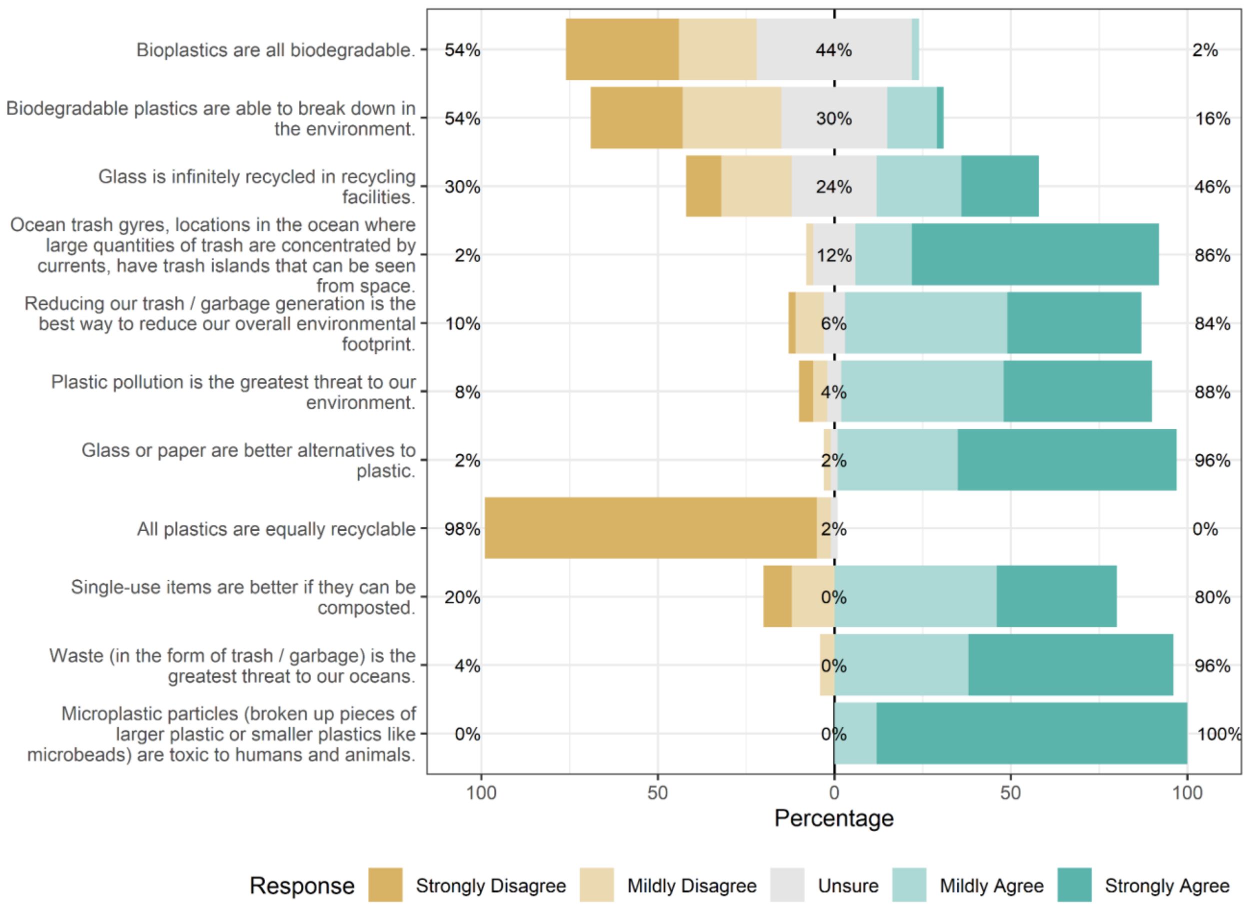


Figure 2.3: Likert plot of the percentage of responses (n=50) to different statements on waste management and plastic pollution that are potential areas of misinformation or uncertainty. Statements are listed in descending order of uncertainty based on percentage of “unsure” responses.

3.4. Mini-review of plastic and waste issue statements

The mini-review results were compared to participant responses on a 3-point Likert scale (Figure 2.4). Agreement between the three populations (Google Scholar, Google, and participants) varied. There was no consistent pattern across topics that participant results were more in line with either the Google Scholar or Google review, but instead were topic specific. Both Google Scholar and Google results disagreed with the statement that ocean trash gyres “have trash islands that can be seen from space,” while participants generally agreed with the statement (84% strongly or mildly agreed). However, Google Scholar, Google, and participants generally disagreed that “All plastics are equally recyclable.” The statements on bioplastic had the highest percentage of “unsure” responses from participants which is somewhat consistent with Google and Google Scholar results, which were generally unsure or in disagreement on these topics. Uncertainty in the review was typically attributed to the need for a topic to have further research or conflicting statements present in the cited works.

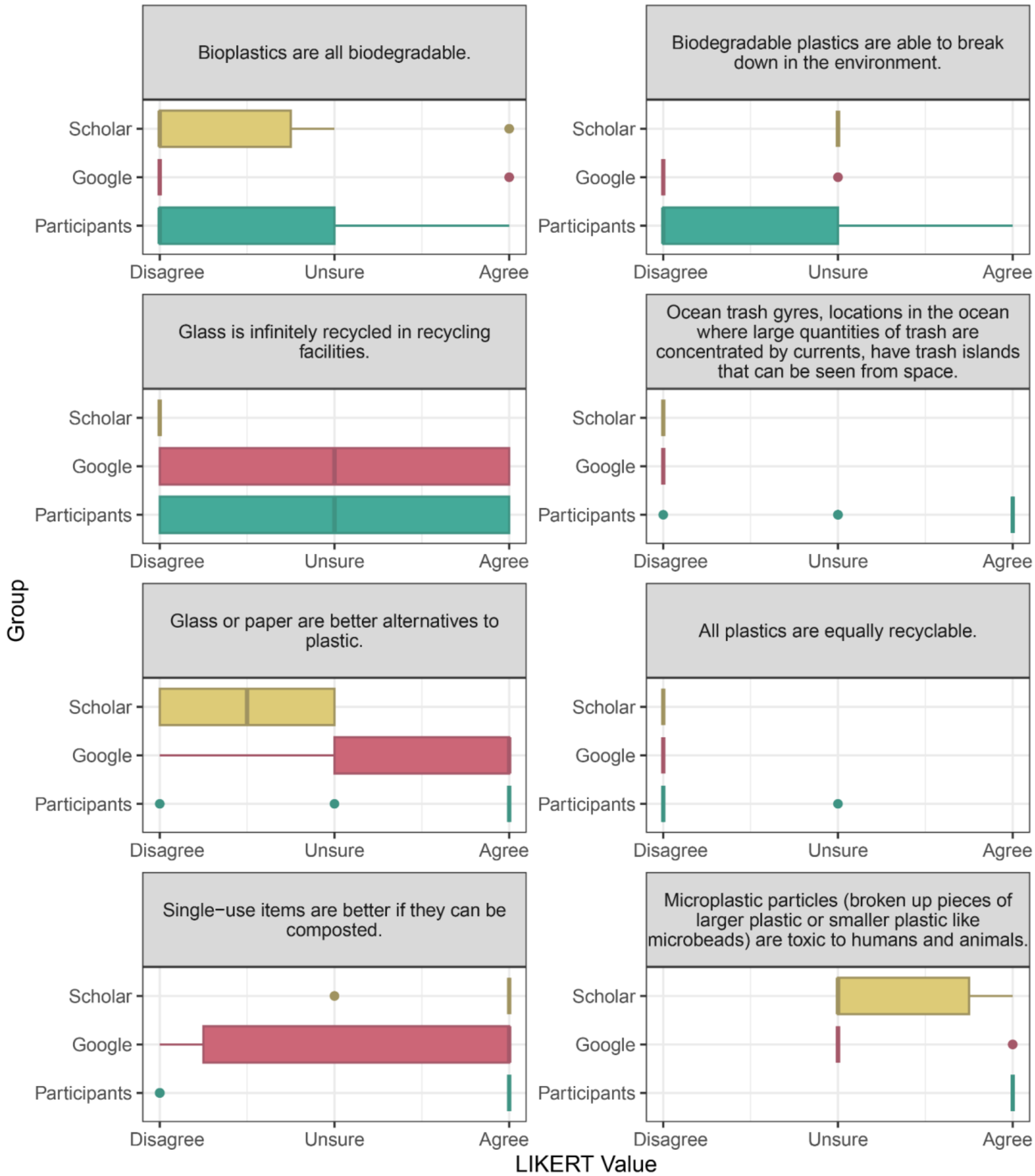


Figure 2.4: Box and whisker plots showing participant responses normalized to a 3-point rating scale for comparison with our mini-review findings on both Google and Google Scholar (Scholar). Group agreement and uncertainty on statements differs depending on the topic. Note that statements including separate conditions (glass or paper and toxicity to humans and animals) had search results split between each affirmative statement.

4. Discussion

4.1. New ecological paradigm (NEP) scale

The NEP scale showed participants in this study are environmentalists. As recommended by previous meta-analysis (Hawcroft and Milfont, 2010), all used NEP items, the mean, the standard deviation, and its internal reliability were reported (see Section 3.1) alongside the sample characteristics to improve the interpretation of results. A meta-analysis (Hawcroft and Milfont, 2010) showed that environmentalists score higher on the NEP scale in comparison with other representative samples. In a sample of thirteen studies investigating environmentalist environmental attitudes, NEP mean scores between 3.44 to 4.70 were reported (Hawcraft and Milfont, 2010). Moreover, prior studies concluded that women tend to have a higher worldview than men (Hawcroft and Milfont, 2010), which is consistent with the largely female demographic (92%) represented in this survey population. Additionally, past studies found a ‘ceiling effect’ suggesting that environmentalists tend to strongly agree or disagree with almost all NEP items (Wiidegren, 1998). Both findings are in line with this study results as almost all responses to the NEP statements were skewed towards agree or disagree with an overall mean of 4.23 (*SD*=0.88). This pattern confirms the prior assumption that participants taking part in a sustainable and reflective social media challenge about waste could fall into the group of environmentalists – at least when it comes to their ecological worldview and attitudes.

4.2. Non-perishable waste generation and composition

The non-perishable waste generation and composition of participants was predominantly paper and cardboard, with general trash items across categories derived from food packaging. This pattern is consistent with other reports, such as What a Waste 2.0 (Kaza et al., 2018) and UNEP's Global Waste Management Outlook (Wilson et al., 2015), though there are slight variations depending on income level and chosen categories. The paper/cardboard category in these reports tends to increase with higher income populations, while plastic and paper categories are almost equal or exceeding in lower income populations. However, in terms of waste management, cardboard and paper composed over half the recycling in 2018 in the United States (EPA, 2020), where the majority (70%) of participants reside. The second highest waste category, plastic, has more worrying waste management implications given its low recycling rate (9% global (OECD, 2022), 5-6% in the U.S. (Beyond Plastics and The Last Beach Cleanup, 2022)) and likelihood of waste mismanagement, resulting in plastic pollution.

The predominance of plastic packaging in various forms is consistent with global plastic production, with packaging comprising 40% of plastic produced (OECD, 2022). Packaging in the form of take-out or take-away also experienced an increase during the COVID-19 pandemic (Janairo, 2021; Parashar and Hait, 2021), increasing the contribution of these items to the overall waste stream and, possibly, into litter and the environment. Plastic food packaging in particular has been found to make up the largest portion of litter in most environmental compartments, excluding marine litter (Morales-Caselles et al., 2021). Even if some of these waste items are recyclable, the decreasing recycling rates of plastic with the continued increase in production presents worrying implications for environmental impacts.

The average of participants (n=25) that included the weight of their non-perishable waste had an average daily waste production (0.157 kg per person per day) well below the worldwide average of 0.74 kg per person per day (Kaza et al., 2018). However, the worldwide average includes other perishable categories of waste which were not measured in this study. Participants' average waste production was below the United States average in 2018 (2.223 kg per person per day or 1.896 kg per person per day accounting for the exclusion of composted or food management material) (EPA, 2020). The highest waste production from a participant was 0.938 kg per day and coincides with the selection of glass as the most common waste category, which likely contributed to this increased weight.

There are solutions on a global, local, and individual scale that can contribute to the overall reduction in waste production that were most common in the surveyed population. Individuals can choose to refuse or reduce food or drink packaging when there are reusable alternatives available, such as the use of reusable bags or bottles. Local initiatives such as reusable takeout systems can help to make these options more widely accessible and available. Additionally, opting out of junk mail and choosing paperless transaction options can further reduce cardboard and paper waste. Policy aimed at reducing single-use items, such as plastic bags (Xanthos and Walker, 2017), can also provide the motivation to find reusable alternatives, especially when combined with a fine. Further study should consider the behavioral component of implementing bans on packaging and any unintended or negative effects of these policy changes or potential material substitutions. There is uncertainty in some of these solutions and options should be considered with regard to other life cycle impacts and the community served, especially if waste management options are limited in a certain area.

4.3. Perception of waste and plastic pollution issues: participant survey and mini-review

Three of the plastic and waste statements were not considered in the mini-review due to their broad nature and difficulty in identifying concrete answers due to their reliance on opinion or rating of various environmental threats. These were statements 5, 6, and 10 (Table 2.2), which focused on reduction of one's overall environmental footprint and the threat plastic pollution or waste poses to the environment or the oceans, respectively. Most participants (at or exceeding 88%) either strongly or mildly agreed with these statements, indicating that the surveyed population placed a great emphasis on the importance of addressing the environmental challenge of waste and plastic pollution, potentially over other issues of concern. This pattern is consistent with the surveyed population's pro-ecological worldview and participation in a social media challenge focused on waste. However, this perspective brings an important issue on drawing comparisons between co-occurring environmental issues. These statements were included since they are often the subject of debate in literature (Miller, 2020; Walker and McKay, 2021) and the priority of climate or ocean pollution as environmental threats are often weighed against one another (Avery-Gomm et al., 2019; Stafford and Jones, 2019). The issue of climate change is often rated or scaled against that of plastic pollution, drawing a false comparison that these issues are considered separate concerns and may be a distraction from one another. Recent work has shown that the climate and plastic crises are intricately connected (Zhu, 2021). To address this misconception, further educational campaigns might be conducted on material usage, including waste and plastic, draw attention to the interconnectedness of these environmental issues. This approach would lend additional strength to tackling either problem.

One proposed method to address the plastic problem is material substitution, such as replacing plastic packaging with alternatives like glass or paper. Most participants (98%) agreed that glass or paper are better alternatives to plastic. It is unclear if this perception contributed to the dominance of cardboard and paper packaging in participants' waste streams. Survey responses more closely aligned with Google results over scholarly articles, which presented evidence against glass or paper from life cycle assessment studies (Garfí et al., 2016; Humbert et al., 2009b, 2009a; Rana, 2020) or uncertainty given the evaluated environmental impacts (Lewis et al., 2010) or disposal method (Pasqualino et al., 2011). Search results on Google largely agreed with this statement, citing the biodegradability of paper (Guarro Casas, n.d.) and a reduction in exposure to hazardous chemicals (Seas and Straws, 2018). The weight of glass packaging is often considered a detriment due to increased emissions from transport (Humbert et al., 2009b). However, note that life cycle assessments often do not consider certain end-of-life impacts, such as pollution, littering, and environmental persistence, especially with regards to plastic (Hann, 2020). Moreover, these impacts can be lessened when materials are able to be reused or recycled.

Participants were split on the statement “Glass is infinitely recycled in recycling facilities,” possibly owing to the differences in the recycling of glass in their local recycling infrastructure. The scholarly article review disagreed with this statement due to material loss from the recycling process (Larsen et al., 2009), potential contamination and quality differences (Bonifazi and Serranti, 2006; Dyer, 2014; Lebullenger and Mear, 2019; Testa et al., 2017), or systematic challenges at recycling facilities (Lebullenger and Mear, 2019; Roy, 1997). However, popular media or website search results were split on this statement, which may add to the confusion communicated to the general public. In the United States, the recycling of glass is challenged by issues presented by the single stream recycling system (Jacoby, 2019) which may introduce issues with quality control and contamination. However, recycling rates for glass are higher in other countries, such as Italy (Testa et al., 2017). Policy efforts to increase source separation of glass by expanding bottle bills, such as the one introduced in the state of New York (Cook et al., 2022), could increase recycling of glass, but also requires further effort on the part of individuals to source separate glass and bring the glass to a designated collection point. Since glass reuse and recycling has an overall lower life cycle impact, it is recommended that reuse and recycling of glass is prioritized where possible.

Similar to glass, the quality and type of plastic material can dictate its recyclability. 98% of participants disagreed with the statement that “All plastics are equally recyclable,” which was consistent with both the Google and Google Scholar review. This statement is falsifiable, given that the complexity of various plastics (color, polymer type, additives) can influence recyclability (Faraca and Astrup, 2019). Though this influences the recycling rates of various plastic resins, plastics are still downcycled during their lifespan. This statement was the only one that had complete alignment between survey participants and review results. Since recycling is dependent on this knowledge, it may be a more commonly educated topic, explaining the consistent alignment across search results.

An alternative to reuse and recycling is the composting of materials. Most participants (80%) agreed that "Single-use items are better if they can be composted." This pattern was consistent with review results, which generally favored the added benefit of soil amendment production with composting of single-use items (Castro-Aguirre et al., 2018; Eco Cycle, n.d.; Narayan et al., 2007). However, it is important that items marketed as compostable are properly tested for potential introduction of either particles or other byproducts into soil amendments. Moreover, while composting may be favorable to landfilling of materials, materials should be conserved with reduction or reuse when possible to prevent regrettable substitution of one material with another.

Statement topics related to bioplastic or biodegradable plastic had the highest uncertainty among survey respondents. The statement "Bioplastics are all biodegradable" is largely aimed at assessing knowledge of the definition of "bioplastic," which is often loosely defined. The labeling and disparate terminology and information regarding bioplastic or biodegradable plastic may contribute to this uncertainty or confusion. According to the European Bioplastics definition (European Bioplastics, n.d.), bioplastics can be either biobased, biodegradable, or both. Despite the bioplastics statement having the highest uncertainty in responses, 54% of respondents recognized that bioplastics are not all biodegradable. Even in the mini-review, 2 out of 10 results in both scholarly articles and Google did not adequately differentiate between bioplastics and biodegradable plastics. The adoption of a consistent terminology in both popular media and scientific articles is necessary going forward.

Compared to the prior statement, there was an increase in respondents who agreed (16%) that “Biodegradable plastics are able to break down in the environment.” This statement is either uncertain or false, depending on the conditions and the type of bioplastic, and points to issues in the communication of information and marketing regarding biodegradable plastic (Filho et al., 2021). These results are consistent with findings in an Australian survey, which found that 58% of respondents were unsure if bioplastics have any negative environmental impacts (Dilkes-Hoffman et al., 2019). It’s possible that this uncertainty arises from a lack of exposure to bioplastics or biodegradable plastics. In the United States alone, there are 4,700 industrial composting facilities (Lewis, 2021), some of which may not accept bioplastics (Goldstein, 2019). If bioplastic is to increase in popularity and become a stable portion of the waste stream, there will need to be an increase in education surrounding its proper disposal and use. All scholarly articles were uncertain concerning this statement, largely due to the influence of environmental conditions on biodegradability (Havstad, 2020; Kjeldsen et al., 2018; Lambert and Wagner, 2017; Luyt and Malik, 2019; Rujnić-Sokele and Pilipović, 2017; Scott, 1990). If it is a widely held belief that biodegradable plastics break down in any environment, this may lead to increases in littering of certain bioplastics (SGA, 2009).

One myth that has played some role in public perception of the plastic pollution issue is the existence of “trash islands” in the ocean arising from the convergence of plastic waste in gyres. This myth has pervaded popular media and has possibly even been instrumental in increasing awareness and response to the plastic pollution issue. This statement is falsifiable with multiple parts of this statement, including the existence of trash islands or that the ocean trash gyres can be seen from space. Most survey participants (86%) agreed, to some extent, that ocean trash gyres have trash islands that can be seen from space. However, both Google and Google Scholar mini-review results consistently agreed that this statement is false despite the general consensus among participants, indicating that this myth has persisted despite efforts to correct it. Instead, sources described the ocean trash gyres as a plastic soup (Gabrys, 2016; Seas and Straws, n.d.; Tischleder, 2016; Wang, 2015) rather than an island. Though this image is less striking than that of a plastic island, the issue of plastics has enough motivating imagery to lend itself to an increase in awareness of this issue (Luo et al., 2022).

The statement on microplastic toxicity to humans and animals is the only statement that received 100% mild or strong agreement among our survey respondents. This is generally consistent with the environmentalist perspective that is prevalent within the surveyed group, which had majority agreement that waste and plastic pollution issues are highly concerning issues and had a generally pro-ecological worldview. By comparison, mini-review results were either uncertain or in agreement with this statement, depending on whether the article in question addressed toxicity in biota or in humans. The mini-review was split between articles addressing either biota or humans, or both. Concerning biota, scholarly articles were more definitive in addressing various types of toxicity already discovered in biota (Lu et al., 2019; Trestrail et al., 2020; Verla et al., 2019), while Google results were more uncertain. This pattern may be due to an uncertainty in how “toxicity” is defined or considered. In the review, I considered any toxicity endpoints mentioned by the authors. However, only one result in the mini-review, from Google, agreed that microplastics are toxic to humans (CIEL, n.d.). Due to the difficulty in exploring these results concurrently, these statements might be separated in the future. I hypothesize that including articles that only address toxicity in both groups (biota and humans) would result in a prevalence of uncertain results due to the lack of direct evidence for microplastic toxicity in humans, though analogous results in other studies exist (Wright and Borm, 2022).

5. Limitations and future research directions

While discussing the assets of the current research, it is important to note some gaps and avenues for future research. Therefore while the respondents themselves were not able to self-identify the responses of participants to the NEP scale are similar to those of other environmentalist samples. Moreover, as the survey was administered after the social media challenge, the respondents may have participated in the challenge because they have a high ecological worldview or that taking part in the challenge impacted their worldview. Therefore, for future research with similar endeavors it may be useful to a) add an item in which participants can self-identify as environmentalists and b) apply a pre-post test design, together with a control condition, to explore if views change by taking part in a sustainable challenge about waste, such as in Heidbreder et al. (2020).

There are also limitations in participants evaluating their own generation of waste. In this survey, participants chose their most common waste visually by the most common number of items. Data were obtained on the total weight of non-perishable waste from half of the participants, since participants were either unable to weigh their collected waste or had already disposed of it prior to completion of the study.

The viewpoints expressed in this survey are biased toward a particular population of environmentally minded individuals and conclusions are limited by the smaller sample size (n=50). Most participants were white/Caucasian (82%), female (92%), and resided in the United States (70%). This pattern may be a result of the reach of the Futuristic February campaign or the survey, as well as potential influences of gender on environmental participation or social media. Other research and media has noted the potential influence of gender on performance of pro-environmental behaviors (Hunt, 2020; Swim et al., 2020), which may have influenced either participation in the social media campaign or survey.

6. Conclusion

This work considered the waste generation and perceptions of participants in a social media campaign, Futuristic February, which is aimed at raising awareness of individual waste production. The sample (n=50) scored high on the NEP scale, indicating a pro-ecological worldview consistent with an environmentalist population (Hawcroft and Milfont, 2010). Non-perishable waste weights were collected from a subset of participants (n=25) and the average was low (*M*=0.157 kg per person per day) compared to global production. Non-perishable waste largely consisted of cardboard and paper waste, specifically food packaging. Various means were offered with which individuals can approach waste reduction in waste categories common to the survey participants, including the reduction of unnecessary waste or material use, reuse of often disposed of items, and the implementation of policies and programs to promote circular principles.

Participants' perceptions of waste and plastic issues and the mini-review of these issues show that the availability of accurate information and educational materials is important to implementation of sustainable waste practices. This includes improving the description and labeling of biodegradable plastics and bioplastics, which were topics of higher uncertainty in survey results. I also found that certain myths about plastic, including the existence of trash islands in the ocean gyres, have persisted despite popular search results providing majority accurate information on the topic.

Chapter 3: Improving the Capture and Monitoring of Microplastics in Freshwater Ecosystems: A Case Study Comparing Urban and Rural Lakes in Central New York

1. Introduction

The lack of standard methods for both collection and processing of microplastic sampling makes challenges comparisons among microplastic studies . There is an abundance of field methods used to collect microplastics in freshwater ecosystems (Razeghi et al., 2021). Sampling can be categorized by the method of volume collection (bulk vs. volume-reduced) and the area sampled (point vs. area). Volume-reduced sampling methods include a step to reduce the volume of water collected in the field, with either a net or sieve, while a set volume is collected in bulk sampling that can be processed fully or reduced in the laboratory. Sampling methods also target either a point location, such as the volume captured with a grab sample, or water captured over an area, such as a mesh net. It has been suggested that volumes exceeding 500 L are required for accurate quantification of microplastic particles in surface waters (Koelmans et al., 2019).

Previous work has explored the impact of sampling volume, sample method, mesh size, and blank correction on reported microplastic concentrations (Watkins et al., 2021). However, less than 5% of the studies considered in the meta-analysis by Watkins et al. (2021) accounted for contamination from the entire collection to measurement process (field to laboratory). Therefore, an analysis of how these sampling methods perform using strict quality control procedures would inform monitoring programs which are designed to assess particle diversity in the environment.

While quality control procedures are commonplace, their use and application vary. There is not a currently accepted, standard practice for the correction or reporting of microplastic concentrations using either field or procedural blanks. Practices include reporting the directly measured values (Baechler et al., 2020; O'Brien et al., 2020) subtraction using various categories (e.g. morphology, color-morphology, polymer type) (Grbić et al., 2020; Hung et al., 2021; Zhu et al., 2021), and the use of quantification limits, such as the limit of detection (LOD) and limit of quantification (LOQ) (Horton et al., 2021; Johnson et al., 2020; Tsering et al., 2022). The use of subtraction by averages could result in under-correction when blank contamination is highly variable over the course of a study. In this research, I relied on the use of quantification limits, including the limit of detection, which has been recommended in previous work (Dawson et al., 2022).

In this work I compared the effectiveness of microplastic capture in two lakes in central New York, focusing on exceedance of detection limits and diversity of captured microplastics. In Chapters 3 and 4, I consider two freshwater ecosystems in central New York, a relatively pristine (Skaneateles Lake) and historically polluted lake (Onondaga Lake). Since I expect regional factors to influence microplastic sources, these two lakes should provide a contrasting perspective on microplastic pollution. Skaneateles Lake is also an important source of drinking water for the region, supplying unfiltered drinking water to the City of Syracuse.

I sampled plastic particles in the surface waters of Onondaga Lake and Skaneateles Lake for 3 years (2019 – 2021). I employed various sampling techniques, including both volume-reduced and bulk sampling, and determined which more commonly provided particle abundances above the LOD and LOQ. I hypothesized that increases in sampling volume, decreases in mesh size, and sampling over an area (net) of water would increase particle capture. Through this work, I aim to:

- Determine the impact of sampling methods (grab, bucket sieved, pump, and net) on microplastic particle capture quantities compared to detection limits;
- Compare the diversity of particles captured among sampling; and
- Characterize the spike recovery of a diverse suite of nine pristine microplastic particles generated from common plastic products.

Ultimately, this work can inform future microplastic monitoring campaigns by discussing the impacts of sampling methods and processing on microplastic capture and recovery.

2. Site Description

Onondaga (43.0903° N, 76.2103° W) and Skaneateles (42.9089° N, 76.4091° W) lakes in central New York (Figure 3.1) provide two contrasting conditions with respect to potential microplastic pollution sources. While Onondaga Lake has previously been known as the most polluted lake in the US (Chanatry, 2012), Skaneateles Lake has been referred to as the cleanest in the world (Dove, 2007). Onondaga Lake is an alkaline dimictic lake proximal to the City of Syracuse, which has a population of approximately 146,000 people (U.S. Census Bureau, 2021). Onondaga Lake occupies an area of approximately 12 km^2 and has a maximum depth of 20 meters (NYS Dept. of Environmental Conservation, 2020). Onondaga Lake receives up to 20% of its inflows from Metropolitan Syracuse Wastewater Treatment Plant (METRO) effluent, with an additional 70% of inflows from two major tributaries, Onondaga Creek and Nine Mile

Creek (NYS Dept. of Environmental Conservation, 2020). Onondaga Creek lies on a rural to urban gradient from its headwaters located approximately 43.5 km south in Tully, New York and flows from upstream at Dorwin Avenue through the city of Syracuse to Spencer Street before discharging into the Inner Harbor and ultimately into Onondaga Lake (Onondaga County Parks, 2023).

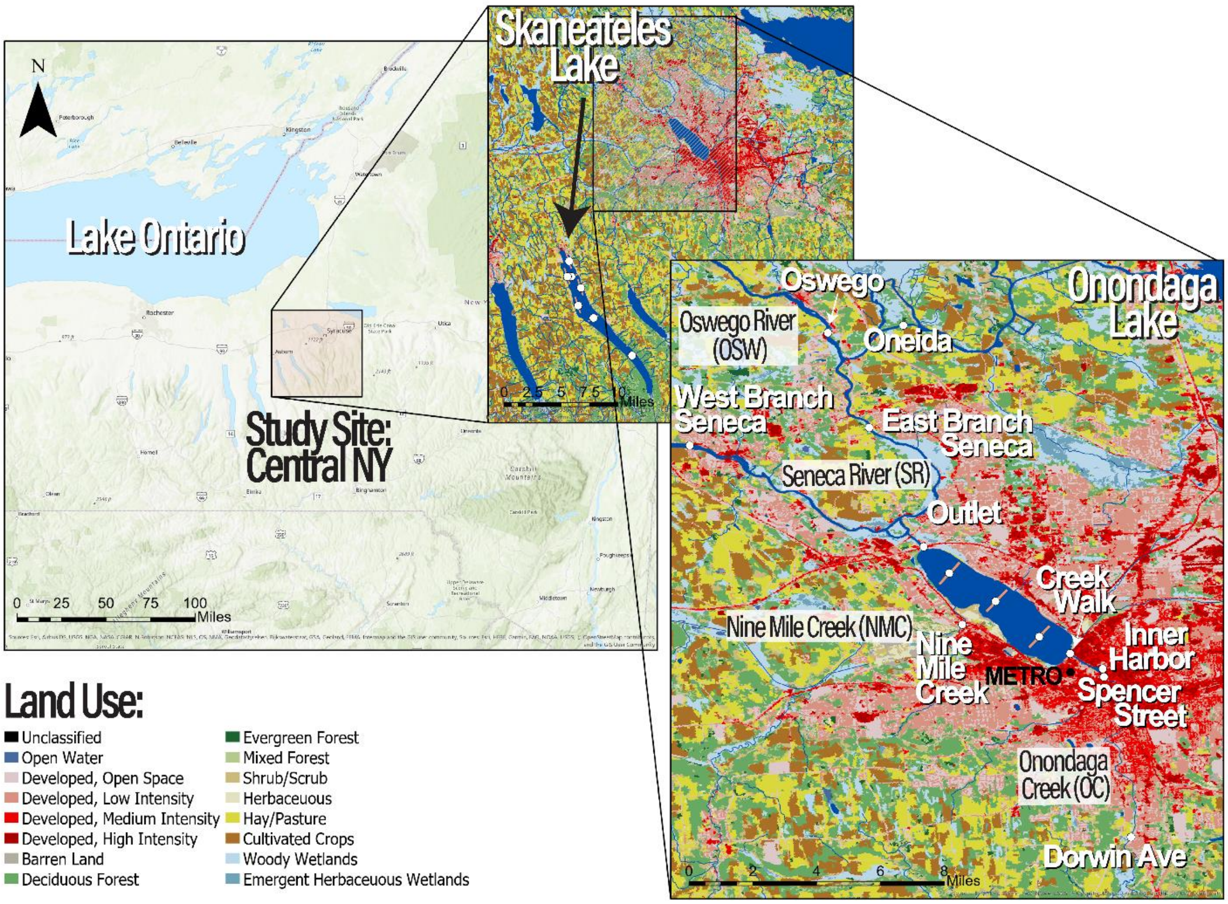


Figure 3.1: Site map showing the location of Onondaga and Skaneateles lakes and associated land use in the general region of Central New York in the United States (Multi-Resolution Land Characteristics Consortium (MRLC), 2011). Locations of sampling are represented with white dots and orange tow lines. Refer to Table 3.1 for sample types collected at each location.

Onondaga Lake has a history of pollution from industrial and urban wastes (Effler, 1996).

Prior to remediation, major pollution sources into the lake was two-fold, with salt and mercury inputs from industrial wastes (Matthews et al., 2013) and excessive nutrients, primarily nitrogen and phosphorus, from combined sewer overflows (CSOs) and wastewater effluent (Effler, 2010). The lake is under continued monitoring and remediation for mercury contamination from industrial waste (Matthews et al., 2013), but has seen remarkable improvements in water quality. Sources and pathways for plastic pollution in Onondaga Lake include street litter, wastewater effluent, and CSO events largely from the Syracuse metropolitan area.

As of December 2021, Onondaga Creek comprised the highest combined sewer area contribution to METRO wastewater treatment plant (73.4%) (Onondaga County Department of Water Environment Protection and Jacobs, 2022). However, CSO discharges are largely located in Syracuse along lower Onondaga Creek, while locations upstream of Syracuse (e.g., Dorwin Avenue), are less impacted. The lower, middle, and upper segments of Onondaga Creek, including tributaries, are considered impaired and are listed on the 303(d) list for pollutants including ammonia, fecal coliform, phosphorus, and turbidity (New York State Department of Conservation, 2018). Additionally, wind, stormwater, and snow melt contribute floatable plastic waste, such as plastic bottles, expanded polystyrene (EPS) food containers, and syringes, to Onondaga Creek, which often collect in the Inner Harbor area immediately before discharge to Onondaga Lake (Collins, 2017). Though CSO discharge remains a potential source of plastic pollution during high flow events, there are some measures to reduce floatable contamination using floatable control facilities, which include net bag, baffles, and vortex separators in outfalls to Onondaga Creek. Additional floatable controls include trash cleanup, street sweeping, catch basin filter insert cleaning, porous pavement vacuuming, and the use of skimmer boats in the Inner Harbor of Onondaga Creek to collect floating litter and woody debris (Onondaga County Department of Water Environment Protection, 2020). Discharge from the Inner Harbor drains past the Creek Walk prior to discharge into Onondaga Lake.

Nine Mile Creek, another major tributary to Onondaga Lake, is a popular trout fishing destination (NYS Dept. of Environmental Conservation, n.d.). The lower reaches of the creek have undergone significant restoration efforts following industrial contamination. In 2014, restoration was completed and included wetlands construction, habitat improvement, and creek bottom replacement (Honeywell International Inc., 2023).

In contrast, Skaneateles Lake is a relatively pristine lake that serves as the source of unfiltered drinking water for the city of Syracuse. Skaneateles is one of the Finger Lakes and has a maximum depth of 90 m and an area of 36 km^2 (NYS DEC, n.d.). The high quality of the lake has allowed Syracuse to withdraw drinking water from the lake without filtration. Water is, however, subject to chlorination and fluoridation at the City of Syracuse Water Plant prior to additions of orthophosphate for lead control and sodium hypochlorite upon discharge from the City’s storage reservoirs (OCWA, n.d.). Potential sources and pathways for plastic pollution into Skaneateles include those from agriculture, surrounding residences, and recreation.

3. Methodology

3.1 Sample collection

Samples were collected in Onondaga and Skaneateles lakes, as well as the major tributaries and outlet of Onondaga Lake (including the Seneca and Oswego Rivers), from 2019 - 2021 (Figure 3.1; Lake sampling included both grab and net (2019, 2020) or pump and net (2021) collections across each site, while every sample type was used for tributary sampling (**Error! Not a valid bookmark self-reference.**).

Table 3.1). Surface water samples were collected using either bulk (grab) or volume-reduced (bucket sampling with a 355 µm or 106 µm sieve, and pump sampling with a 106 µm sieve, and net) sampling methods. These varying sampling techniques were adapted over the study period to improve microplastic capture with the resources available. In 2021, to accommodate for the collection of net samples at each site, some sampling locations were slightly adjusted to provide better access to streams (Appendix

B-3). Lake sampling included both grab and net (2019, 2020) or pump and net (2021) collections across each site, while every sample type was used for tributary sampling (**Error! Not a valid bookmark self-reference.**).

Table 3.1: Summary of dates, locations, and sample types collected over the 2019 - 2021 study period.

Month	Year	River / Creek Sample Locations	Sample Types	Lakes Sampled	Sample Types
October	2019	Tributaries, Outlet (Onondaga)	Grab	Onondaga, Skaneateles	Net, Grab
June	2020	Tributaries, Outlet (Onondaga), Seneca and Oswego Rivers	Bucket 355 μm, Net (Spencer Street)	Onondaga	Net, Grab
August	2020			Onondaga	Net, Grab
September	2020	Tributaries, Outlet (Onondaga), Seneca and Oswego Rivers	Bucket 106 μm, Net (Spencer Street)	Onondaga, Skaneateles	Net, Grab

Month	Year	River / Creek Sample Locations	Sample Types	Lakes Sampled	Sample Types
November	2020			Onondaga	Net, Grab
July (Stratified)	2021	Tributaries, Outlet (Onondaga)	Pump, Net	Onondaga, Skaneateles	Pump, Net
November (Mixed)	2021		Pump, Net	Onondaga	Pump, Net
December (Mixed)	2021	Tributaries, Outlet (Onondaga)	Pump, Net		

Due to time constraints, Onondaga Lake samples were typically collected one trawl at a time in 2019 and 2020, with trawls conducted from transects in the north, middle, and south area of the lake within the same month, when possible. In 2021, lake positions were revisited and sampled within the same day. Sampling in 2021 was conducted in July, prior to lake turnover, and in November and December 2021, after lake turnover. The sampling was conducted in collaboration with the Upstate Freshwater Institute, a local NGO that has monitored the quality of Onondaga Lake and its remediation for over 30 years. Samples were collected in Skaneateles Lake with assistance from the Skaneateles Lake Association using opportunistic sampling when boats were available, which was less frequent than Onondaga Lake. Due to the size of Skaneateles Lake and the course of boat expeditions, surface water samples were collected along the northern shoreline in 2019 and 2020, rather than shore to shore. When Skaneateles Lake was revisited in July 2021, samples were collected shore to shore at 3 lake positions. Due to the late timing of lake turnover in 2021, it was not possible to sample Skaneateles Lake due to the closing of docks for the winter. A depth profile was sampled at the central location of each lake just below the surface, at the thermocline, and in the hypolimnion during stratification using a bilge pump. Following turnover, the same depths were re-sampled in Onondaga Lake. A YSI Exo Sonde was used to collect data on temperature and turbidity at the time of sampling.

Surface water samples within each lake consisted of a net trawl for 20-30 minutes with grab samples collected at the start, middle, and end of each tow consistent with Barrows et al. (2017). In 2021, pump samples were collected at the approximate middle of each tow. Lake trawl samples were collected with a HydroBios microplastic sampling net (Hydro-Bios # 438 214) with a mouth opening 70 x 40 cm and a mechanical flow meter (Hydro-Bios #438 110). This net is rated for wind conditions up to 3 knots (1.54 m/s) and efforts were made to only sample during Beaufort scale conditions of 3 knots or less. The net was attached to a metal cable which was secured to either the vessel, a pole, or a pulley system. Geographic coordinates were recorded at the start and end of each trawl and are available in Appendix Table B.2. Net samples skimmed the top 20 cm of the surface and were trawled for 20-30 minutes. After sample collection, the net was sprayed from the outside from top to bottom with a backpack sprayer filled with DI water. A net blank was collected once a day, except for one sampling event in Skaneateles Lake. Net blanks were collected to simulate the set-up for a new sample after an initial trawl by rinsing the net down, re-attaching the cod end, and rinsing down the net to collect the blank as would be conducted for a sample. In the instance when the net blank was not available, the available net blank for the site was used to assess either potential sample carryover or sample loss.

Grab, bucket, and pump samples were used over the course of this study. Grab samples were rinsed three times with stream water prior to collection. When the water surface could not be reached to safely collect a grab sample, a stainless-steel bucket with a natural fiber rope was used. When a bucket was used to acquire grab samples, the jar was submerged in the bucket to acquire a sample. Otherwise, grab samples were collected using pre-rinsed 0.95 L glass jars from the surface of the water. Bucket samples were collected with either a 355 or 106 µm sieve (Lake sampling included both grab and net (2019, 2020) or pump and net (2021) collections across each site, while every sample type was used for tributary sampling (**Error! Not a valid bookmark self-reference.**).

Table 3.1). A stainless-steel bucket was used to collect water from the surface of the river, stream, or harbor and was rinsed into the sieve into a secondary bucket. A volume of 19.5 L or 39 L was collected using the bucket sampling method, with less volume collected in areas with excessive plant and woody debris, specifically the Inner Harbor of Onondaga Lake. Particles and detritus collected on the sieve were then rinsed into a sample collection jar with DI water. Volume-reduced surface (depth = 13 cm) and water column samples were collected using a bilge pump. The pump was run for 2 minutes with water from the site prior to sample collection. Afterward, water from the pump was sieved through a 106 μm sieve into a bucket until 97.5L of water was sampled.

In 2021, two sample locations (Spencer Street and Nine Mile Creek) presented difficulties with respect to either the volume of material collected or flow estimation. In July 2021, both net samples collected an abundance of material which resulted in over 60 filters. A subsample of filters was randomly chosen from each size fraction to determine morphology and polymer abundance. At the Spencer Street location in July, a pump sample was not able to be collected due to the high amount of discharge during the time of collection. Due to low flow velocity at the Nine Mile Creek location sampled in 2021, the flow meter was not effective in determining the volume of sample collected. I was able to estimate water velocity in July 2021 by timing the movement of a jar over a length of the stream three times. However, these measurements were not made in December 2021, so particle concentration was not estimated.

In transit, samples and blanks were stored in containers or coolers. On return to the lab, samples and blanks were covered in aluminum foil. Organic rich samples, typically in net samples and some bucket samples, were refrigerated, while samples low in organics were stored in cabinets prior to processing. Further details on sample collection can be found in Appendix B-1 and B-2.

3.2 Sample processing

Organic rich samples were sieved into 4 size fractions (4.75-mm, 1.00-mm, 0.355-mm, and 0.020-mm), while samples low in organics were sieved only through the lower sieve (0.020-mm) to limit sample loss. Samples with visible woody debris and plant material had each piece of material rinsed off into the sieves with DI water, removed, and discarded. Fibrous organic material was left in the sieves to be further processed. After sieving, each sieve was rinsed through either a glass funnel or directly into a glass beaker that was covered with aluminum foil. After sieving all samples were processed in a class-1000 clean room for organics removal using methods modified from Masura et al. (2015). In short, each sample fraction was processed with 20 mL of both 30% hydrogen peroxide and Fe (II) sulfate solution. Each fraction was heated and stirred, if necessary, for a minimum of one hour and a maximum of one week, with continued additions of both peroxide and iron solution as needed. After processing, samples were vacuum filtered onto mixed cellulose ester gridded filters (Fisher Cat. #09-806-216). Care was taken to prevent filter clogging by spreading samples over multiple filters, as needed. Further details of processing are provided in Appendix B-4.

3.3 Particle characterization

A stereo microscope was used for picking suspected plastic particles, which were described based on color and morphology using a decision tree (Figure 3.2). Eight morphology categories were used: fiber, fiber bundle, film, foam, fragment, pellet, sphere, and fiber/fragment.

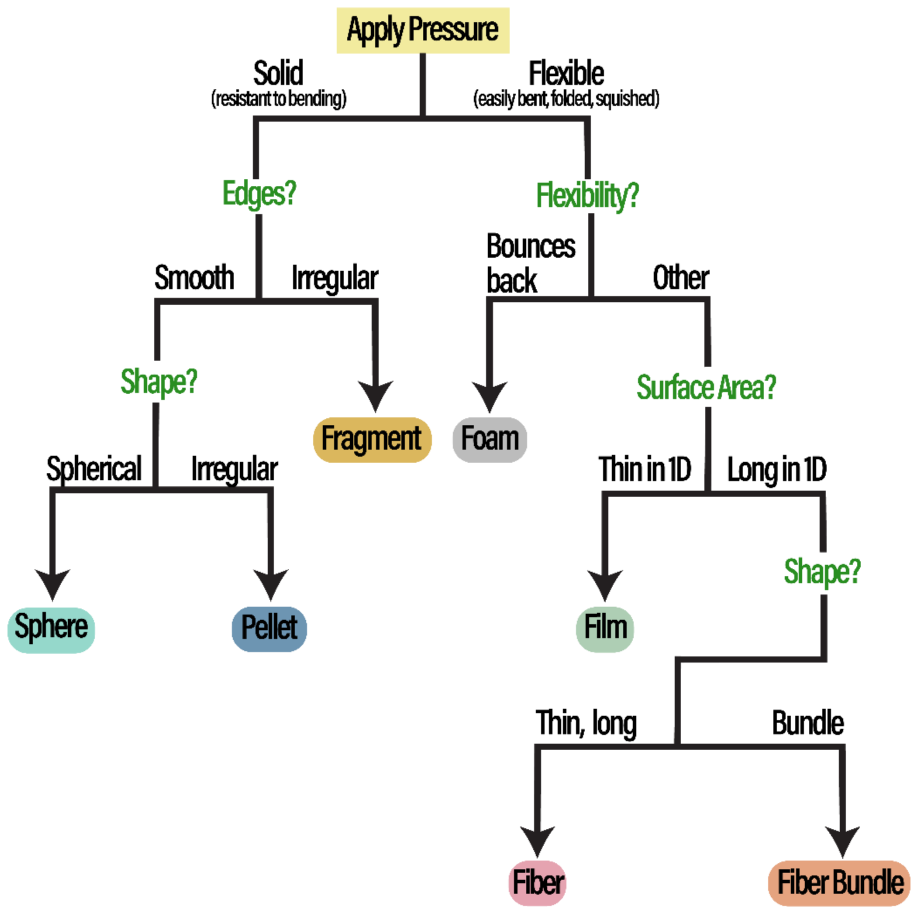


Figure 3.2: Morphology decision tree used to determine the relevant morphology for a particle based on shape and flexibility. This decision tree incorporated 7 morphologies: sphere, pellet, fragment, foam, film, fiber, and fiber bundle. In addition, an 8th category, fiber/fragment was added to accommodate particles with overlapping characteristics from these categories. Images of each particle type can be found in Appendix B-5.

The fiber/fragment category was added during counting to accommodate a recurring morphology which had characteristics of both a fiber and fragment. Transparent and white fibers were typically not counted because of an abundance of bleached organic material from the hydrogen peroxide treatment. Particles were stored on double-sided tape stuck to a transparency and stored in petri dishes, similar to (Hung et al., 2021). Particles from each sample were randomly subsampled following blank correction with the following method: <10 particles- all particles were selected; 10-50 particles- 10 particles were randomly selected; and >50 particles- 20% of particles were selected. These selected particles were measured and photographed using a Hirox high-resolution digital microscope prior to polymer characterization using ATR-FTIR. Particles were measured along their long axis (length) and a visually determined average width (width). Example particle images are provided in Appendix B-5.

An ATR-FTIR (Bruker Tensor 27 model) with a diamond crystal was used to confirm the identity of these particles, with the subsample having priority, followed by potentially natural particles, then the remaining particles. Every picked particle noted as potentially natural was tested on the ATR-FTIR. Before testing each particle, the stage was cleaned using a drop of ethyl alcohol and blown clean using air from a vacuum line. A background scan was run prior to each sample. For both the background and sample scans, 32 scans with a resolution of 4 cm^{-1} in the range of 4000 cm^{-1} – 600 cm^{-1} were run to obtain a clear spectrum. Particles selected for ATR-FTIR spectroscopy required manual manipulation, therefore particles that were too small to be moved or were unable to be removed from particle storage could not be placed on the ATR crystal. The spectra collected were uploaded to the software Open Specy to confirm the identity of selected particles (Cowger et al., 2021). Matches were considered acceptable if there was consistency in the top three matches and the Pearson's Correlation Coefficients for the top two matches were 0.80 or above. If matches were below this value, or there was no consistency in the top three matches, the particles were re-analyzed. Additionally, if there was a CO_2 peak at 2342 cm^{-1} that prevented the spectra from matching above 0.80, the beta version of Open Specy was used to flatten the peak, while the original Open Specy database was still used when recording the top matches from the modified spectra (Cowger et al., 2021). If after this process the matches still failed to meet the set standards, results were considered inconclusive. Overall, 1,356 suspected plastic particles were chemically analyzed, which was 16.9% of all particles or 20.8% of particles after correction and elimination of pink fibers (see section 3.4 below). I determined a false positive rate of 9.3%, which was calculated based on the percent of particles chemically analyzed that were eliminated as suspected plastic particles based on the match to natural material (i.e., cotton, cellulose, fur). I did not apply this false positivity rate as a correction to concentration values since this was determined from a subset of the particle population and I used a strict correction method that rigorously accounted for blank contamination. Since I did not confirm all plastic particles, this work will refer to concentrations of suspected plastic particle concentrations which is inclusive of both macro- and micro-plastic particles.

3.4 Quality assurance and quality control

Various quality assurance and quality control protocols were used to either prevent or quantify sample contamination. Plastic materials were avoided whenever possible, with the exception of particle storage which used pre-rinsed plastic petri dishes. Care was taken to pre-rinse any sampling or laboratory glassware with either soap or methanol, accompanied with a triple DI water rinse. Samples transported from the field were cushioned with only bright pink 100% cotton towels, which were a similar color to laboratory coats worn in the lab. Once returned to the lab, each sample was relabeled with a sequential identification number. The original sample ID was recorded and altered to a new numeric ID to reduce processing and counting bias. Unless necessary for reference, the sampling location was unknown to the analyst until inputting data from the counting stage. Throughout the entire laboratory processes, pink laboratory coats were worn; any pink fibers picked were not included in further analysis and were treated as contamination. Counter spaces near samples being sieved, processed, or counted were cleaned with DI water and a pink sponge and dried before and after use. After inspecting the pink sponge and pink fragments found in samples, I eliminated any particles matching the morphology of the abrasive or sponge-side of the sponge as contamination and switched to a natural fiber, cellulose sponge.

The removal of organic material, which had the highest potential for contamination, was conducted in a class-1000 clean room to reduce airborne particle contamination. During sample processing, perforations were found in the 20 µm sieve which I estimated covered an approximate area of 2% of the sieve. The sieve was immediately replaced after the perforations were found, though a small amount of sample loss from the 355 µm – 100 µm size range could have occurred during this time.

Blanks were processed both in the field and the laboratory to determine any sources of contamination. This process was improved with time to better quantify outside sources of contamination. Net blanks were collected in 2019 / 2020. In 2020, I improved on past quality assurance/quality control (QA/QC) procedures detailed by collecting field blanks. Field blanks were collected by placing a pre-rinsed 106 µm sieve next to equipment during the duration of pump or tow sampling. After the sample was collected, the sieve was rinsed into a separate jar and collected as a sample. Additional equipment blanks were taken every three net or pump samples or at least once per sampling day by setting up either the pump or net for another sample and rinsing or pumping DI water through the equipment and collecting the DI water as a sample would be collected.

Procedural blanks were sample jars that were filled with DI water in the lab. Both net and procedural blanks were processed as regular samples. To calculate blank correction parameters for 2019 / 2020 samples, I performed a run of 10 procedural blanks, 5 of which were processed through all 4 sieves and the other 5 through only the 20 µm sieve to represent the processing of either a net sample or a grab sample, respectively. These blanks were used to calculate the LOD and LOQ for all samples. For 2021 samples, I processed one laboratory blank per processing batch to establish quantification limits. The only morphologies present in blanks were fibers and films in 2019/2020 and fibers and fragments in 2021. The LOD for blank morphologies was calculated as 3*SD of all blanks by morphology category and was subtracted from each sample. Samples below the LOD were considered below detection and were not considered for further analysis. An additional quantification threshold, the LOQ, was set as 10*SD of blanks by morphology and the number of morphology categories below this limit were determined for each sample. Further information on the LOD and LOQ can be found in Appendix Table B.1.

Common contaminants from laboratory processing were cross-referenced for polymer identification. This included: laboratory coat fibers (cellulose), double-sided tape used for particle storage (polyurethane acrylic resin), and Kim-wipes (cellulose). Particles matching these contaminants in form or material were further examined and, in the case of tape contamination, were considered inconclusive.

3.5 Spike test

I designed a pilot spike test that spanned the full range of microplastic morphology types, in addition to major polymer types (Table 3.2).

Table 3.2: Characteristics and origin of spiked microplastic particles. Particles with a * next to their morphology description underwent additional processing in the freezer mill.

Origin	**Color**	**Morphology**	**Polymer Type**	**Average Length (µm)**	**Average Width (µm)**
Packaging	White	Foam	Expanded polystyrene (EPS)	4416 ± 443	2892 ± 583
Plastic bag	White	Film	Low-density polyethylene (LDPE)	4156 ± 405	3876 ± 435
Shampoo bottle	Blue	Fragment*	High-density polyethylene (HDPE)	4670 ± 283	4180 ± 652
Petri-dish storage bag	Translucent	Film	Low-density polyethylene (LDPE)	4174 ± 56.8	3212 ± 255
Purchased	Orange	Sphere	Polyethylene (PE)	168 ± 11.2	163 ± 12.4
Local manufacturer	Transparent	Pellet	Polymethyl methacrylate (PMMA)	3872 ± 380	3712 ± 237
Plastic bottle	Transparent	Fragment	Polyethylene terephthalate (PET)	4564 ± 374	3788 ± 459
Take-out cup	Translucent / green	Fragment*	Polylactic acid (PLA)	3982 ± 361	2430 ± 992
Thread	Blue	Fiber	Polyethylene terephthalate (PET)	11900 ± 1300	29.3 ± 4.62

Particles were prepared by cutting common plastic items into 5 mm squares using an X-ACTO knife. Two of these particle types (HDPE fragments and PLA fragments) were weathered in a freeze mill to create more irregular sizes and shapes. A random subsample of three to five particles were selected for size determination and imaging on a Hirox digital microscope. Particles were manually counted and stored in petri dishes and processed in the same manner as either pump or net samples. Spike samples processed as pump samples were treated with one addition of Fenton's reagent for one hour, while samples processed as net samples received five additions of Fenton's reagent over two days. Samples were vacuum filtered and counted to determine particle recovery during laboratory processing. Particles were only included in the recovered count if they were consistent with the original particle in color or size. This step excluded smaller particles which may have broken from the original particle during processing or possible sources of contamination (e.g., blue fibers) that were not intentionally added. Since the polyester thread was cut and prepared at the time of particle counting and spike preparation, three fibers were measured after processing from a random pump spike sample.

3.6 Data analysis

Data analysis was performed in Microsoft Excel and R Statistical Software (R Core Team, 2022) using the tidyverse (Wickham et al., 2019), ggplot2 (Wickham, 2016), and vegan (Oksanen et al., 2022) packages. Sampling volume was determined using either jar weight (grab), secondary bucket estimate (bucket and pump), or a flowmeter (net). The LOD was subtracted from every sample and net blank based on morphology counts. After subtraction, the remaining counts per morphology were compared to the LOQ to determine the number of categories below quantification.

Pre-subtraction counts were used to obtain color-morphology abundance to calculate measures of diversity, rather than morphology alone, for a more exhaustive account of particle diversity. Samples which had a total count of 0 before or after subtraction were not included in the diversity analysis.

The Shannon-Wiener Diversity Index (Shannon, 1948) was calculated for each sample using the vegan package in R (Oksanen et al., 2022) with the formula as follows:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

where S is the total number of color-morphology pairings in the sample, and p_i is the proportion of color-morphology pairings present in all suspected microplastics in the sample.

4. Results and Discussion

4.1 Impact of sampling method on microplastic capture

In total, I collected 8,034 particles from all samples, excluding blanks, 818 of which were eliminated as suspected plastic particles based on: visual or chemical matches to common contaminants, such as laboratory coat or sponge fibers, or natural materials, such as particles with cell structure present or chemical matches to cellulose or cotton.

Of these eliminated particles, 306 or 3.80% of all particles were pink fibers, which were attributed to possible laboratory contamination originating from pink dyed laboratory coats or sponge fibers. Blank correction using the LOD approach subtracted an additional 684 particles based on the results laboratory blanks, leaving 6,532 suspected plastic particles across all sample types (Grab = 48 particles, Bucket 355 µm = 59 particles, Bucket 106 µm = 755 particles, Pump = 42 particles, and Net = 5,628 particles). Concentrations ranged from 0 particles/L (below detection) to 36.4 particles/L in all samples collected across all study locations.

Grab sampling resulted in the lowest proportion of samples above detection relative to the total number of samples collected (Figure 3.3). Though pump sampling (97.5 L) had an increased volume of water collected relative to bucket (19 – 39.5 L) and grab samples (~1 L), it was the sampling method with the least samples above detection. In contrast, net samples consistently yielded detectable levels of suspected plastic particles. Prior work has reported grab sample concentrations exceeding net sample concentrations in surface water sampling (Barrows et al., 2017; Covernton et al., 2019; Green et al., 2018; Hung et al., 2021). Notably, grab (or bulk) sampling is less prone to contamination and more likely to capture smaller particles which would bypass the larger mesh size associated with a net (Barrows et al., 2017). Since smaller particle sizes have a greater opportunity for increased uptake and retention from inhalation or ingestion in humans (Wright and Kelly, 2017) and aquatic life (Kögel et al., 2020), it is important that monitoring campaigns consider smaller size fractions where possible.

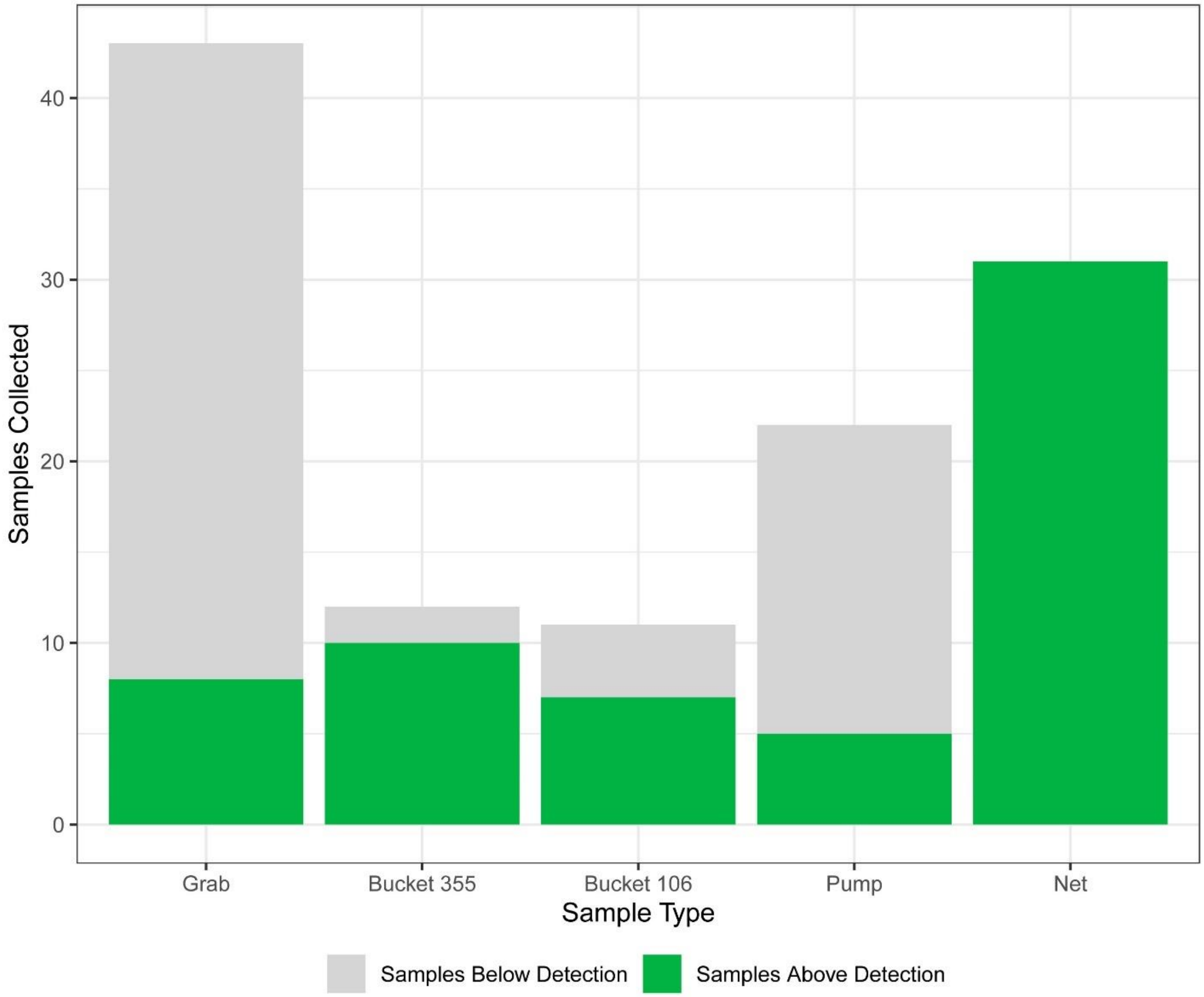


Figure 3.3: Total samples collected by sample collection type, showing the number of samples below the limit of detection in gray and above detection in green. Numbers following bucket sample types correspond to the sieve size in µm. The detection limit used here is defined as 3*SD of laboratory blanks, which was subtracted by morphology category from all samples. Grab samples were the most frequent type of collection but had the lowest percent of samples above detection. Pump samples had the overall least number of samples above detection. In contrast, samples collected by net were consistently above the limit of detection.

However, if collected in quantities that fail to exceed the ambient contamination found in the laboratory, these concentrations may be unreliable. The few grab samples that were above the LOD had 50-100% of morphology categories below the LOQ. Although these samples had detectable quantities of suspected plastic particles, at least half to all of the morphology classes were not present at quantifiable levels. Of the five samples that exceeded the LOD for pump sampling, four were below the LOQ in 50% or more morphology categories. The only pump sample that exceeded the LOQ in 75% of morphology categories was collected from the Inner Harbor, a common location for plastic floatable collection. Unfortunately, due to the low particle capture from pump sampling, I was unable to determine the concentration of particles in lake depth profiles. Increased particle capture might be possible with pump sampling that uses an in-line filter (Arienzo et al., 2021) or is able to sample a higher volume of material over a shorter period of time. Future research might also consider the use of depth sampling with net devices (Lenaker et al., 2019), which would have an increased capture.

Prior research has noted the LOD/LOQ approach may result in underestimation due to particle loss from sample processing (Horton et al., 2021), however, note that detection limit approaches can provide essential information on quantification capabilities. Recent work modeling various correction techniques recommended increased usage of the LOD to account for contamination from blanks (Dawson et al., 2022). It has also recently been recommended for use in the Arctic Monitoring and Assessment Programme (AMAP) Report (Farmen et al., 2021). The use of procedural or laboratory blanks for establishing quantification limits is especially important when considering the variability that exists among laboratories and accessibility to equipment or contamination reduction measures, such as laminar flow hoods or clean rooms.

Microplastic samples are highly prone to contamination, which is exacerbated in low-volume samples with low counts and higher proportions of contaminant morphologies, such as fibers. Grab sampling provides a fast and efficient method for sample collection for potential microplastics in freshwaters. However, this sampling method had significant drawbacks in its ability to collect quantifiable amounts of particles that are representative of the freshwater environment of interest. However, this limitation is not a reflection of bulk sampling methodologies, but rather the need to prioritize recovery and quantification limits of a protocol when designing a monitoring campaign. As suggested by (Miller et al., 2020), piloting methods in the field prior to a monitoring study can refine methods and study design. The quantification of smaller particles at low volumes may be less of a concern when using other particle enumeration methods with lower size detection limits (Okoffo et al., 2023; Primpke et al., 2017).

The highest particle concentrations in study waters were found in grab and bucket samples, likely owing to a lower sampling volume that elevates concentrations of even lower particle counts. Importantly, despite the blank correction protocol, there is less confidence in grab samples compared to other collection methods due to difficulties in chemical analysis of these particles (Appendix Table B.3). However, the highest concentration of any sample (36.4 particles/L) was found in a bucket sample from the Inner Harbor. Bucket sampling had variable success depending on sampling location. Bucket samples processed through a 355 μm sieve had more samples above detection than samples collected through a 106 μm sieve. However, since samples were not collected using both sieve sizes at the same location at the same time, it is not possible to conclude if mesh size had an influence on capture or if the decrease in capture was influenced by differences in particle concentration at the sample locations.

Though bucket sampling was more effective at capturing more particles than grab sampling, this pattern is attributed to sampling focused in areas of macroplastic collection within the Inner Harbor. When grab samples were collected in October 2019, I collected a sample from the northern edge of Onondaga Creek, which was below the LOD. The next sampling campaigns in June and September 2020 shifted the sampling location to the Inner Harbor basins, where floatable materials are commonly found. This material is also strategically collected by Onondaga County's WEP with skimmer boats to reduce the influx of floatable plastics into Onondaga Lake (Onondaga County Department of Water Environment Protection, 2020). Bucket sample collection in the Inner Harbor represented most of detectable particles found in bucket samples (Bucket 355 µm = 68%, Bucket 106 µm = 94%). I compared the eastern corner of the southern basin of the Inner Harbor with the western corner during the June 2020 bucket 355 µm sampling and found a 97.5% increase in particle concentration when sampling in the eastern corner. When conducting bucket 106 µm sampling in September 2020, I compared the eastern corner of the southern basin of the Inner Harbor with the northern edge of Onondaga Creek. I found concentrations were 202% higher in the eastern corner of the southern basin than Onondaga Creek. In areas of high floatable collection, plastic particle concentrations will be much higher, but not necessarily representative of the surrounding waters. These changes in concentration and particle recovery show the high variability that can result from point sampling and further stresses the importance of choosing point sampling locations strategically depending on the research questions being explored. In this case, the Inner Harbor floatables provide key insight into the types and quantities of plastic materials originating upstream. Though some of these floatables are removed, they may contribute to microplastic formation and persist in the environment.

4.2 Comparison of diversity between sampling methods

In addition to particle concentrations, there were notable differences in the number and type of morphologies recovered by each method (Figure 3.4). From highest to lowest, the number of average morphology categories (± SD) captured by each method, including only samples above the LOD, was 4.42 ± 1.43 (Net, n = 31), 2.4 ± 1.17 (Bucket 355, n = 10), 2.38 ± 0.74 (Grab, n = 8), 2.2 ± 1.10 (Pump, n = 5), and 1.71 ± 1.89 (Bucket 106, n = 7) compared to a total category count of 8. Net samples also collected a higher diversity of polymer types and sizes, though this pattern is skewed by the size limitations of the chemical identification method (Figure 3.4).

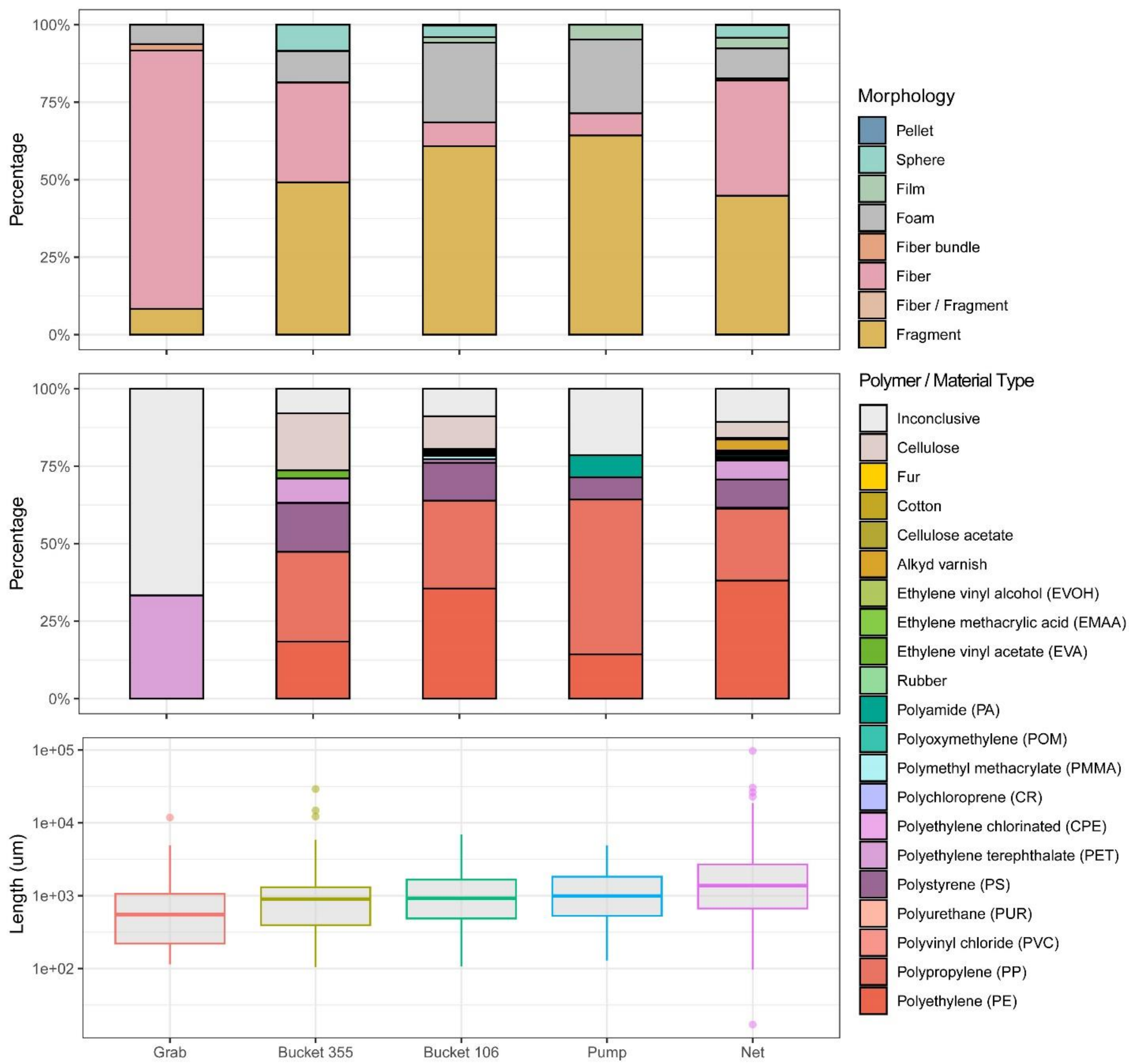


Figure 3.4: From top to bottom: morphologies, material types, and length (μm) of particles from each sampling method. Morphology and material types are expressed as a relative percentage of all samples that exceeded the LOD. Length (μm) is expressed on a log scale with box plots representing the spread of measured lengths for subsampled particles from this study, with dots noted as outliers. Note that sample types that preferentially collected smaller particles or more fiber morphologies, such as grab sampling, were less likely to be chemically identified by ATR-FTIR, contributing to higher inconclusive results.

However, it is difficult to draw conclusions on recovery given the variation in sample locations present. Comparing only samples collected from Onondaga Lake, I found that grab samples captured only 2 morphology categories (n = 1), pump samples captured an average of 1.67 ± 0.58 (n = 3) compared to 4.39 ± 1.39 average categories with net samples (n = 13). This pattern is consistent with findings from a study conducted in the San Francisco Bay in California by (Hung et al., 2021), which found that manta trawls captured a higher diversity of morphologies compared to 1-L grabs and 10-L pumps. However, this work also reported an increased likelihood of recovery of smaller size ranges and fiber particle morphologies in grab samples (Hung et al., 2021). Morphology recovery is important information to evaluate source allocation given the immense diversity of microplastics in the environment (Grbić et al., 2020; Helm, 2017; Rochman et al., 2022, 2019). For example, fibers indicate inputs from textiles, pellets from plastic manufacturing, and foam from single-use expanded polystyrene foam insulation or packaging (Rochman et al., 2019).

I also used the Shannon Diversity Index to explore particle diversity in samples using color-morphology pairings. Sampling method and location resulted in notable differences in the diversity index, based on color and morphology, of particles captured (Figure 3.5). Diversity indices ranged from 0 (Bucket 106, Oswego River) to 2.78 (Net, Spencer Street). Average diversity (± SD) by sampling type, including only samples above the LOD, from highest to lowest was 2.05 ± 0.35 (Net), 1.42 ± 0.74 (Pump), 1.10 ± 0.46 (Bucket 355), 1.00 ± 0.33 (Grab), and 0.97 ± 0.81 (Bucket 106).

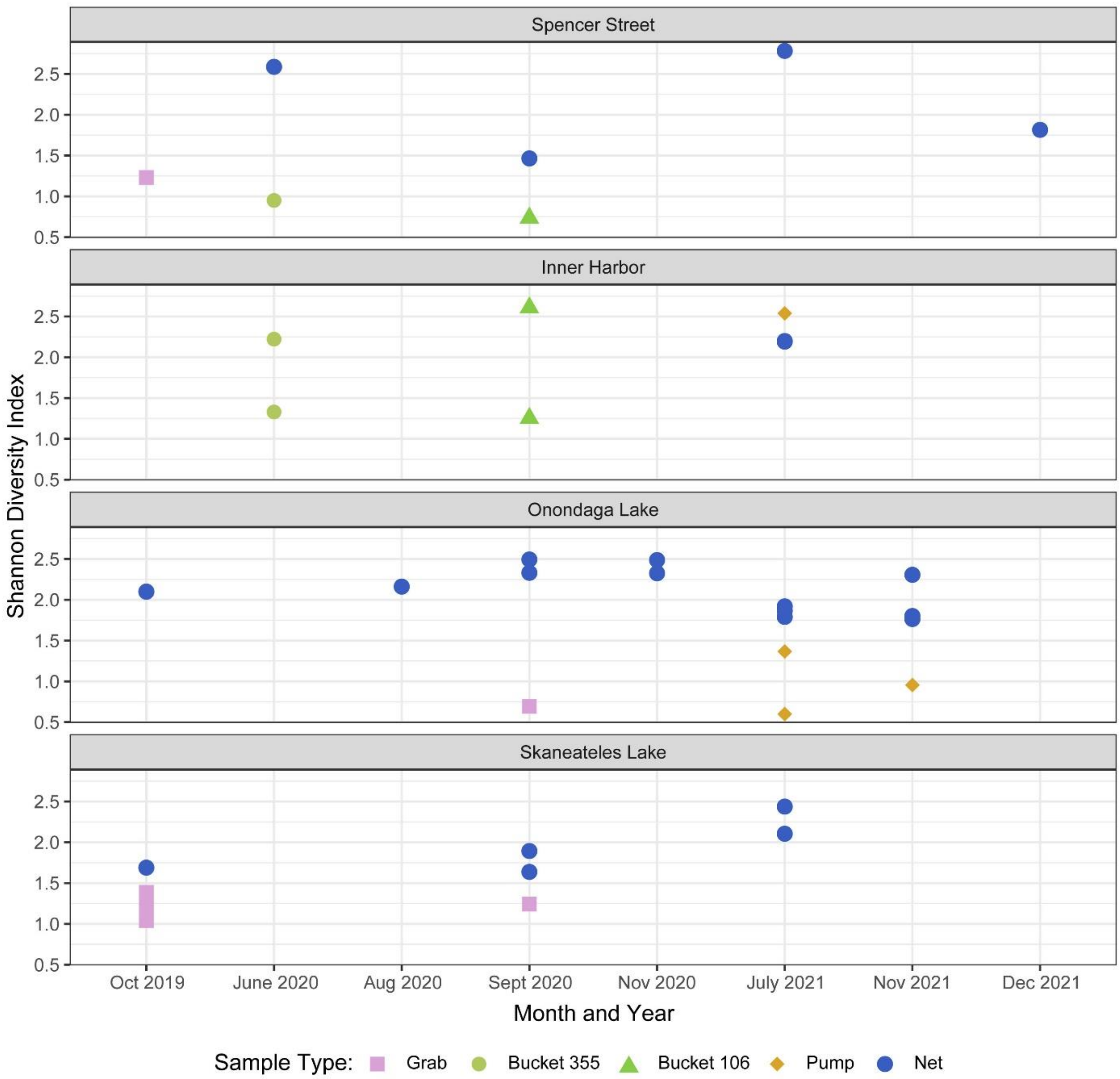


Figure 3.5: Shannon diversity index of microplastic samples exceeding the LOD from Spencer Street and the Inner Harbor along Onondaga Creek, as well as Onondaga and Skaneateles lakes, for each sample collection. Shape and color of dots depicts the sample type. Diversity index was calculated using the frequency of color and morphologies present in each sample prior to blank subtraction. Note the x-axis is not scaled with time and the time between each collection is variable.

In most samples, the diversity index was higher in net samples than pump samples collected at the same location. The only exception was in a pump sample collected at the Inner Harbor in July 2021. The Inner Harbor is the only site with visible floatable plastic pollution in its surface waters. This site was sampled with a net twice in July

2021, once before skimmer boat collection and once after. These two samples had identical diversity indices (2.20 before skimmer boat collection and 2.19 after skimmer boat collection), despite an increased concentration in the second sample. This pattern may indicate that despite collection of floatable materials, the diversity and concentration of suspected plastic particles remains consistent. This result is also important in the context of floatable removal. Concentrations increased from 2.37×10^{-2} particles/L to 1.59×10^{-1} particles/L after skimmer boat collection, possibly from the recirculation or resuspension of material at depth or the further breakdown of larger plastics.

Even with the same method of sample collection, there are differences in diversity with time and position at each site. Plastic particle samples in Onondaga Lake had relatively consistent diversity indices with lake position (SD 0.00138 – 0.915), with the highest standard deviation in samples collected in September and November 2020 and the lowest in October 2019. Skaneateles Lake had an increase in diversity in July 2021 compared to prior sampling, which may be the result of sampling along the shoreline in prior sampling campaigns compared to shore-to-shore transect sampling. Diversity was highest in the northern part of Skaneateles Lake, which is more developed and proximal to Skaneateles Village and recreational beaches. Diversity is also dependent on sampling position within the Inner Harbor area in both June and September 2020. Bucket samples within the Inner Harbor reflect the positional changes associated with either visible plastics collection (high diversity) and little to no visible plastics (low diversity) on either the opposite side of the basin (June 2020) or outside of the Harbor's basin (September 2020) in the main reach of Onondaga Creek.

Net samples taken at Spencer Street had highly variable diversities with time. Sample collection in July coincided with an unusually wet summer, which contributed to high discharges in Onondaga Creek. However, this diversity was considered using a subsample of filters, so actual diversity may differ on examination of the larger particle population. Overall, diversity was higher in summer months at Spencer Street, compared to Fall observations.

In my sample locations, the use of only low-volume point sampling methods (bulk or volume-reduced) likely resulted in underestimation of particle diversity and potential sources of plastic contamination. Therefore, I relied primarily on net sample concentrations to explore plastic particle observations in Onondaga and Skaneateles lakes in Chapter 4.

4.3 Particle recovery and spike test

The inclusion of positive controls significantly improves the quality of data and allows for comparison of recovery across diverse types of particles (Way et al., 2022). In this spike recovery test, I found an average particle recovery across morphology types for spiked DI pump and net samples of 85.7% and 80.2%, respectively (Figure 3.6). The two morphology types with the lowest recovery were spheres and fibers. These morphologies also had the lowest average width (fiber = 29.3 μm, sphere = 163 μm), with all other spiked particles exceeding a width of 2000 μm.

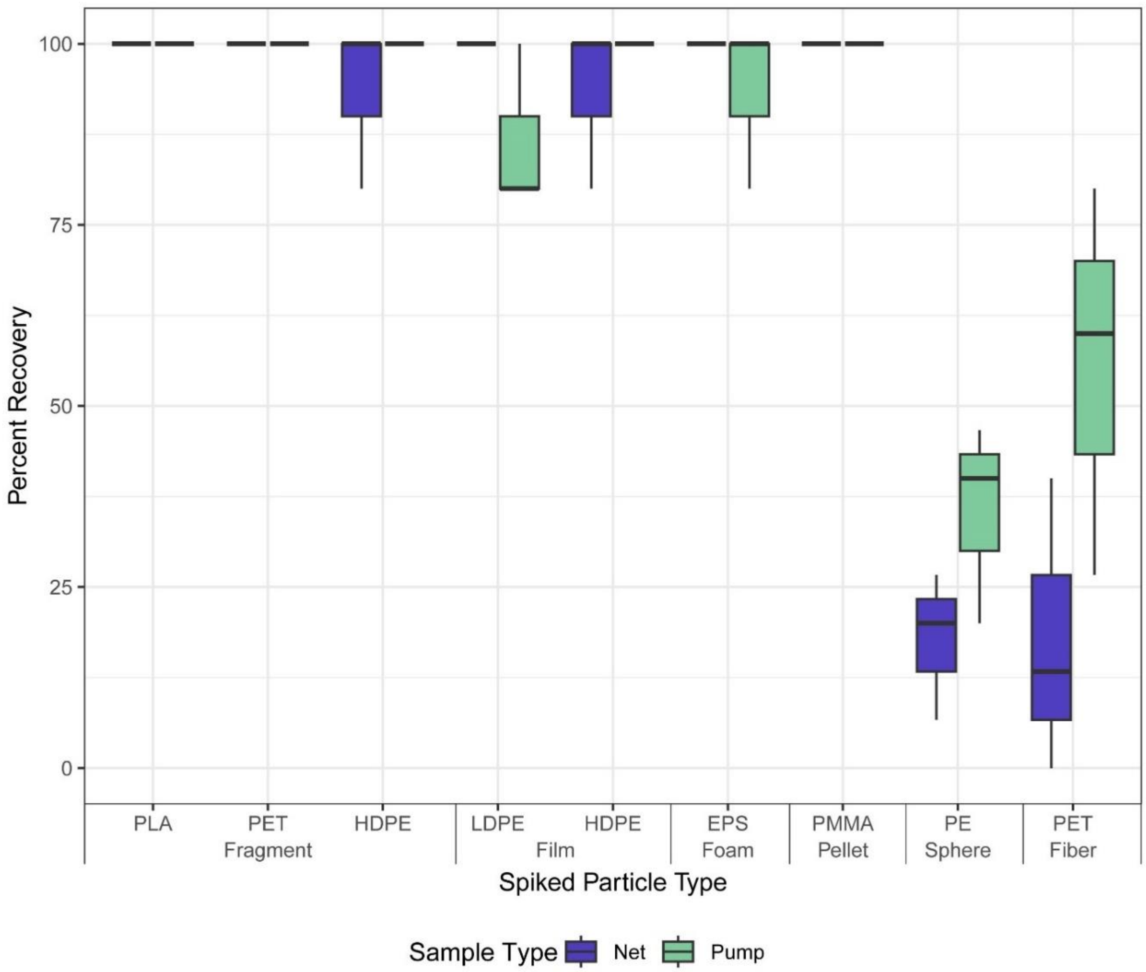


Figure 3.6: Percent recovery of spiked plastic particles in DI water, processed as either pump or net samples. Pump samples were sieved through one 20 µm sieve and processed with one addition of Fenton's reagent for approximately one hour. Net samples were sieved sieve-separated into four size classes and processed separately with five additions of Fenton's reagent for approximately two days.

For both spheres and fibers, spiked DI pump samples usually recovered more particles than those processed as net samples. This difference is likely due to sample loss from additional sieving and processing. Since spiked DI net samples were sieved into four size classes, each size class had potential for sample loss from size-separated sieving, filtering, and counting, likely increasing the cumulative loss.

These spike test results are important to consider in the context of estimated plastic particle concentrations in Onondaga and Skaneateles lakes. Smaller particles and morphologies with a smaller width may not be recovered as readily as larger particles, resulting in an underestimation of smaller particles. Though this work provides a good first estimate of the abundance of particles in Onondaga and Skaneateles lakes, there are likely additional, smaller particles that were not recovered with this protocol. Spheres and fibers may have been underestimated in samples, especially in net samples that have increased loss both from capture with the 300 μm mesh and increased laboratory processing.

Aside from the spheres and fibers in this spike test, all other morphologies would be considered large microplastics (>1mm) or small macroplastics (>5 mm) if measured along the longest axis. Since these results indicate size as an important quality in recovery, further work should explore a smaller size range in assessing particle recovery. Inherent differences present between various polymer types may not be as readily noticeable at larger particle sizes, which are more readily recovered (Way et al., 2022). Additionally, the inclusion of organic material may impact important processing factors which could either increase or decrease recovery. Therefore, further work should include increased use of matrix spikes to assess matrix interference and potential interactions with naturally occurring organic and plant material that may impact retention or cause physical changes in particles. For example, an increase in organic material may contribute to higher temperatures in processing, which may melt, reform, or otherwise alter particles and subsequent reported concentrations from their original form (Munno et al., 2018).

6. Conclusion

The sampling methods used to determine microplastic concentration and diversity of freshwater bodies can highly influence results, potentially contributing to unreliable values when counts fail to exceed quantification thresholds. Point sampling (grab, bucket, or pump sampling) contributed to variable results depending on the sample location and whether plastic floatables were present. In contrast, net sampling provided more consistent concentration values, but likely underrepresents smaller sized particles. Diversity was higher in net samples or in sample locations with noticeable floatable collection, such as the Inner Harbor. The use of spike testing in this study showed a decreased recovery with smaller-width particles, particularly spheres and fibers. Increased processing resulting from size-separation and additional processing common in net sampling caused a decrease in particle recovery. The increased use of quantification thresholds (LOD and LOQ) in future microplastics work would improve harmonization of data sets across geographic regions.

Chapter 4: Exploring the Inter-Annual Variability in Microplastics in Seasonally Stratified Lakes using Net Sampling

1. Introduction

Monitoring freshwater ecosystems for microplastics requires consideration of both concentration, types, and diversity of particle populations. Microplastic concentrations allow for the consideration of sources, hot spots and potential risks over time and space. Particle diversity can be used for source apportionment and potential source allocation, given relationships between particle morphology and chemical composition for a given source (Grbić et al., 2020; Helm, 2017; Rochman et al., 2022, 2019). Particle diversity can also impact the likelihood of biota ingesting particles in the environment. Certain colors or morphologies of microplastics have been found to be preferentially ingested by goldfish (Xiong et al., 2019).

Microplastics in freshwater environments are an emerging concern globally, but the extent of contamination of freshwater bodies in New York State is largely unknown. Since microplastics occur from a variety of sources (see Chapter 3: Section 1), regional patterns have been observed owing to variations in urbanization or seasonality (Malla-Pradhan et al., 2022; Stovall and Bratton, 2022). However, there have been limited observations of the quantity and distribution of microplastics from lake inputs to in-lake conditions, as well as the inter-annual variability associated with seasonal stratification in lakes.

Stratification occurs due to density differences in the water column of lake waters, often determined by differences in temperature that occur associated with the changing of seasons. Stratification can limit the transfer of essential nutrients or dissolved oxygen between the upper (epilimnion) and bottom (hypolimnion) waters of lakes. Once water temperatures begin to equalize from changing seasons or the actions of wind or runoff are great enough to mix the upper and lower layers, lake turnover begins. Lake turnover creates isothermal conditions and allows for the uniform mixing of lake waters. In the study site in central New York, turnover in lakes of adequate depth is common twice a year, in the spring and fall. If lake stratification can limit the transfer of essential nutrients, could it also affect the transport of plastic particles? Any variation in microplastic distribution with lake stratification would impact not only the results of monitoring campaigns, but also any ingestion or exposure by biota that may mistake plastic particles for food.

Onondaga Lake was the focus of this study due to its higher likelihood for microplastic contamination from the surrounding urban area. Therefore, I hypothesized that Onondaga Lake would have higher concentrations and greater particle diversity than Skaneateles Lake. In addition to lake water, I collected additional samples at the major tributaries (Onondaga Creek and Nine Mile Creek) and outlet, which drains into the Seneca and Oswego Rivers, of Onondaga Lake. I also anticipated the southern portion of Onondaga Lake (Figure 3.1), which receives riverine discharge from an urban reach of Onondaga Creek and wastewater effluent inflows from the Metropolitan Syracuse Wastewater Treatment plant (METRO), would have higher concentrations compared to other lake locations. Moreover, sample concentrations from a given location were expected to vary over time. I used ecological measures of species diversity, including the Shannon Diversity Index (Shannon, 1948), to understand particle populations with respect to sampling method and location. Through this work, I aim to:

- Characterize the abundance and properties of suspected plastic particles collected in surface net trawls in Onondaga and Skaneateles lakes;
- Quantify the variation in microplastic characteristics from lake inputs to in-lake conditions;
- Investigate the potential impact of seasonal stratification on microplastic concentration and diversity over the 3-year sampling period; and
- Evaluate the potential influences of inflows and seasonality on microplastic concentrations and distributions in Onondaga Lake.

2. Site Description

The study site is summarized in Chapter 3, Section 2.

3. Methods

Methods are consistent with those detailed in Chapter 3, Section 3, focusing only on samples collected with nets (instead of grab, bucket, or pump samples)since net sampling provided more reliable and consistent measures of plastic particle diversity and concentration (see Chapter 3). Data analysis was performed in Microsoft Excel and R Statistical Software (R Core Team, 2022) using the tidyverse (Wickham et al., 2019), ggplot2 (Wickham, 2016), and vegan (Oksanen et al., 2022) packages. Briefly, data analysis consisted of the calculation of the LOD and LOQ for a set of blanks, the subtraction of the LOD from all samples by morphology, the calculation of the diversity index using color-morphology pairings (see Chapter 3, section 3.6), and statistical testing. I tested the null hypothesis that the concentrations of net samples collected from each lake were equal using the Wilcoxon-Rank Sum Test. All statistical analyses were set at a p-value of 0.05 to indicate statistical significance.

5. Results & Discussion

4.1 Abundance and characterization of suspected plastic particles

Net sample concentrations ranged from 6.68×10^{-5} particles/L to 1.59×10^{-1} particles/L (Figure 4.1), with the highest concentrations in samples collected from the Inner Harbor, Creek Walk, or Onondaga Lake (South). The highest net concentration in Onondaga Lake was found in a southern transect in November 2020, after fall turnover (1.32×10^{-2} particles/L). The results of the Wilcoxon-Rank Sum Test indicates that there was a statistically significant ($W = 64$, $p = 0.03$) difference between suspected plastic particle concentrations in net samples collected from Onondaga and Skaneateles lakes. The average suspected plastic particle concentration for Onondaga Lake was 1.40×10^{-3} particles/L ± 3.56×10^{-3}, which is higher, and more variable compared to 1.65×10^{-4} particles/L ± 8.22×10^{-5} for Skaneateles Lake. Average diversity values in net samples collected from Onondaga Lake were higher (2.11) than Skaneateles Lake (1.98). These findings are consistent with my original hypothesis that Onondaga Lake would have higher concentrations and a more diverse particle population than Skaneateles due to a higher likelihood of plastic pollution inputs from surrounding urban areas and contributions from WWTP effluent and CSO discharges.

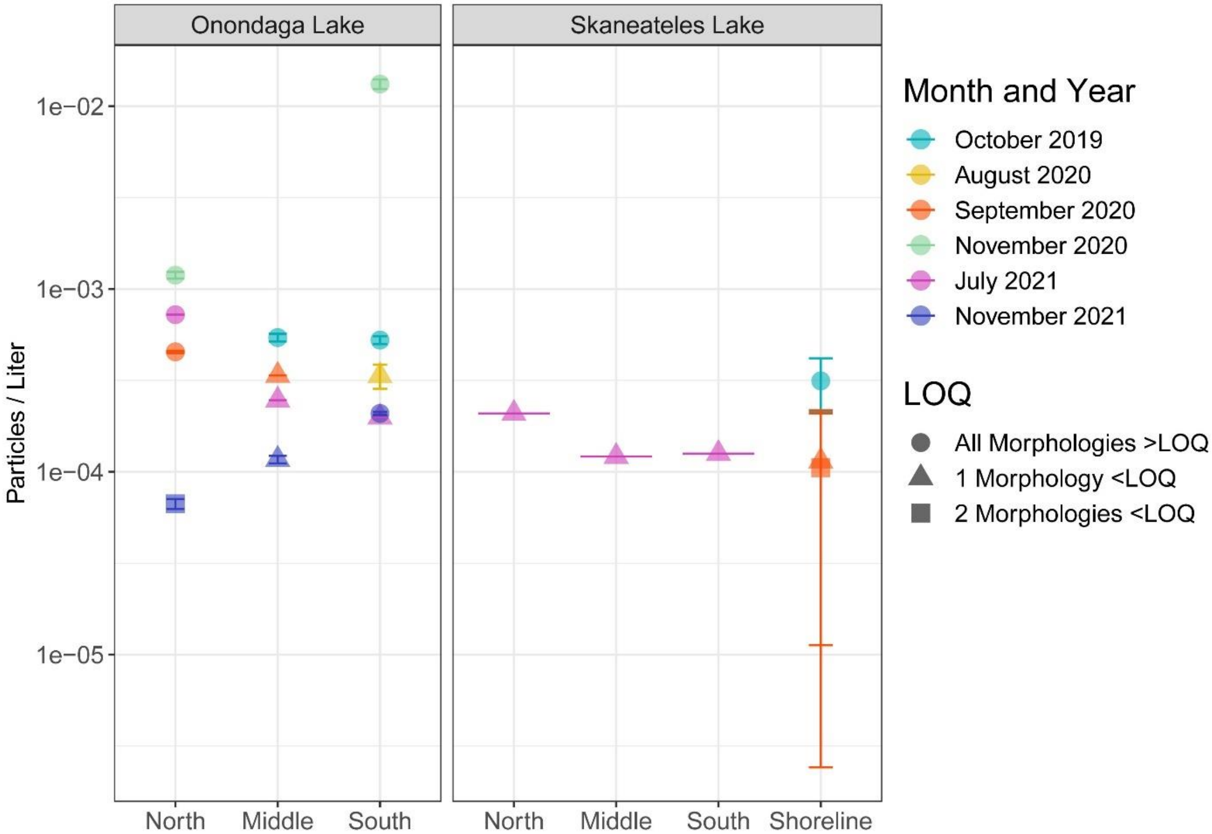


Figure 4.1: Suspected plastic particles per liter, determined from surface net trawl sampling, for both Onondaga and Skaneateles lakes through time and with various lake positions. The symbol color indicates the month and year of sampling. Samples collected in 2019 and 2020 were collected on one trawl per day, while samples in 2021 were all collected on the same day. Symbol shape indicates the number of morphologies below the LOQ. Error bars reflect ± the net blank collected at the time of collection or, if not available, a net blank collected from the same site.

Samples collected in July 2021 had higher concentrations on the northern side of both lakes (Figure 4.1). After lake turnover in Onondaga Lake in mid-November, the opposite spatial pattern was observed, in which plastic particle concentrations increased southward. I also noted a 1 to 2 order of magnitude difference in concentrations between concentrations in November 2020 and 2021, which is further discussed in Section 4.2.

Samples collected on Skaneateles Lake's shoreline showed a higher variability in concentration, likely owing to positional differences that might arise from distribution of material along the shore. Since all shoreline samples were collected in the northern portion of the lake, there may have been higher and lower areas of particle collection depending on proximity to sources on the shore. Also, sampling from shore to shore may have integrated some of the variability present in shoreline sampling.

The most prevalent morphologies consisted of fragments (44.7%) and fibers (37.3%). These results align with prior work reporting fragments and fibers as prevalent morphologies in freshwater ecosystems (Razeghi et al., 2021). Macroplastic films were recently identified as the most commonly found litter in roadside ditches in a study in the Finger Lakes region (Pietz et al., 2021), but were less common in my surface water samples (3.43% of total particles). Moving downstream Onondaga Creek from the rural Dorwin Avenue sample location to the more urbanized Onondaga Lake and to the outlet, there is an increase in the relative proportion of fragments at each site (Figure 4.2). This pattern is consistent with increasing sources of plastic pollution from urban sources. While lake outlet waters primarily contain plastic fragments and films, there was an overall lower capture of particles from this site (n=14). Foams are highly prevalent at the Inner Harbor, where floatable plastic material collects and is removed using skimmer boats. Despite this method of source control, foams were still found downstream at the Creek Walk location.

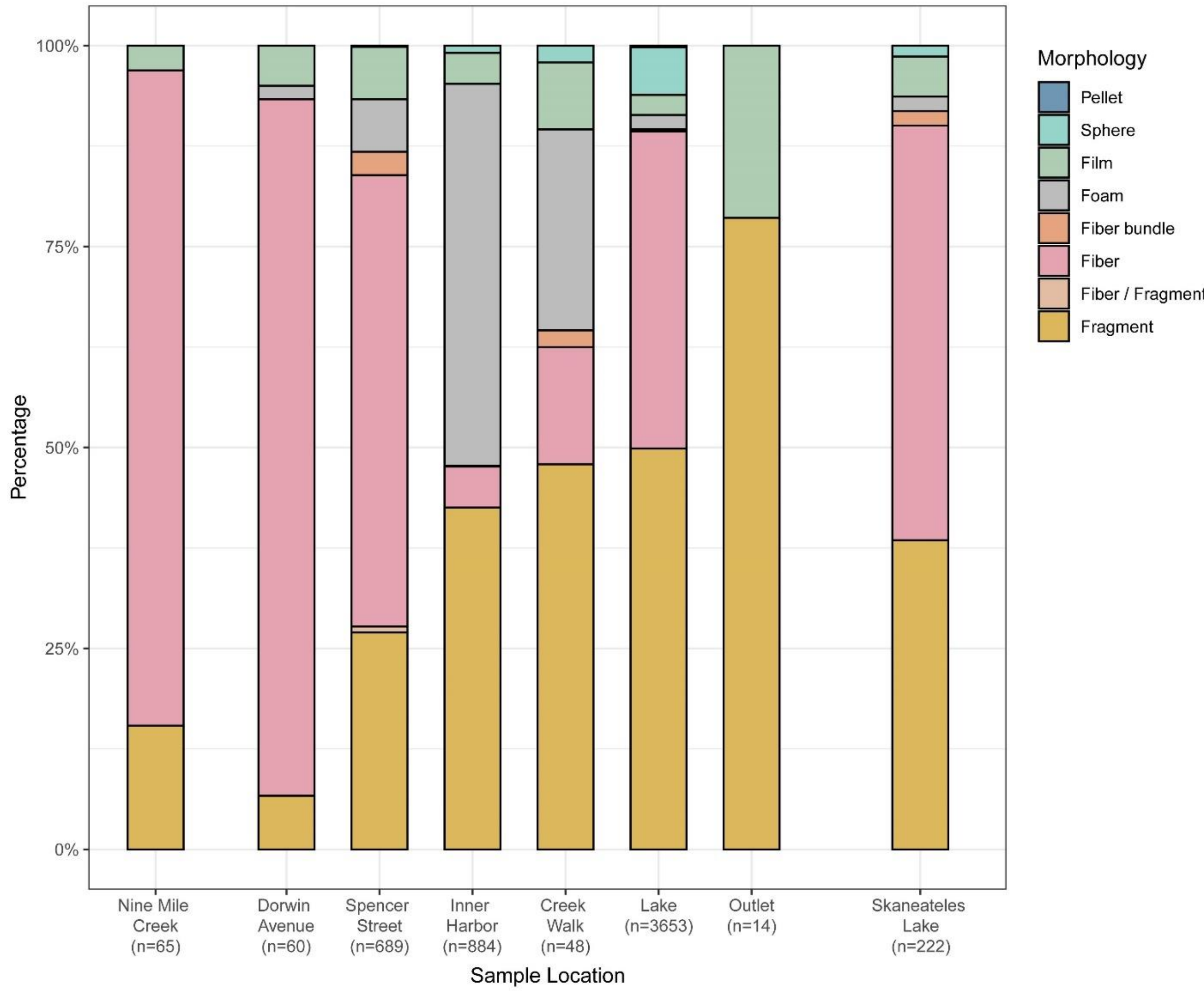


Figure 4.2: Relative percentage of morphology categories for each site based on all net samples collected. The Dorwin Avenue, Spencer Street, Inner Harbor, and Creek Walk sites are all going upstream Onondaga Creek into Onondaga Lake. Nine Mile Creek is another major tributary to Onondaga Lake.

Compared to Onondaga Lake, Skaneateles Lake has a higher proportion of fiber and fiber bundle morphologies. Spheres were also found in Skaneateles Lake in lower abundance, all in the northern portion of the lake from either a shoreline or shore-to-shore sample collection. These morphology changes are consistent with the primarily residential and agricultural land use surrounding Skaneateles Lake.

The three most abundant particle colors before blank subtraction were blue (32.6%), white (20.9%), and translucent (14.7%). However, note that white and translucent fibers were not counted in this study due to the high likelihood of false positives from bleached organic material. The size and chemical characteristics of particles were determined for a random subset of particles (Figure 4.3).

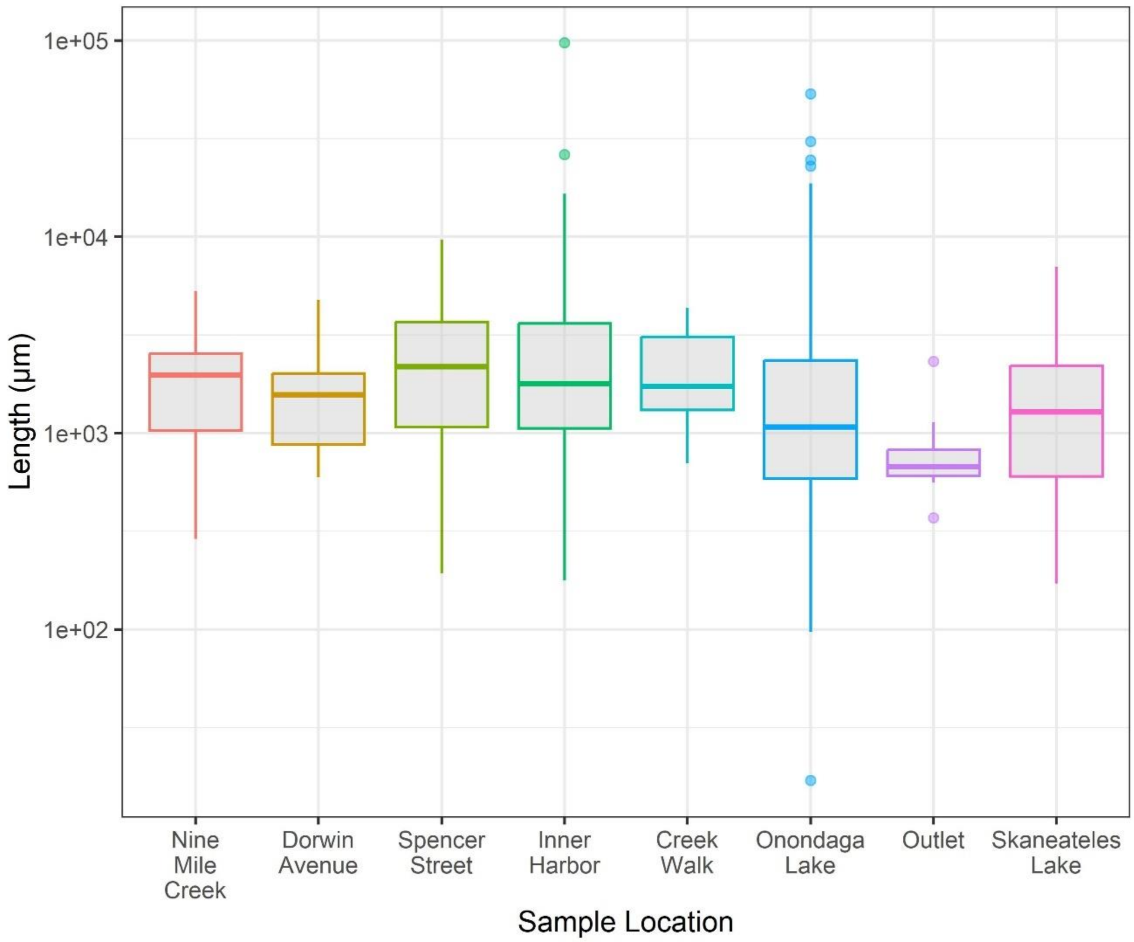


Figure 4.3: Length (μm) of subsampled particles from all net samples taken at each site, expressed on a log scale on the y-axis. Box plots represent the spread of measured lengths for particles from this study, with dots noted as outliers. Particle lengths were the most variable in the Inner Harbor and Onondaga Lake.

Suspected plastic particles measured an average length of 2424 μm ± 4350 μm. The size range of particles measured for both size classification and chemical analysis was 2807 ± 5288 μm. The size range of particles analyzed by ATR-FTIR is higher than all measured particles, likely owing to the necessity of physical manipulation of the particles with forceps. A total of 518 particles of the 860 subsampled particles were able to be evaluated by ATR-FTIR. Particle length was higher and more variable at Spencer Street, the Inner Harbor, and Onondaga Lake compared to other sites. The Outlet site had a lower particle length and variability, possibly owing to the decrease in capture compared to other sites. Average particle length was higher in Skaneateles Lake compared to Onondaga Lake, but lengths were more variable in particles from Onondaga Lake.

The dominant polymer categories included polyethylene (PE) (38.1%), polypropylene (PP) (23.2%), inconclusive (10.7%), and polystyrene (PS) (9.12%). The dominant polymer categories were consistent with patterns of global plastic production, which have noted polyethylene (28.5%) and polypropylene (16.71%) as highly produced polymers (Geyer et al., 2017).

The relative proportion of material types varied by location (Figure 4.4). These findings inform potential sources and losses of various material types from Onondaga Lake and its major tributaries. Compared to the more rural location at Dorwin Avenue, Spencer Street had greater diversity of material types, which may be due to proximal source inputs from CSOs and the surrounding urban area. The large proportion of inconclusive results from Dorwin Avenue is consistent with the higher percentage of fiber morphologies found at this site compared to Spencer Street (Figure 4.2). Polystyrene was more abundant in the Inner Harbor and Creek Walk locations but is less prominent in the Spencer Street site upstream of these two sites. The samples collected at Spencer Street in Onondaga Creek were in shallow, freely flowing water, proximal to CSO discharge areas which could explain the contrast in particle material types found at this site. Additionally, this site is proximal to downtown Syracuse, an abated CSO location, and receives waters from other CSO outfalls (Onondaga County Department of Water Environment Protection and Jacobs, 2022). The Spencer Street location was also notably measured with net sampling in 2020 and 2021, potentially adding diversity introduced from annual changes, while other tributary locations were sampled with other methods described in Chapter 3.

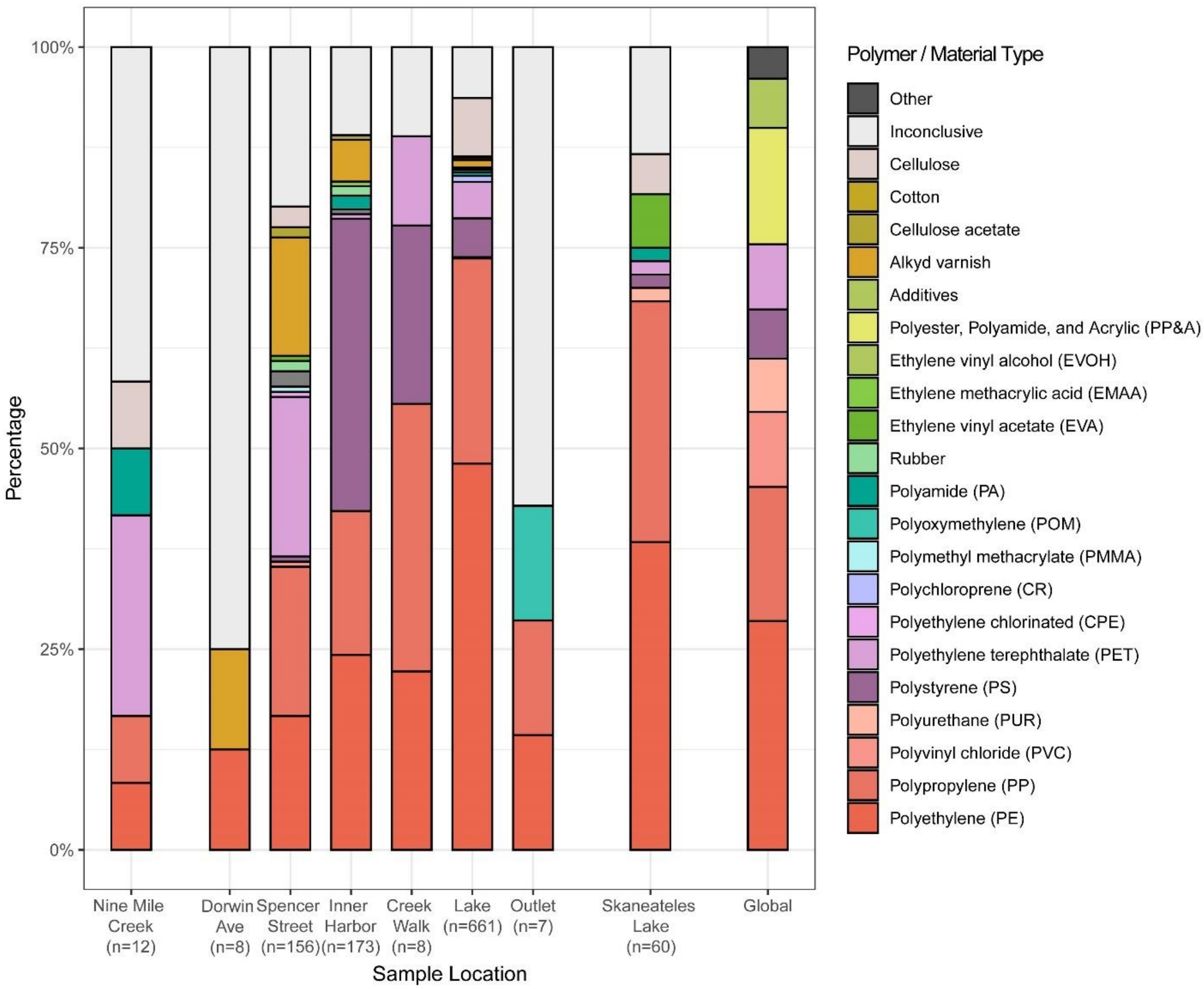


Figure 4.4: Relative proportions (% of all particles collected) of different polymer types collected by net sampling for sites compared to global plastic production in 2015 (Geyer et al., 2017).The Dorwin Ave, Spencer Street, Inner Harbor, and Creek Walk locations are four sampling locations on Onondaga Creek, a major tributary of Onondaga Lake which drains through an urban area and experiences combined sewer overflows. The

high rate of inconclusive results present in some of the sample locations was attributed to low match rates (R^2 values), potential tape contamination, and mixed match results which did not indicate one material.

The loss of certain material types from the Inner Harbor to the Creek Walk may be indicative of removal by skimmer boat collection. However, there is still a higher percentage of polystyrene in the Creek Walk compared to Onondaga Lake. Loss of some of these materials might occur due to wind action, deposition on the shoreline, particle loss from sinking and turbulence to sediments, or dilution with additional sources not quantified here. Most significant, it was not possible to sample microplastics in METRO wastewater treatment plant effluent which represents approximately 20% of the inflow to Onondaga Lake due to the COVID pandemic. There was more spheres (which were typically polyethylene) in Onondaga Lake relative to tributary locations (Figure 4.2), which may indicate additional input of materials from METRO directly into Onondaga Lake. There is a decrease in material types detected from within Onondaga Lake to the outlet, which could indicate the retention of particles within Onondaga Lake or the inadequate capture of certain particle types with my chosen location or method.

Since only surface water was sampled with net tows, it’s also possible that polymers denser than freshwater would be present lower in the water column or in lake sediments. These types include plastics like polyvinyl chloride (specific gravity = 1.16 - 1.30) and polyethylene terephthalate (specific gravity = 1.34 - 1.39) (GESAMP, 2019). Changes in particle density could also occur over time as biofilms develop on older plastic particles, impacting their distribution in the water column (Miao et al., 2021).

4.2 Potential impacts of seasonality and residence time

Plastic pollution in lakes has been found to vary depending on regional sources and factors, such as human activities (Yonkos et al., 2014; Zhang et al., 2015) and proximity to major cities (Eriksen et al., 2013). However, the impacts of seasonality, including increases in high runoff events or differences between the wet and dry season, vary, with some studies reporting a dilution effect with increased precipitation, while others note an influx of material following antecedent dry periods (Talbot and Chang, 2022). These varying impacts could be attributed to regional differences, or factors such as lake residence time (Free et al., 2014). The residence time of Onondaga Lake is on the order of months (approximately 3 months), with a flushing rate of approximately 4 times per year (Upstate Freshwater Institute, 2013), while Skaneateles Lake's residence time is on the order of years (~18 years) (Schaffner and Oglesby, 1978). The fast-flushing rate of Onondaga Lake could partly explain the high variability in concentrations of suspected plastic particles over the study period.

I also suspect that seasonal stratification and tributary plunging within Onondaga Lake could impact the concentration and distribution of microplastics found in the study. Lake turnover can resuspend microplastics that are present within the water column or lake sediments, contributing to elevated concentrations during these time periods. Turnover in Onondaga Lake occurred on October 28th, 2020 approximately one to two weeks prior to November sampling in the northern and southern lake positions, respectively. Turnover-induced increases in microplastic concentration has been suspected in other water bodies, including lakes from Busan, South Korea (Jung et al., 2022). While another study conducted on Lake Tollense in northeastern Germany found no impact on concentrations before and after turnover, they have noted a vertical distribution of particles in the water column (Tamminga and Fischer, 2020). The authors noted that particle shape, in addition to wind direction, were important factors in the distribution of microplastics at depth. Notably, Lake Tollense has a greater mean depth (17.8 m) compared to Onondaga Lake (10 m) (NYS Dept. of Environmental Conservation, 2020), which may impact resuspension of material from bottom sediments to the surface.

Microplastics can also accumulate at the thermocline, as found in the Baltic Sea (Uurasjärvi et al., 2021). A model by Elagami et al. (2023) found that residence time in the epilimnion was highly dependent on particle size and density. Estimated settling velocities from their work noted that larger, more dense plastic particles would be more likely to sink into the sediment layer during stratified conditions (Elagami et al., 2023). Prior work in the marine environment has also noted the importance of wind-driven mixing and sinking of particles in the ocean surface (Kooi et al., 2016; Kukulka et al., 2012).

Previous research on Onondaga Lake has noted seasonal temperature and salinity differences between Onondaga Lake and its major tributaries, notably Onondaga Creek, but to a lesser extent Nine Mile Creek and METRO effluent, contribute to these tributaries entering the lake as an underflow from May - October (Effler et al., 2002). However, METRO effluent is more likely to enter surface waters compared to the other major tributaries in Onondaga Lake during this time (Effler et al., 2002). Onondaga Creek, more so than Nine Mile Creek, plunges to the metalimnion in Onondaga Lake during the summer through early fall (Effler et al., 2009). It is possible that this plunging results in a stratification of microplastic particles in the water column, which would be readily redistributed to the surface during mixing (Figure 4.5).

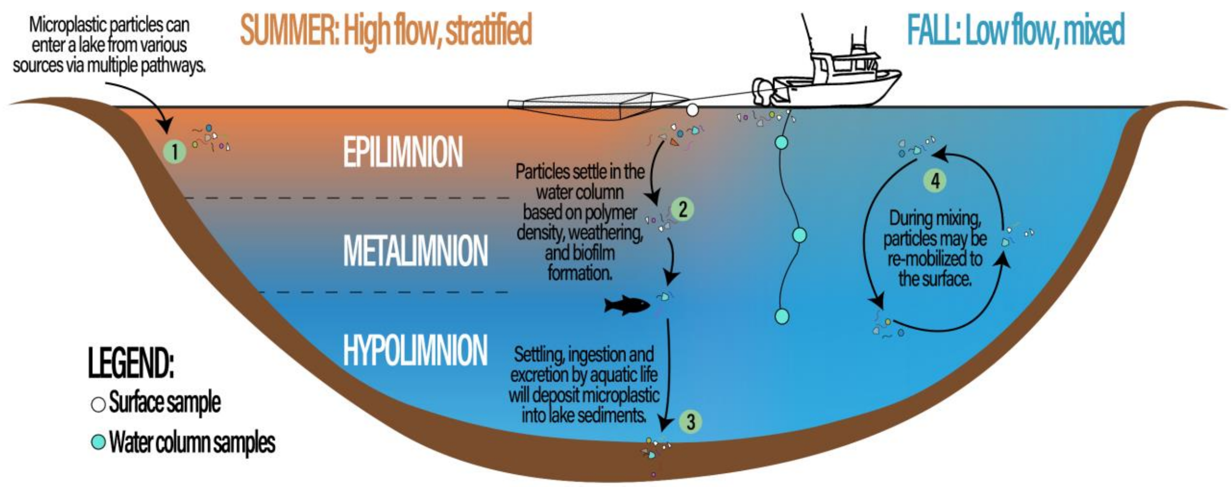


Figure 4.5: Cross-section of a dimictic lake, showing sampling locations and the processing and hypothesized movement of microplastics through the water column during the Summer (stratified) and Fall (mixed). Note that in Onondaga Lake, major tributaries including Onondaga Creek, and to a lesser extent the METRO effluent and Nine Mile Creek, may enter the lake as an underflow within the metalimnion (Effler et al., 2009). “Boat” by Hey Rabbit, TH, from the Noun Project (Hey Rabbit, TH, n.d.).

This pattern would explain both the elevated concentrations following lake turnover in 2020, as well as the lack of significant difference between the northern and southern lake positions during prior sampling efforts. However, it is important to consider how the turnover event in 2020 contrasts with that in 2021, which was two orders of magnitude lower in concentration.

I compared the turnover events in Fall 2020 and Fall 2021 using additional data on CSO events (NYS Dept. of Environmental Conservation, 2023), lake profiles (Upstate Freshwater Institute, 2023), weather data from a station at Syracuse Hancock International Airport (NOAA, 2023), and USGS gauging station data at Spencer Street

(U.S. Geological Survey, 2021). Turnover in 2020 occurred on October 28th, which was followed by a period of wet weather from October 28th to November 3rd prompting a CSO event at W Newell St. in Onondaga Creek on October 29th and November 3rd, which is reflected in the discharge data at the USGS Spencer Street gauging station (Appendix Figure C.3) (U.S. Geological Survey, 2021). Afterward, there was a period of no precipitation from November 4th (northern lake sampling) to November 9th (southern lake sampling). High wind speeds 18.0 - 30.6 km/hr were directed W/SW prior to sampling in the north basin and were predominantly E/SE prior to and on the day of sampling in the south basin. Lake profiles indicate isothermal conditions during all days of sampling, with no marked changes in turbidity at the surface (Appendix Figure C.5).

In Fall 2021, turnover occurred later than is typical in Onondaga Lake, with stratification persisting until November 19th. Temperature-based stratification ended on November 6th, while salinity-based stratification ended on November 19th. A dry spring and wet summer caused large differences in salinity and density between the upper and lower waters of Onondaga Lake (D. Matthews, Upstate Freshwater Institute, Personal Communication). Discharge at the Spencer Street USGS gauging station reached a peak of 943 cfs on November 12th, with lower discharge events on November 19th and 26th (Appendix Figure C.4)(U.S. Geological Survey, 2021). After the end of salinity stratification, turbidity reached a high of approximately 24 NTU at the near surface. However, by the time of sample collection (November 30th), turbidity at the surface decreased to around 3 NTU and there was a visible build-up of macroplastic material on the shoreline of the lake (Appendix Figure C.6).

Without further information, it is difficult to conclude which parameters are most important in controlling microplastic abundance with time and space. Likely, there are multiple contributors, including the direction and intensity of wind prior to sampling (Kooi et al., 2016; Kukulka et al., 2012; Tamminga and Fischer, 2020), the influence of mixing or stratification in the water column (Uurasjärvi et al., 2021; Zhou et al., 2021), and a potential dilution or flushing effect that may arise from increases in precipitation prior to sampling, with the latter characterized by periods of antecedent dry weather (Schmidt et al., 2018). The CSO event prior to sampling in November 2020 followed by a period of dry weather and isothermal, mixed conditions within the lake could have contributed to higher concentrations, since Onondaga Creek was not entering the lake as an interflow at this time. In comparison, turnover in November 2021 was later than normal and was characterized by a two-stage turnover. Further investigation of seasonality of this phenomenon outside of the fall sampling depicted in this work will assist in restricting the extent of particle mixing, especially within the water column. As evidenced by this study, concentrations could vary by orders of magnitude within the same lake in 3 years, which could result in vastly different potential risk of exposure to biota in the region.

5. Conclusion

In this chapter I consider variations in plastic particle form and concentration through time and space in two highly contrasting lake environments, Onondaga and Skaneateles Lakes. Plastic particle concentrations were statistically higher in Onondaga Lake compared to Skaneateles Lake (W = 64, p = 0.03), owing to its higher potential for plastic inputs from CSOs, urban runoff, and wastewater effluent inputs. Concentrations in Onondaga Lake varied with time and lake position. Compared to Skaneateles Lake, plastic particle concentrations in Onondaga Lake were highly variable. This can be attributed to its much shorter residence time (3 months) compared to Skaneateles (18 years) and the more abundant pathways for contamination. While Onondaga Lake samples collected in 2020 had notably high concentrations which we partially attribute to lake turnover, samples in November 2021 showed a decrease in almost all lake positions. Possible explanations for this difference could arise from the delay in lake turnover in November 2021, short term influences on concentrations, and a CSO outfall in November 2020 which could have increased concentrations.

Chapter 5: Major Findings and Implications for Future Research and Policy

1. Major Findings

Circular economy approaches must be informed by further research into both the human and environmental dimensions of plastic and waste products. By better understanding both the human perception and the environmental implications of waste management practices, we can better inform policy and educational campaigns aimed at addressing sources of mismanaged waste. This work informs these approaches by providing a multi-disciplinary perspective on plastic waste, including human perceptions and production of waste (Chapter 2), quality assurance and quality control considerations of field monitoring for plastic particles (Chapter 3), and the application of these findings to a 3-year sampling campaign in two central New York lakes (Chapter 4).

In Chapter 2 I explored the results of a survey administered after completion of a social media campaign, Futuristic February, which is aimed at increasing individual awareness of non-perishable waste generation. Even though the surveyed sample (n=50) scored high on the NEP scale, indicating a pro-ecological worldview consistent with environmentalists (Hawcroft and Milfont, 2010), suggesting they might be more likely to seek out information on environmental topics, there was high uncertainty on statements related to bioplastics and biodegradable plastics (44% - 30%). Most participants (86%) also agreed that there were trash islands in the ocean gyres. These topics show the pervasive nature of misinformation, which may partially raise awareness on plastic pollution, but also undercuts effectiveness of mitigation efforts. Education on these topics and a more accurate portrayal of uncertainty could further improve steps to reduce waste and inform people of packaging alternatives. This approach is especially important with regards to circular economy opportunities and potential substitution of materials that can be either reused or recycled more effectively. Though a substitution may be environmentally favorable, if it is not properly understood with respect to both use and disposal, this approach could have unforeseen negative consequences.

These consequences, including the eventual release of plastic products into the environment and the need to properly quantify microplastic generation using reliable sampling methods and rigorous quality assurance and quality control (QA/QC). Currently, methods for collecting and quantifying plastic particles in the environment are non-standardized, resulting in incomparability among studies. It is nearly impossible to compare microplastic concentrations between two freshwater environments in which different collection and processing methods were used, especially if the degree of stringency in QA/QC procedures between the studies differ. To inform the effectiveness of monitoring microplastics in the freshwater environment, I tested various sampling collection techniques throughout a 3-year sampling campaign in an urban and a rural lake in central New York (Chapter 3). In these efforts I found that point sampling (grab, bucket and pump methods) had highly variable results and were less likely to exceed the LOD compared to high-volume, areal capture methods such as net sampling. However, results were variable depending on whether plastic floatables were present and downstream of CSOs and a highly urbanized stream reach. Though net sampling likely underrepresented smaller particles, this method collected a higher diversity with respect to color and morphology compared to other methods. A spike test involving a diverse set of particles showed a decrease in recovery with smaller-width particles, particularly associated with the increased sample transfer and processing associated with net samples. This work shows the importance of rigorous quality control in microplastics sampling and processing and further consideration for quantification thresholds of individual laboratories prior to and during a monitoring campaign. If accessibility and financial restrictions exist, these quantification thresholds can help to quantify the volume of a particular matrix needed to obtain reliable results regardless of the chosen method. These improvements in quantification could inform regional efforts to reduce inputs of plastic waste into the environment.

Lastly, in Chapter 4 I applied the methods evaluated and refined in Chapter 3 to monitor Onondaga and Skaneateles lakes for plastic particles from 2019 – 2021 and potential impacts of seasonal stratification. Plastic particle concentrations were higher in Onondaga Lake compared to Skaneateles Lake, owing to its higher potential for plastic inputs from CSOs, urban runoff, and wastewater effluent inputs. Concentrations in Onondaga Lake were also more variable with time and lake position compared to Skaneateles Lake. The short residence time and smaller number and nature (urban stream, CSOs, wastewater effluent) of major inflows to Onondaga Lake (3 months) compared to Skaneateles Lake (18 years) could result in higher variation in concentrations in Onondaga Lake over a shorter time scale. I also compared two fall turnover events in Onondaga Lake, which had varying impacts on plastic particle abundance, likely influenced by the high delay in turnover in 2021 and the increased inputs from CSO outflows in 2020.

While the marine environment has been highly characterized for plastic pollution, there are still many unknowns regarding the distribution and transport of plastic particles in freshwater environments. If plastic particle concentrations can vary so widely on such short time scales, risk assessments should be careful to consider the time scales on which monitoring data were collected; approaches for integrating cumulative impacts of time varying microplastic concentrations; and the impacts that lake residence time and other regional factors may have on particle populations. Furthermore, this research notes the importance of utilizing sampling methods that considers the full diversity of particle populations.

2. Policy Implications

These findings have implications for policy regarding both local and global material usage. Though there have been remarkable improvements in CSO management in Onondaga Creek, further policy addressing key sources of waste and improvements in the capture of street litter may improve downstream conditions. Despite the collection of larger floatable plastics using skimmer boats in the Inner Harbor of Onondaga Creek, plastic materials are still not adequately captured. The recent ban in the state of New York on the use of expanded polystyrene foam take-out containers and packing peanuts will likely decrease the abundance of foam and polystyrene materials in the Inner Harbor (New York State Senate, 2021), however there are additional measures that can also improve capture of smaller materials. These include additional trash capture devices such as SeaBins or Littatraps, which are effectively used in the Toronto harbor to capture litter within the marina and storm drains, respectively (U of T Trash Team, n.d.). The patterns of material types and abundance of materials found in this study indicate a sharp increase in materials and diversity from CSOs and other sources near Spencer Street going into the Inner Harbor. Trash capture devices within the harbor may help to tackle some of these materials but may be less effective during high discharge events which may prompt CSO events. Further improvements in floatable management, especially in downtown areas with more impervious surfaces near Onondaga Creek, and the use of improved street litter capture and downtown waste management can further reduce this impact.

However, other key sources of plastic material should be addressed at the production and use phase. Based on prior findings by Morales-Caselles et al. (2021) and my findings in Chapter 2, food packaging is the predominant source of plastic pollution in the freshwater environment and a highly produced portion of non-perishable waste. Alternatives should be considered from a circular perspective and their lasting impact on the environment. Furthermore, the second most common morphology in net samples from all sample locations was fibers (37.3%). Reduction in microfiber release requires an increased consideration for fiber shedding from material fabrication to release from daily wear, as well as washing (De Falco et al., 2020). This issue can be partially addressed by requiring microfiber filters in new washing machines and dryers, but should also be considered from early stages of clothing fabrication and use. There are interventions from consumer behaviors to policy which must be cooperatively approached to address the global microfiber problem, especially in the advent of increasing production of fast fashion and textiles (Liu et al., 2021).

3. Future Research Directions

Future research on these topics should look to address the following regarding the human dimension of plastic pollution (Chapter 2):

- The impact of educational interventions and non-perishable waste production, particularly in diverse groups which may rate lower on the NEP scale regarding pro-ecological worldview.
- Potential alternatives to food packaging materials, such as local reusable take-out container initiatives. The impact of these initiatives on the local population and their perception of environmental initiatives would help provide a foundation to expand these elsewhere depending on local needs and scalability.

Furthermore, aspects of quality assurance and quality control in monitoring (Chapter 3) could be further characterized with regard to:

- The recovery of a diverse range of polymer types, sizes, and shapes with sample processing.
- The development and use of standard reference materials in microplastic research.
- The impacts of various types of matrices on particle recovery.

- Methods to reduce microplastic contamination during both collection and processing.

And lastly, areas of further research for microplastics in seasonally stratified lakes, including work in Onondaga and Skaneateles Lakes, (Chapter 4) include:

- Improved characterization of the impacts of seasonal turnover on microplastic circulation.
- Improved methodologies for the characterization of microplastics at depth in the water column of lakes.
- The use of sediment coring for reconstruction of microplastic depositional history and fate in lakes.
- Characterization of concentrations and removal from lake to tap in drinking water from Skaneateles Lake.

Appendix A: Uncertainties About Waste Using a Global Online Survey and Review Approach: Environmentalist Perceptions, Waste Composition and Views from Media and Science

Table A.1: Ecological Worldview (NEP Scores) among Futuristic February Participants (n=50).

Do you Agree or Disagree that…	**Mean**	**SD**
1. We are approaching the limit of the number of people the earth can support.	4.26	1.14
2. Humans have the right to modify the natural environment to suit their needs.	4.20	0.96
3. When humans interfere with nature it often produces disastrous consequences.	4.70	0.53
4. Human ingenuity will ensure that we do NOT make the earth unlivable.	3.28	1.20
5. Humans are severely abusing the environment.	4.97	0.33
6. The earth has plenty of natural resources if we just learn how to develop them.	2.48	1.47
7. Plants and animals have as much rights as humans to exist.	4.88	0.71
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.	4.47	0.93
9. Despite our special abilities humans are still subject to the laws of nature.	4.85	0.48
10. The so called ecological crisis facing humankind has been greatly exaggerated.	4.68	0.93
11. The earth is like a spaceship with very limited room and resources.	4.25	0.85
12. Humans were meant to rule over the rest of nature.*	4.78	0.93
13. The balance of nature is very delicate and easily upset.	4.03	1.13
14. Humans will eventually learn enough about how nature works to be able to control it.	4.05	1.14
15. If things continue on their present course we will soon experience a major ecological catastrophe.	4.88	0.46
Total	**4.32**	**0.88**

Note. Agreement with the odd numbered items and disagreement with the even numbered items display a pro-ecological worldview response. Strongly disagree = 1, Mildly disagree = 2, Unsure = 3, Mildly agree = 4, Strongly agree = 5. The scale is reversed for even numbered questions. SD = Standard Deviation.

Table A.2: Trash summary categories assigned to write-in answers provided by survey participants.

Trash Summary Category	Describe the most common type of trash found in the category selected above (for example: plastic water bottles or food containers, aluminum cans, glass juice bottles):
Beverage Container	Beer and Seltzer cans; Orange juice; Sparkling water cans; Water bottle; Aluminum cans, glass bottles
Bottles	Glass bottles; Plastic bottles/containers; Wine bottles
Boxes	Amazon boxes; Cardboard boxes; Boxes; Mostly boxes
Cans	Aluminum cans; Aluminum cans
Cardboard	Cardboard
Disposable paper products	Napkins/paper towel; Tissues
Food packaging	Cardboard boxes/containers from "canned" beans; Cardboard food boxes; Pasta boxes; Paperboard food packaging; Plastic bags from pantry food; Food-related packaging; Cans from food; Tea bags; Plastic food packaging; Food/tea cartons; Plastic food packaging; Food cardboard packages; Cheese it boxes; Food packaging in general; Cardboard boxes for packaged goods like granola bars; Plastic food containers; Boxes that held food/drinks
Mail	Junk mail; Mail; Junk mail; Junk mail; Ads from local businesses; Mail (I don't receive junk mail); Paper/Mail; Junk mail
Packaging	Packaging
Paper	Scrap paper
Receipts	Receipts
Stickers	Stickers
Takeout Boxes	Takeaway food containers; Pizza boxes; Take out

Note: Only the first listed item provided by participants was considered to determine the most common type of trash found. The complete answers can be found in the Survey Excel doc.

Appendix A-1: Internal Review Board Status

This work received Institutional Review Board exemption (#20-054) on February 28, 2020.

Appendix A-2: Survey

Individual Non-Perishable Waste Generation and Perceptions of Waste and the Environment following the Futuristic February Social Media Campaign
Charles Driscoll and Laura Markley, Civil and Environmental Engineering

Informed consent statement and survey will be administered through Qualtrics.

Informed Consent Statement:

My name is Laura Markley, and I am a PhD student at Syracuse University in the Department of Civil and Environmental Engineering. I am inviting you to participate in a research study. Involvement in the study is voluntary, so you may choose to participate or not. This sheet will explain the study to you and please feel free to ask questions about the research if you have any. I will be happy to explain anything in detail if you wish.

I am interested in learning more about (1) factors influencing individual waste generation (2) components of non-perishable waste and (3) perceptions of waste and the environment. You are being asked to participate in this study by providing weights and descriptions of your waste collected during Futuristic February. Afterward, you'll be asked questions about your perception of the waste issue and the relationship between humans and the environment. These questions do not have right or wrong answers, but are designed with your experience and your perceptions in mind. We ask only for candid, open responses that provide us with information about your personal views and correct data on the weight and type of non-perishable trash collected during February. This survey will take an estimated 10-15 minutes of your time.

Your information will be kept confidential to the best of our ability. This survey will not ask for any private identifying information that could be linked to you. Whenever one works with email or the internet there is always the risk of compromising privacy, confidentiality, and/or anonymity. Your confidentiality will be maintained to the degree permitted by the technology being used. It is important for you to understand that no guarantees can be made regarding the interception of data sent via the internet by third parties.

The benefits of this research are that you will be helping us to better understand how you feel about waste production and sustainability. By being involved you are allowing your thoughts to be heard. This study will better inform future research and provide background knowledge on the components and factors influencing individual waste generation. You will also be providing valuable information on perceptions of waste, plastic pollution, and the environment. This information is vital to securing a more sustainable future.

The risks to you of participating in this study are minimal, and are not greater than risks ordinarily encountered in daily life. All information will be kept confidential, and you will remain anonymous. No identifying information will be included in papers or presentations resulting from this research. If you do not want to take part, you have the right to refuse to take part, without penalty. If you decide to take part and later no longer wish to continue, you have the right to withdraw from the study at any time, without penalty.

If you have any questions, concerns, or complaints about the research, contact Laura Markley at lamarkle@syr.edu.

All of my questions have been answered if I have them, I am 18 years of age or older, and I wish to participate in this research study.

Multiple Choice: Yes or No

Survey:

Thank you for taking the time to fill out this survey after participating in Futuristic February.

These questions will gather information that will be used to further understand the factors contributing to waste generation and the most prominent forms of waste. Your answers are for study purposes only. Please answer openly and honestly.

If you collected your waste for Futuristic February with a group (household, school, family, etc) and your waste can be categorized SEPARATELY (they are not mixed together and you know your waste from the other persons'), you may fill out 1 survey per person, otherwise denote the number of people who participated in the group waste collection.

What country do you live in?
Fill in blank

What city/town do you live in?
Fill in blank

I collected my waste....
Separately: the non-perishable waste is from me alone.
As a group: the non-perishable waste is from multiple people and I would not be able to weigh each person's trash separately.

If "separately": skip to demographic information
If "as a group": display questions below:

What type of group?
Household (Family/Roommates)
Classroom
School
Other

If "Other":
Fill in Blank
Groups skip to end of demographic information.

Demographic Information:
Age:
18-20
21-29
30-39
40-49
50-59
60 or older

Gender:
Female
Male
Non-binary/third gender
Prefer to self-describe
Prefer not to say
Other

I identify my ethnicity as (select all that apply):
Asian
Black/African
Caucasian
Hispanic/Latinx
Native American
Pacific Islander
Prefer not to answer
Other

If Other:
Type in the ethnicity with which you identify here:
Fill in blank

Which of the categories best describes your employment status?
Undergraduate student
Graduate student

Employed, working 1-39 hours per week
Employed, working 40 or more hours per week
Not employed, looking for work
Not employed, not looking for work
Retired
Disabled, not able to work

Please select your income range before taxes:
Under $20,000
$20,001 – $40,000
$40,001 – $60,000
$60,001 – $80,000
$80,001 – $100,000
$100,001 or over

What is the highest level of education you have completed or degree you have received?
Secondary education without graduation (K-11 or 12, but did not graduate)
High school degree or equivalent (e.g. GED)
Vocational training
Some college but no degree
Associate degree
Bachelor Degree
Master's Degree
Specialist Degree
Doctorate

Please select the category that best describes the degree of urbanization of the neighborhood in which you live:
Highly urbanized, I live in a busy city where the buildings are close to each other.
Urbanized, I live in a city where the buildings are close, but there is still some breathing room.
Suburban, I live in a neighborhood with spacing out of houses and apartments with occasional noise.
Exurban – large lots but still in a neighborhood with a kind of sub-urban feel. I have to commute a relatively long distance to work
Rural, I live in an area where houses are much further apart and it is very quiet.

Groups skip to here.

Futuristic February Non-perishable Waste Information:

For how many days did you collect your non-perishable waste (the entire month of February is 29 days)?
29 days
Other

If Other:
Input the amount of days you collected your waste for:
Fill in blank.

After participating in Futuristic February, I consider my waste stream (including the amount of trash and recycling I produce):
Very sustainable – in my opinion, I produce very little waste in comparison to most people.
Sustainable - I try to reduce, reuse, recycle and have a low waste output, and feel that my efforts result in more sustainable practices and less waste than most people.
Average - I produce an amount of waste that I consider to be roughly equivalent to the amount of waste that most people produce.
Excessive - I produce more waste than the average person.

Weighing your non-perishable waste:

To weigh your waste, we suggest placing it all in a **garbage bag** or in a **large box or secondary container.**

If the secondary container is **NOT** part of your trash, record the weight of the container (box or otherwise) below.
If the secondary container **IS** part of your trash, record the total weight.

A regular kitchen or bathroom scale is suitable for weighing. Make sure the bag or box is balanced and is being fully weighed on the scale.

What is the weight of your collected non-perishable waste?
Fill in blank

Weight of secondary container (if NOT part of your trash), otherwise skip:
Fill in blank

Of your collected waste materials, what is the most commonly occurring?
(by number of objects, a visual estimate of the most abundant material is okay - no need to count them all)

Plastic (Films, bags, bottles, food containers, Styrofoam)

Cardboard and paper (shipping boxes, pizza boxes, cereal boxes, shoe boxes, pasta boxes, cardboard egg cartons, sheets of paper, junk mail, tissue)

Aluminum / Steel (Cans, foil)

Glass (Bottles, salsa jars, pickle jars, wine bottles, seltzer bottles)

Other

Images above from:
Crystal Crees. Slide 3441453 [digital image]. http://slideplayer.com/slide/3441453/
Department of Environmental Protection, Montgomery County Maryland.
https://www2.montgomerycountymd.gov/DepHowDoI/material.aspx?tag=paper&material_key=24

South Central Solid Waste Authority. https://scswa.net/why-recycle-aluminum-and-tin-steel-cans/
Denver Recycling Directory. https://www.denvergov.org/content/denvergov/en/trash-and-recycling/recycling/recycling-directory-dropoff-locations.html#!rc-cpage=41190

If other, describe here:
Fill in blank

Describe the most common type of trash found in the category selected above (for example: plastic water bottles or food containers, aluminum cans, glass juice bottles):
Fill in blank

Perceptions of Waste & Plastic Pollution Issues:

Listed below are statements about waste and plastic pollution. For each one, please indicate whether you STRONGLY AGREE, MILDLY AGREE, are UNSURE, MILDLY DISAGREE or STRONGLY DISAGREE with it.

If you are completing this survey as a group, you may discuss the statements together.

Waste (in the form of trash / garbage) is the greatest threat to our oceans.
Plastic pollution is the greatest threat to our environment.
Microplastic particles (broken up pieces of larger plastic or smaller plastics like microbeads) are toxic to humans and animals.
Bioplastics are all biodegradable.
Biodegradable plastics are able to break down in the environment.
Ocean trash gyres, locations in the ocean where large quantities of trash are concentrated by currents, have trash islands that can be seen from space.
Reducing our trash / garbage generation is the best way to reduce our overall environmental footprint.
Single-use items are better if they can be composted.
Glass is infinitely recycled in recycling facilities.
Glass or paper are better alternatives to plastic.
All plastics are equally recyclable.

Perception of the Relationship between Humans and the Environment:

Listed below are statements about the relationship between humans and the environment. For each one, please indicate whether you STRONGLY AGREE, MILDLY AGREE, are UNSURE, MILDLY DISAGREE or STRONGLY DISAGREE with it.

If you are completing this survey as a group, you may discuss the statements together.

We are approaching the limit of the number of people the earth can support.
Humans have the right to modify the natural environment to suit their needs.
When humans interfere with nature it often produces disastrous consequences.
Human ingenuity will ensure that we do NOT make the earth unlivable.
Humans are severely abusing the environment.
The earth has plenty of natural resources if we just learn how to develop them.
Plants and animals have as much rights as humans to exist.
The balance of nature is strong enough to cope with the impacts of modern industrial nations.
Despite our special abilities humans are still subject to the laws of nature.
The so-called “ecological crisis” facing humankind has been greatly exaggerated.
The earth is like a spaceship with very limited room and resources.
Humans were meant to rule over the rest of nature.
The balance of nature is very delicate and easily upset.
Humans will eventually learn enough about how nature works to be able to control it.
If things continue on their present course, we will soon experience a major ecological catastrophe.

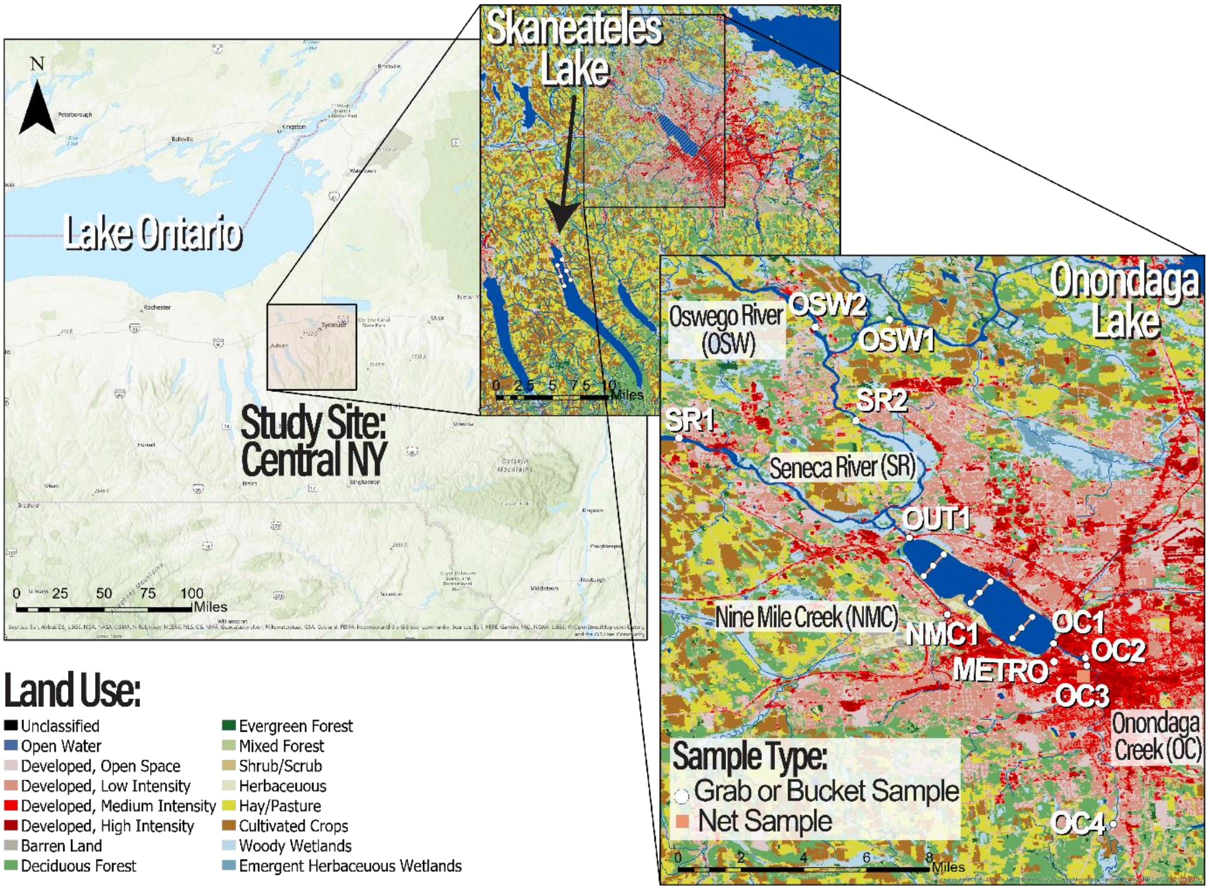
Thank you for completing this survey!

If you have any outstanding questions, please feel free to contact us at

lamarkle@syr.edu.

Appendix B: Improving the Capture and Monitoring of Microplastics in Freshwater Ecosystems: A Case Study Comparing Urban and Rural Lakes in Central New York

Appendix B-1: Sampling Protocol for 2019 / 2020



Sample Protocol

Field Supplies List

- **Watch**
- **Camera**
- **Tape for labeling**
- **Sharpie for labeling**
- **GPS unit or phone with GPS app**
- **Data recording sheets and binder**
- **Wash bottle**
- **Spray backpack filled with DI water**
- **Carboy filled with DI water**
- **Extra aluminum foil**
- **Extra rope**

- **Cooler or tub to carry samples in**

Net sampling:

- **Microplastic sampling net**
    - Prep in lab: Shake contents into garbage can. Make sure hardware is tight on net.
- **Flow meter**
    - Prep in lab: Make sure flow meter is attached to net and is tightened. Clean if needed. Check batteries.
- **Pre-Rinsed Three Times (with DI water) mason jar (1 per sample) + 1 field blank and 1 equipment blank**

Grab sampling:

- **Wading boots**
- **Pre-Rinsed Three Times (with DI water) mason jars + 1 field blank and 1 equipment blank**

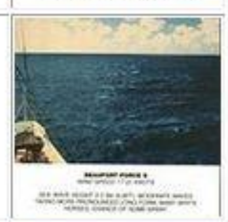
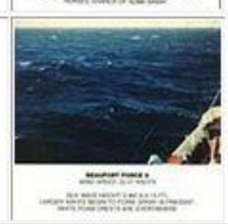
Bucket sampling:

- **Stainless steel bucket with natural fiber rope (for bridge sampling)**
- **Orange Home Depot bucket**
- **100 um sieve**
- **Extra DI water**
- **DI water bottle**

Net sampling Technique

Open Water:

1. Make sure you are wearing a life jacket. If any team members are wearing synthetic clothing, record the number of articles on the boat made of synthetics on the data sheet.
2. Record the beaufort sea state on the data recording sheet (see table below). If the sea state is above 3, do not proceed with sampling. If it is below 3, proceed to next step.

Beaufort number	Wind speed	Wave height	Sea conditions	Sea state photo
0	< 1kt	0 m 0 ft	Flat.	
1	1 – 3kt	0 – 0.2 m 0 – 1 ft	Ripples without crests.	
2	4 – 6kt	0.2 – 0.5m 1 – 2 ft	Small wavelets. Crests of glassy appearance, not breaking	
3	7 – 10kt	0.5 – 1m 2 – 3.5ft	Large wavelets. Crests begin to break; scattered whitecaps	
4	11 – 16kt	1 – 2m 3.5 – 6ft	Small waves with breaking crests. Fairly frequent whitecaps.	
5	17 – 21kt	2 – 3m 6 – 9ft	Moderate waves of some length. Many whitecaps. Small amounts of spray.	
6	22 – 27kt	3 – 4m 9 – 13ft	Long waves begin to form. White foam crests are very frequent. Some airborne spray is present.	

https://blog.metservice.com/Sea_State_and_Swell
(“Sea State and Swell | MetService Blog,” 2015)

3. Label sample bottle with the following convention: SITE _DATE_NET. Site (see below), Naming convention for blanks: SITE _DATE_BLNK.
4. Place sample bottle in a secure location. Make sure it is not left open.
5. Make sure the net and flow meter are secure and the hardware is tightened.
6. Record the rotations on the flow meter before starting.
7. Make sure the net is not tangled and will flow freely.
8. Once in starting position, record starting lat/long and start time on data sheet.
9. Take a grab sample at starting point, either by using the bucket and natural fiber rope or by rinsing sample bottle 3x with lake water (on opposite side of vessel to leave desired location undisturbed) prior to collecting sample in desired starting location. Make sure to label: SITE _DATE_GRAB.
10. Start timer once net is deployed.
11. Deploy net on boom. Make sure it is outside the wake of the vessel.
12. Maintain a consistent heading with the vessel toward the sample end point.
13. Keep boat at steady pace as it proceeds across the lake to the desired end point.
14. Halfway through towing (~15 minutes in), collect a second grab sample and record the lat/long (see step 9 for process).
15. Record starting boat speed. Record the stopping lat/long and time. Record ending boat speed.
16. Once at ending point after reaching either desired location or towing for 30 minutes, retrieve net carefully.
17. Rinse microplastics in top part of the net from the outside into the cod-end of the net using backpack.
18. Remove cod end after sufficiently rinsing. Rinse cod end into correct sample bottle.
19. Take one more grab sample near end point of tow (see step 9 for process). Record the lat/long.

BLANKS for Open Water Net Sampling:

20. If an equipment blank has not been taken, make sure a blank is taken for the day. Return cod end to net. Rinse net thoroughly into cod-end as you usually would.
21. Remove cod end, rinse into sample bottle with correct naming convention.
22. Take one field blank per sampling event. Place mason jar filled with DI water open on the boat during sample collection.

Stream:

1. Make sure you are wearing a reflective vest and the area is safe. If waters are too rapid or otherwise dangerous, do not proceed with sampling. Wear waders if you will be wading into stream or river. If you are sampling from a bridge, ensure there are no cars or trains coming.
2. Label sample bottle with the following convention: LOCATION _DATE_NET. LOCATION (see table below), Naming convention for blanks: LOCATION_SECTION _DATE_BLNK.
3. Place labeled bottled in a secured location. Do not leave it open.

Location:	Naming Convention:
Nine Mile Creek	NMC
Onondaga Creek	OC (1, 2)
Seneca River	SR
Oswego River	OSW
Oneida River	ONEIDA

4. Double check hardware on net prior to deployment.
5. Ready your timer or watch to track the timing of the sampling.
6. Record rotation number of flow meter prior to deploying net.
7. Deploy the net by facing the opening of the net upstream without disturbing the sediment in front of the net.
8. Release the net behind the frame allowing it to completely open, unobstructed.
9. Start time after net is placed in water and released. Sample for 10-30 minutes, depending on flow conditions. Higher flows will result in a faster sampling process.
10. Record rotations from flow meter after deploying.

EQUIPMENT & FIELD BLANKS for Stream Sampling:

11. If a blank has not been taken, make sure a blank is taken for the day. Return cod end to net. Rinse net thoroughly into cod-end as you usually would.
12. Remove cod end, rinse into sample bottle with correct naming convention.
13. For field blank, leave sample container filled with DI water open to air during net sampling collection.

Grab / Bulk sampling Technique

1. Make sure you are wearing a reflective vest or safety vest and the area is safe. If waters are too rapid or otherwise dangerous, do not proceed with sampling.

Wear waders if you will be wading into stream or river. If you are sampling from a bridge, ensure there are no cars or trains coming.

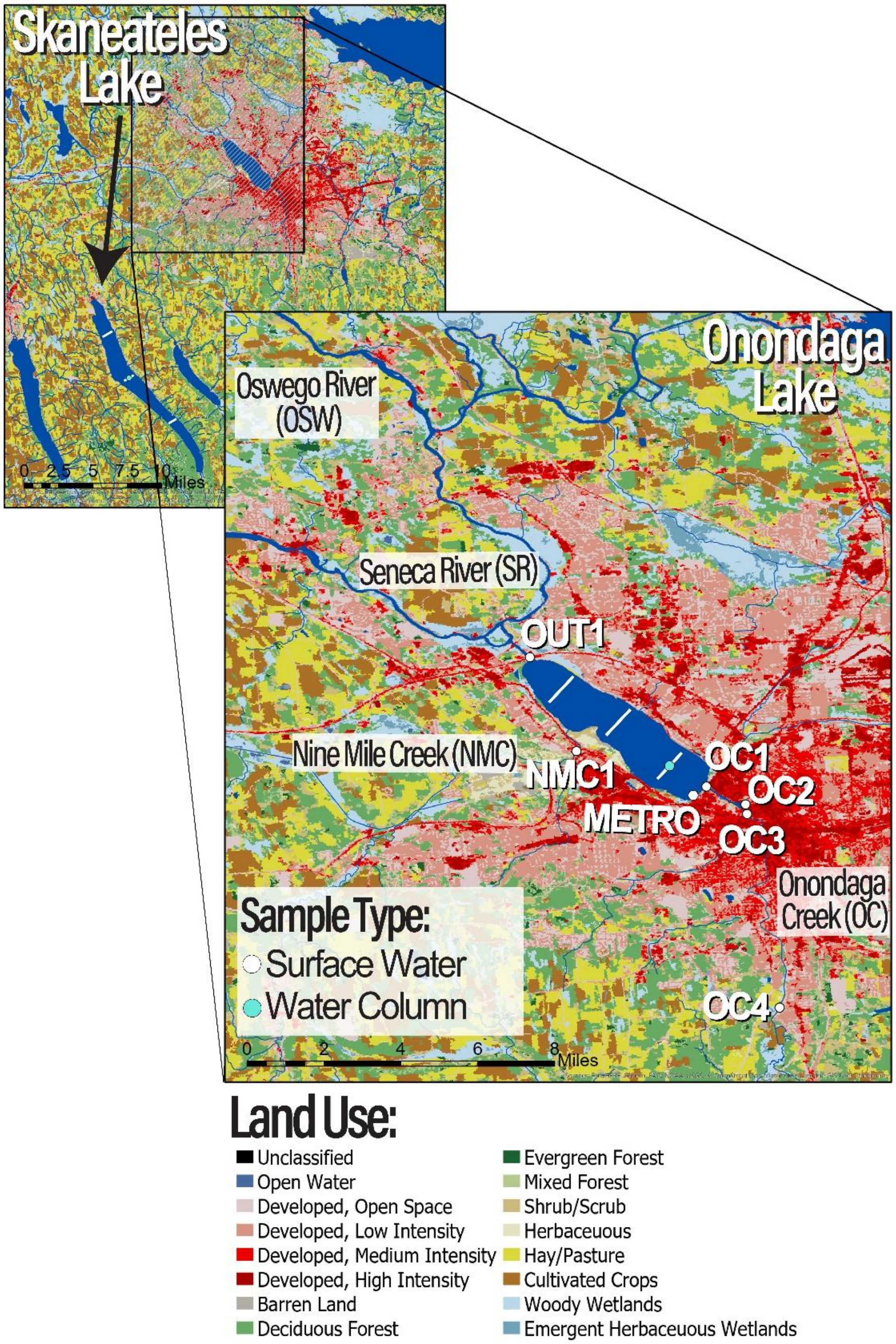
2. Label sample bottle with the following convention: SITE _DATE_GRAB. SITE (see table below), Naming convention for blanks: LOCATION_SECTION _DATE_BLNK.

Location:	Naming Convention:
Onondaga Lake	OND (1, 2, 3)
Nine Mile Creek	NMC
Onondaga Creek	OC (1, 2)
Metro Effluent Sample	METRO
Seneca River	SR
Oswego River	OSW
Oneida River	ONEIDA
Skaneateles Lake	SL (1, 2 3)

3. If you can reach the water without a bucket (not on a bridge), rinse sample bottle downstream or on the other side of the vessel from the sample location THREE TIMES.
4. If using a bucket, tighten rope sufficiently. Check surroundings. Dip bucket into surface of the river or stream to obtain a small sample.
5. Rinse the bucket three times prior to collecting sample.
6. Pass bucket water through the 100 um sieve into second collection bucket.
7. Fill collection bucket twice (depending on amount of detritus present in sample).
8. Rinse the jar 3 times with stream water.
9. Rinse sieve contents into pre-rinsed jar with DI water bottle.
10. If collecting without a bucket, collect sample by skimming surface of water 3 times prior to capping sample. Record on sample sheet.

Appendix B-2: Sampling Protocol for 2021

Sample Locations:



Sample Protocol

Field Supplies List

- **Watch**
- **Camera**
- **Tape for labeling**
- **Sharpie for labeling**
- **GPS unit or phone with GPS app**
- **Data recording sheets and binder**
- **Wash bottle**
- **Spray backpack filled with DI water**
- **Carboy filled with DI water**
- **Cooler or tub to carry samples in**
- **Sample jars (Triple-rinsed with DI water)**
    - **Net sample jars**
    - **Pump sample jars**
    - **Field blank jars**
    - **Extra jars (in case of overflow)**

Net sampling:

- **Microplastic sampling net**
    - Prep in lab: Shake contents into garbage can. Make sure hardware is tight on net. Rinse with spray backpack if needed.
- **Flow meter**
    - Prep in lab: Make sure flow meter is attached to net and is tightened. Clean if needed.

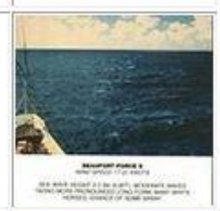
Pump sampling:

- **(2) Orange Home Depot buckets with marked off volume**
- **106 um sieve**
- **Bilge pump**
- **Car battery (charged)**
- **(2) 4 gallon carboys filled with DI water**
- **DI water bottle**
- **CTD / Exo sonde for measurements of conductivity, temperature, and DO with depth**

Net sampling Technique

Open Water:

1. Make sure you are wearing a life jacket. If any team members are wearing synthetic clothing, record the number of articles on the boat made of synthetics on the data sheet.
2. Record the beaufort sea state on the data recording sheet (see table below). If the sea state is above 3, do not proceed with sampling. If it is below 3, proceed to next step.

Beaufort number	Wind speed	Wave height	Sea conditions	Sea state photo
0	< 1kt	0 m 0 ft	Flat.	
1	1 – 3kt	0 – 0.2 m 0 – 1 ft	Ripples without crests.	
2	4 – 6kt	0.2 – 0.5m 1 – 2 ft	Small wavelets. Crests of glassy appearance, not breaking	
3	7 – 10kt	0.5 – 1m 2 – 3.5ft	Large wavelets. Crests begin to break; scattered whitecaps	
4	11 – 16kt	1 – 2m 3.5 – 6ft	Small waves with breaking crests. Fairly frequent whitecaps.	
5	17 – 21kt	2 – 3m 6 – 9ft	Moderate waves of some length. Many whitecaps. Small amounts of spray.	
6	22 – 27kt	3 – 4m 9 – 13ft	Long waves begin to form. White foam crests are very frequent. Some airborne spray is present.	

https://blog.metservice.com/Sea_State_and_Swell
("Sea State and Swell | MetService Blog," 2015)

3. Label sample bottle with the following convention: SITE _DATE_NET. Site (see below), Naming convention for blanks: SITE_DATE_BLANK.

4. Place sample bottle in a secure location. Make sure it is not left open.
5. Make sure the net and flow meter are secure and the hardware is tightened.
6. Record the rotations on the flow meter before starting.
7. Make sure the net is not tangled and will flow freely.
8. Once in starting position, record starting lat/long and start time on data sheet.
9. Place 106 µm sieve out in the open for the duration of the net sampling event.
10. Start timer once net is deployed.
11. Deploy net on boom. Make sure it is outside the wake of the vessel.
12. Maintain a consistent heading with the vessel toward the sample end point.
13. Keep boat at steady pace as it proceeds across the lake to the desired end point.
14. Halfway through towing (~15 minutes in), collect a pump sample and record the lat/long (see step 9 for process).
15. Record starting boat speed. Record the stopping lat/long and time. Record ending boat speed.
16. Once at ending point after reaching either desired location or towing for 30 minutes, retrieve net carefully.
17. Rinse microplastics in top part of the net from the outside into the cod-end of the net using backpack.
18. Remove cod end after sufficiently rinsing. Rinse cod end into correct sample bottle.
19. Rinse 106 µm sieve into sample jar after completion of net tow.
20. Rinse net and cod end down without returning cod end with spray backpack before next sample.

BLANKS for Open Water Net Sampling:

1. If an equipment blank has not been taken, make sure a blank is taken for the day or every 3 net samples. Return cod end to net. Rinse net thoroughly into cod-end as you usually would.
2. Remove cod end, rinse into sample bottle with correct naming convention.
3. Take one trip blank per sampling event. Place mason jar filled with DI water open on the boat during sample collection.

Stream:

1. Make sure you are wearing a reflective vest and the area is safe. If waters are too rapid or otherwise dangerous, do not proceed with sampling. Wear waders if you will be wading into stream or river. If you are sampling from a bridge, ensure there are no cars or trains coming.

2. Label sample bottle with the following convention: LOCATION _DATE_NET. LOCATION (see table below), Naming convention for blanks: LOCATION_SECTION _DATE_BLNK.
3. Place labeled bottled in a secured location. Do not leave it open.
4. Double check hardware on net prior to deployment.
5. Ready your timer or watch to track the timing of the sampling.
6. Record rotation number of flow meter prior to deploying net.
7. Deploy the net by facing the opening of the net upstream without disturbing the sediment in front of the net.
8. Release the net behind the frame allowing it to completely open, unobstructed.
9. Start time after net is placed in water and released. Sample for 10-30 minutes, depending on flow conditions. Higher flows will result in a faster sampling process.
10. Record rotations from flow meter after deploying.

EQUIPMENT & FIELD BLANKS for Stream Sampling:

1. If a blank has not been taken, make sure a blank is taken for the day or every 3 net samples. Return cod end to net. Rinse net thoroughly into cod-end as you usually would.
2. Remove cod end, rinse into sample bottle with correct naming convention.
3. For field blank, leave sample container filled with DI water open to air during net sampling collection.

Pump sampling Technique

1. Make sure you are wearing a reflective vest or safety vest and the area is safe. If waters are too rapid or otherwise dangerous, do not proceed with sampling. Wear waders if you will be wading into stream or river. If you are sampling from a bridge, ensure there are no cars or trains coming.
2. Label sample bottle with the following convention: SITE _DATE_GRAB. SITE (see table below), Naming convention for blanks: LOCATION_SECTION _DATE_BLNK.

Location:	Naming Convention:
Onondaga Lake	OND (1, 2, 3)
Nine Mile Creek	NMC

Onondaga Creek	OC (1, 2)
Metro Effluent Sample	METRO
Seneca River	SR
Skaneateles Lake	SL (1, 2 3)

3. When taking pump sample, check surroundings. Attach the pump to the car battery. Red is (+) positive and black is (-) negative.
4. Let the pump run water through it for 90 seconds prior to taking sample.
5. Pass pump water through the 106 um sieve into second collection bucket.
6. Fill collection bucket 5 times, swapping out the bucket to empty it overboard when it reaches the targeted volume (marked with sharpie).
7. Rinse the jar 3 times with water.
8. Rinse sieve contents into pre-rinsed jar with DI water bottle.

EQUIPMENT & FIELD BLANKS for Pump Sampling:

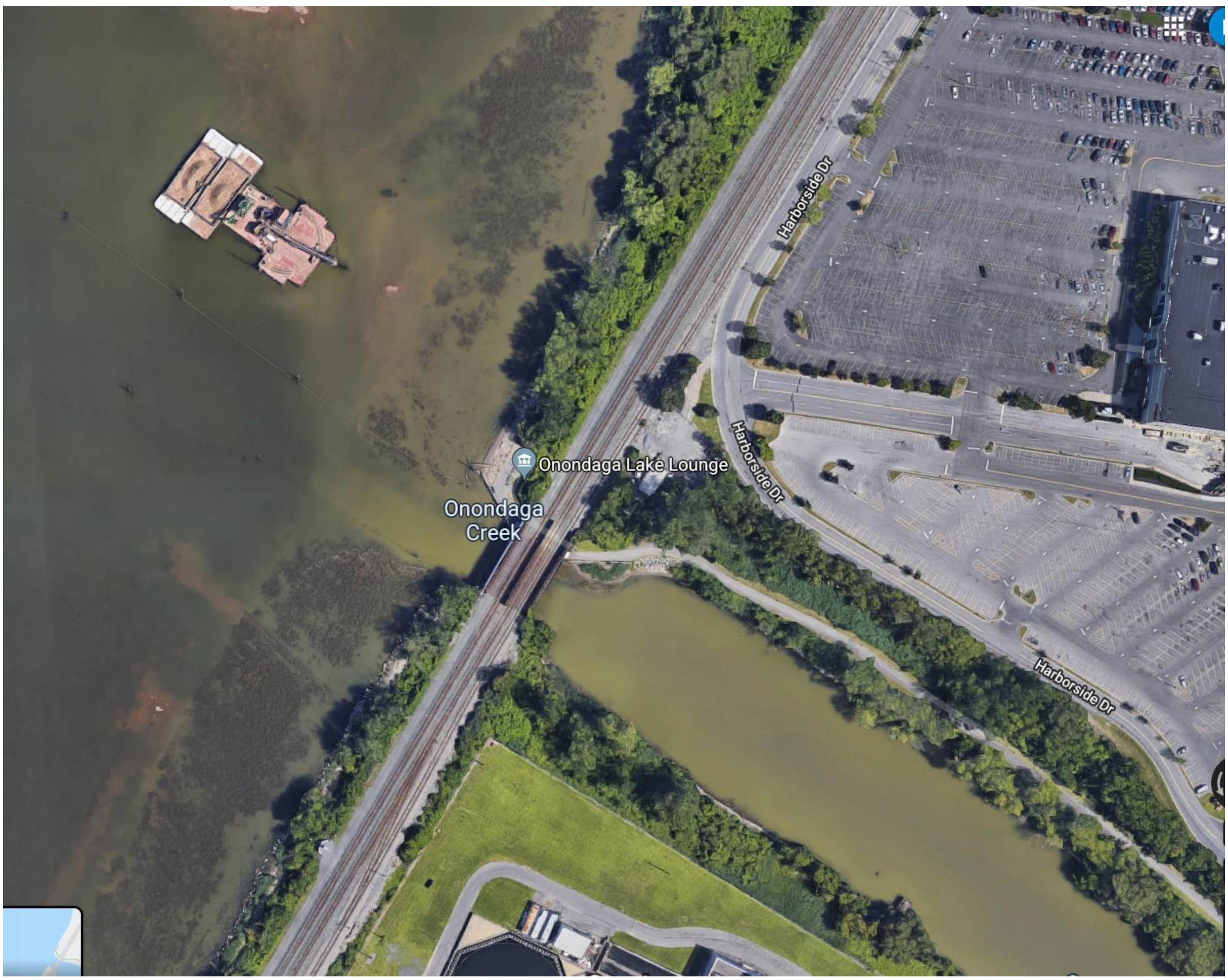
1. If a blank has not been taken, make sure a blank is taken for the day or every 3 pump samples.
2. Rinse end of pump with DI water prior to taking blank.
3. Place pump into designated DI water carboy.
4. Attach the pump to car battery. Red is (+) positive and black is (-) negative.
5. Run pump through sieve until designated volume is reached in secondary, smaller bucket.
6. For field blank, leave sample container filled with DI water open to air during net sampling collection.

Appendix B-3: Satellite images of sampling locations during 2019/2020 and 2021 sampling.

All images captured from Google Maps (Google, n.d.).

INLETS:

Onondaga Creek (Creek Walk): OC1, Outlet into Onondaga Lake

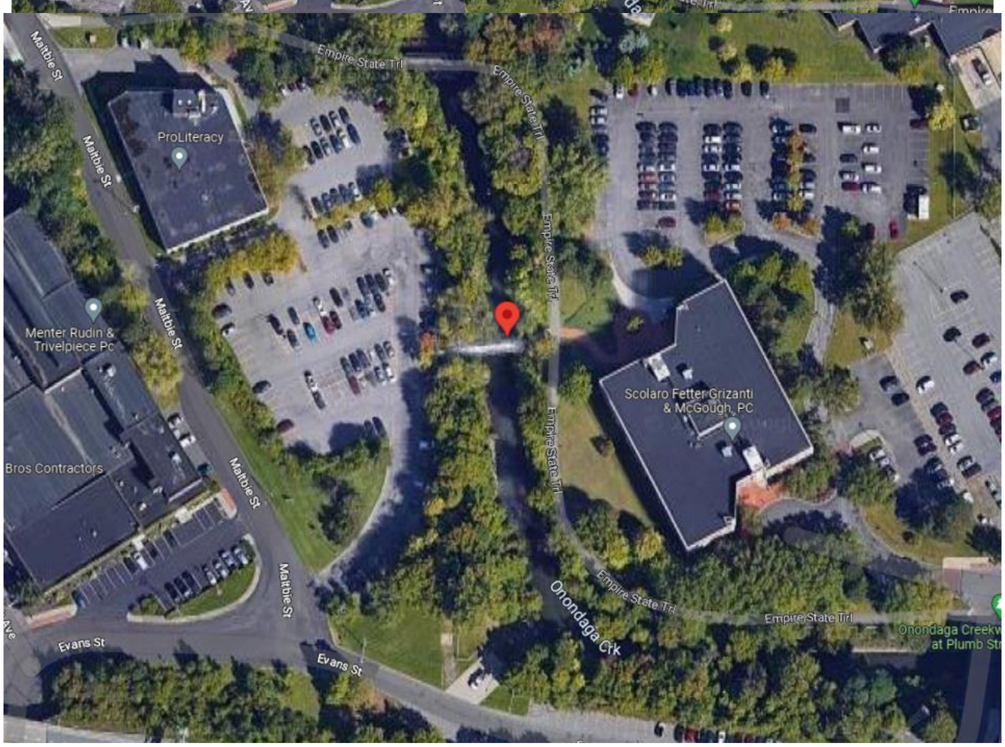


Outlet of Onondaga Creek

Onondaga Creek (Inner Harbor): OC2, Inner Harbor

Inner Harbor Area

Onondaga Creek (Spencer Street): OC3, Spencer Street USGS Station

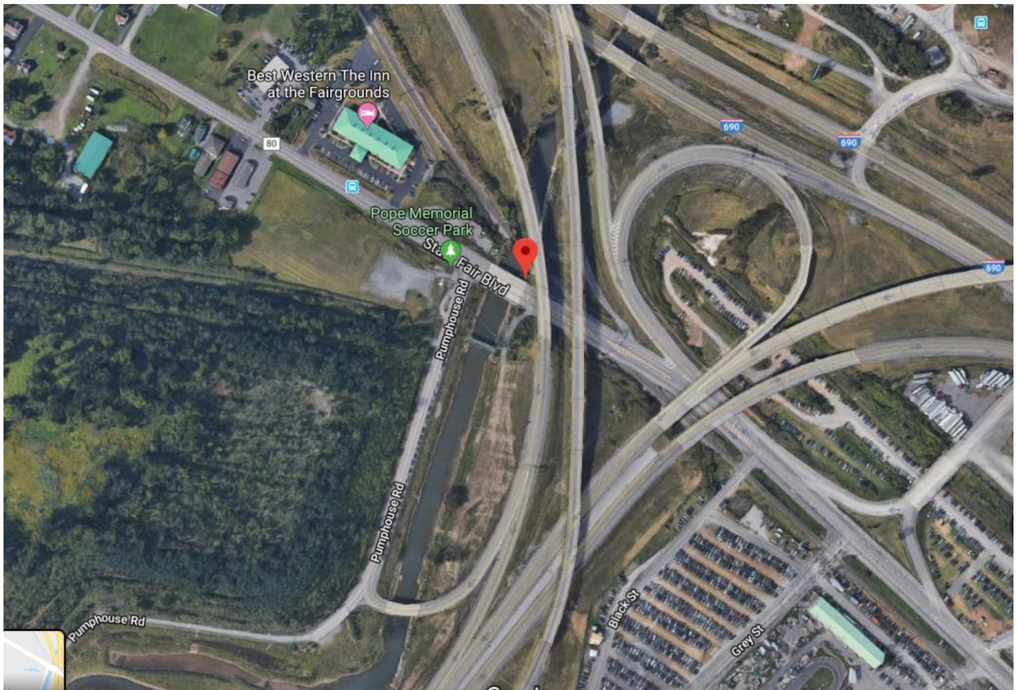


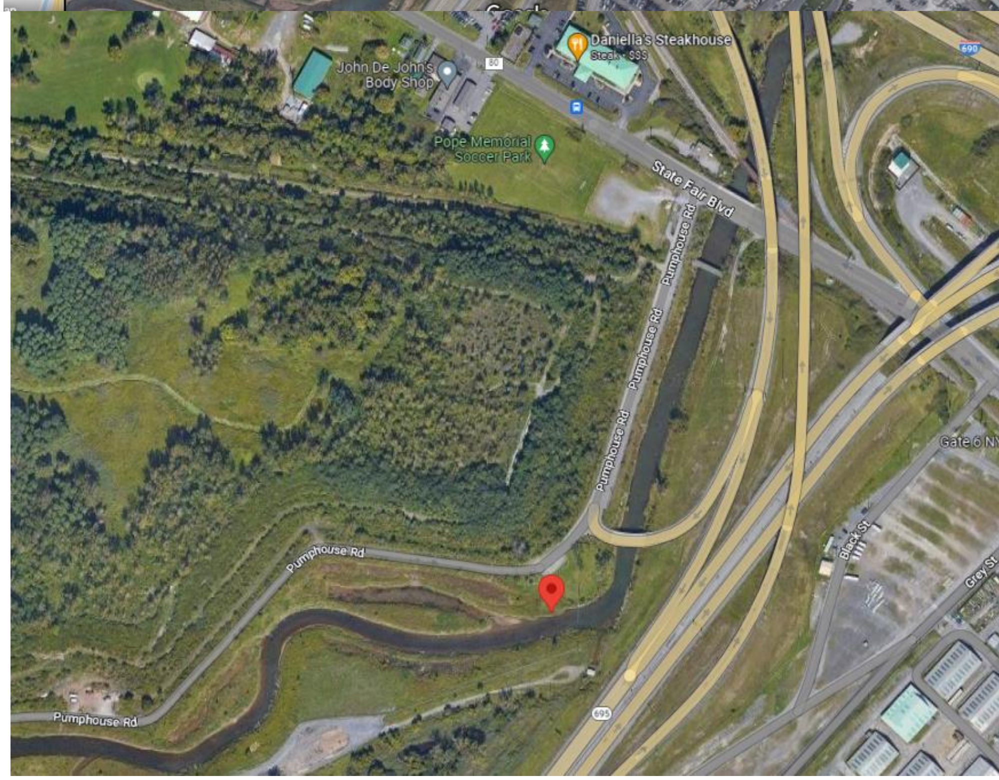
2019/2020 (First Image): Near Spencer Street USGS Station
2021 (Second Image): Slightly downstream from a bridge

Onondaga Creek (Dorwin Avenue): OC4, Dorwin Ave USGS Station

Near Dorwin Avenue USGS Station (decommissioned)

Nine Mile Creek: NMC2, at previous USGS gauging station

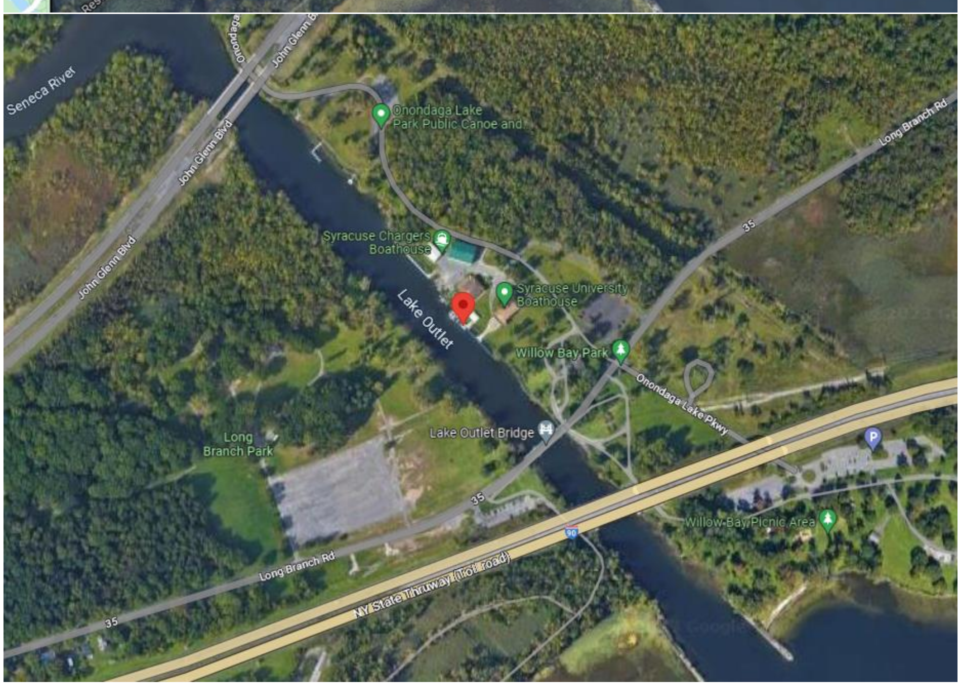




2019/2020 (First Image): Near USGS gauging station (Decommissioned)
2021 (Second Image): Slightly upstream at Honeywell Canoe and Kayak Launch

OUTLETS:

Outlet: OUT1, Outlet of Onondaga Lake



2019/2020 (First Image): Underpass of NY State Thruway
2021 (Second Image): Slightly upstream at dock of Syracuse University Boathouse

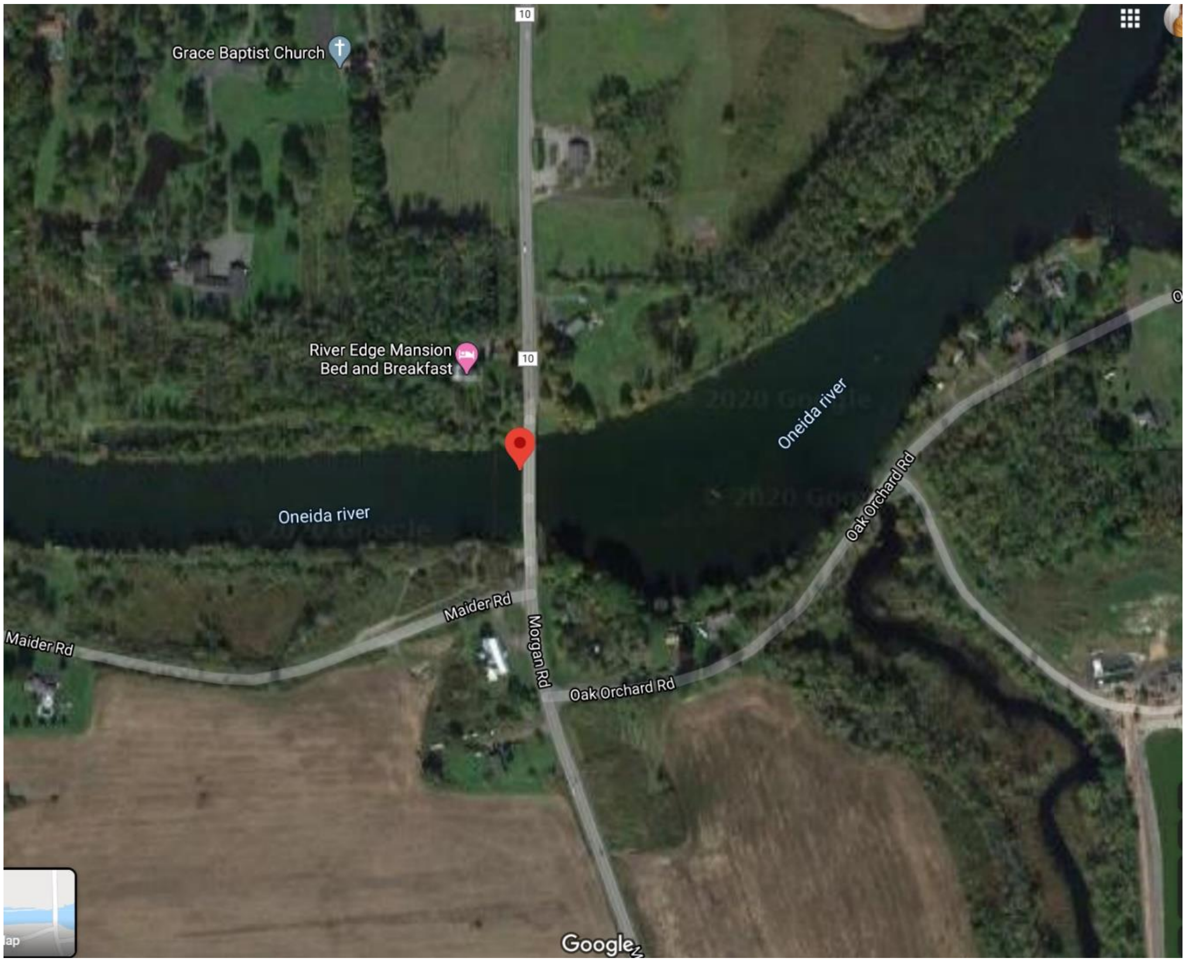
Seneca River: SR1, Left branch of Seneca River (2019/2020 Only)

Left branch of Seneca River at dock of J&S Marine

Seneca River: SR2, Right branch of Seneca River (2019/2020 Only)

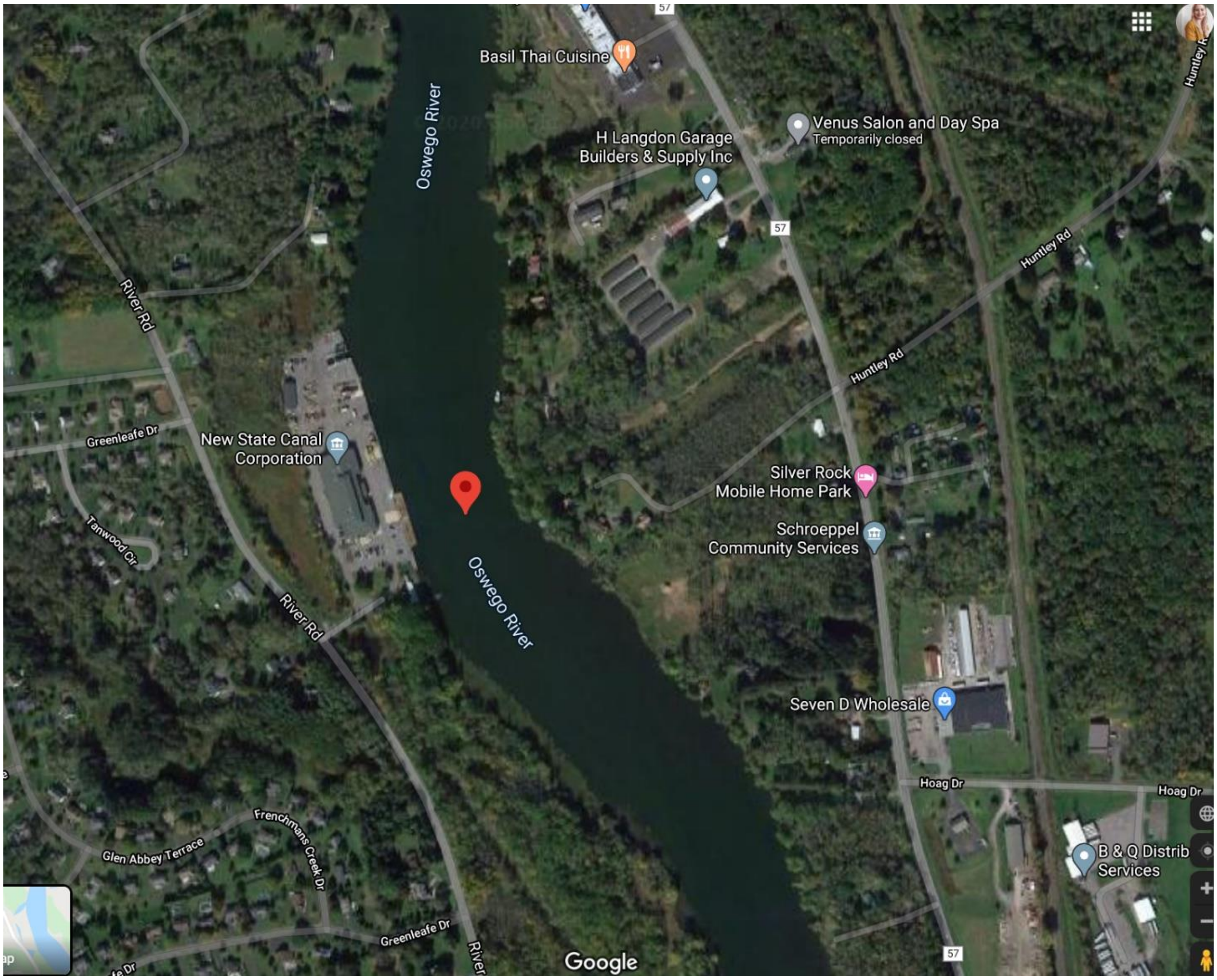
Right branch of Seneca River at dock by Elks Lodge

Oneida River: ONEIDA1, branch into Oneida River



Oneida River, branch off of Oswego River

Oswego River: OSW1



Oswego River

Appendix B-4: Laboratory Methods for the Analysis of Microplastics in the Freshwater Environment

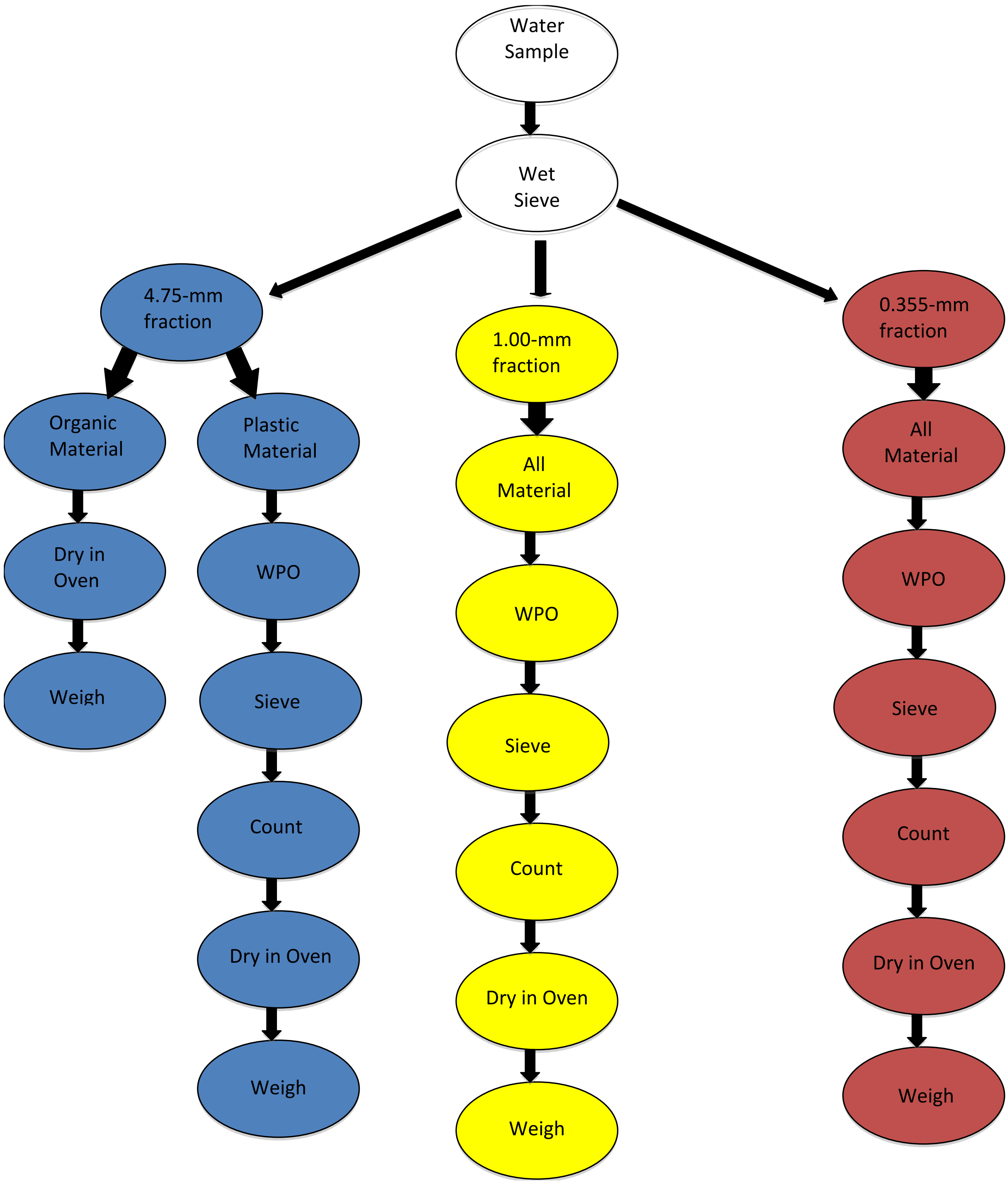
(Obtained and modified from Mason, 2019)

ABSTRACT

This method can be used for the analysis of plastic debris as suspended solids in water samples collected by a surface net. Plastics include hard plastics, soft plastics (e.g., foams), films, line, and sheets. The method involves the filtration of solids obtained by 330-335 micron surface net, like a Manta net, through sieves to isolate the solid material of the appropriate size. The sieved material is dried to determine the solids mass in the sample. The solids are subjected to wet peroxide oxidation (WPO) in the presence of an Fe(II) catalyst to digest labile organic matter. Plastic material is removed, rinsed and collected to determine the microplastics concentration.

The method is adapted from the draft NOAA protocol dated 10 March 2011 and is applicable to the determination of many of the common plastics including polyethylene, polypropylene, polyvinyl chloride, and polystyrene (Marine Debris Program, 2015).

Figure 1. Flow diagram for the analysis of microplastics in water samples.



PROTOCOLS:

WET SIEVING

MATERIALS

- **Prior to wet sieving and organics processing, take a clean, large mason jar in 428 and rinse it 3x with DI water. Fill it with DI water and close it tightly. Dry the jar and label it with: DI_Blank_Month_Day_Year, example: DI_Blank_1_26_22. Weigh the jar in 416 prior to going into the clean room.**
- **U.S. standard stainless steel sieves (4.75-mm, 1.00-mm, 355 um, and 20 um)**
- **Beakers**
- **Forceps/Tweezers**
- **Watch glasses**
- **Distilled/Deionized water**
- **Kim wipes**
- **Paper towels**
- **Aluminum foil**
- **Label tape**
- **Lab coat**
- **Shoe covers (in room prior to clean room)**

HIGH ORGANICS SAMPLE (Net samples, some bucket samples):

1. Record sample ID in laboratory notebook.
2. Clean sample prep sink, surrounding counter, the notebook counter area, and the hood with the stir and heat plates with a damp cellulose sponge. Wipe dry with paper towels.
3. Rinse all sieves with DI water until clean, even if cleaned prior. Clean with cellulose sponge and pressurized DI water.
4. Rinse 4 previously cleaned beakers with DI water.
5. Prepare 4 tinfoil covers for each beaker. It is best to make sure the foil piece is as wide as the beaker and fold it in half into a square. Cover each beaker.
6. Place label tape on each piece of foil and write down the sample number and size fraction in sharpie (Example: >4.75, 4.75 – 1, 1 – 355, 355 – 20).
7. Pour freshwater surface net sample through stacked arrangement of four sieves (4.75-mm, 1.00-mm, 0.355-mm, 0.020-mm, in order from top to bottom sieve) slowly and incrementally.
8. After adding in ~$\frac{1}{4}$ of the water sample, check the 0.020-mm (20 um) sieve to make sure it is not overflowing. Tap the bottom of the sieve with gloves on to help

the water get through the sieve. DO NOT use fingernails or any sharp objects!!!! Only use the tips of your fingers to gently tap the sieve.

9. Continue this process until all the water sample is through the stacked sieves.
10. Rinse sample bottle and lid with distilled water and pour over the sieve set to ensure complete evacuation of container. Repeat at least 3 times. For at least one of these rinses, make sure to completely close the jar and shake it to get loose any stuck material from the lid and jar.
11. Starting with the 4.75 mm sieve, rinse with DI water to the best of your ability to get all <4.75 mm fractions through the sieve.
12. If any organics are present (leaves, wood pieces, bugs) rinse them off with DI water and place them on a watchglass or foil boat for disposal.
13. If any organics are present that look FIBROUS, like a clump of fibrous organic material, DO NOT take them out of the sieve. Rinse them to the best of your ability and leave them on the sieve for digestion.
14. After rinsing, place the prepared beaker for the appropriate size fraction next to the sink. Put the sieve at a 90-degree angle onto the beaker and rinse down using DI water. Position the sieve so that any contents washed out the opposite side of the sieve will also end up in the beaker.
15. Rinse the sieve to get all particles off the sieve, rinsing half at a time as you move the sieve a quarter turn each time. You may need to use cleaned tweezers to get remaining stuck particles but take care to not alter the size of the sieve with the tweezers. This should ONLY be done on higher mesh sizes (4.75 mm, 1.0 mm). Tweezers should never be near the 355 or 20 um sieves.
16. After sample is thoroughly rinsed into beaker, cover with labeled foil. This sample fraction is read for WPO!
17. Repeat steps 14-16 for each sieve size, rinsing the sieve and tweezers each time.
18. Organic material (leaves, detritus) can be discarded after separated from sample.

LOW ORGANICS SAMPLE (Grab samples, some bucket samples, DI blanks):

1. Record sample ID in laboratory notebook.
2. Clean sample prep sink and counter with cellulose sponge. Wipe dry.
3. Rinse 20 um sieve with DI water until clean, even if cleaned prior.
4. Rinse the previously cleaner beaker with DI water.
5. Prepare 1 tinfoil cover for the beaker. Label with the sample number and size fraction (in this case, “all”)
6. Pour sample through 20 um sieve.
7. Rinse sample bottle with distilled water 3 times and put through the sieve. For at least one of the rinses, make sure to completely close the jar and shake it to get loose any stuck material from the lid and jar.
8. After rinsing, place a cleaned beaker (rinse with DI water prior to collecting sample) by the sink. Put the sieve at a 90-degree angle onto the beaker and rinse

down using DI water. Position the sieve so that any contents washed out the opposite side of the sieve will also end up in the beaker.

9. Rinse the sieve to get all particles off the sieve, rinsing half at a time as you move the sieve a quarter turn each time.
10. After sample is thoroughly rinsed into beaker, cover with labeled foil. This sample is read for WPO!

<u>WET PEROXIDE OXIDATION (WPO)</u> {of remaining material} (Hurley et al., 2018)

CAUTION: This mixture is highly reactive

MATERIALS

- **30% Hydrogen Peroxide (in clean room)**
- **0.05 M Fe(II) solution (prepared by adding 7.5 g of $FeSO_4{\circ}7H_20$, FW = 278.02 g/mol (Fisher cat. 1146-500, CAS 7782-63-0), to 500 mL of water + 3 mL of concentrated sulfuric acid (CAS 7664-93-9))**
- **Hot plates (in clean room)**
- **Infrared thermometer**
- **Stir bars**
- **600mL beakers**
- **Distilled/Deionized water (in clean room)**
- **Analytical balance (precise to 0.001 mg)**
- **Graduated cylinder covered with a small square of tin foil**
- **4 oz jam jars**
- **20 um sieve (in clean room)**
- **Lab coat**
- **Shoe covers (in room prior to clean room)**

1. Prior to processing, rinse area under hood with cellulose sponge and DI water. Dry and remove any particles or potential contamination from hood and hot plates.
2. In the laboratory notebook, make a table with 3 columns: Sample ID, Additions, and Time. The time column should be the largest horizontally. It is advised to give each sample a couple of lines, with more lines for high organics samples that require more additions.
3. Prior to WPO, note down the sample ID. Note that high organics samples will have 4 beakers in your table, one for each size fraction.
4. Put on goggles and gloves EVERY TIME you are near the open hood in the clean room, even if you are simply moving a beaker.
5. Add 20mL 0.05 M Fe(II) solution and 20mL 30% Hydrogen Peroxide (H_2O_2) to each beaker from the sieve process using a graduated cylinder. Solution should appear amber in color.
6. Mark down the time and the first addition in the laboratory notebook.
7. Let sit for 5 minutes at room temperature prior to proceeding.

8. Make sure hot plates are plugged in and clean.
9. After 5 minutes, the beaker can be placed on a stirring or heat plate with a clean stir bar.
10. Allow each beaker to get heated until bubbling. Remove from hot plate.
11. For samples that are heating, monitor the temperature using the infrared thermometer. When samples approach 70 °C, remove from heat or turn off the heat plate.
12. Continue adding 20mL aliquots of 30% H_2O_2 and Fe(II) solution (in equal quantities) until all organic material has been oxidized in all samples. Write down the time and number of additions in the laboratory notebook as you go. Typically, you should wait until the reaction is no longer proceeding effectively (not bubbling or no change has occurred for some time) before an addition. Solution color will change from amber to yellow as material is oxidized. Once the solution color is yellow, more peroxide can be added to ensure continuous oxidation.
13. If the oxidation appears to be no longer proceeding despite additional H_2O_2, it may be a dilution effect (as water is produced as a by-product of the reaction). Sieve the beaker contents through a 0.020-mm sieve (to ensure no plastic particles are lost) and transfer the remaining material back to the beaker. Re-start the WPO by adding 20mL 0.05 M Fe(II) solution and 20mL of Hydrogen Peroxide (H_2O_2), and applying heat.
14. Once reaction is complete, let samples cool until they can be handled safely. Every beaker should have a MINIMUM processing time of 1 hour. For low organics samples, this is typically long enough to process. However, high organics samples may take up to a week to digest sufficiently prior to further processing.
15. Once complete, bring covered sample to the sink. Rinse and label a 4 oz jam jar.
16. Place the waste bucket in the sink and put on goggles. This waste bucket will collect the acidic waste product produced from the digest.
17. Pour beaker contents through the 20 um sieve over the waste bucket. Rinse the beaker through the sieve with DI water 3 times.
18. If the beaker has a stir bar in it, rinse the tweezers and use them to remove the stir bar. Rinse the stir bar with DI water into the beaker.
19. After rinsing, place the used beaker on the counter by the sink. Put the sieve at a 90-degree angle onto the beaker and rinse down using DI water. Position the sieve so that any contents washed out the opposite side of the sieve will also end up in the beaker.
20. After sample is thoroughly rinsed into beaker, pour into pre-rinsed and labeled 4 oz jam jar. Use DI water to rinse all of beaker contents into the jar. It helps to tilt the beaker and spray upward at an angle.

21. Use a second 4 oz jam jar if the contents are exceed one jar. If an additional jar is needed, mark them as (1) and (2).
22. Take the foil from the top of the beaker and rip the piece in contact with the peroxide off. Throw piece away. Keep the labeled piece and wrap the bottom of the jam jar to shield it from UV light.
23. Unplug hotplates when finished.
24. Clean used areas of the lab. If the trash is over ½ full, empty it into the trash outside the clean room with gloves on.

VACUUM FILTRATION

MATERIALS

- **Kim wipes**
- **Buchner funnel apparatus (3 pieces)**
- **Methanol (for rinsing, if needed)**
- **Whatman mixed cellulose ester gridded filters**
- **Tweezers**
- **DI water bottle**
- **Label tape**
- **4 oz jam jars**

1. Rinse Buchner funnel apparatus pieces (3 pieces: funnel bottle, base with stopper, and sample containment) with DI water prior to use. If not yet cleaned, rinse with methanol once and triple rinse with DI water.

2. Rinse off area under hood with pink sponge. Dry.

3. Set up apparatus by attaching funnel bottle to vacuum line. Make sure the top of the base with stopper (where filter is placed) has been dried off and the bottom of the sample containment piece (which sits on the filter) is free of particles/debris. Wipe both with Kim wipes.

4. Attach stopper to funnel so it is fully leveled. Use clean tweezers to place a new filter onto the apparatus. Filter should sit mostly centered and should not be ripped. If it rips, throw it away and retrieve a new filter.

5. Turn on vacuum to allow filter to sit firmly on apparatus. Use DI water to wet the filter.

6. Put sample containment piece on the filter, as in line with the base as possible.

7. Attach ring stand holder to these pieces to hold them in place. Make sure to not tip them over.

8. Select a sample to filter. Write sample ID in laboratory notebook.

9. Is the sample quite dirty and likely to clog the filter? Pour half or less of the sample into the filter. Wait for it to pass through before continuing. It is best to disperse particles, so they are not too concentrated for counting.

10. If sample is not dirty and unlikely to clog the filter, pour all the sample into the top of the filter. Rinse container and lid 3 times with DI water. Ensure all particles are out of the sample jar.

11. Once one filter is done, use DI water to rinse down through the sample containment unit. Make sure to rinse at the bottom last, where particles may collect. Be thorough.

12. Remove top portion of the apparatus. Check the side that is in contact with the filter for any particles. If possible, rinse these onto the filter with care.

13. Once it is clean and no particles are left, turn off the vacuum. Prepare sample jar for filter by drying it or rinsing and drying, if needed. Label it properly.

14. Put filter carefully into the jar. Set the lid onto the jar so it is covered, but not fully sealed. Leave in the hood to dry.

15. If you have more of the sample to filter, add a new filter and continue until all of filter is done. Be sure to label each consecutive filter as SAMPLEID Size Fraction (1), (2), (3), and so on. Mark in laboratory notebook.

16. Once you are ready to move on to a new sample, carefully clean all 3 pieces of the apparatus with DI water three times. Wipe dry and repeat this procedure.

17. Once finished, rinse apparatus with methanol once and DI water 3 times. Put on drying rack.

Table B.1: Uncorrected and corrected sample counts, separated by morphology type, for each sample arranged by date of collection.

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
25_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.84	Fiber	Grab	1	2.21	7	23	0
27_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.8	Fiber	Grab	4	2.21	7	23	0
28_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.82	Fragment	Grab	1	0.00	0	0	1
28_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.82	Fiber	Grab	7	2.21	7	23	0
30_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.82	Film	Grab	2	0.71	3	8	0
30_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.82	Fragment	Grab	1	0.00	0	0	1
30_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.82	Fiber	Grab	1	2.21	7	23	0
31_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.84	Fiber	Grab	1	2.21	7	23	0
31_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.84	Film	Grab	2	0.71	3	8	0
31_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.84	Foam	Grab	1	0.00	0	0	1
32_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.81	Film	Grab	1	0.71	3	8	0
32_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	0.81	Fiber	Grab	1	2.21	7	23	0
29_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	194082	Fiber	Net	51	2.21	7	23	44
29_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	194082	Fragment	Net	17	0.00	0	0	17
29_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	194082	Film	Net	3	0.71	3	8	0
33_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	NA	Fragment	Net Blank	2	0.00	0	0	2
33_19	SK	Skaneateles Lake	10/15/2019	Shoreline	2019	NA	Fiber	Net Blank	25	2.21	7	23	18
1_19	NMC1	Nine Mile Creek	10/23/2019		2019	0.84	Fiber	Grab	21	2.21	7	23	14

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
1_19	NMC1	Nine Mile Creek	10/23/2019		2019	0.84	Fiber bundle	Grab	1	0.00	0	0	1
3_19	OC2	Inner Harbor	10/23/2019		2019	0.93	Fiber	Grab	1	2.21	7	23	0
34_19	OC3	Spencer Street	10/23/2019		2019	NA	Foam	Grab	1	0.00	0	0	1
34_19	OC3	Spencer Street	10/23/2019		2019	NA	Fragment	Grab	1	0.00	0	0	1
34_19	OC3	Spencer Street	10/23/2019		2019	NA	Fiber	Grab	28	2.21	7	23	21
5_19	OC3	Spencer Street	10/23/2019		2019	0.93	Fiber	Grab	7	2.21	7	23	0
6_19	OC4	Dorwin Avenue	10/23/2019		2019	0.92	Fiber	Grab	1	2.21	7	23	0
7_19	OUT1	Outlet	10/23/2019		2019	0.93	Fiber	Grab	2	2.21	7	23	0
8_19	SR1	West Branch Seneca	10/23/2019		2019	0.93	Fiber	Grab	12	2.21	7	23	5
9_19	SR2	East Branch Seneca	10/23/2019		2019	0.92	Fiber	Grab	5	2.21	7	23	0
10_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	176988	Sphere	Net	11	0.00	0	0	11
10_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	176988	Foam	Net	7	0.00	0	0	7
10_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	176988	Fiber	Net	63	2.21	7	23	56
10_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	176988	Film	Net	2	0.71	3	8	0
10_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	176988	Pellet	Net	1	0.00	0	0	1
10_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	176988	Fragment	Net	21	0.00	0	0	21
11_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	0.82	Fiber	Grab	2	2.21	7	23	0
12_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	0.79	Fiber	Grab	1	2.21	7	23	0
13_19	OND2	Onondaga Lake	10/29/2019	Middle	2019	0.83	Film	Grab	1	0.71	3	8	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
14_19	OND3	Onondaga Lake	10/29/2019	South	2019	194082	Fiber	Net	48	2.21	7	23	41
14_19	OND3	Onondaga Lake	10/29/2019	South	2019	194082	Film	Net	2	0.71	3	8	0
14_19	OND3	Onondaga Lake	10/29/2019	South	2019	194082	Sphere	Net	8	0.00	0	0	8
18_19	METRO	METRO Effluent	10/29/2019		2019	3.74	Fiber	Grab	1	2.21	7	23	0
18_19	METRO	METRO Effluent	10/29/2019		2019	3.74	Film	Grab	1	0.71	3	8	0
14_19	OND3	Onondaga Lake	10/29/2019	South	2019	194082	Fragment	Net	52	0.00	0	0	52
14_19	OND3	Onondaga Lake	10/29/2019	South	2019	194082	Fiber bundle	Net	1	0.00	0	0	1
15_19	OND3	Onondaga Lake	10/29/2019	South	2019	NA	Fiber	Grab	1	2.21	7	23	0
16_19	OND3	Onondaga Lake	10/29/2019	South	2019	0.82	Fiber	Grab	3	2.21	7	23	0
17_19	OND3	Onondaga Lake	10/29/2019	South	2019	0.85	Fiber	Grab	1	2.21	7	23	0
19_19	OND	Onondaga Lake	10/29/2019	NA	2019	NA	Film	Net Blank	1	0.71	3	8	0
19_19	OND	Onondaga Lake	10/29/2019	NA	2019	NA	Fiber	Net Blank	11	2.21	7	23	4
19_19	OND	Onondaga Lake	10/29/2019	NA	2019	NA	Fragment	Net Blank	1	0.00	0	0	1
43_20	OC2	Inner Harbor	6/4/2020		2020	19.5	Fiber	Bucket 355	17	2.21	7	23	10
43_20	OC2	Inner Harbor	6/4/2020		2020	19.5	Fragment	Bucket 355	21	0.00	0	0	21
43_20	OC2	Inner Harbor	6/4/2020		2020	19.5	Film	Bucket 355	2	0.71	3	8	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
43_20	OC2	Inner Harbor	6/4/2020		2020	19.5	Sphere	Bucket 355	3	0.00	0	0	3
43_20	OC2	Inner Harbor	6/4/2020		2020	19.5	Foam	Bucket 355	6	0.00	0	0	6
45_20	NMC1	Nine Mile Creek	6/4/2020		2020	39	Fiber	Bucket 355	4	2.21	7	23	0
46_20	OC1	Creek Walk	6/4/2020		2020	39	Fiber	Bucket 355	5	2.21	7	23	0
46_20	OC1	Creek Walk	6/4/2020		2020	39	Sphere	Bucket 355	1	0.00	0	0	1
47_20	OC2	Inner Harbor	6/4/2020		2020	39	Fiber	Bucket 355	4	2.21	7	23	0
47_20	OC2	Inner Harbor	6/4/2020		2020	39	Sphere	Bucket 355	1	0.00	0	0	1
47_20	OC2	Inner Harbor	6/4/2020		2020	39	Fragment	Bucket 355	1	0.00	0	0	1
48_20	OC3	Spencer Street	6/4/2020		2020	39	Fragment	Bucket 355	1	0.00	0	0	1
48_20	OC3	Spencer Street	6/4/2020		2020	39	Fiber	Bucket 355	4	2.21	7	23	0
49_20	OC4	Dorwin Avenue	6/4/2020		2020	39	Fiber	Bucket 355	9	2.21	7	23	2
50_20	OC4	Dorwin Avenue	6/4/2020		2020	39	Fiber	Bucket 355	2	2.21	7	23	0
50_20	OC4	Dorwin Avenue	6/4/2020		2020	39	Fragment	Bucket 355	3	0.00	0	0	3
44_20	OC3	Spencer Street	6/4/2020		2020	240940	Fiber bundle	Net	9	0.00	0	0	9
44_20	OC3	Spencer Street	6/4/2020		2020	240940	Film	Net	30	0.71	3	8	27
44_20	OC3	Spencer Street	6/4/2020		2020	240940	Foam	Net	23	0.00	0	0	23
44_20	OC3	Spencer Street	6/4/2020		2020	240940	Fragment	Net	61	0.00	0	0	61
44_20	OC3	Spencer Street	6/4/2020		2020	240940	Fiber / Fragment	Net	4	0.00	0	0	4

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
44_20	OC3	Spencer Street	6/4/2020		2020	240940	Fiber	Net	208	2.21	7	23	201
59_20	BLANK	Onondaga Creek	6/4/2020		2020	NA	Fiber	Net Blank	51	2.21	7	23	44
59_20	BLANK	Onondaga Creek	6/4/2020		2020	NA	Fragment	Net Blank	1	0.00	0	0	1
53_20	SR1	West Branch Seneca	6/5/2020		2020	39	Fiber	Bucket 355	9	2.21	7	23	2
54_20	SR2	East Branch Seneca	6/5/2020		2020	39	Film	Bucket 355	1	0.71	3	8	0
54_20	SR2	East Branch Seneca	6/5/2020		2020	39	Fragment	Bucket 355	1	0.00	0	0	1
54_20	SR2	East Branch Seneca	6/5/2020		2020	39	Fiber	Bucket 355	5	2.21	7	23	0
55_20	ONEIDA1	Oneida River	6/5/2020		2020	39	Film	Bucket 355	1	0.71	3	8	0
55_20	ONEIDA1	Oneida River	6/5/2020		2020	39	Fiber	Bucket 355	11	2.21	7	23	4
55_20	ONEIDA1	Oneida River	6/5/2020		2020	39	Fragment	Bucket 355	1	0.00	0	0	1
56_20	OSW1	Oswego	6/5/2020		2020	39	Fragment	Bucket 355	1	0.00	0	0	1
56_20	OSW1	Oswego	6/5/2020		2020	39	Fiber	Bucket 355	8	2.21	7	23	1
62_20	OND3	Onondaga Lake	8/20/2020	South	2020	196980	Fiber	Net	50	2.21	7	23	43
62_20	OND3	Onondaga Lake	8/20/2020	South	2020	196980	Fragment	Net	18	0.00	0	0	18
62_20	OND3	Onondaga Lake	8/20/2020	South	2020	196980	Film	Net	5	0.71	3	8	2
62_20	OND3	Onondaga Lake	8/20/2020	South	2020	196980	Sphere	Net	3	0.00	0	0	3
63_20	OND1	Onondaga Lake	8/20/2020	North	2020	NA	Fiber	Grab	2	2.21	7	23	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
64_20	OND1	Onondaga Lake	8/20/2020	North	2020	0.88	Fiber	Grab	1	2.21	7	23	0
66_20	BLANK	Onondaga Lake	8/20/2020	NA	2020	NA	Foam	Net Blank	3	0.00	0	0	3
66_20	BLANK	Onondaga Lake	8/20/2020	NA	2020	NA	Fiber	Net Blank	14	2.21	7	23	7
68_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.79	Fiber	Grab	4	2.21	7	23	0
70_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.81	Fiber	Grab	5	2.21	7	23	0
72_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.68	Film	Grab	2	0.71	3	8	0
72_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.68	Fiber	Grab	4	2.21	7	23	0
73_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.8	Fragment	Grab	1	0.00	0	0	1
73_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.8	Film	Grab	1	0.71	3	8	0
73_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.8	Fiber	Grab	4	2.21	7	23	0
74_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.79	Fiber	Grab	4	2.21	7	23	0
74_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	0.79	Film	Grab	1	0.71	3	8	0
67_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	312900	Fiber bundle	Net	1	0.00	0	0	1
67_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	312900	Film	Net	8	0.71	3	8	5
67_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	312900	Sphere	Net	1	0.00	0	0	1
67_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	312900	Fragment	Net	6	0.00	0	0	6
67_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	312900	Fiber	Net	27	2.21	7	23	20
71_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	253680	Fragment	Net	7	0.00	0	0	7
71_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	253680	Foam	Net	1	0.00	0	0	1
71_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	253680	Film	Net	2	0.71	3	8	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
71_20	SK	Skaneateles Lake	9/1/2020	Shoreline	2020	253680	Fiber	Net	28	2.21	7	23	21
75_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	202062	Foam	Net	1	0.00	0	0	1
75_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	202062	Film	Net	10	0.71	3	8	7
75_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	202062	Fragment	Net	26	0.00	0	0	26
75_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	202062	Fiber	Net	40	2.21	7	23	33
75_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	202062	Fiber bundle	Net	1	0.00	0	0	1
76_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	0.78	Fiber	Grab	1	2.21	7	23	0
76_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	0.78	Foam	Grab	1	0.00	0	0	1
77_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	0.86	Fiber	Grab	4	2.21	7	23	0
78_20	OND2	Onondaga Lake	9/10/2020	Middle	2020	0.8	Fiber	Grab	4	2.21	7	23	0
79_20	BLANK	Onondaga Lake	9/10/2020	NA	2020	NA	Fiber	Net Blank	5	2.21	7	23	0
80_20	OND1	Onondaga Lake	9/16/2020	North	2020	161070	Sphere	Net	2	0.00	0	0	2
80_20	OND1	Onondaga Lake	9/16/2020	North	2020	161070	Film	Net	11	0.71	3	8	8
80_20	OND1	Onondaga Lake	9/16/2020	North	2020	161070	Fragment	Net	27	0.00	0	0	27
80_20	OND1	Onondaga Lake	9/16/2020	North	2020	161070	Fiber	Net	34	2.21	7	23	27
80_20	OND1	Onondaga Lake	9/16/2020	North	2020	161070	Foam	Net	8	0.00	0	0	8

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
80_20	OND1	Onondaga Lake	9/16/2020	North	2020	161070	Fiber bundle	Net	1	0.00	0	0	1
81_20	OND1	Onondaga Lake	9/16/2020	North	2020	0.83	Fiber	Grab	1	2.21	7	23	0
82_20	OND1	Onondaga Lake	9/16/2020	North	2020	0.87	Fiber	Grab	2	2.21	7	23	0
83_20	OND1	Onondaga Lake	9/16/2020	North	2020	0.85	Fiber	Grab	2	2.21	7	23	0
84_20	BLANK	Onondaga Lake	9/16/2020	NA	2020	NA	Fragment	Net Blank	1	0.00	0	0	1
84_20	BLANK	Onondaga Lake	9/16/2020	NA	2020	NA	Fiber	Net Blank	2	2.21	7	23	0
85_20	OC1	Creek Walk	9/24/2020		2020	39	Fiber	Bucket 106	18	2.21	7	23	11
86_20	OC2	Inner Harbor	9/24/2020		2020	19.5	Fiber	Bucket 106	37	2.21	7	23	30
86_20	OC2	Inner Harbor	9/24/2020		2020	19.5	Pellet	Bucket 106	2	0.00	0	0	2
86_20	OC2	Inner Harbor	9/24/2020		2020	19.5	Sphere	Bucket 106	28	0.00	0	0	28
86_20	OC2	Inner Harbor	9/24/2020		2020	19.5	Film	Bucket 106	17	0.71	3	8	14
86_20	OC2	Inner Harbor	9/24/2020		2020	19.5	Foam	Bucket 106	176	0.00	0	0	176
86_20	OC2	Inner Harbor	9/24/2020		2020	19.5	Fragment	Bucket 106	459	0.00	0	0	459
87_20	OC2	Inner Harbor	9/24/2020		2020	39	Fiber	Bucket 106	14	2.21	7	23	7
88_20	OC3	Spencer Street	9/24/2020		2020	39	Fiber	Bucket 106	8	2.21	7	23	1
90_20	OC4	Dorwin Avenue	9/24/2020		2020	39	Fiber	Bucket 106	10	2.21	7	23	3

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
91_20	NMC1	Nine Mile Creek	9/24/2020		2020	39	Fiber	Bucket 106	2	2.21	7	23	0
89_20	OC3	Spencer Street	9/24/2020		2020	41034	Fragment	Net	11	0.00	0	0	11
89_20	OC3	Spencer Street	9/24/2020		2020	41034	Fiber / Fragment	Net	1	0.00	0	0	1
89_20	OC3	Spencer Street	9/24/2020		2020	41034	Fiber	Net	39	2.21	7	23	32
92_20	BLANK	Spencer Street	9/24/2020		2020	NA	Fiber	Net Blank	11	2.21	7	23	4
94_20	OUT1	Outlet	9/25/2020		2020	39	Foam	Bucket 106	18	0.00	0	0	18
94_20	OUT1	Outlet	9/25/2020		2020	39	Fiber	Bucket 106	10	2.21	7	23	3
96_20	SR2	East Branch Seneca	9/25/2020		2020	39	Fiber	Bucket 106	4	2.21	7	23	0
97_20	OSW1	Oswego River	9/25/2020		2020	39	Fiber	Bucket 106	10	2.21	7	23	3
109_20	OND1	Onondaga Lake	11/4/2020	North	2020	178962	Sphere	Net	18	0.00	0	0	18
109_20	OND1	Onondaga Lake	11/4/2020	North	2020	178962	Fragment	Net	124	0.00	0	0	124
109_20	OND1	Onondaga Lake	11/4/2020	North	2020	178962	Film	Net	1	0.71	3	8	0
109_20	OND1	Onondaga Lake	11/4/2020	North	2020	178962	Fiber	Net	78	2.21	7	23	71
110_20	OND1	Onondaga Lake	11/4/2020	North	2020	0.89	Fiber	Grab	6	2.21	7	23	0
111_20	OND1	Onondaga Lake	11/4/2020	North	2020	0.87	Fiber	Grab	2	2.21	7	23	0
112_20	OND1	Onondaga Lake	11/4/2020	North	2020	0.85	Fiber	Grab	4	2.21	7	23	0
113_20	BLANK	Onondaga Lake	11/4/2020	NA	2020	NA	Sphere	Net Blank	1	0.00	0	0	1

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
113_20	BLANK	Onondaga Lake	11/4/2020	NA	2020	NA	Fragment	Net Blank	7	0.00	0	0	7
113_20	BLANK	Onondaga Lake	11/4/2020	NA	2020	NA	Fiber	Net Blank	8	2.21	7	23	1
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Fiber bundle	Net	4	0.00	0	0	4
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Pellet	Net	6	0.00	0	0	6
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Fragment	Net	1433	0.00	0	0	1433
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Sphere	Net	155	0.00	0	0	155
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Foam	Net	49	0.00	0	0	49
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Film	Net	70	0.71	3	8	67
114_20	OND3	Onondaga Lake	11/9/2020	South	2020	205548	Fiber	Net	1010	2.21	7	23	1003
115_20	OND3	Onondaga Lake	11/9/2020	South	2020	0.82	Fiber	Grab	4	2.21	7	23	0
116_20	OND3	Onondaga Lake	11/9/2020	South	2020	0.78	Fiber	Grab	3	2.21	7	23	0
117_20	OND3	Onondaga Lake	11/9/2020	South	2020	0.84	Fiber	Grab	2	2.21	7	23	0
118_20	BLANK	Onondaga Lake	11/9/2020	NA	2020	NA	Fragment	Net Blank	4	0.00	0	0	4
118_20	BLANK	Onondaga Lake	11/9/2020	NA	2020	NA	Sphere	Net Blank	2	0.00	0	0	2
118_20	BLANK	Onondaga Lake	11/9/2020	NA	2020	NA	Fiber	Net Blank	165	2.21	7	23	158
136_21	OND1	Onondaga Lake	7/9/2021	North	2021	197568	Film	Net	1	0.00	0	0	1

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
136_21	OND1	Onondaga Lake	7/9/2021	North	2021	197568	Fiber	Net	99	2.82	9	29	90
136_21	OND1	Onondaga Lake	7/9/2021	North	2021	197568	Sphere	Net	6	0.00	0	0	6
136_21	OND1	Onondaga Lake	7/9/2021	North	2021	197568	Fragment	Net	47	0.24	1	3	46
137_21	OND1	Onondaga Lake	7/9/2021	North	2021	97.5	Fiber	Pump	11	2.82	9	29	2
138_21	Air Blank	Air Blank	7/9/2021		2021	NA	Fiber	Air Blank	13	2.82	9	29	4
139_21	OND2	Onondaga Lake	7/9/2021	Middle	2021	162414	Fragment	Net	11	0.24	1	3	10
139_21	OND2	Onondaga Lake	7/9/2021	Middle	2021	162414	Film	Net	1	0.00	0	0	1
139_21	OND2	Onondaga Lake	7/9/2021	Middle	2021	162414	Fiber bundle	Net	2	0.00	0	0	2
139_21	OND2	Onondaga Lake	7/9/2021	Middle	2021	162414	Fiber	Net	36	2.82	9	29	27
140_21	OND2	Onondaga Lake	7/9/2021	Middle	2021	97.5	Fiber	Pump	8	2.82	9	29	0
141_21	Air Blank	Air Blank	7/9/2021		2021	NA	Fiber	Air Blank	8	2.82	9	29	0
142_21	OND3	Onondaga Lake	7/9/2021	South	2021	241248	Fiber	Net	32	2.82	9	29	23
142_21	OND3	Onondaga Lake	7/9/2021	South	2021	241248	Foam	Net	1	0.00	0	0	1
142_21	OND3	Onondaga Lake	7/9/2021	South	2021	241248	Fragment	Net	25	0.24	1	3	24
143_21	Air Blank	Air Blank	7/9/2021		2021	NA	Fiber	Air Blank	1	2.82	9	29	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
144_21	Net Blank	Net Blank	7/9/2021		2021	NA	Fiber	Net Blank	28	2.82	9	29	19
145_21	OND_ Profile _1	Onondaga Lake	7/9/2021	NA	2021	97.5	Fiber	Pump	8	2.82	9	29	0
146_21	Pump Blank	Pump Blank	7/9/2021		2021	NA	Fiber	Pump Blank	8	2.82	9	29	0
147_21	Profile	Onondaga Lake	7/9/2021	NA	2021	97.5	Fragment	Pump	1	0.24	1	3	0
147_21	Profile	Onondaga Lake	7/9/2021	NA	2021	97.5	Fiber	Pump	10	2.82	9	29	1
148_21	Profile	Onondaga Lake	7/9/2021	NA	2021	97.5	Fiber	Pump	6	2.82	9	29	0
154_21	OC3	Spencer Street	7/13/2021		2021	NA	Foam	Net	22	0.00	0	0	22
154_21	OC3	Spencer Street	7/13/2021		2021	NA	Pellet	Net	1	0.00	0	0	1
154_21	OC3	Spencer Street	7/13/2021		2021	NA	Fiber bundle	Net	10	0.00	0	0	10
154_21	OC3	Spencer Street	7/13/2021		2021	NA	Fragment	Net	109	0.24	1	3	108
154_21	OC3	Spencer Street	7/13/2021		2021	NA	Fiber	Net	107	2.82	9	29	98
154_21	OC3	Spencer Street	7/13/2021		2021	NA	Film	Net	16	0.00	0	0	16
155_21	Net Blank	Net Blank	7/13/2021		2021	NA	Film	Net Blank	4	0.00	0	0	4
155_21	Net Blank	Net Blank	7/13/2021		2021	NA	Fragment	Net Blank	2	0.24	1	3	1
155_21	Net Blank	Net Blank	7/13/2021		2021	NA	Fiber	Net Blank	25	2.82	9	29	16

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
156_21	Pump Blank	Pump Blank	7/13/2021		2021	NA	Fiber bundle	Pump Blank	1	0.00	0	0	1
156_21	Pump Blank	Pump Blank	7/13/2021		2021	NA	Fiber	Pump Blank	14	2.82	9	29	5
156_21	Pump Blank	Pump Blank	7/13/2021		2021	NA	Fragment	Pump Blank	1	0.24	1	3	0
157_21	OC4	Dorwin Avenue	7/13/2021		2021	45612	Foam	Net	1	0.00	0	0	1
157_21	OC4	Dorwin Avenue	7/13/2021		2021	45612	Fiber	Net	47	2.82	9	29	38
157_21	OC4	Dorwin Avenue	7/13/2021		2021	45612	Film	Net	3	0.00	0	0	3
157_21	OC4	Dorwin Avenue	7/13/2021		2021	45612	Fragment	Net	5	0.24	1	3	4
158_21	Air Blank	Air Blank	7/13/2021		2021	NA	Fiber	Air Blank	11	2.82	9	29	2
159_21	OC4	Dorwin Ave	7/13/2021		2021	97.5	Fragment	Pump	1	0.24	1	3	0
159_21	OC4	Dorwin Ave	7/13/2021		2021	97.5	Fiber	Pump	6	2.82	9	29	0
149_21	OC1	Creek Walk	7/14/2021		2021	840	Fiber	Net	16	2.82	9	29	7
149_21	OC1	Creek Walk	7/14/2021		2021	840	Sphere	Net	1	0.00	0	0	1
149_21	OC1	Creek Walk	7/14/2021		2021	840	Foam	Net	12	0.00	0	0	12
149_21	OC1	Creek Walk	7/14/2021		2021	840	Fiber bundle	Net	1	0.00	0	0	1
149_21	OC1	Creek Walk	7/14/2021		2021	840	Film	Net	4	0.00	0	0	4
149_21	OC1	Creek Walk	7/14/2021		2021	840	Fragment	Net	24	0.24	1	3	23
150_21	OC1	Creek Walk	7/14/2021		2021	97.5	Fragment	Pump	1	0.24	1	3	0
150_21	OC1	Creek Walk	7/14/2021		2021	97.5	Fiber	Pump	4	2.82	9	29	0
151_21	OC2	Inner Harbor	7/14/2021		2021	12558	Sphere	Net	3	0.00	0	0	3
151_21	OC2	Inner Harbor	7/14/2021		2021	12558	Foam	Net	138	0.00	0	0	138

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
151_21	OC2	Inner Harbor	7/14/2021		2021	12558	Fiber	Net	39	2.82	9	29	30
151_21	OC2	Inner Harbor	7/14/2021		2021	12558	Fragment	Net	116	0.24	1	3	115
151_21	OC2	Inner Harbor	7/14/2021		2021	12558	Film	Net	11	0.00	0	0	11
152_21	Air Blank	Air Blank	7/14/2021		2021	NA	Fiber	Air Blank	5	2.82	9	29	0
153_21	OC2	Inner Harbor	7/14/2021		2021	97.5	Fiber	Pump	9	2.82	9	29	0
153_21	OC2	Inner Harbor	7/14/2021		2021	97.5	Foam	Pump	10	0.00	0	0	10
153_21	OC2	Inner Harbor	7/14/2021		2021	97.5	Fragment	Pump	25	0.24	1	3	24
153_21	OC2	Inner Harbor	7/14/2021		2021	97.5	Film	Pump	1	0.00	0	0	1
160_21	NMC	Nine Mile Creek	7/14/2021		2021	NA	Fiber	Net	39	2.82	9	29	30
160_21	NMC	Nine Mile Creek	7/14/2021		2021	NA	Fragment	Net	6	0.24	1	3	5
161_21	Air Blank	Air Blank	7/14/2021		2021	NA	Fiber	Air Blank	3	2.82	9	29	0
162_21	NMC	Nine Mile Creek	7/14/2021		2021	97.5	Fragment	Pump	4	0.24	1	3	3
162_21	NMC	Nine Mile Creek	7/14/2021		2021	97.5	Fiber	Pump	7	2.82	9	29	0
163_21	Net Blank	Net Blank	7/14/2021		2021	NA	Foam	Net Blank	1	0.00	0	0	1
163_21	Net Blank	Net Blank	7/14/2021		2021	NA	Fiber	Net Blank	46	2.82	9	29	37
164_21	Pump Blank	Pump Blank	7/15/2021		2021	NA	Fragment	Pump Blank	1	0.24	1	3	0
164_21	Pump Blank	Pump Blank	7/15/2021		2021	NA	Fiber	Pump Blank	10	2.82	9	29	1

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
165_21	OUT1	Outlet	7/15/2021		2021	6888	Fragment	Net	12	0.24	1	3	11
165_21	OUT1	Outlet	7/15/2021		2021	6888	Film	Net	3	0.00	0	0	3
165_21	OUT1	Outlet	7/15/2021		2021	6888	Fiber	Net	1	2.82	9	29	0
166_21	Air Blank	Air Blank	7/15/2021		2021	NA	Fiber	Air Blank	3	2.82	9	29	0
167_21	OUT1	Outlet	7/15/2021		2021	97.5	Fiber	Pump	4	2.82	9	29	0
167_21	OUT1	Outlet	7/15/2021		2021	97.5	Fragment	Pump	1	0.24	1	3	0
168_21	OC2	Inner Harbor	7/15/2021		2021	3696	Fragment	Net	262	0.24	1	3	261
168_21	OC2	Inner Harbor	7/15/2021		2021	3696	Fiber	Net	24	2.82	9	29	15
168_21	OC2	Inner Harbor	7/15/2021		2021	3696	Sphere	Net	5	0.00	0	0	5
168_21	OC2	Inner Harbor	7/15/2021		2021	3696	Fiber bundle	Net	1	0.00	0	0	1
168_21	OC2	Inner Harbor	7/15/2021		2021	3696	Foam	Net	282	0.00	0	0	282
168_21	OC2	Inner Harbor	7/15/2021		2021	3696	Film	Net	23	0.00	0	0	23
169_21	SK1	Skaneateles Lake	7/23/2021	North	2021	244692	Sphere	Net	2	0.00	0	0	2
169_21	SK1	Skaneateles Lake	7/23/2021	North	2021	244692	Film	Net	2	0.00	0	0	2
169_21	SK1	Skaneateles Lake	7/23/2021	North	2021	244692	Fiber bundle	Net	2	0.00	0	0	2
169_21	SK1	Skaneateles Lake	7/23/2021	North	2021	244692	Fragment	Net	31	0.24	1	3	30
169_21	SK1	Skaneateles Lake	7/23/2021	North	2021	244692	Fiber	Net	22	2.82	9	29	13
169_21	SK1	Skaneateles Lake	7/23/2021	North	2021	244692	Foam	Net	2	0.00	0	0	2
170_21	Air Blank	Air Blank	7/23/2021		2021	NA	Fragment	Air Blank	1	0.24	1	3	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
170_21	Air Blank	Air Blank	7/23/2021		2021	NA	Fiber	Air Blank	6	2.82	9	29	0
171_21	SK1	Skaneateles Lake	7/23/2021	North	2021	97.5	Fiber	Pump	8	2.82	9	29	0
172_21	SK2	Skaneateles Lake	7/23/2021	Middle	2021	231042	Foam	Net	1	0.00	0	0	1
172_21	SK2	Skaneateles Lake	7/23/2021	Middle	2021	231042	Fiber	Net	14	2.82	9	29	5
172_21	SK2	Skaneateles Lake	7/23/2021	Middle	2021	231042	Film	Net	2	0.00	0	0	2
172_21	SK2	Skaneateles Lake	7/23/2021	Middle	2021	231042	Fiber bundle	Net	1	0.00	0	0	1
172_21	SK2	Skaneateles Lake	7/23/2021	Middle	2021	231042	Fragment	Net	20	0.24	1	3	19
173_21	Air Blank	Air Blank	7/23/2021		2021	NA	Fiber	Air Blank	5	2.82	9	29	0
174_21	Profile	Skaneateles Lake	7/23/2021	NA	2021	97.5	Fiber	Pump	5	2.82	9	29	0
175_21	Profile	Skaneateles Lake	7/23/2021	NA	2021	97.5	Fiber	Pump	6	2.82	9	29	0
176_21	Profile	Skaneateles Lake	7/23/2021	NA	2021	97.5	Fiber	Pump	3	2.82	9	29	0
177_21	Pump Blank	Skaneateles Lake	7/23/2021	NA	2021	97.5	Fiber	Pump	5	2.82	9	29	0
178_21	SK3	Skaneateles Lake	7/23/2021	South	2021	159180	Fiber	Net	20	2.82	9	29	11
178_21	SK3	Skaneateles Lake	7/23/2021	South	2021	159180	Film	Net	2	0.00	0	0	2
178_21	SK3	Skaneateles Lake	7/23/2021	South	2021	159180	Fragment	Net	7	0.24	1	3	6
179_21	Air Blank	Air Blank	7/23/2021		2021	NA	Fiber	Air Blank	6	2.82	9	29	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
180_21	SK3	Skaneateles Lake	7/23/2021	South	2021	97.5	Fiber	Pump	2	2.82	9	29	0
181_21	Net Blank	Net Blank	7/23/2021		2021	NA	Fiber	Net Blank	8	2.82	9	29	0
182_21	OND1	Onondaga Lake	11/30/2021	North	2021	239526	Film	Net	2	0.00	0	0	2
182_21	OND1	Onondaga Lake	11/30/2021	North	2021	239526	Fragment	Net	3	0.24	1	3	2
182_21	OND1	Onondaga Lake	11/30/2021	North	2021	239526	Fiber	Net	20	2.82	9	29	11
182_21	OND1	Onondaga Lake	11/30/2021	North	2021	239526	Sphere	Net	1	0.00	0	0	1
183_21	OND1	Onondaga Lake	11/30/2021	North	2021	97.5	Fiber	Pump	6	2.82	9	29	0
183_21	OND1	Onondaga Lake	11/30/2021	North	2021	97.5	Film	Pump	1	0.00	0	0	1
184_21	Net Blank	Net Blank	11/30/2021		2021	NA	Fragment	Net Blank	2	0.24	1	3	1
184_21	Net Blank	Net Blank	11/30/2021		2021	NA	Fiber	Net Blank	25	2.82	9	29	16
185_21	Air Blank	Air Blank	11/30/2021		2021	NA	Fiber	Air Blank	2	2.82	9	29	0
186_21	OND2	Onondaga Lake	11/30/2021	Middle	2021	179928	Fiber	Net	25	2.82	9	29	16
186_21	OND2	Onondaga Lake	11/30/2021	Middle	2021	179928	Fragment	Net	6	0.24	1	3	5
187_21	OND2	Onondaga Lake	11/30/2021	Middle	2021	97.5	Fiber	Pump	5	2.82	9	29	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
188_21	Air Blank	Air Blank	11/30/2021		2021	NA	Fiber	Air Blank	3	2.82	9	29	0
189_21	OND3	Onondaga Lake	11/30/2021	South	2021	239736	Fragment	Net	35	0.24	1	3	34
189_21	OND3	Onondaga Lake	11/30/2021	South	2021	239736	Fiber	Net	8	2.82	9	29	0
189_21	OND3	Onondaga Lake	11/30/2021	South	2021	239736	Film	Net	3	0.00	0	0	3
189_21	OND3	Onondaga Lake	11/30/2021	South	2021	239736	Sphere	Net	13	0.00	0	0	13
190_21	Air Blank	Air Blank	11/30/2021		2021	NA	Fiber	Air Blank	2	2.82	9	29	0
190_21	Air Blank	Air Blank	11/30/2021		2021	NA	Fragment	Air Blank	1	0.24	1	3	0
191_21	Profile	Onondaga Lake	11/30/2021	NA	2021	NA	Fiber	Pump	3	2.82	9	29	0
192_21	Profile	Onondaga Lake	11/30/2021	NA	2021	97.5	Fragment	Pump	1	0.24	1	3	0
192_21	Profile	Onondaga Lake	11/30/2021	NA	2021	97.5	Fiber	Pump	6	2.82	9	29	0
193_21	Profile	Onondaga Lake	11/30/2021	NA	2021	97.5	Fragment	Pump	1	0.24	1	3	0
193_21	Profile	Onondaga Lake	11/30/2021	NA	2021	97.5	Fiber	Pump	4	2.82	9	29	0
194_21	Air Blank	Air Blank	11/30/2021		2021	NA	Fiber	Air Blank	5	2.82	9	29	0

Sample No	ID	Location	Date	Position	Year	Volume (L)	Morphology	Sample Type	Count	SD (Blanks)	LOD	LOQ	Count - LOD
195_21	Pump Blank	Pump Blank	11/30/2021		2021	NA	Fiber	Pump Blank	6	2.82	9	29	0
196_21	OC3	Spencer Street	12/13/2021		2021	121968	Fiber bundle	Net	1	0.00	0	0	1
196_21	OC3	Spencer Street	12/13/2021		2021	121968	Film	Net	2	0.00	0	0	2
196_21	OC3	Spencer Street	12/13/2021		2021	121968	Fragment	Net	7	0.24	1	3	6
196_21	OC3	Spencer Street	12/13/2021		2021	121968	Fiber	Net	65	2.82	9	29	56
197_21	Net Blank	Net Blank	12/13/2021		2021	NA	Fragment	Net Blank	2	0.24	1	3	1
197_21	Net Blank	Net Blank	12/13/2021		2021	NA	Fiber	Net Blank	10	2.82	9	29	1
198_21	OC4	Dorwin Ave	12/13/2021		2021	37422	Fiber	Net	23	2.82	9	29	14
198_21	OC4	Dorwin Ave	12/13/2021		2021	37422	Fragment	Net	1	0.24	1	3	0
199_21	Pump Blank	Pump Blank	12/13/2021		2021	NA	Fiber	Pump Blank	1	2.82	9	29	0
200_21	Air Blank	Air Blank	12/13/2021		2021	NA	Fiber	Air Blank	2	2.82	9	29	0
201_21	NMC	Nine Mile Creek	12/13/2021		2021	NA	Film	Net	2	0.00	0	0	2
201_21	NMC	Nine Mile Creek	12/13/2021		2021	NA	Fragment	Net	6	0.24	1	3	5
201_21	NMC	Nine Mile Creek	12/13/2021		2021	NA	Fiber	Net	32	2.82	9	29	23
202_21	NMC	Nine Mile Creek	12/13/2021		2021	97.5	Fiber	Pump	8	2.82	9	29	0
203_21	Air Blank	Air Blank	12/13/2021		2021	NA	Fiber	Air Blank	5	2.82	9	29	0

Table B.2: Corrected counts, concentrations, coordinates, and Shannon diversity indices for all samples arranged by date of sample collection.

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
31_19	SK	Grab	Shoreline	10/15/2019	42.91285	-76.40074			0.84	1	1.19E+00	1.386
25_19	SK	Grab	Shoreline	10/15/2019	42.93234	-76.41864			0.84	0	0.00E+00	N/A
27_19	SK	Grab	Shoreline	10/15/2019	42.92719	-76.41225			0.8	0	0.00E+00	N/A
33_19	SK	Net Blank	Shoreline	10/15/2019					194082	20	1.03E-04	0.726
28_19	SK	Grab	Shoreline	10/15/2019	42.91975	-76.40804			0.82	1	1.22E+00	1.213
30_19	SK	Grab	Shoreline	10/15/2019	42.91888	-76.40448			0.82	1	1.22E+00	1.040
32_19	SK	Grab	Shoreline	10/15/2019	42.90576	-76.39736			0.81	0	0.00E+00	N/A
29_19	SK	Net	Shoreline	10/15/2019	42.91888	-76.40448	42.90576	-76.39736	194082	61	3.14E-04	1.689
2_19	OC1	Grab	NA	10/23/2019	43.06778	-76.1775			0.94	0	0.00E+00	N/A
3_19	OC2	Grab	NA	10/23/2019	43.06111	-76.16278			0.93	0	0.00E+00	N/A
8_19	SR1	Grab	NA	10/23/2019	43.12333	-76.26472			0.93	5	5.38E+00	0.451
1_19	NMC1	Grab	NA	10/23/2019	43.08111	76.226389			0.84	15	1.79E+01	0.752
34_19	OC3	Grab	NA	10/23/2019						23		1.232
5_19	OC3	Grab	NA	10/23/2019	43.05718	-76.16163			0.93	0	0.00E+00	N/A
6_19	OC4	Grab	NA	10/23/2019	42.98472	-76.15			0.92	0	0.00E+00	N/A
7_19	OUT1	Grab	NA	10/23/2019	43.11639	-76.24389			0.93	0	0.00E+00	N/A
9_19	SR2	Grab	NA	10/23/2019	43.13	-76.25444			0.92	0	0.00E+00	N/A
11_19	OND2	Grab	Middle	10/29/2019	43.09861	-76.20972			0.82	0	0.00E+00	N/A

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
10_19	OND2	Net	Middle	10/29/2019	43.09333	-76.21167	43.09028	-76.21333	176988	96	5.42E-04	2.099
12_19	OND2	Grab	Middle	10/29/2019	43.09333	-76.21167			0.79	0	0.00E+00	N/A
13_19	OND2	Grab	Middle	10/29/2019	43.09028	-76.21333			0.83	0	0.00E+00	N/A
14_19	OND3	Net	South	10/29/2019	43.07361	-76.1875	43.07083	-76.19111	194082	102	5.26E-04	2.101
15_19	OND3	Grab	South	10/29/2019	43.08083	-76.18722				0	0.00E+00	N/A
19_19	OND	Net Blank	NA	10/29/2019					194082	5	2.58E-05	1.285
16_19	OND3	Grab	South	10/29/2019	43.07361	-76.1875			0.82	0	0.00E+00	N/A
17_19	OND3	Grab	South	10/29/2019	43.07083	-76.19111			0.85	0	0.00E+00	N/A
18_19	METRO	Grab	NA	10/29/2019	43.06323	-76.17894			3.74	0	0.00E+00	N/A
49_20	OC4	Bucket 355	NA	6/4/2020	42.98492	-76.15001			39	2	5.13E-02	0.937
59_20	BLANK	Net Blank	NA	6/4/2020					240940	45	1.87E-04	1.248
46_20	OC1	Bucket 355	NA	6/4/2020	43.06766	-76.17759			39	1	2.56E-02	0.451
48_20	OC3	Bucket 355	NA	6/4/2020	43.05718	-76.16163			39	1	2.56E-02	0.950
50_20	OC4	Bucket 355	NA	6/4/2020	42.98492	-76.15001			39	3	7.69E-02	1.332
47_20	OC2	Bucket 355	NA	6/4/2020	43.06131	-76.16295			39	2	5.13E-02	1.330
45_20	NMC1	Bucket 355	NA	6/4/2020	43.08103	-76.22664			39	0	0.00E+00	N/A
43_20	OC2	Bucket 355	NA	6/4/2020	43.06102	-76.16259			19.5	40	2.05E+00	2.222
44_20	OC3	Net	NA	6/4/2020	43.05718	-76.16163			240940	325	1.35E-03	2.587
53_20	SR1	Bucket 355	NA	6/5/2020	43.12333	-76.26542			39	2	5.13E-02	0.965

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
56_20	OSW1	Bucket 355	NA	6/5/2020	43.21099	-76.288			39	2	5.13E-02	1.149
54_20	SR2	Bucket 355	NA	6/5/2020	43.13001	-76.25434			39	1	2.56E-02	1.475
55_20	ONEIDA1	Bucket 355	NA	6/5/2020	43.2045	-76.21752			39	5	1.28E-01	1.044
52_20	OUT1	Bucket 355	NA	6/5/2020	43.11663	-76.24432			39	0	0.00E+00	N/A
62_20	OND3	Net	South	8/20/2020	43.07173	-76.20275	43.08185	-76.18895	196980	66	3.35E-04	2.161
66_20	BLANK	Net Blank	NA	8/20/2020					196980	10	5.08E-05	1.518
63_20	OND1	Grab	North	8/20/2020	43.07173	-76.20275				0	0.00E+00	N/A
64_20	OND1	Grab	North	8/20/2020	43.07612	-76.19678			0.88	0	0.00E+00	N/A
65_20	OND3	Grab	South	8/20/2020	43.08185	-76.18895				0	0.00E+00	N/A
73_20	SK	Grab	Shoreline	9/1/2020	42.91054	-76.42082			0.8	1	1.25E+00	1.242
71_20	SK	Net	Shoreline	9/1/2020	42.89922	-76.41518	42.92011	-76.42695	253680	29	1.14E-04	1.637
67_20	SK	Net	Shoreline	9/1/2020	42.86783	-76.40185	42.89069	-76.41022	312900	33	1.05E-04	1.893
68_20	SK	Grab	Shoreline	9/1/2020	42.86615	-76.4013			0.79	0	0.00E+00	N/A
69_20	SK	Grab	Shoreline	9/1/2020	42.87921	-76.40738			0.8	0	0.00E+00	N/A
70_20	SK	Grab	Shoreline	9/1/2020	42.89069	-76.41022			0.81	0	0.00E+00	N/A
72_20	SK	Grab	Shoreline	9/1/2020	42.90134	-76.41556			0.68	0	0.00E+00	N/A
74_20	SK	Grab	Shoreline	9/1/2020	42.92011	-76.42695			0.79	0	0.00E+00	N/A
75_20	OND2	Net	Middle	9/10/2020	43.08583	-76.21102	43.08605	-76.21565	202062	68	3.37E-04	2.494
76_20	OND2	Grab	Middle	9/10/2020	43.08583	-76.21102			0.78	1	1.28E+00	0.693

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
77_20	OND2	Grab	Middle	9/10/2020	43.0929	-76.21207			0.86	0	0.00E+00	N/A
78_20	OND2	Grab	Middle	9/10/2020	43.08605	-76.21565			0.8	0	0.00E+00	N/A
79_20	BLANK	Net Blank	NA	9/10/2020					202062	0	0.00E+00	N/A
80_20	OND1	Net	North	9/16/2020	43.10873	-76.22652	43.09522	-76.23115	161070	73	4.53E-04	2.331
84_20	BLANK	Net Blank	NA	9/16/2020					161070	1	6.21E-06	0.637
81_20	OND1	Grab	North	9/16/2020	43.10873	-76.22652			0.83	0	0.00E+00	N/A
82_20	OND1	Grab	North	9/16/2020	43.10293	-76.22978			0.87	0	0.00E+00	N/A
83_20	OND1	Grab	North	9/16/2020	43.09522	-76.23115			0.85	0	0.00E+00	N/A
92_20	BLANK	Net Blank	NA	9/24/2020					41034	4	9.75E-05	0.760
88_20	OC3	Bucket 106	NA	9/24/2020	43.05725	-76.16171			39	1	2.56E-02	0.736
90_20	OC4	Bucket 106	NA	9/24/2020	42.98495	-76.15015			39	3	7.69E-02	0.639
87_20	OC2	Bucket 106	NA	9/24/2020	43.06139	-76.16497			39	7	1.79E-01	1.253
85_20	OC1	Bucket 106	NA	9/24/2020	43.06768	-76.17767			39	11	2.82E-01	0.778
89_20	OC3	Net	NA	9/24/2020	43.05725	-76.16171			41034	44	1.07E-03	1.465
86_20	OC2	Bucket 106	NA	9/24/2020	43.06104	-76.16246			19.5	709	3.64E+01	2.608
91_20	NMC1	Bucket 106	NA	9/24/2020	43.08114	-76.22666			39	0	0.00E+00	N/A
97_20	OSW1	Bucket 106	NA	9/25/2020	43.21128	-76.288			39	3	7.69E-02	0.000
94_20	OUT1	Bucket 106	NA	9/25/2020	43.11638	-76.24415			39	21	5.38E-01	0.768

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
95_20	SR1	Bucket 106	NA	9/25/2020	43.12335	-76.2654			39	0	0.00E+00	N/A
96_20	SR2	Bucket 106	NA	9/25/2020	43.13024	-76.254			39	0	0.00E+00	N/A
98_20	ONEIDA1	Bucket 106	NA	9/25/2020	43.20451	-76.21768			39	0	0.00E+00	N/A
110_20	OND1	Grab	North	11/4/2020	43.09195	-76.22583			0.89	0	0.00E+00	N/A
111_20	OND1	Grab	North	11/4/2020	43.09745	-76.2192			0.87	0	0.00E+00	N/A
112_20	OND1	Grab	North	11/4/2020	43.10178	-76.15			0.85	0	0.00E+00	N/A
109_20	OND1	Net	North	11/4/2020	43.09195	-76.22583	43.10178	-76.21687	178962	213	1.19E-03	2.487
113_20	BLANK	Net Blank	NA	11/4/2020					178962	9	5.03E-05	1.836
115_20	OND3	Grab	South	11/9/2020	43.0713	-76.19928			0.82	0	0.00E+00	N/A
116_20	OND3	Grab	South	11/9/2020	43.07715	-76.19453			0.78	0	0.00E+00	N/A
117_20	OND3	Grab	South	11/9/2020	43.08312	-76.19033			0.84	0	0.00E+00	N/A
114_20	OND3	Net	South	11/9/2020	43.0713	-76.19928	43.08312	-76.19033	205548	2717	1.32E-02	2.325
118_20	BLANK	Net Blank	NA	11/9/2020					205548	164	7.98E-04	0.463
140_21	OND2	Pump	Middle	7/9/2021	43.09436	-76.21548			97.5	0	0.00E+00	N/A
141_21	Air Blank	Air Blank	NA	7/9/2021					NA	0	N/A	N/A
143_21	Air Blank	Air Blank	NA	7/9/2021					NA	0	N/A	N/A
145_21	OND_Profile_1	Pump	NA	7/9/2021	43.07895	-76.19856			97.5	0	0.00E+00	N/A
146_21	Pump Blank	Pump Blank	NA	7/9/2021					NA	0	N/A	N/A

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
148_21	OND_Profile_3	Pump	NA	7/9/2021	43.07895	-76.19856			97.5	0	0.00E+00	N/A
136_21	OND1	Net	North	7/9/2021	43.09608	-76.23434	43.10626	-76.22311	197568	143	7.24E-04	1.791
137_21	OND1	Pump	North	7/9/2021	43.1006	-76.22942			97.5	2	2.05E-02	0.600
139_21	OND2	Net	Middle	7/9/2021	43.08958	-76.21637	43.09881	-76.21107	162414	40	2.46E-04	1.920
142_21	OND3	Net	South	7/9/2021	43.07405	-76.20408	43.083	-76.1888	241248	48	1.99E-04	1.866
147_21	OND_Profile_2	Pump	NA	7/9/2021	43.07895	-76.19856			97.5	1	1.03E-02	1.367
138_21	Air Blank	Air Blank	NA	7/9/2021					NA	4	N/A	0.937
144_21	Net Blank	Net Blank	NA	7/9/2021					NA	19	N/A	0.736
159_21	OC4	Pump	NA	7/13/2021	42.98463	-76.15022			97.5	0	0.00E+00	N/A
157_21	OC4	Net	NA	7/13/2021	42.98463	-76.15022			45612	46	1.01E-03	1.961
154_21	OC3	Net	NA	7/13/2021	43.05647	-76.1613			101472	256	N/A	2.783
155_21	Net Blank	Net Blank	NA	7/13/2021					NA	21	N/A	1.397
156_21	Pump Blank	Pump Blank	NA	7/13/2021					NA	6	N/A	1.927
158_21	Air Blank	Air Blank	NA	7/13/2021					NA	2	N/A	0.860
150_21	OC1	Pump	NA	7/14/2021	43.06766	-76.1776			97.5	0	0.00E+00	N/A
152_21	Air Blank	Air Blank	NA	7/14/2021					NA	0	N/A	N/A
161_21	Air Blank	Air Blank	NA	7/14/2021					NA	0	N/A	N/A
162_21	NMC	Pump	NA	7/14/2021	43.07775	-76.2285			97.5	3	3.08E-02	1.642

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
160_21	NMC	Net	NA	7/14/2021	43.07775	-76.2285			49980	36	7.20E-04	1.807
153_21	OC2	Pump	NA	7/14/2021	43.06152	-76.1633			97.5	35	3.59E-01	2.538
151_21	OC2	Net	NA	7/14/2021	43.06153	-76.16325	43.06112	-76.16418	12558	297	2.37E-02	2.199
149_21	OC1	Net	NA	7/14/2021	43.06766	-76.1776			840	49	5.83E-02	2.426
163_21	Net Blank	Net Blank	NA	7/14/2021					NA	38	N/A	1.453
166_21	Air Blank	Air Blank	NA	7/15/2021					NA	0	N/A	N/A
167_21	OUT1	Pump	NA	7/15/2021	43.11848	-76.24597			97.5	0	0.00E+00	N/A
165_21	OUT1	Net	NA	7/15/2021	43.11853	-76.24606	43.11805	-76.24546	6888	14	2.03E-03	1.733
168_21	OC2	Net	NA	7/15/2021	43.06153	-76.16325	43.06112	-76.16418	3696	587	1.59E-01	2.192
164_21	Pump Blank	Pump Blank	NA	7/15/2021					NA	1	N/A	1.121
172_21	SK2	Net	Middle	7/23/2021	42.86144	-76.36035	42.848497	-76.370406	231042	28	1.21E-04	2.105
170_21	Air Blank	Air Blank	NA	7/23/2021					NA	0	N/A	N/A
171_21	SK1	Pump	North	7/23/2021	42.91798	-76.41415			97.5	0	0.00E+00	N/A
173_21	Air Blank	Air Blank	NA	7/23/2021					NA	0	N/A	N/A
174_21	SK_Profile1	Pump	NA	7/23/2021	42.86256	-76.37828			97.5	0	0.00E+00	N/A
175_21	SK_Profile2	Pump	NA	7/23/2021	42.86058	-76.3767			97.5	0	0.00E+00	N/A
176_21	SK_Profile3	Pump	NA	7/23/2021	42.85876	-76.37382			97.5	0	0.00E+00	N/A
169_21	SK1	Net	North	7/23/2021	42.91735	-76.40414	42.91631	-76.42447	244692	51	2.08E-04	2.438

Sample No	Sample ID	Sample Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volume (L)	Count	Conc (n/L)	Shannon Diversity
177_21	Pump Blank	Pump	NA	7/23/2021					97.5	0	0.00E+00	N/A
179_21	Air Blank	Air Blank	NA	7/23/2021					NA	0	N/A	N/A
180_21	SK3	Pump	South	7/23/2021	42.81332	-76.30476			97.5	0	0.00E+00	N/A
181_21	Net Blank	Net Blank	NA	7/23/2021					NA	0	N/A	N/A
178_21	SK3	Net	South	7/23/2021	42.81337	-76.29808	42.808857	-76.304758	159180	20	1.26E-04	2.105
185_21	Air Blank	Air Blank	NA	11/30/2021					NA	0	N/A	N/A
187_21	OND2	Pump	Middle	11/30/2021	43.0926	-76.21386			97.5	0	0.00E+00	N/A
188_21	Air Blank	Air Blank	NA	11/30/2021					NA	0	N/A	N/A
190_21	Air Blank	Air Blank	NA	11/30/2021					NA	0	N/A	N/A
191_21	OND_Profile_1	Pump	NA	11/30/2021	43.07874	-76.19832			97.5	0	0.00E+00	N/A
192_21	OND_Profile_2	Pump	NA	11/30/2021	43.07874	-76.19832			97.5	0	0.00E+00	N/A
193_21	OND_Profile_3	Pump	NA	11/30/2021	43.07874	-76.19832			97.5	0	0.00E+00	N/A
194_21	Air Blank	Air Blank	NA	11/30/2021					NA	0	N/A	N/A
195_21	Pump Blank	Pump Blank	NA	11/30/2021					NA	0	N/A	N/A
182_21	OND1	Net	North	11/30/2021	43.10362	-76.22078	43.09654	-76.23584	239526	16	6.68E-05	1.764
183_21	OND1	Pump	North	11/30/2021	43.10113	-76.23584			97.5	1	1.03E-02	0.956

Sampl e No	Sample ID	Sampl e Type	Lake Position	Date	Lat	Long	Lat End	Long End	Volum e (L)	Coun t	Conc (n/L)	Shanno n Diversity
186_21	OND2	Net	Middle	11/30/2021	43.09743	-76.20752	43.0881	-76.21693	179928	21	1.17E-04	1.802
189_21	OND3	Net	South	11/30/2021	43.08288	-76.18877	43.07289	-76.20391	239736	50	2.09E-04	2.306
184_21	Net Blank	Net Blank	NA	11/30/2021					NA	17	N/A	1.204
199_21	Pump Blank	Pump Blank	NA	12/13/2021	42.98476	-76.15012			NA	0	N/A	N/A
200_21	Air Blank	Air Blank	NA	12/13/2021					NA	0	N/A	N/A
202_21	NMC	Pump	NA	12/13/2021	43.07776	-76.22858			97.5	0	0.00E+00	N/A
203_21	Air Blank	Air Blank	NA	12/13/2021					NA	0	N/A	N/A
198_21	OC4	Net	NA	12/13/2021	42.98476	-76.15012			37422	14	3.74E-04	1.197
196_21	OC3	Net	NA	12/13/2021	43.05644	-76.16131			121968	65	5.33E-04	1.815
197_21	Net Blank	Net Blank	NA	12/13/2021					NA	2	N/A	1.234
201_21	NMC	Net	NA	12/13/2021	43.07776	-76.22858			NA	30	Velocity too low.	1.915

Table B.3: Total number of particles of each morphology and sample type that were chemically analyzed by FTIR.

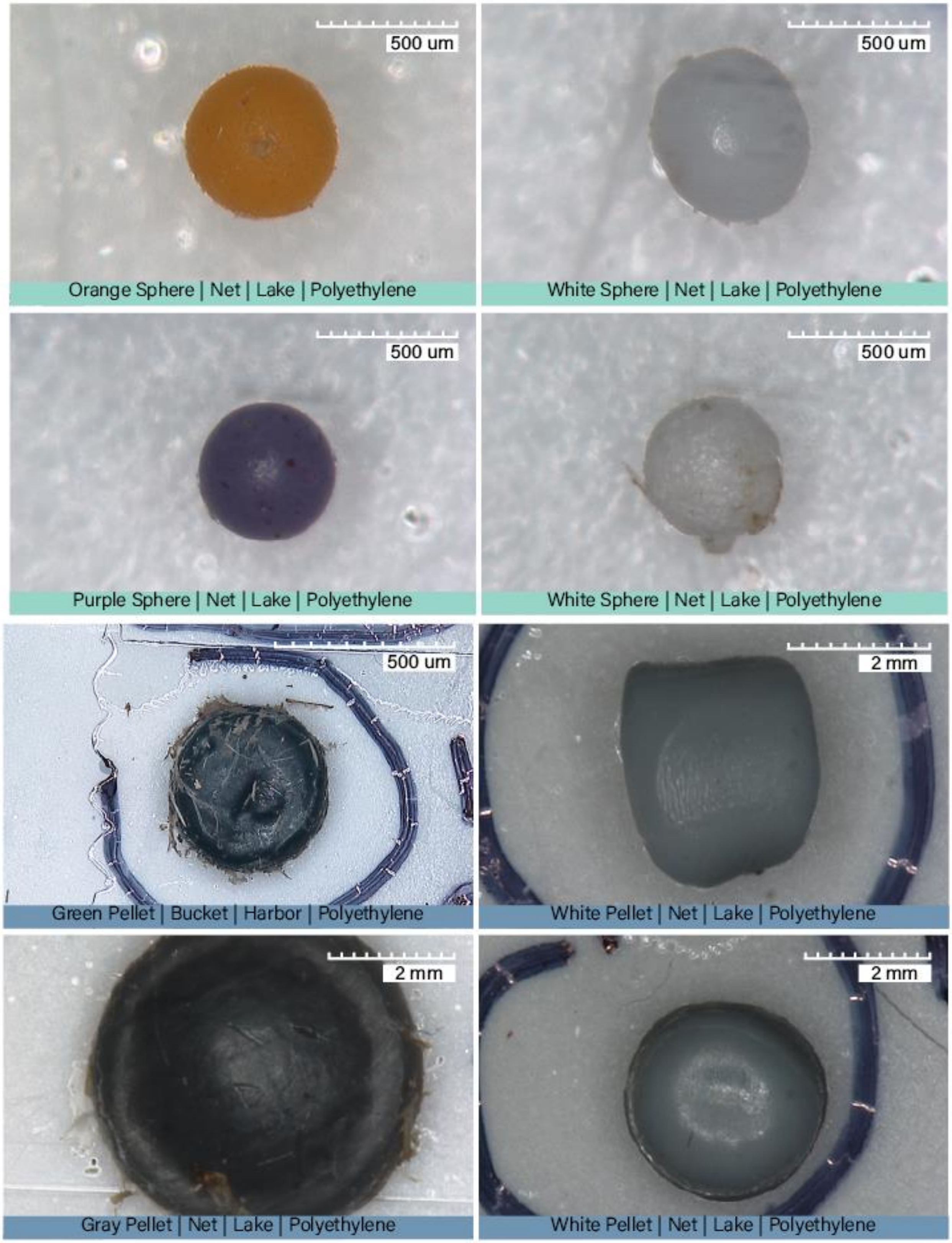
Sample Type	Morphology	Number Analyzed by FTIR
Grab	Fiber	2
Grab	Fragment	1
Bucket 355	Fiber	5
Bucket 355	Film	3
Bucket 355	Foam	6
Bucket 355	Fragment	23
Bucket 355	Sphere	1
Bucket 106	Fiber	12
Bucket 106	Film	6
Bucket 106	Foam	35
Bucket 106	Fragment	106
Bucket 106	Pellet	2
Bucket 106	Sphere	19
Pump	Fiber	7
Pump	Foam	1
Pump	Fragment	6
Net	Fiber	153
Net	Fiber / Fragment	2
Net	Fiber bundle	22
Net	Film	90
Net	Foam	148
Net	Fragment	568
Net	Pellet	9
Net	Sphere	94

Table B.4: Total morphologies after subtraction, number chemically analyzed by FTIR, and the percentage of each morphology analyzed by FTIR. Note that samples exceeding 100% analyzed are due to subtraction of cellulose results from morphology counts.

Morphology	Total After Subtraction	Number Analyzed by FTIR	Percentage Analyzed by FTIR
Fiber	2219	179	8.1%
Fiber / Fragment	5	2	40.0%
Fiber bundle	36	22	61.1%

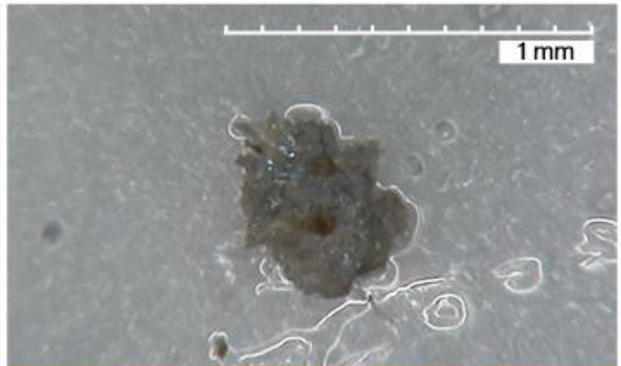
Morphology	Total After Subtraction	Number Analyzed by FTIR	Percentage Analyzed by FTIR
Film	209	99	47.4%
Foam	761	190	25.0%
Fragment	3036	704	23.2%
Pellet	10	11	110.0%
Sphere	262	114	43.5%

Appendix B-5: Images of various colors and morphologies of particles from samples.

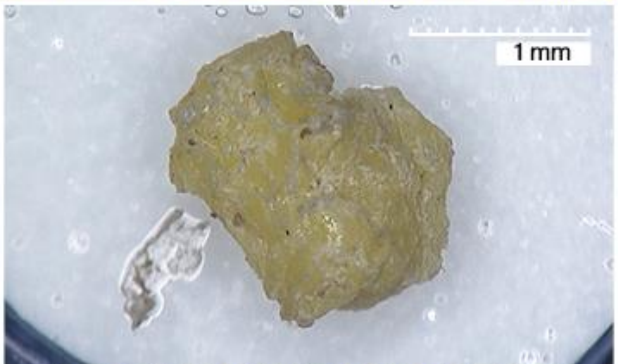



500 um
Orange Fragment | Net | Lake | Polyethylene
1 mm
Transparent Fragment | Net | Lake | Polypropylene
1 mm
Black Fragment | Net | Lake | Polypropylene
1 mm
White Fragment | Bucket | Harbor | Polypropylene
1 mm
Black Fragment | Net | Lake | Polypropylene
1 mm
White Fragment | Bucket | Harbor | Polypropylene

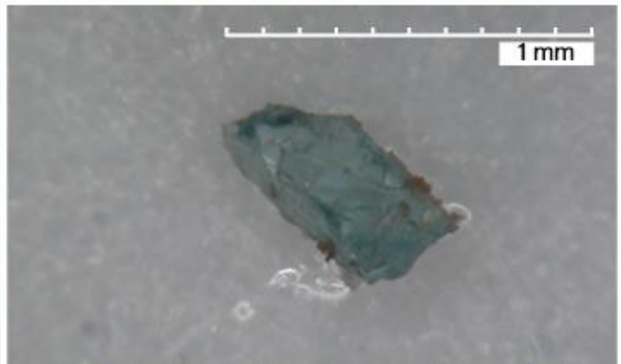
Purple Fragment | Bucket | Harbor | Polypropylene



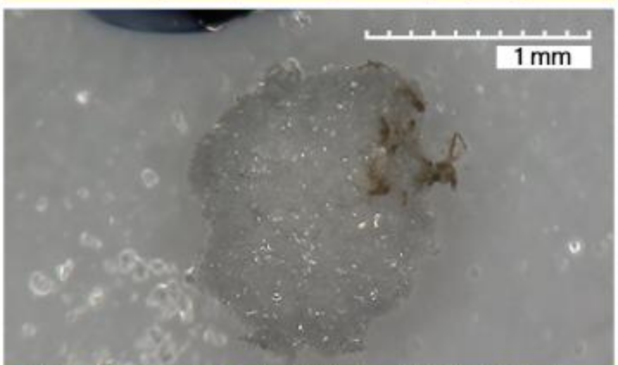
Gray Fragment | Bucket | Harbor | Polychloroprene



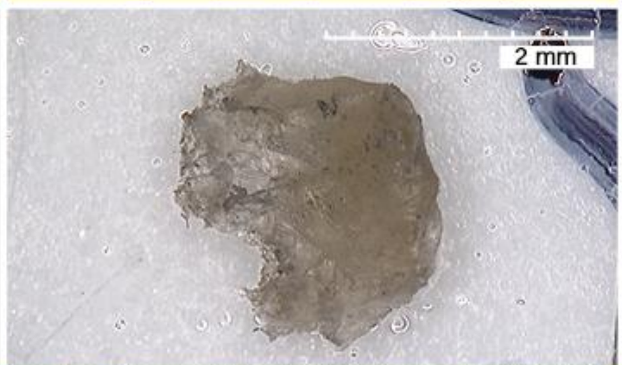
Yellow Fragment | Bucket | Harbor | Polyethylene



Blue Fragment | Bucket | Harbor | Polypropylene



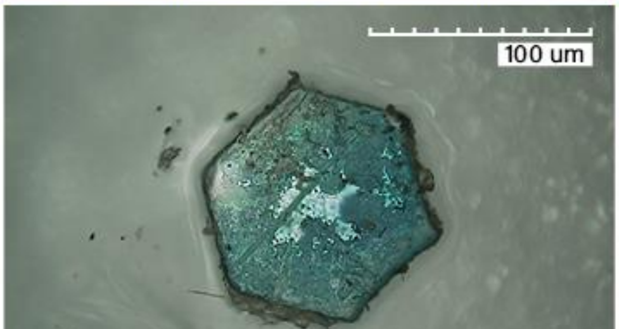
White Fragment | Bucket | Harbor | Methyl Cellulose



Gray Fragment | Bucket | Harbor | Polyethylene

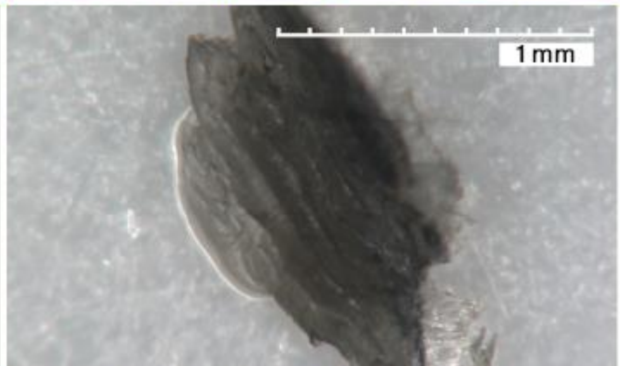
Black Fragment | Net | Lake | Polypropylene

Transparent Fragment | Net | Lake | Polypropylene



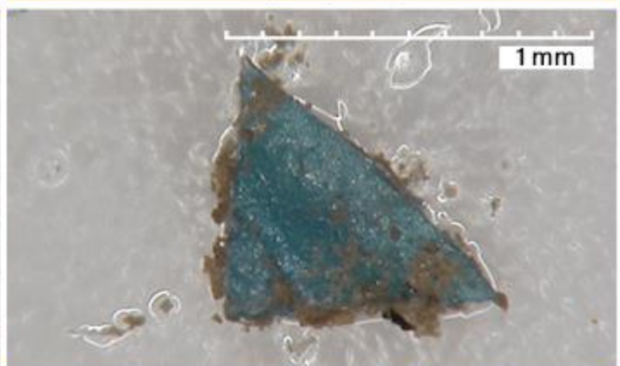
Note: This is likely a piece of glitter.

Blue Fragment | Bucket | Harbor | PET

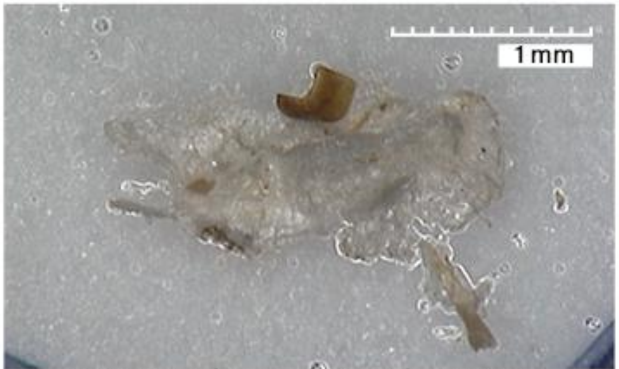


Gray Fragment | Net | Lake | Polyamide

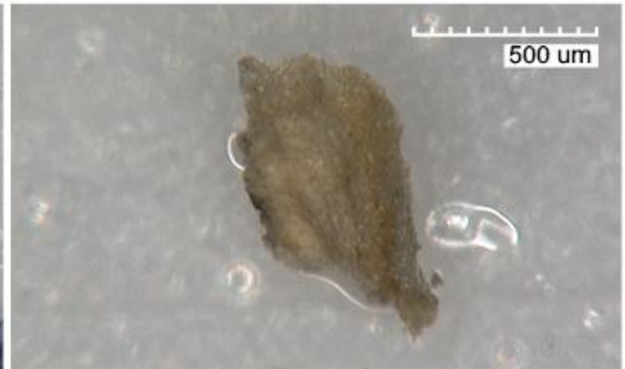
Transparent Fragment | Net | Lake | Alkyd Varnish



Blue Fragment | Net | Lake | Polyethylene



White Foam | Bucket | Harbor | Polystyrene

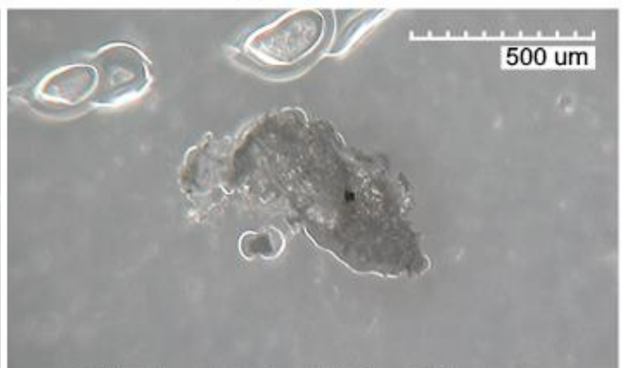


Tan Foam | Net | Creek | Alkyd Varnish

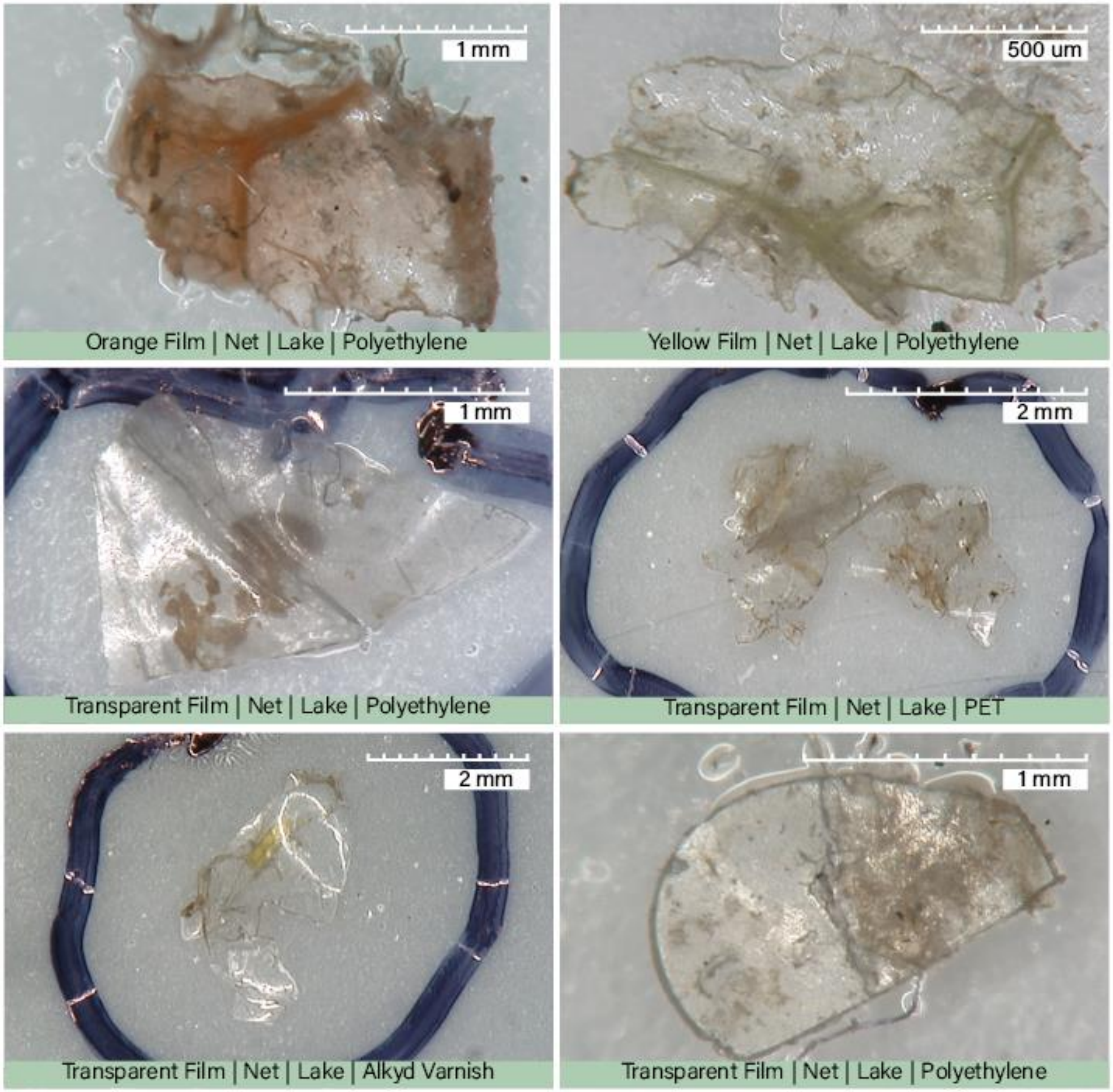
White Foam | Bucket | Harbor | Polystyrene

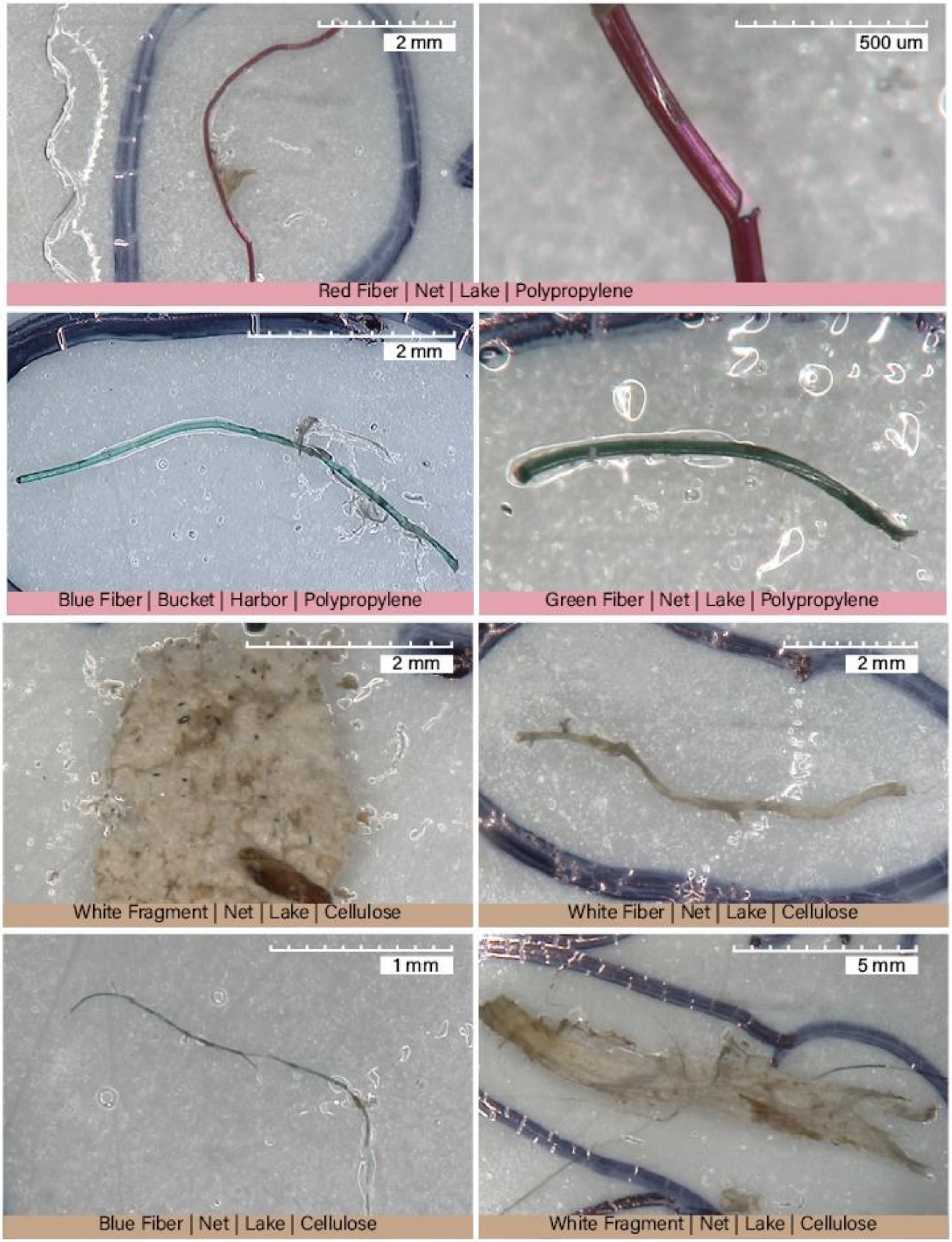
White Foam | Net | Lake | Polystyrene

White Foam | Bucket | Harbor | Polyethylene



White Foam | Bucket | Harbor | Polystyrene


1 mm
Orange Film | Net | Lake | Polyethylene
500 um
Yellow Film | Net | Lake | Polyethylene
1 mm
Transparent Film | Net | Lake | Polyethylene
2 mm
Transparent Film | Net | Lake | PET
2 mm
Transparent Film | Net | Lake | Alkyd Varnish
1 mm
Transparent Film | Net | Lake | Polyethylene


2 mm
500 um
Red Fiber | Net | Lake | Polypropylene
2 mm
Blue Fiber | Bucket | Harbor | Polypropylene
Green Fiber | Net | Lake | Polypropylene
2 mm
White Fragment | Net | Lake | Cellulose
2 mm
White Fiber | Net | Lake | Cellulose
1 mm
Blue Fiber | Net | Lake | Cellulose
5 mm
White Fragment | Net | Lake | Cellulose

Appendix C: Exploring the Inter-Annual Variability in Microplastics in Seasonally Stratified Lakes using Net Sampling

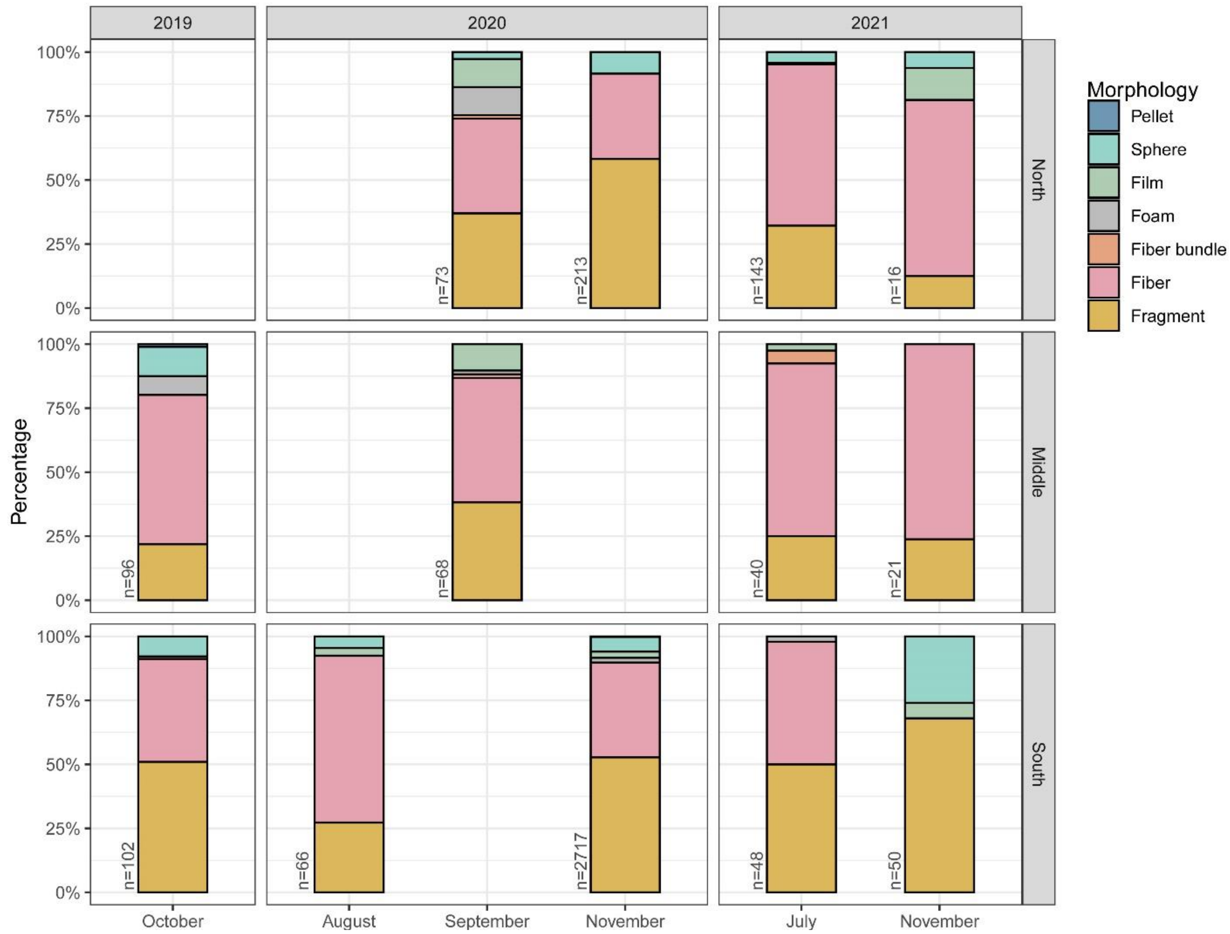


Figure C.1: Relative proportion of morphologies with time at the northern, middle, and southern lake positions in Onondaga Lake during different months (depicted on the x-axis on a non-linear scale). N-values depict the total number of particles at a specific time and lake position.

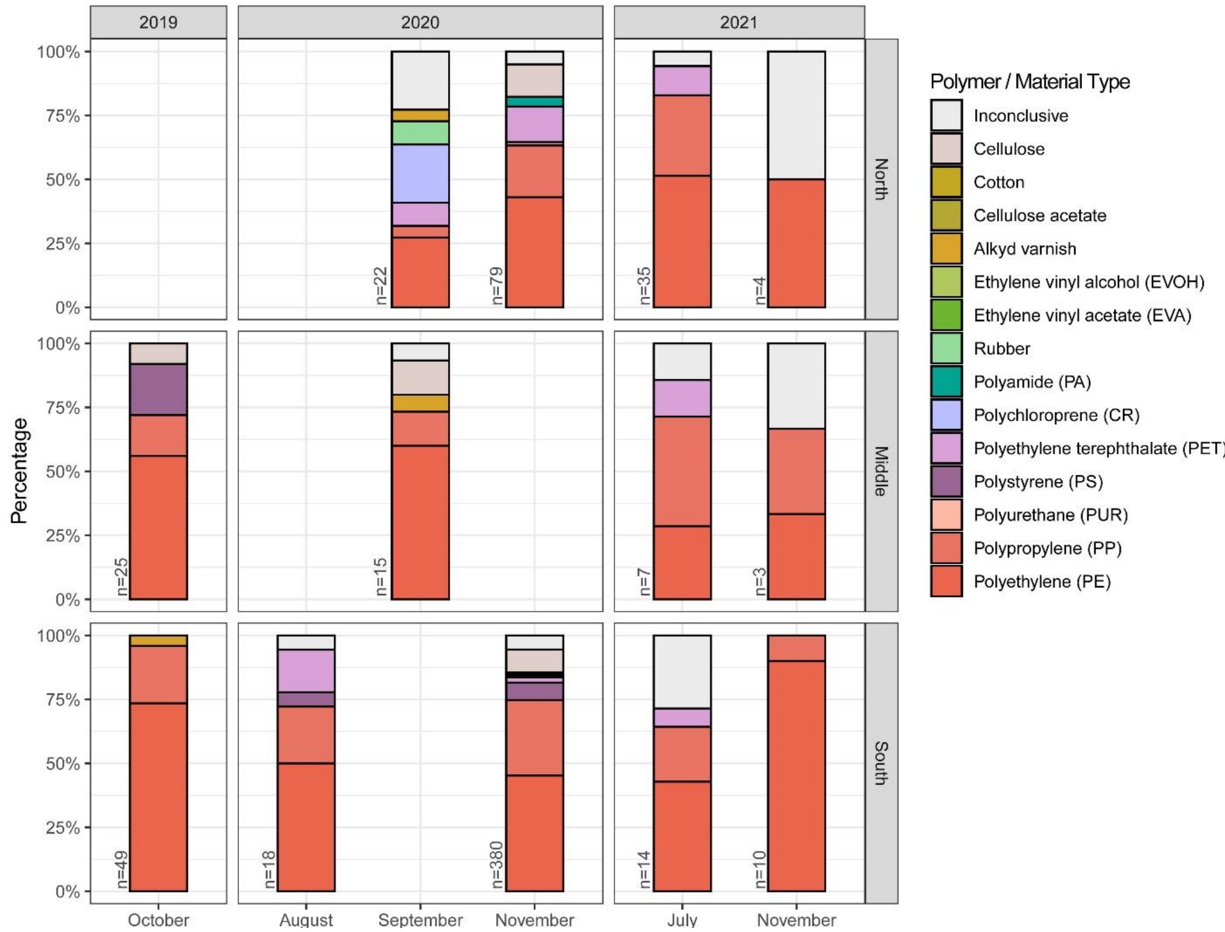


Figure C.2: Relative proportion of material types for particles subsampled for ATR-FTIR with time at the northern, middle, and southern lake positions in Onondaga Lake during different months (depicted on the x-axis on a non-linear scale). N-values depict the number of chemically confirmed particles at a specific time and lake position.

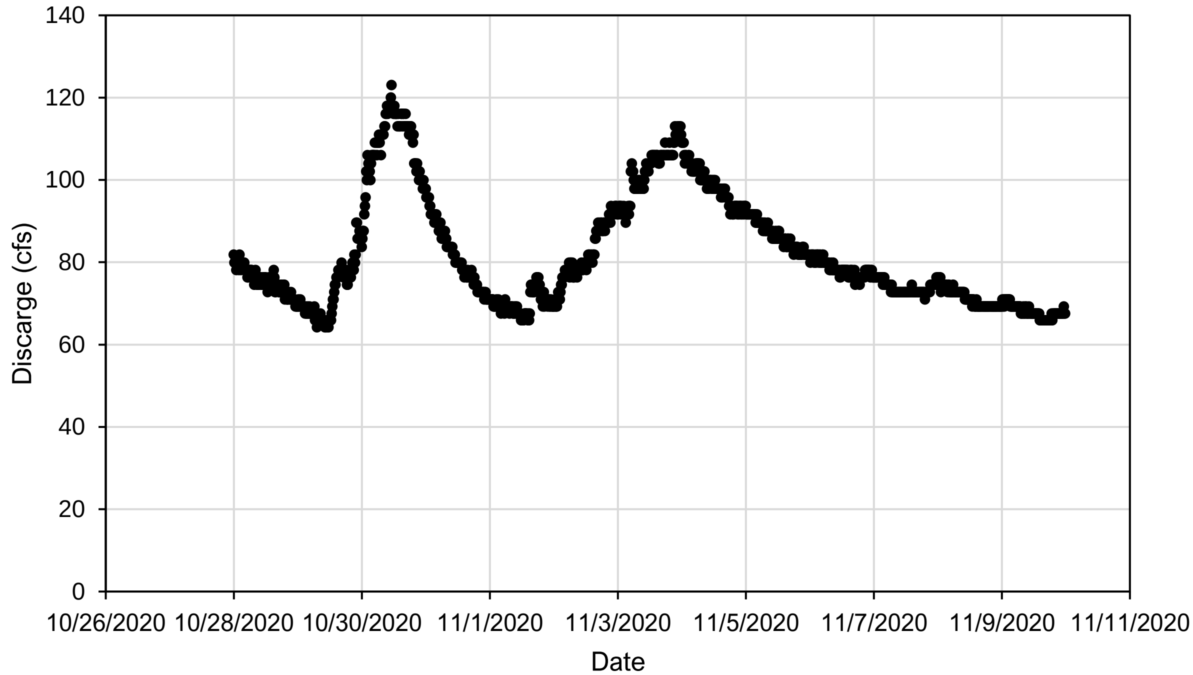


Figure C.3: Discharge at the Spencer Street USGS gauging station prior to and after Fall Lake turnover in 2020 (U.S. Geological Survey, 2021). Note the scale change in relation to Figure C.4.

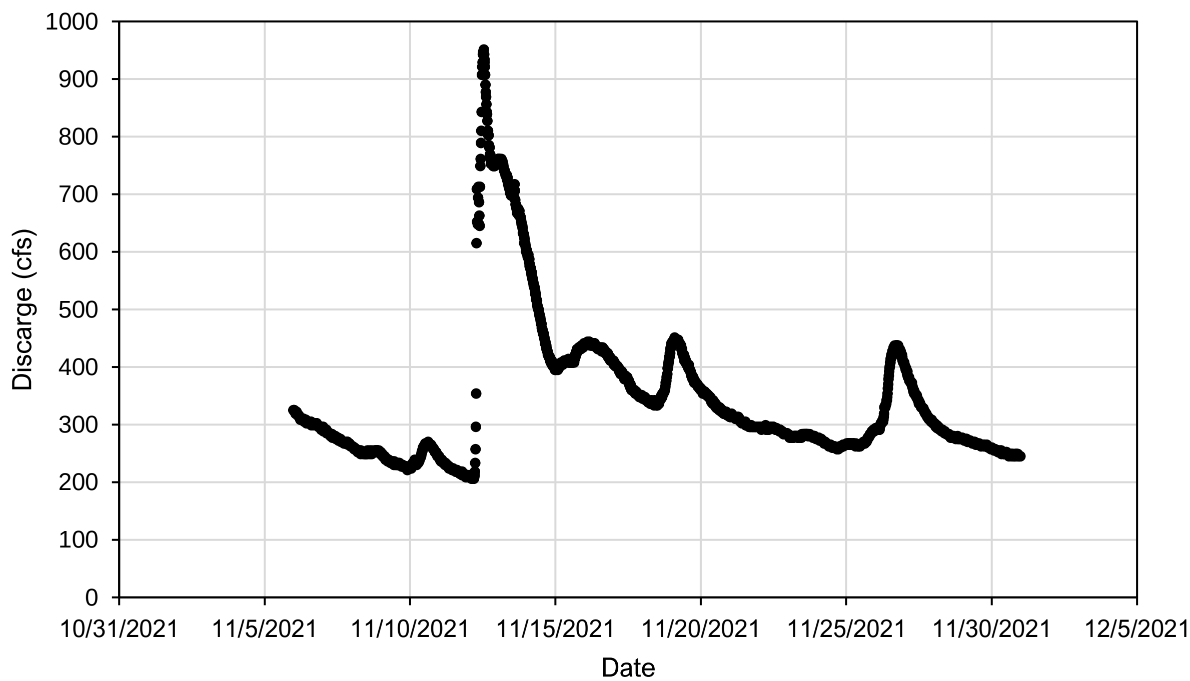
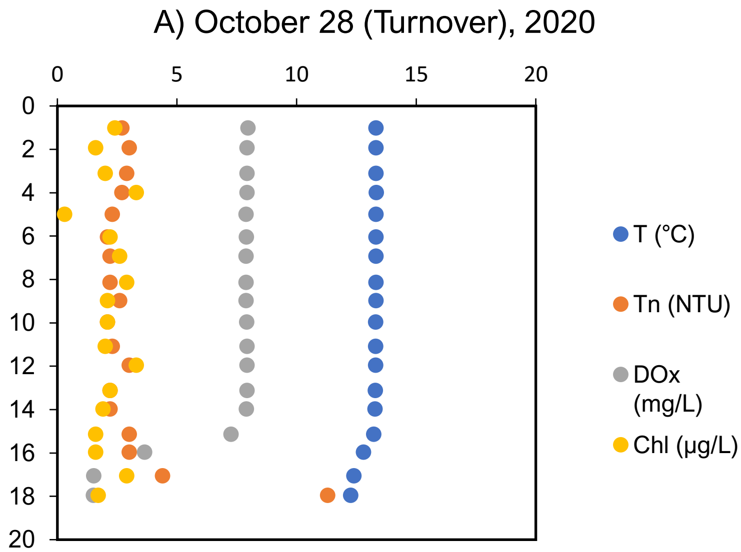
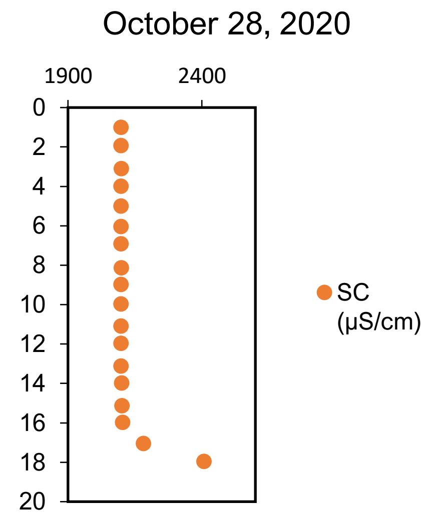
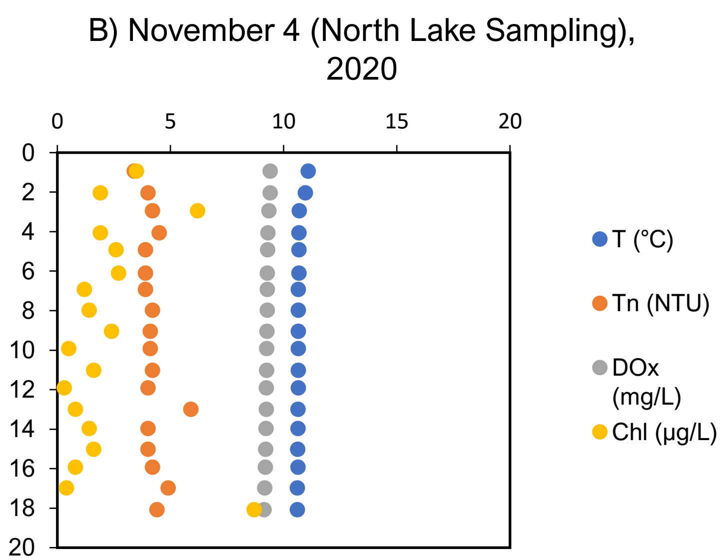
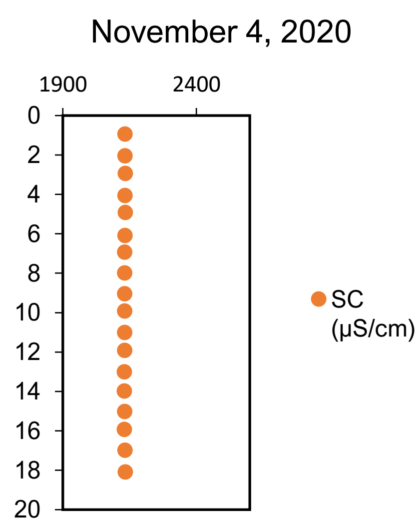


Figure C.4: Discharge at the Spencer Street USGS gauging station prior to and after Fall Lake turnover in 2021 (U.S. Geological Survey, 2021). Note the scale change in relation to Figure C.3.


A) October 28 (Turnover), 2020
0
5
10
15
20
0
2
4
6
8
10
12
14
16
18
20
T (°C)
Tn (NTU)
DOx (mg/L)
Chl (µg/L)


October 28, 2020
1900
2400
0
2
4
6
8
10
12
14
16
18
20
SC (µS/cm)


B) November 4 (North Lake Sampling), 2020
0
5
10
15
20
0
2
4
6
8
10
12
14
16
18
20
T (°C)
Tn (NTU)
DOx (mg/L)
Chl (µg/L)


November 4, 2020
1900
2400
0
2
4
6
8
10
12
14
16
18
20
SC (µS/cm)

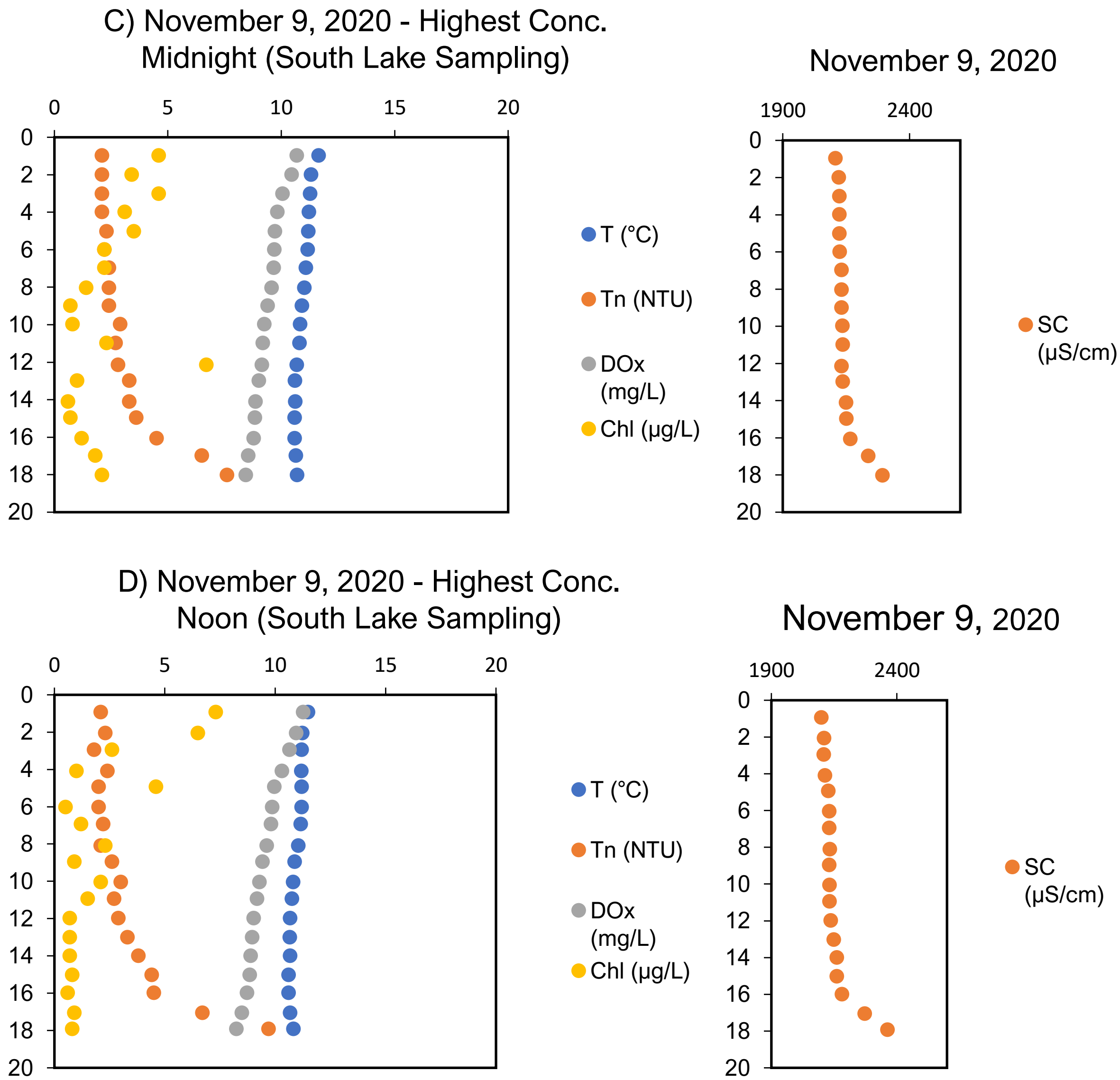
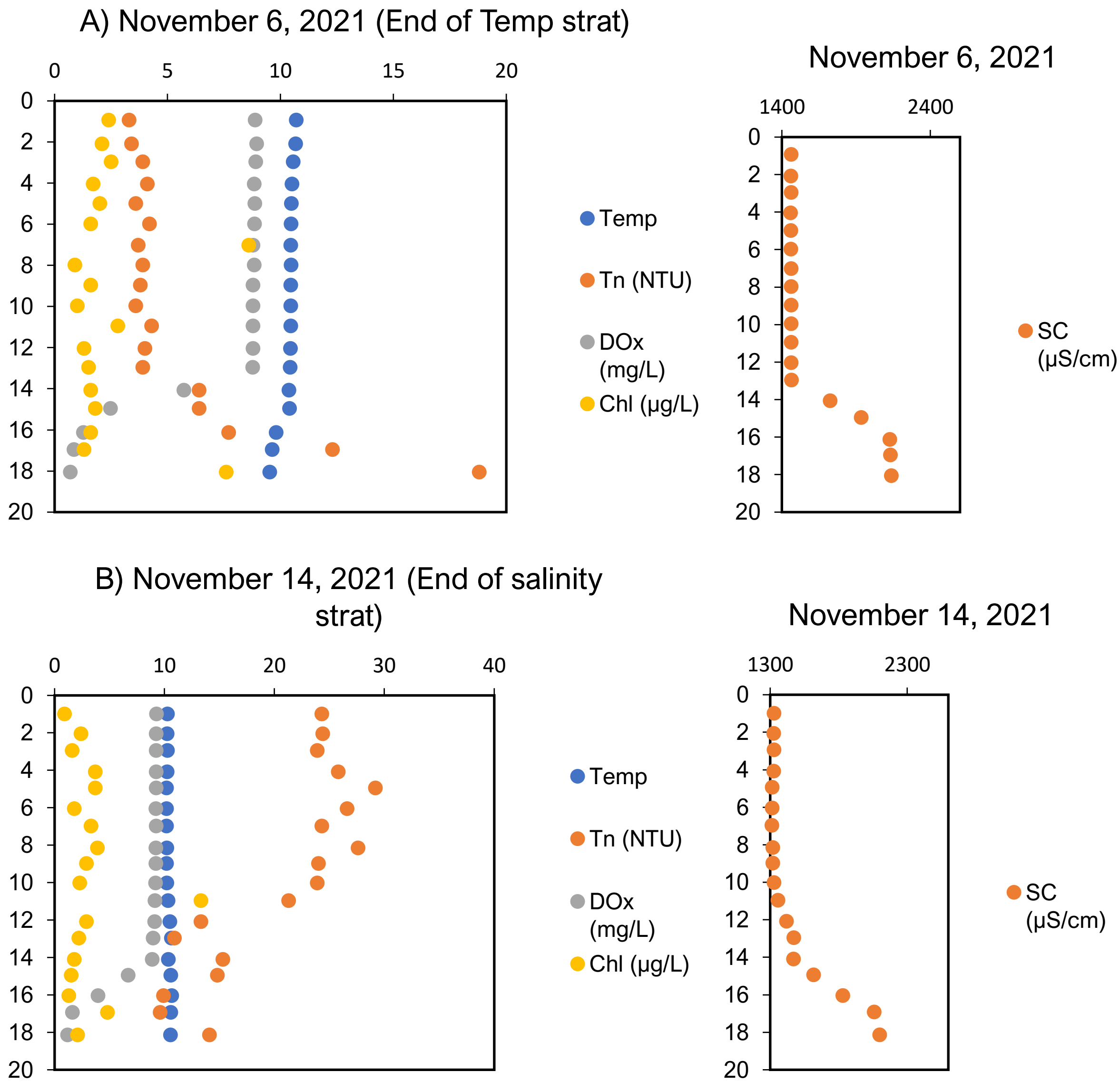


Figure C.5: Onondaga Lake temperature (°C), turbidity (NTU), dissolved oxygen (mg/L), chlorophyll (µg/L), and specific conductance (µS/cm) profiles in South Deep for: A) the day of fall turnover on October 28, 2020, B) the day of northern lake sampling on November 4, 2020, C) midnight on the day of southern lake sampling on November 9, 2020, and D) noon the day of southern lake sampling on November 9, 2020 (Upstate Freshwater Institute, 2023).


A) November 6, 2021 (End of Temp strat)
0 5 10 15 20
0 2 4 6 8 10 12 14 16 18 20
Temp
Tn (NTU)
DOx (mg/L)
Chl (µg/L)
November 6, 2021
1400 2400
SC (µS/cm)
B) November 14, 2021 (End of salinity strat)
0 10 20 30 40
Temp
Tn (NTU)
DOx (mg/L)
Chl (µg/L)
November 14, 2021
1300 2300
SC (µS/cm)

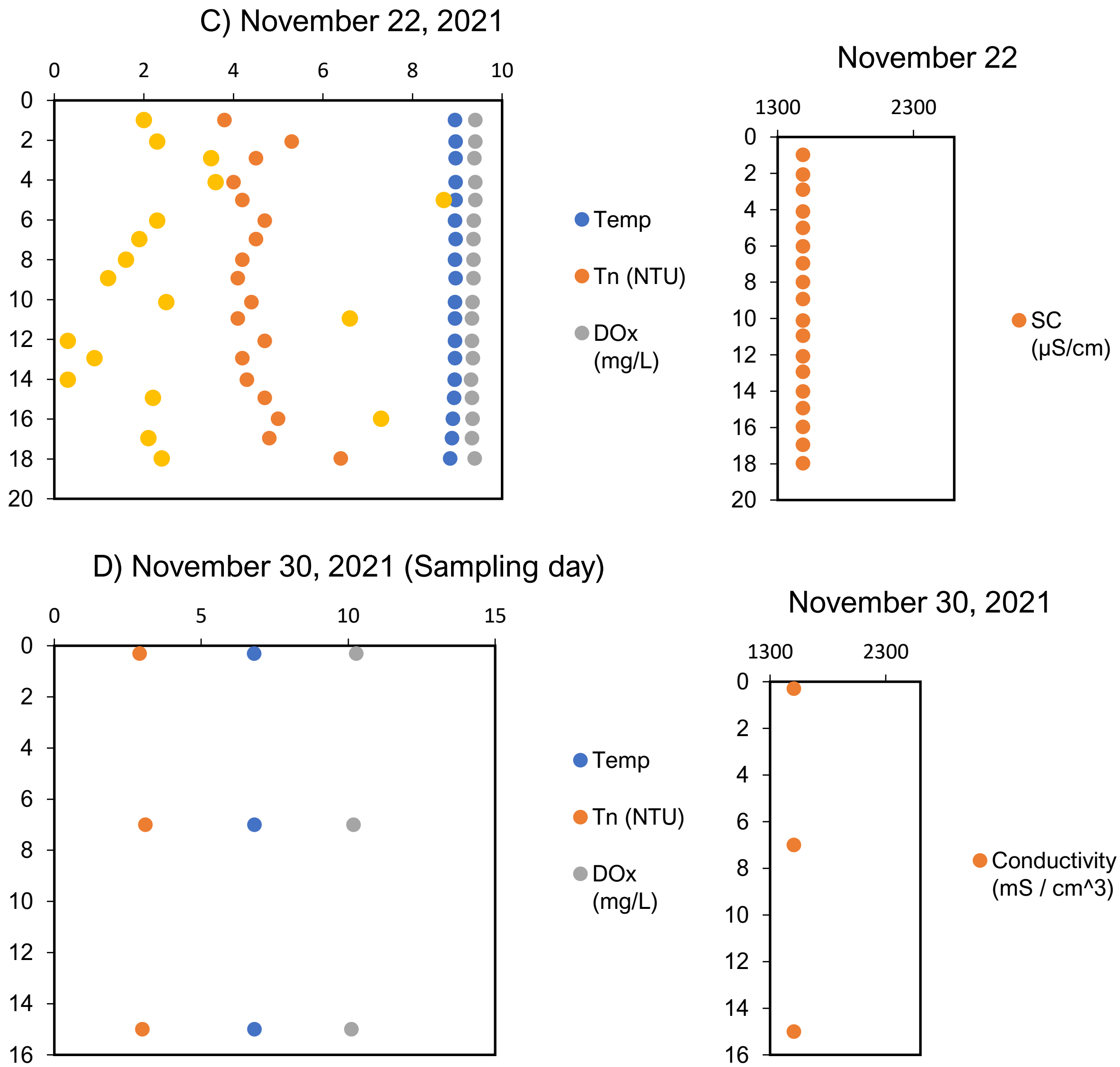


Figure C.6: Onondaga Lake temperature (°C), turbidity (NTU), dissolved oxygen (mg/L), chlorophyll (μg/L), specific conductance (μS/cm), and conductivity (mS/cm3) profiles in South Deep for: A) the end of temperature stratification on November 6, 2021, B) the end of salinity stratification and complete lake turnover on November 14, 2021, C) the last available profile in Fall 2021 on November 22, 2021 (Upstate Freshwater Institute, 2023), and D) the day of sampling on November 30, 2021.

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Vita

Laura Markley

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EDUCATION

Anticipated: May 2023	PhD, Civil and Environmental Engineering EMPOWER NSF Research Trainee *A multi-disciplinary approach to plastic pollution from environmental sampling to global surveying: Quality assurance, freshwater contamination, and popular opinions* Syracuse University – Syracuse, NY
May 2017	M.S., Earth and Environmental Science *Characterization of the Goethite-Hematite ratio in Modern and Ancient Soils in the MidAtlantic Region as a Paleoprecipitation Proxy* Lehigh University – Bethlehem, PA
May 2015	B.S. (Honors), Environmental Earth Science *Arsenic in Groundwater Resources of Lebanon, Connecticut: Geologically Sourced or Anthropomorphic?* Eastern Connecticut State University – Willimantic, CT

PUBLICATIONS & BOOK CHAPTERS (Link to Google Scholar)

2023	T. Walker, B. Baechler, **L. Markley**, M. Grünzner, I. Akuoko, C. Bowyer, C. Menzel, S. Muntaha, A. Macdonald, D. Allen, E. Cowan, PLASTIC PULSE OF THE PUBLIC – A review of survey-based research on how people use plastic *(In Review)*
	L. Markley, M. Grünzner, T. Walker, Uncertainties about waste using a global online survey and review approach: Environmentalist perceptions, waste compositions and views from media and science *(In Review)*
	F.C. Mihai, S. Gündoğdu, F. Khan, **L. Markley**, G. Suaria, “Microplastics in freshwater environments.” Microplastics in the Ecosphere - Air, water, soil and food, edited by Vithanage, M., Prasad, M.N, V., Wiley & Sons, Inc., USA *(Expected: Early 2023)*
2022	F.C. Mihai, S. Gündoğdu, F. Khan, A. Olivelli, **L. Markley**, T. Emmerik, January 2022, “Plastic pollution in marine and freshwater

environments: abundances, sources, and mitigation.” Emerging Contaminants in the Environment: Challenges and Sustainable Practices, edited by Sarma, H., Dominguez, D., and Lee, W., Elsevier, USA (Link)

2021 F.C. Mihai, S. Gündoğdu, **L. Markley**, A. Olivelli, F. Khan, C. Gwinnet, J. Guterbelet, N. Reyna-Bensusan, Markley, P. Llanquileo Melgarejo, C. Meidiana, S. Elagroudy, V. Ishchenko, S. Penney, Z. Lenkiewicz, M. Molinos-Senante, December 2021, Plastic pollution, waste management issues and circular economy opportunities in rural communities, Sustainability (Link)

GRANTS

Sept 2021 – Aug 2022 **Exploring the Sources, Fate, and Processing of Microplastics in Seasonally Stratified Lakes**
Principal Investigators: Charles Driscoll, Laura Markley, Christopher Junium, Melissa Chipman, Syracuse University
New York State Water Resources Institute at Cornell University
Awarded: $14,500

June 2019 – Dec 2020 **Microplastic pollution in Onondaga and Skaneateles lakes in central New York**
Principal Investigators: Charles Driscoll, Laura Markley, Syracuse University
New York State Water Resources Institute at Cornell University
Awarded: $9,853

Oct 2018 – Oct 2019 **Investigating the Influence of UV and Temperature on the Leaching of Estrogenic Compounds from Polyethylene Terephthalate (PET) Plastic Water Bottles using Bioanalytical and Chemical Analyses**
Education Model Program on Water-Energy Research (EMPOWER): The National Science Foundation (NSF NRT) Graduate Research Traineeship Program at SU
Awarded: $2,100

FIELD & LAB EXPERIENCE

Field:

Microplastics:
Surface and depth water sample collection, including volume reduced (bucket, pump, and net) and bulk (grab) sampling techniques

Water Quality:
Surface and groundwater sampling
Flow characterization and discharge transects in streams and small rivers

Operation and deployment of an EXO1 Water Quality Sonde
Alkalinity, turbidity, pH, and color measurements

Soil Characterization:
Pit digging and clearing for sample collection, including oriented samples for paleomagnetic analyses
Pit description, such as color and horizon characterization

Lab:

Microplastics:
Water sample preparation, including sieving, wet peroxide oxidation (WPO), and vacuum filtration
QA/QC protocols and method detection limit development for a microplastics lab
Visual sample description and counting using a stereomicroscope and Hirox digital microscope
Polymer characterization using ATR-FTIR and Raman spectroscopy
Freeze-milling of plastics in preparation for spike and recovery testing

Soil Characterization:
Soil size characterization (particle size distribution analysis)
Chemical (bulk elemental analysis, iron oxide crystallinity analysis) characterization

Cell Culture:
Aseptic technique and growing and counting of cells, including fibroblast and MCF-7 cells

COMPUTER SKILLS

Highly proficient – Microsoft Office Suite, Adobe Suite, Blackboard Learn, Zoom, Kahoot, Graphic Design
Proficient – WordPress, ArcGIS, R Studio

AWARDS AND RECOGNITIONS

2022	Wen-Hsiung and Kuan-Ming Li Graduate Fellowship
2016	Best Poster Award, Earth and Environmental Science Graduate Symposium
2015	Outstanding Student Award in Chemistry and Physics
2011 – 2015	Academic Excellence Award in Environmental Earth Science
2011 – 2015	Dean's List Honors
2014	GSA / ExxonMobil Bighorn Basin Field Award
2014	People's Choice Award: Poster, Northeast Arc Users Group Conference
2013 – 2014	Environmental Club President
2012 – 2013	Chemistry Achievement Award

EXPERIENCE

January 2023 – Current **Part-Time Student Employee**

Syracuse Center for Sustainable Community Solutions and

Environmental Finance

Center – Syracuse, NY

- Manage, update, and perform data analysis database for a comprehensive New York State local recycling program database.
- Research the flow of materials to material recycling facilities (MRFs) and the differences in recycling material acceptance between New York State counties.

Aug 2017 – Current **EMPOWER NSF NRT and SU Graduate Fellow**

Syracuse University – Syracuse, NY

- Manage, budget, and apply for grant funding for research focused on microplastics in freshwater
- Research and write lab protocols to collect, analyze, and enumerate microplastic in freshwater samples
- Train and mentor undergraduate students
- Facilitate collaborations across disciplines to address methodological challenges in microplastic science

Aug 2021 – May 2022 **Graduate Teaching Assistant**

Syracuse University – Syracuse, NY

- Graded semi-weekly homework assignments and provide extra help for students for CEE 274: Sustainability in Civil and Environmental Systems
- Organized and distributed class materials through Blackboard, graded weekly lab reports and provided written feedback for CEE 327: Fluid Mechanics

Dec 2018 – May 2019 **Sustainable Materials Management Steward**

Syracuse University's Center for Sustainable Community Solutions / Environmental Finance Center – Syracuse, NY

- Received training on the fundamentals of sustainable materials management, including food waste, single-use plastics, recycling, and the circular economy
- Organized 2 clean-ups in the Syracuse area, one in Westcott and the other in Downtown Syracuse. Participants cleaned up a total of 45 bags of trash
- Hosted a Waste Reduction Workshop at the Cazenovia Public Library focused on plastic pollution and waste reduction and a Waste Reduction Info table at Athleta in Destiny USA on the 5 R's of Waste Reduction

June 2017 – Aug 2017 **Field Course Teaching Assistant**

Syracuse University – Syracuse, NY

- Prepared materials and equipment for a summer domestic field course in central New York and the Hubbard Brook Experimental Forest through the EMPOWER program

- Performed preliminary measurements and set-up for experiments, including: the use of multiple methods for determining stream velocity, a DOC stream addition using coffee, and the use and deployment of a CRT sensor for lake profiles

Aug 2016 – May 2017 **Graduate Teaching Assistant**
Lehigh University – Bethlehem, PA
- Independently taught students on varying lab topics for every 3-hour weekly lab session for EES/CEE 316: Hydrogeology
- Assisted in set-up and execution of labs for EES 376: Geochemistry of Natural Waters
- Graded semi-weekly lab reports and provided extensive feedback

Aug 2015 – Aug 2016 **Lehigh School of Arts and Sciences Fellow**
Lehigh University – Bethlehem, PA
- Characterized the size and geochemistry of various soil profiles via particle size distribution analysis (PSDA), bulk elemental analysis, and iron oxide crystallinity analysis
- Developed a novel method for the characterization of the Goethite-Hematite (G/H) ratio using paleomagnetic techniques

May 2015 – Aug 2015 **GeoCorps Water Quality / Hydrogeology Resource Assistant**
U.S. Forest Service – Campton, NH
- Statistically and spatially analyzed water quality data collected since 2006 from an abandoned mine site that had undergone two CERCLA removal actions by the Forest Service to determine trends in water quality and removal action effectiveness
- Assisted in data collection with the Eco Team, including deployment of CRT monitors in streams, collection, and analysis of water samples near camping sites for E. Coli monitoring, and electro-fishing for characterization of fish species

Sept 2015 – May 2015 **Subject Tutor**
Eastern Connecticut State University – Willimantic, CT
- Provided supplementary instruction in the subjects of Hydrology and two sections of Physics (with and without calculus)
- Supplementary instruction was performed in a group setting, with 2 instruction sessions per subject, each session lasting 1.5 hours

May 2014 – May 2015 **Honors Undergraduate Research Assistant**
Eastern Connecticut State University – Willimantic, CT

- Scanned and organized over 2,000 well completion reports and water quality reports from the Lebanon, CT town hall to obtain data on groundwater hydrology
- Collected 100 water samples in accordance with state guidelines to be analyzed by a certified laboratory at the Department of Public Health
- Used ArcGIS to create maps of the groundwater surface and various water quality parameters to determine potential sources of arsenic

July 2013 – Aug 2013 **Sedimentary Research Assistant**
Drzewiecki Stratigraphy, LLC – Storrs, CT
- Spent 5 weeks in multiple field locations in Spain to collect material for the creation of a field guide for Statoil
- Measured stratigraphic sections, described rock types, and analyzed structural changes in rock formation
- Funded by Statoil ASA (Norwegian Oil company) and Drzewiecki Stratigraphy LLC

Aug 2012 **Sedimentary Research Assistant**
Eastern Connecticut State University – Willimantic, CT
- Assisted in using X-Ray Fluorescence (XRF) spectrometer and gamma ray spectrometer over a two-week period to measure trace elements in rock cores for the purpose of correlation of ancient lake beds in Connecticut

June 2012 **GPR, Vibracore, Laser Scanning, and Total Station Assistant**
Eastern Connecticut State University – Willimantic, CT
- Collected data using ground penetrating radar (GPR), vibracoring, laser scanning, and surveying at various outdoor locations over a two-week period

SCIENCE COMMUNICATION

Jan 2021 – Current **Plastic and Waste Journal Club**
- Host and organize a monthly journal club on topics related to waste and plastic pollution with over 300 members from various sectors, universities, and countries
- Facilitate online discussions focused on scientific gaps in current literature and potential avenues for future research and/or collaboration

May 2018 – Aug 2021 **Waste-Free PhD**
@wastefreephd | wastefreephd.com
- Wrote and created blog and social media content addressing scientific misinformation and minimal waste living
- Addressed questions from the public and provided research-based summaries on scientific topics ranging from circular economy approaches to plastic pollution impacts

March 2019 – Feb 2021 **Graphic Designer and Sustainability Expert**
Fetagetaboutit Plant-Based, Minimal-Waste Cookbook

- Served as the sole graphic designer for a 174-page cookbook project funded entirely through a successful $5,500 Kickstarter campaign
- Provided evidence-backed minimal-waste tips for reducing plastic usage and food waste in the kitchen and advised team on additional waste efforts, such as secondhand sourcing of photography props
- Conducted a waste audit of a Pop-Up Event and produced a report for attendees displaying composted, incinerated, and recycled waste produced in the kitchen

TECHNICAL PRESENTATIONS

Sept 2022 **L. Markley**, M. Grünzner, T. Walker, *Uncertainties about waste using a global online survey and review approach: Environmentalist perceptions, waste compositions and views from media and science.* Platform Presentation: 7th International Marine Debris Conference, September 2022. Busan, Republic of Korea.

Sept 2022 **L. Markley**, C. Driscoll, N. Mark, M. Montesdeoca. *Improving the capture and monitoring of microplastics in freshwater ecosystems: A case study in surface waters of Onondaga Lake in Syracuse, New York.* Poster Presentation: 7th International Marine Debris Conference, September 2022. Busan, Republic of Korea.

Dec 2021 N. Mark., **L. Markley**, C.T. Driscoll, Civil and Environmental Engineering, Syracuse University. *Microplastics in a Historically Polluted, Urbanized Lake: Trends and Source Attribution using Morphological Characterization.* Virtual Poster Presentation: AGU Fall Meeting 2021, Hybrid

Nov 2021 **L. Markley**, C.T. Driscoll, A. Costello Staniec, Civil and Environmental Engineering, Syracuse University. *Seasonal Variation in Microplastic Form and Concentration Between a Historically Polluted and Relatively Pristine Lake.* Online Platform Presentation and Live Lightning Talk: SETAC North America 2021, Virtual

Nov 2020 **L. Markley**, C. T. Driscoll, Civil and Environmental Engineering, Syracuse University. *Goldilocks and the Three Surface Water Sampling Methods.* Platform Presentation: MICRO2020 International Conference, Virtual

Nov 2020 **L. Markley**, C.T. Driscoll, A. Costello Staniec, E. Huth, Syracuse University. *Distribution and Potential Sources of Freshwater Microplastics in Onondaga and Skaneateles Lakes.* Platform Presentation: Society of Environmental Toxicology and Chemistry (SETAC) North America, Virtual

Nov 2019 **L. Markley**, C.T. Driscoll, Civil and Environmental Engineering, Syracuse University. *To Drink or Not to Drink? Estrogenic Activity of PET Bottled Water Under Various Storage Conditions*. Poster Presentation: Society of Environmental Toxicology and Chemistry (SETAC) North America, Toronto

Nov 2018 **L. Markley**, Civil Engineering, Syracuse University. *Plastics Pollution, Impacts, and Prevention*. Oral Presentation: NYSAR 29th Annual NYS Recycling Conference. Cooperstown, NY

Dec 2017 **L. Markley**, S.C. Peters, F.J. Pazzaglia, K.P. Kodama, Earth and Environmental Sciences, Lehigh University. *Characterization of the Goethite-Hematite ratio in Modern and Ancient Soils in the mid-Atlantic Region as a Paleoprecipitation Proxy.* Poster Presentation: AGU Fall Meeting. New Orleans, Louisiana

March 2017 **L. Markley**, S.C. Peters, F.J. Pazzaglia, Earth and Environmental Sciences, Lehigh University. *Characterization of the goethite/hematite ratio in modern and ancient soils in Pennsylvania as a Paleoclimatic Indicator*. Poster Presentation: Joint 52nd Northeastern Annual Section / 51st North-Central Annual Section Geological Society of America Meeting – 2017. Pittsburgh, Pennsylvania

April 2015 **L. Markley**, M. Metcalf, Environmental Earth Science, Eastern Connecticut State University. *Evaluating Geologic or Anthropogenic Influences on Arsenic Contamination in Groundwater*. Oral Presentation: CREATE Conference. April 2015. Eastern Connecticut State University, Willimantic, CT

March 2015 **L. Markley**, M. Metcalf, Environmental Earth Science, Eastern Connecticut State University*. Evaluating Source of Arsenic in Groundwater Resources of Lebanon, Connecticut*. Poster Presentation: Northeast Geological Society of America Conference. Bretton Woods, NH

Nov 2014 **L. Markley**, M. Metcalf, Environmental Earth Science, Eastern Connecticut State University*. Developing an Understanding of the Spatial Distribution of Arsenic in Groundwater*. Oral Presentation: Council of Public Liberal Arts Colleges, Northeast Regional Undergraduate Research, Scholarly and Creative Activity Conference. Keene State College, NH

Oct 2014 **L. Markley**, M. Metcalf, Environmental Earth Science, Eastern Connecticut State University*. Investigating the Arsenic Mystery in Groundwater Resources of Lebanon, Connecticut*. Poster Presentation: Northeast Arc Users Group Conference. October 2014. Mystic Marriot, Groton, CT

March 2014 **L. Markley**, P. Drzewiecki, J. Olandt, Environmental Earth Science, Eastern Connecticut State University*. Sea Level and Tectonic Controls on the Development of the Santonian Collades de Basturs Carbonate Platform, South-Central Pyrenees, Spain*. Poster Presentation: Northeast Geological Society of America Conference. Lancaster, PA

April 2013 **L. Markley**, T. Bugden, M. Maher, J. Hyatt, Environmental Earth Science, Eastern Connecticut State University*. Analyzing Subsurface Geologic Conditions in Eastern Connecticut State University's Arboretum Using Vibracoring*. Poster Presentation: Arts & Sciences Research Conference and Exhibition. Eastern Connecticut State University, Willimantic, CT

PROFESSIONAL ACTIVITIES

Development & Workshops:

June 2021 Online Workshop on Microplastic Research – ETH Zürich, National and Kapodistrian University of Athens, University of Gothenberg, Hof University

Mar 2021 – April 2021 SETAC Microplastics in Humans and the Environment Seminar Series

Oct 2020 – Nov 2020 Microplastics Health Effects Workshop – SCCWRP

Nov 2019 Microplastics: Gotta Catch Them All! QA/QC Best Management Practices for Robust Microplastic Method Development, Workshop, SETAC Toronto

Feb 2019 Alan Alda Center for Communicating Science Workshop

Sept 2018 – June 2019 Women in Science and Engineering Future Professionals Program (WiSE-FPP)

Memberships:

February 2019 – Present Society of Toxicology (SOT)
January 2019 – Present SETAC – Hudson-Delaware Chapter
November 2018 – Present Society of Environmental Toxicology and Chemistry (SETAC)

Conference Sessions:

Nov 2021 Microplastics Research Priorities: Detection, Analysis, and Effects. Session Co-Chair. S. Athey, L. Markley, M. Seeley, SETAC North America 42nd Annual Meeting.

INVITED TALKS

Oct 2022 PNW Consortium Interest Group / Journal Club. Virtual, Presenter.
Feb 2021 Plastic Waste Reduction Summit. Atlantic Health Oceans Initiative. Virtual, Panelist.
Nov 2020 Sustainability Beauty Science Panel. The Eco Well. Virtual, Panelist.
July 2020 Virtual Bio-Art Mixer. Syracuse University. Virtual, Presenter and Panelist.
Feb 2020 Green Beauty Night. The Eco Well. Los Angeles, CA. Panelist.

GUEST LECTURES AND COMMUNITY ENGAGEMENT

Sept 2022 — *The Plastic Problem.* Guest Lecture, Intro to Environmental Engineering, Syracuse University

July 2021 — *Social Media and Science.* Oral Presentation: Summer REU Student Program, Syracuse University

June 2021 — *How to write an abstract.* Oral Presentation: Summer REU Student Program, Syracuse University

Oct 2020 — *The Plastic Age*. Guest Lecture, Water Science, Syracuse University School of Arts and Sciences

Oct 2019 — *The Plastic Age*. Guest Lecture, Environmental Sociology, October 2019, Syracuse University Maxwell School of Citizenship and Public Affairs

July 2019 — *Kick Waste to the Curb*. Workshop, Tully Free Library

April 2019 — The 5 R's of Waste Reduction, Info Table, Earth Day Event, Athleta at Destiny USA, Syracuse

April 2019 — Waste Not: A Deep Dive into Waste Reduction, First Steps, and the Science Behind It. Cazenovia Public Library

April 2019 — Co-Organizer: Clean-Up Downtown with Recess Coffee, Happy, Probably, and Waste-Free PhD. Recess Coffee at Montgomery Street

April 2019 — Chemicals in Everyday Products: The Good, the Bad, and the Ugly. Salt City Coffee

March 2019 — Co-Organizer: Clean-Up Westcott with Recess Coffee, Happy, Probably, and Waste-Free PhD. Recess Coffee at Harvard Place

Jan 2019 — *Our Plastic Planet: Plastics Pollution, Impacts, and Prevention.* Oral Presentation: Central New York Model United Nations Conference (CNYMUN), Syracuse University

Oct 2018 — *Our Plastic Planet: A Scientific and Individual Responsibility.* Oral Presentation: Environmental Seminar, Syracuse University

July 2018 — *How to Review Scientific Papers.* Oral Presentation: Summer REU Student Program, July 2018, Syracuse University

MEDIA APPEARANCES

April 2021 — "Talking Trash with Laura Markley, Waste and Plastics Researcher in the College of Engineering and Computer Science," Syracuse University News, Jen Maser

Aug 2019 — "Episode 4: Estrogen-mimicking chemicals and microplastics," Endocrine Disruptors Podcast

July 2019 “Interview with Laura Markley about plastic waste in personal care,” The Eco Well Podcast

April 2019 “Eliminating Plastics,” News Channel 9 Syracuse

April 2019 “Interview with Laura Markley,” The Leveraged PhD

April 2019 “What’s Being Done to Pick Up Trash in the City? Your Stories,” News Channel 9 Syracuse