LEVERAGING WPI PROJECT CENTERS FOR COLLABORATIVE MICROPLASTICS RESEARCH

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Leveraging WPI Project Centers for Collaborative Microplastics Research

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by
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Report Submitted to:

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ABSTRACT

Our project gauged WPI Project Center Directors' interest in collaborative research through a microplastics pilot. We conducted interviews and surveys of Project Center Directors, which revealed the discrepancy between the desire for collaborative research at WPI and its current state, as well as the barriers causing it. We also interviewed an Icelandic microplastics expert and developed and tested a microplastics sampling kit as a pilot collaborative research project. Lastly, to engage Project Center Directors in collaborative research, we created a website that showcases student microplastics research projects.

EXECUTIVE SUMMARY

BACKGROUND

Microplastics, or pieces of plastic less than five-millimeters in length, make up 92% of total plastic in the oceans. They are one of the most common pollutants affecting every corner of the globe (EPA, n.d.). More than one-third of microplastics in the ocean come from microfibers in the wastewater discharge of washing machines (Wood, 2019). The other two most common types of microplastics in the ocean are microbeads and shards (Figure 1: Booth, 2017; Tse, 2015; Romaguera, 2019). Shards are plastics that enter the ocean as larger pieces and degrade into microplastics. Microplastic shards occurring from the deterioration of car tires account for 28% of the microplastic in our ocean (Wood, 2019). Lastly, microbeads are small pieces of plastic added to washable cosmetic products such as soap, shampoo, and toothpaste (Hersher, 2020).

According to The Lancet, a UK medical publication, 84% of global drinking water samples contained microplastics (The Lancet Planetary Health, 2017). This study is concerning because microplastics are incredibly adhesive towards toxic chemicals, which are then passed to humans after ingestion. Humans exposed to these toxic chemicals have been shown to have organ damage (Wayman, C., & Niemann, H. 2021).

In order to track the problem of microplastics on a global scale, researchers have employed several methodologies that vary in complexity, cost, effectiveness, and the type of microplastics they detect. The three most common sampling methodologies are the sand method, the water method, and the trawl method. In utilizing the sand method, sand is taken from the surface of the beach and inspected visually for microplastics. The water method uses a large container to collect water from the ocean and pass it through a fine-mesh, typically around 100-micrometers to strain out

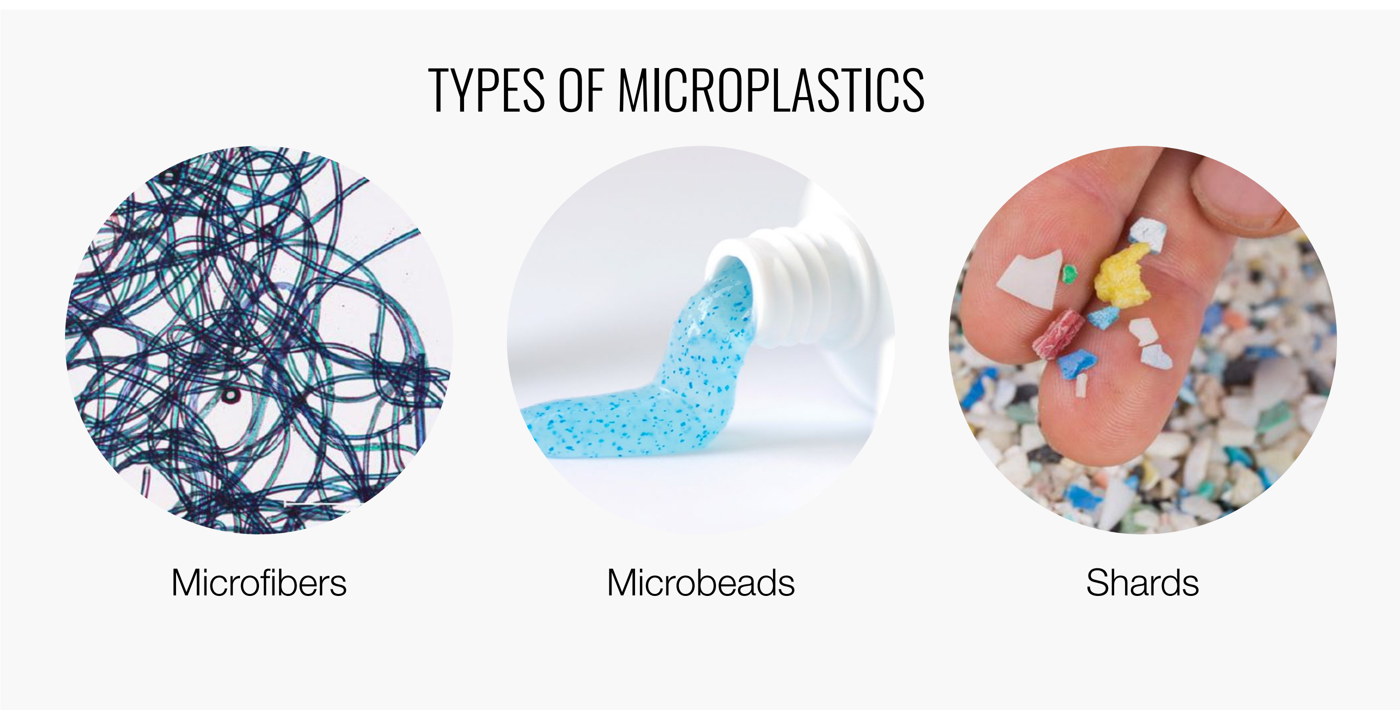

Figure 1: Types of microplastics (Booth, 2017; Tse, 2015; Romaguera, 2019)

any particulate matter (Green et. al., 2018). Lastly, the trawl method utilizes a specialized net dragged through the water behind a boat to collect microplastics.

After collecting samples using a collection methodology, the samples must be analyzed for microplastics. Before analysis, the samples must be chemically treated to ensure that there is no biological contamination or sand present. The simplest form of analysis is

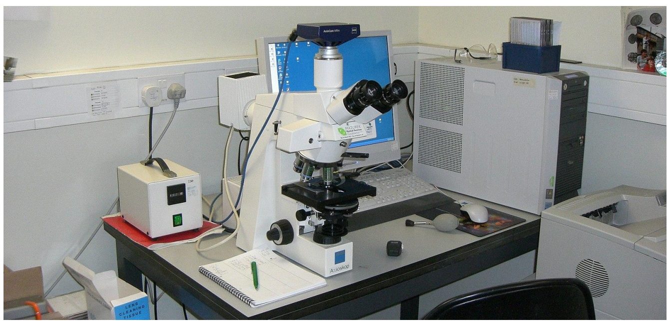

Figure 2: Microscope (Wheeler, 2007)

visual inspection of the sample using a microscope (Figure 2: Shim et al., 2017; Nakajima et al., 2019). However, there are also many other methods of analysis that provide much higher accuracy and reliability of data, such as Fourier transform infrared spectroscopy, which provides the type of plastic present (Shim et al., 2017).

Despite the existence of microplastic monitoring programs on local, regional, and international scales, the data they gather is often incomparable. This is due to the variety of both collection and analysis techniques available (Green et. al., 2018). In order to bring together these efforts, a coordinated data collection program utilizing citizen science is necessary. Citizen science is the participation of civilians in the scientific process to collect, categorize, transcribe, or analyze large amounts of data (Bonney et al., 2014). By utilizing individuals who are already at or willing to go to specific locations to collect data, the public can simultaneously conduct research. This utilization of individuals at unique locations is beneficial for ocean microplastics tracking as samples need to be collected from beaches and waterfronts around the world.

The Global Projects Program (GPP) at WPI provides a mechanism for microplastic data collection worldwide. The GPP sends WPI students to over 50 project centers across 37 countries to complete an Interactive Qualifying Project (IQP) as a graduation requirement (Worcester Polytechnic Institute, n.d). This means that WPI students travel to these 37 countries continuously throughout the year. Traditionally, IQPs address topics identified by a local sponsor organization in the community. This means that projects usually have a local focus geographically. In recent years, some IQPs have shifted focus to promoting global collaboration in addition to supporting local community sponsors. This global collaboration is essential for ensuring the longevity of our project, as data must be collected over a prolonged period of time.

PROJECT OBJECTIVES & METHODS

The goal of our project was to gauge WPI Project Center Directors' interest in collaborative research through a microplastics pilot.

OBJECTIVES

1. Evaluate the feasibility of connected research at WPI's project centers
2. Learn how to engage Project Center Directors in connected research
3. Establish a microplastics sampling methodology
4. Develop an exhibit for WPI's microplastic IQPs

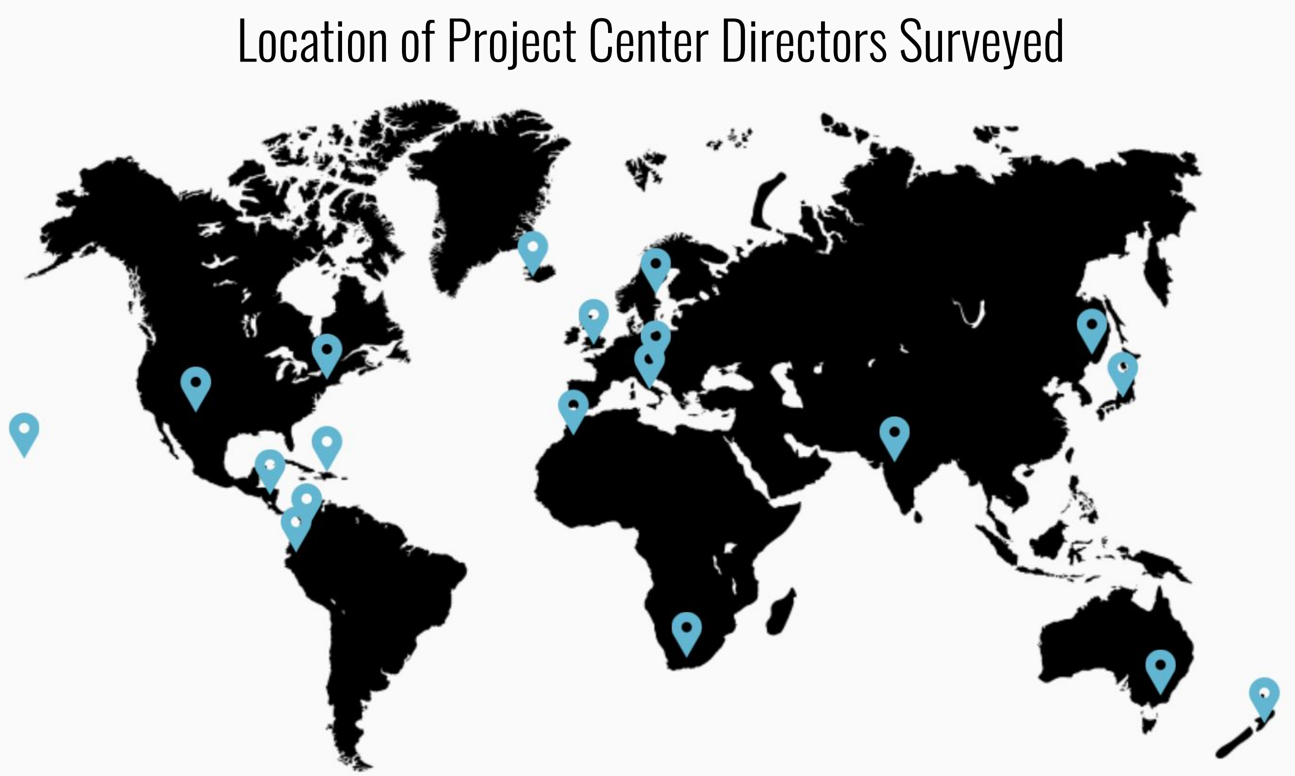

Figure 3: Locations of Project Center Directors surveyed

To gauge general perspectives on collaborative research in WPI's Global Project Program, we surveyed Project Center Directors. The survey questions were divided into two groups: the respondents' perspectives on collaborative research in general, and the respondents' interest in a collaborative microplastics project. We sent the survey to 55 Project Center Directors by email. Of those 55, we received 19 responses. As some respondents direct multiple centers, these 19 responses represent 22 of 57 unique project centers (Figure 3).

To understand the perspectives of Project Center Directors in depth, we conducted eight interviews. We conducted these interviews in a semi-structured manner to probe deeper into topics that each particular interviewee was interested in. We also interviewed Valtýr Sigurðsson, a biologist and researcher for BioPol (Skagaströnd, Iceland), a biotechnology company that leads Iceland's microplastics research. In this interview, we asked questions about the history of his research, the effects microplastics have on Iceland, and the methodologies used in his research.

We conducted field testing to evaluate our microplastics sampling kit. Our prototype kit consisted of a 12-inch diameter, 100-micrometer stainless steel mesh, a 235-millimeter funnel, and a five-liter bucket. We filled the bucket with water 15 feet from the shore and poured the water through the mesh and funnel. Repeating this process ten times to obtain a 50-liter sample ensures that enough water is tested to provide accurate data.

Finally, to promote future collaborative research, we designed a website that stories student-conducted microplastics research. This site will be hosted on the Global Lab website to ensure it is easily accessible to the WPI Project Center Directors. We worked with Global Lab Co-Director Professor Leslie Dodson and Global Lab Production Manager Jeremiah Valero who agreed to create and host the webpage from our fully developed design. The website is the culmination of our project and hosts information about microplastics, as well as summaries of student conducted microplastics projects.

RESULTS

We found that limited amount of undergraduate, project center-based collaborative research is currently conducted at WPI. Out of the 19 Project Center Directors surveyed, 14 responded that they seldom or never participated in collaborative research across multiple centers. In our survey the

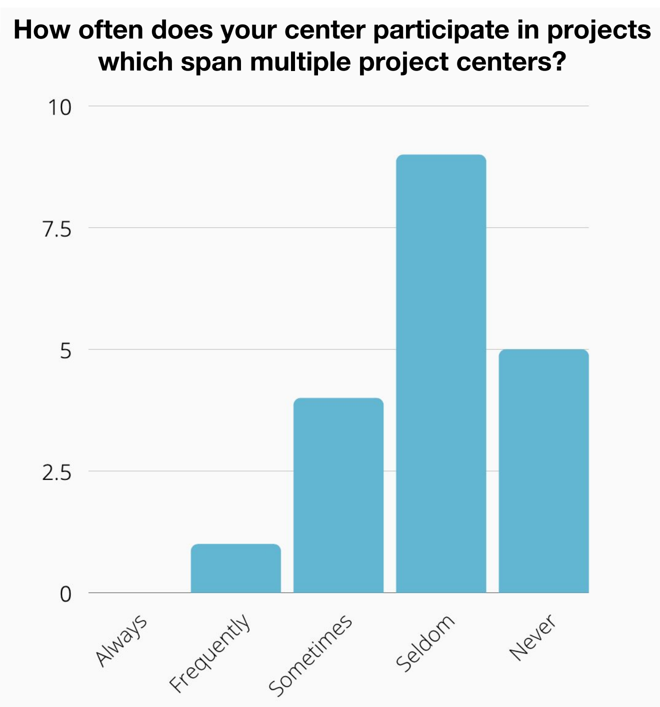

Figure 4: Survey question responses

Project Center Directors identified three main barriers for collaborative research IQPs: organizational challenges, time constraints, and communication challenges. Five Project Center Directors listed all three as important barriers, and 16 listed at least one of the three as a barrier to collaborative research.

Despite this, all the Project Center Directors surveyed indicated that they would like to participate in more collaborative research.

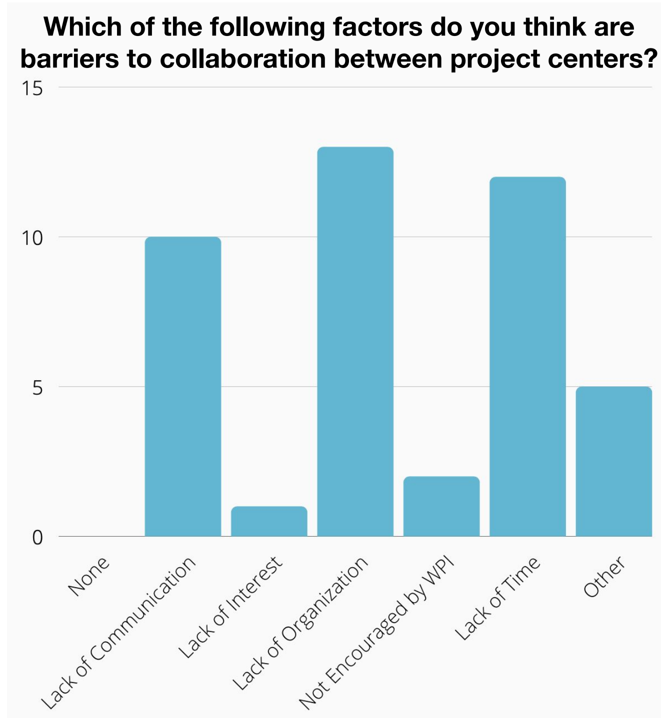

Figure 5: Further survey question responses

In follow-up interviews with the Project Center Directors, many were able to elaborate on the barriers to collaboration and show that the barriers are not always what they initially appear. Professor DiMassa explained that communication and time as barriers might actually mean that two project centers running in different terms might not have the time or ability to communicate because they are just not active at the same time. Professor Shockey also provided further insight into what a lack of organization as a barrier might mean to Project Center Directors. She stated that in her past collaborative research projects, the initial project description was very open ended. This meant the final deliverable of each project varied significantly enough to make comparison of them difficult. In total, the interviews were an excellent way to learn more about how Project Center Directors perceived problems and how the solutions and sometimes the problems themselves may not seem intuitive.

Lastly we asked in the interviews about the Project Center Director's willingness to travel with use and store a microplastic testing kit. All eight of the Project Center Directors we interviewed responded that they would be willing to take a kit with them to their project center. After travelling to Iceland, we were able to test the time and cost effectiveness of our kit at Nauthólsvík Geothermal Beach. It took us 14 minutes to test a 50 liter sample of water. While at the beach, we also filmed and took pictures of the process to develop instructional material.

RECOMMENDATIONS

In order to ensure that measures are taken in the future to continue the lasting impact of this project, we propose a set of recommendations for Project Center Directors and student clubs. Firstly, We suggest that future IQPs and Major Qualifying Projects (MQP) continue our research on microplastic sampling methods. The methods used in sampling can always be improved to be more precise, reliable, inexpensive, or more in depth. Improving upon our procedure for optimal sampling conditions can also improve the ease or reliability of the data collected and is another important aspect that future projects should focus on.

Next, a future team of MQP students could create a project dedicated to the testing and characterization of the microplastic samples. This is because they will need to be analyzed in a lab to obtain useful information on concentration, plastic type, and particle size.

Additionally, establishing a continuous program to analyze these samples as they are received from project centers would facilitate robust and continuous data collection. This could be done periodically through occasional MQPs or continuously through a WPI student group. Next, Project Center Directors should engage in future IQPs and MQPs to work on microplastics solutions to limit microplastic pollution, environmental policy development, or better understanding of how ocean currents move microplastics around the globe.

Lastly, we recommend that Project Center Directors continue to create IQPs dedicated to storying WPI's research in common topics of community science. This allows thematic subjects of WPI research to be properly catalogued to inspire future projects on the subjects. In coordination with the WPI Global Lab, a series of projects storying these common themes would bolster collaborative research at WPI.

Figure 6: Testing of microplastics kit

ACKNOWLEDGMENTS

We would like to acknowledge and thank those who participated and assisted in our IQP project. This would not have been possible without their time, support, and guidance.

Professor Leslie Dodson: Thank you for supporting our project through continuous feedback and giving us a platform to showcase our Storying Microplastics webpage.

Professors Laura Roberts and Tanja Dominko: For supporting our project through the terms by providing feedback and valuable contacts.

Valtýr Sigurðsson: In participating in our interview and providing an insight into the extent of the microplastics problem in Iceland.

Thank you to the following professors who participated in our interviews: John-Michael Davis, Daniel DiMassa, Dominic Golding, Courtney Kurlanska, Stephen McCauley, Aaron Sakulich, Ingrid Shockey, and Stephan Sturm.

MEET THE TEAM

Aaron Boyer

My name is Aaron Boyer, and I was born in Gretna, Louisiana. I am majoring in Aerospace Engineering at WPI with a minor in Robotics. During my time here in Iceland I have learned that Icelanders are some of the most easy going people and being here has been a joy. Working on our project I have realized the connectivity of varying fields of engineering and the importance of applying them to humanitarian work. I can not wait to see the final culmination of our work and the difference it will make at WPI.

Billy Garvey

My name is Billy Garvey. I am from Londonderry, New Hampshire, and I am studying Chemical Engineering at WPI. I have had a great time experiencing the culture of Iceland and meeting people here through the lens of this project. I will never forget the experience of exploring the City of Reykjavik and speaking with random strangers that I met on the street.

Patrick Hyland

My name is Patrick Hyland. I am from Tyngsboro, Massachusetts and am an Electrical Computer Engineering student at WPI. I have thoroughly enjoyed working on this project, working with my team and meeting the great people of Iceland. I am very grateful to have met so many amazing individuals while also creating a new kind of IQP project in the process.

Jared Leonard

My name is Jared Leonard. I am from Williston, Vermont, and am studying Data Science at WPI. During my time in Iceland, I have enjoyed spending time immersed in the unique culture and incredible landscapes the county offers. I also appreciate the unique opportunity this project has given me to work on a term-long project with students across multiple disciplines. In the future, I look forward to watching how our project creates structural changes at WPI that foster connected research.

AUTHORSHIP

This paper was written collaboratively by all team members. Each section was outlined by the team, and then writing was distributed to individual team members. Once the sections were written, each team member edited all sections of the paper. The original authors of each section are found below:

Aaron Boyer: Executive summary, WPI Resources, Microplastics, Evaluation of the Microplastics Sampling Kit, and Act on Data Collected

Billy Garvey: Citizen Science, Sampling Methodologies, Analysis Methods, Research Approach, Barriers to Collaboration, Conclusions, Microplastics Sampling Kit and Instructional Material

Patrick Hyland: Abstract, Acknowledgements, Interest in Microplastics, Storying Microplastics Website, Revising Sampling Techniques

Jared Leonard: Plastics, Microplastics, Sources of Microplastics, Impacts of Microplastics, Collaborative Research - An Untapped Opportunity, A Desire to Collaborate, Revising Sampling Techniques

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BACKGROUND

CITIZEN SCIENCE

To meet the demands of global crises we are experiencing today, coordinated data collection programs must be put in place to bring together local, regional, and international efforts. One of the tools best suited to conduct research on an international scale is citizen science. By cultivating civilian participation as a tool in the scientific process, scientists can achieve global data collection on an otherwise unimaginable scale (US General Services Administration. n.d). When the scientific community addresses issues requiring large amounts of data to be collected, categorized, transcribed, or analyzed, citizen science can help ease the burden on scientists (Bonney et al., 2014). By engaging volunteers who are already at or willing to go to specific locations to collect data, the public can simultaneously conduct research at multiple centers.

One excellent example of the utilization of citizen science is the Audubon Christmas Bird Watch. Established in 1900, this project enlists the help of volunteers throughout North America to count bird species. The data amassed by the National Audubon Society is used to guide conservation policy and activism. Through their activism and conservation efforts, the National Audubon Society has had several impressive achievements, such as downlisting the bald eagle from endangered to threatened (National Audubon Society, n.d.).

Citizen science projects are complex endeavors. As such, there are many aspects to consider when designing a citizen science program. Researchers at the Israel Institute of Technology performed a case study comparing six successful widespread citizen science programs and cataloged which factors they had in common. These six programs were the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS), eBird, Foldit, Galaxy Zoo, Open Air Laboratories (OPAL), and PatientsLikeMe. The study found several factors that were shared between many of these successful programs (Figure 7). It found that allowing users to participate without prior knowledge was a common factor. Similarly, a simple platform for data collection was shared between many programs. The programs also provided a social platform for their users, such as online forums or chat rooms. These allowed users to discuss their findings and ask questions about the project and data collection process, creating a more engaging experience. Lastly, all six projects facilitated the dissemination of results with their users, allowing volunteers to see the impacts of their work clearly (Golumbic, 2015). Although these are essential aspects to consider, the resources and infrastructure available to put these programs in place are even more critical.

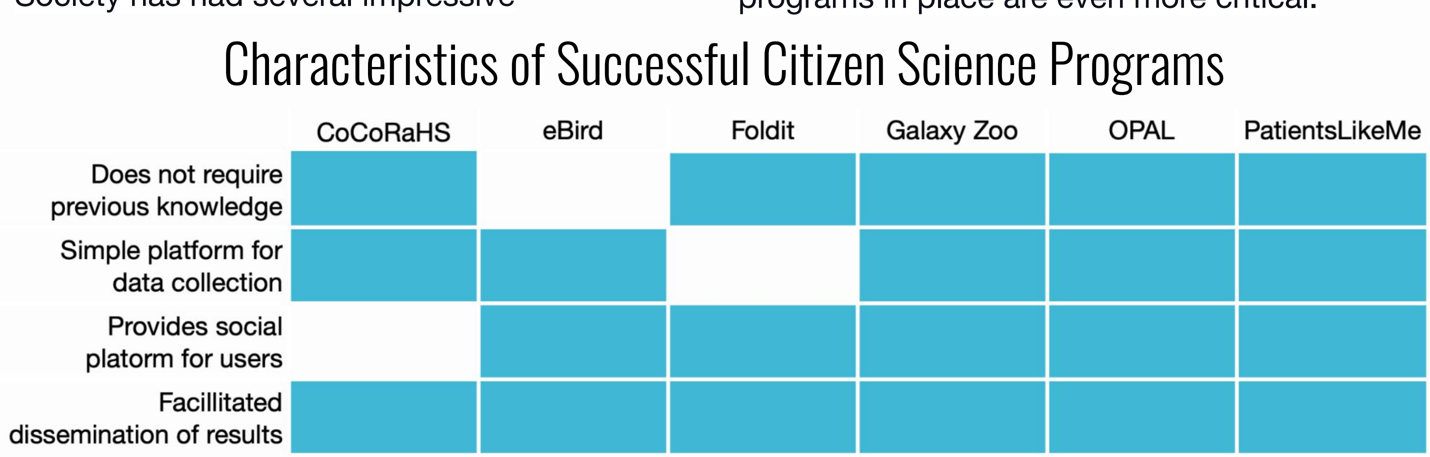

Figure 7: Characteristics of successful citizen science programs (Golumbic, 2015)

Figure 8: WPI Project Centers (Worcester Polytechnic Institute, n.d.)

WPI RESOURCES

WPI boasts an extensive Global Projects Program (GPP) that sends students to over 50 project centers across 37 countries (Figure 8: Worcester Polytechnic Institute, n.d). The IQP is designed as a way for students to conduct projects integrating science and engineering with societal relevance to local communities at these project centers. WPI considers the IQP a valuable experience as it "requires students to address a problem that lies at the intersection of science or technology with social issues and human needs" (Cape Town Project Center, n.d, para 1). This unique perspective allows WPI students to apply their skills in science and technology to effect social change that has a meaningful difference.

Traditionally IQPs have entailed students working with a sponsor organization in a local community. This means that the project outcomes directly support local efforts. In recent years, some IQPs have shifted focus to promoting global collaboration in addition to supporting local community sponsors. One example of a series of IQPs involving collaboration among project centers is the Storying Climate Change series sponsored by Professor Ingrid Shockey (WPI Global Lab, 2019). For this series, students traveling to countries including India, Iceland, Japan, and New Zealand were tasked with interviewing locals to chronicle perceptions on how climate change has affected their lives. To ensure that the Storying Climate Change project would have continued application in other project centers, a digital exhibit of the information was created and is hosted on the Global Lab website. This exhibit of climate change stories acts as an inspiration to Project Center Directors who may be interested in continuing this project in a new location.

The Global Lab at WPI is “devoted to collective action research and impactful partnerships that cut across sectors and lead to positive social change and environmental restoration" (WPI Global Lab, n.d.). The Global Lab provides resources and opportunities to help elevate student projects to connect people and ensure more lasting positive impacts. They have previously helped facilitate student IQPs involved with the Storying Climate Change projects by providing information, training, and innovative multimedia solutions.

Although WPI has an impressive network of project centers in many countries, WPI is not yet leveraging the global locations to collect data. Students often conduct projects that are similar in nature at different locations, however these projects are almost always disconnected and do not collaborate. For example, several IQPs have been conducted on the topic of microplastics, in Iceland, Australia, and Hong Kong. The Iceland and Hong Kong projects focused on developing methodologies for collecting and analyzing microplastics samples, while the Melbourne project was focused on developing a citizen science collection approach (Akyildiz et al., 2015; Bayas et al., 2017; Alexander et al., 2018). These projects conducted similar research and found similar results. While each microplastic project focused on a specific aspect of microplastics research, WPI project centers could be leveraged to provide a much clearer picture of plastic pollution on a global scale.

PLASTICS

Plastic pollution has become a growing problem ever since the first plastic was first produced in 1907 by Leo Baekeland (Mercelis, 2020). Today the six most commonly used types of plastic are Polyethylene Terephthalate (PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-Density Polyethylene (LDPE), Polypropylene (PP), and Polystyrene (PS) (EPE, 2019). While each type of plastic has various uses, they are all synthetic substances made by processing petroleum. As a result of their chemical composition, most bacteria cannot break down plastic, resulting in plastic not decomposing like organic matter (Urbanek, 2018). This has not prevented plastic from being adopted by almost every industry, resulting in more than 381 million metric tons of plastic being produced annually. With most of this plastic in products with short life spans, more than 275 million metric tons of plastic are thrown away each year.

MICROPLASTICS

Ocean currents connect the world, moving warm water from the equator towards the poles and cold water from the poles back to the tropics. Pollutants often travel in these ocean currents as they move around the world (EPA, n.d.).

Figure 9: Shard plastic from ocean

This process can result in a disconnect between the source of pollution and the areas affected by that pollution. Microplastics, which make up 92% percent of total plastic in the oceans, are one of the most common pollutants affecting every corner of the globe (Coyle et. al., 2020). Originating from all over the world, microplastics come in many forms.

SOURCES OF MICROPLASTICS

More than one-third of microplastic in the ocean comes from microfibers in wastewater discharge of washing machines. When clothes made using synthetic textiles are washed, they break down, releasing microfibers (Wood, 2019). Another source of pollutants are microbeads. Microbeads are small pieces of plastic added to washable cosmetic products such as soap, shampoo, and toothpaste. When these products are washed off, the microbeads they contain are washed down the drain (Hersher, 2020).

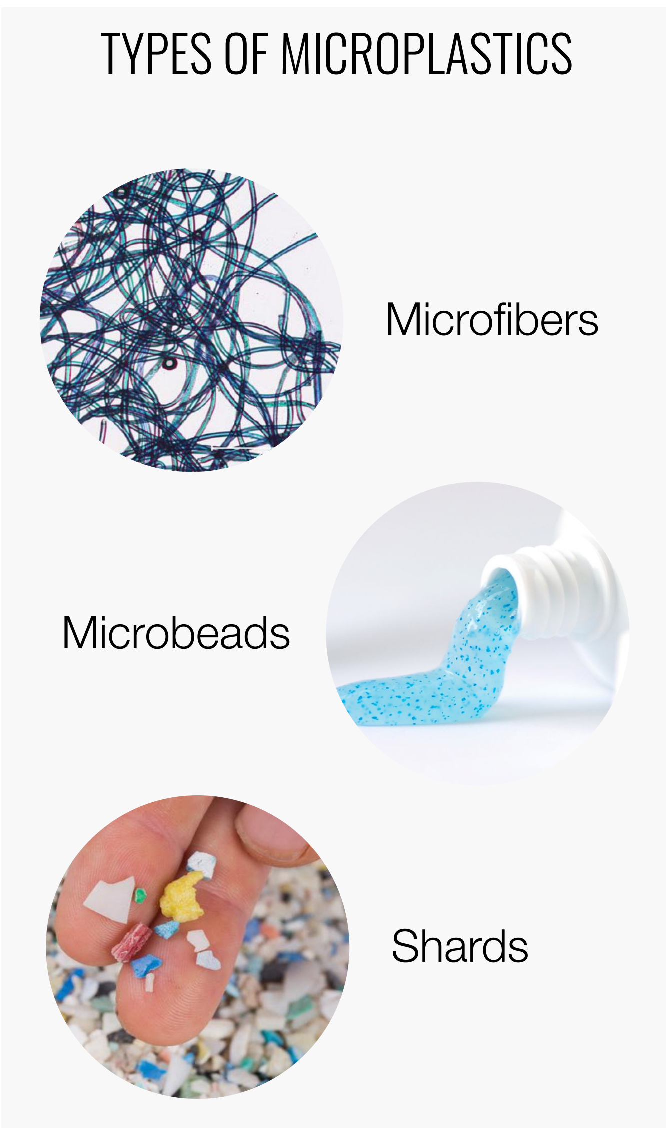

Figure 10: Types of microplastics (Booth, 2017; Tse, 2015; Romaguera, 2019)

Due to most wastewater treatment plants not being equipped to remove synthetic fibers and microbeads, they are discharged with the treated wastewater. Not all microplastics enter the ocean as microplastics; some enter as large pieces of plastic that, with time, degrade into microplastics. In the ocean, plastic is broken down by solar UV radiation, which is most potent at the water's surface. Waves can also

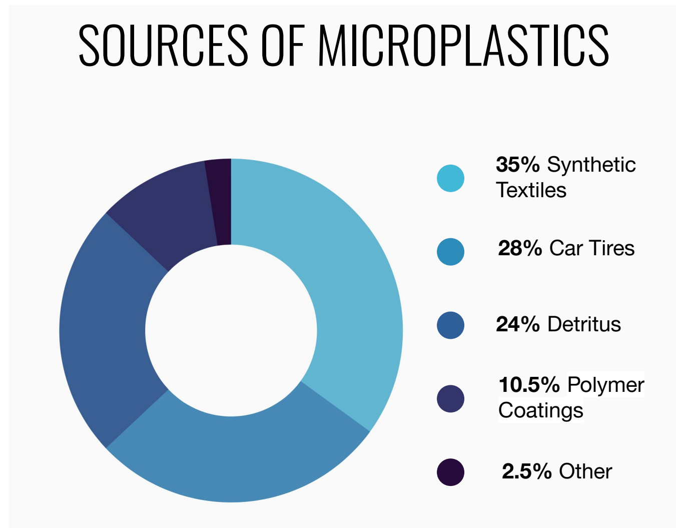

Figure 11: Sources of microplastics (Wood, 2019)

break larger plastics down into smaller and smaller pieces until they become microplastics (Hersher, 2020).

This process is called degradation, and the rate at which it occurs is affected by water temperature, among other factors (Hahladakis, J. 2020). Microfibers are the greatest contributor to microplastic pollution at 35% of all microplastics in our oceans. Car tires are the second leading source of microplastic pollution accounting for 28% of the microplastic in our oceans (Figure 11: Wood, 2019). In addition to car tires, microplastics can originate from road markings, marine coatings, and many other sources (Wood, 2019). With microplastics constantly entering the ocean, understanding their impact on humans and marine life is essential.

IMPACTS OF MICROPLASTICS

According to The Lancet, a UK medical publication, 84% of global drinking water samples contained microplastic (The Lancet Planetary Health, 2017). This study is concerning because microplastics have high affinities for toxic chemicals, which are then passed to humans after ingestion (Wayman, C., & Niemann, H. 2021). Exposure to microplastics can lead to organ damage, immune system problems, increased inflammatory responses and increased oxidative stress (Wayman, C., & Niemann, H. 2021).

Several reports have shown that these microplastics can also have adverse effects on all trophic levels of aquatic life. Filter feeders consume microplastics which subsequently travel up the trophic levels, eventually contaminating the fish humans consume.

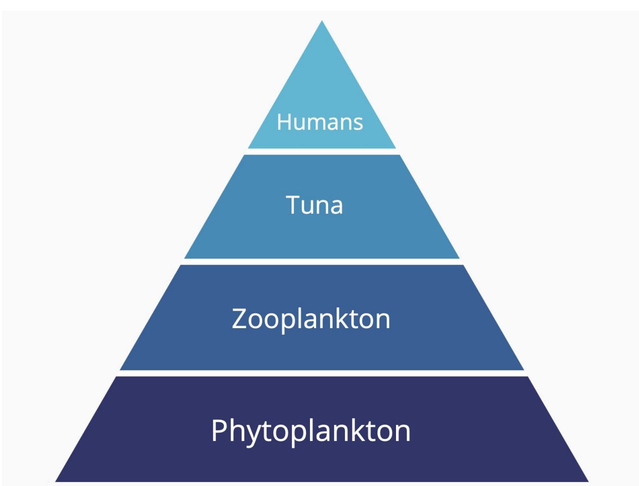

Figure 12: Ocean Trophic Levels (Coastal Carolina University, 1994)

Fish also often mistake pieces of plastic for food. This act causes the fish's stomach to fill with plastic (Figure 13: Eriksen, 2008), making them feel full when they are not getting the nutrients they need to survive. The fish will begin losing weight with time and eventually starve to death (Hahladakis, J. 2020).

Figure 13: Plastics Found in Fish Dissection (Eriksen, 2008)

A 2020 study examined 270 fish and found that seven percent of the fish had microplastics in their edible tissue (Daniel et al., 2020). Due to the risks microplastics pose to the environment and humans, tracking them is critical to understanding the problem's scale.

SAMPLING METHODOLOGIES

Researchers have already established several methodologies for tracking microplastics that vary in complexity, cost, effectiveness, and type of microplastics detected. The three most common sampling methodologies are the sand method, the water method, and the trawl method. The sand method involves taking a sample of surface beach sand in a glass jar or other container. In this sampling method, it's important to note down the sampling location relative to the tide line, as well as the depth of the sample collected (Besley et al., 2017). Next is the water method, which involves collecting water with a large container and passing it through a fine-mesh, typically around 100-micrometers (Green et. al., 2018). The amount of water passed through the sieve varies, although most studies agree 50 to 100

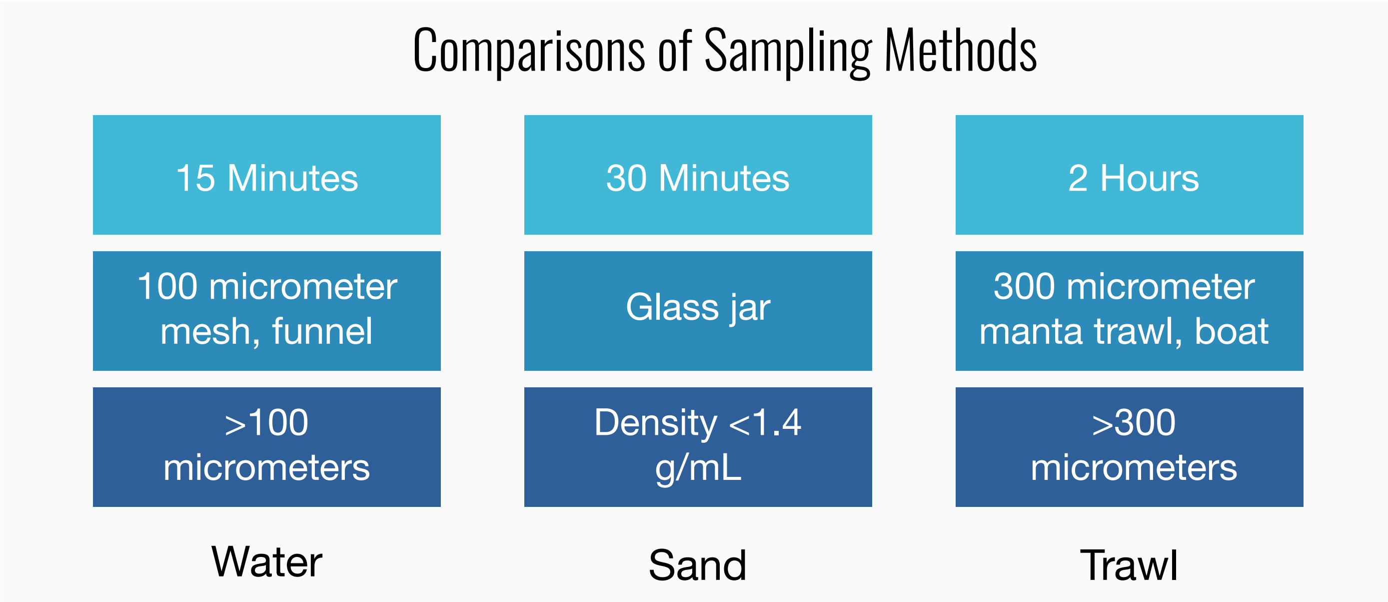

Figure 14: Comparisons of sampling methods (Green et. al, 2018; Besley et. al., 2017)

liters is sufficient to obtain a large enough sample (Zheng et al., 2021). The last method is the trawl method. For this method, a specialized net with a 300 to 500 micrometer mesh is dragged behind a boat to collect microplastics floating in the water. This allows for a much larger volume of water to be sampled than the water method, and it allows samples to be taken at a variety of depths. However, this method cannot collect smaller microplastics, which will pass through the net's mesh (Green et al., 2018). A summary of several aspects of these collection methods can be found in Figure 14 (Green et. al., 2018, Besley et. al., 2017). Regardless of the method used for collection, additional analysis is necessary to obtain useful data from the samples.

ANALYSIS METHODOLOGIES

There are several established methods of analyzing microplastics samples ranging from inexpensive materials to specialized lab equipment. The first and simplest method is visual inspection of the sample. This is most often done with a microscope in order to detect smaller microplastics in the sample. Before the visual inspection, the sample is treated with concentrated hydrogen peroxide to dissolve organic matter, then heated to remove water. Occasionally, density separation is used to separate the low density plastics from the dense rocks and sand, although this can leave out the more dense plastics in the sample. This separation can use several different liquids, such as zinc chloride, sodium iodide, or even corn syrup (Shim et al., 2017; Nakajima et al., 2019). This method is inexpensive, but cannot identify the types of plastics in the sample. Another method of analysis is Fourier-transform infrared spectroscopy (FTIR). This method is very accurate and can identify the type of plastic in the sample, but the equipment required is expensive and time consuming to operate (Shim et al., 2017). Lastly, recent testing has been done on the identification of microplastics through thermal analysis, or differential scanning calorimetry (DSC). This method is less labor intensive than FTIR, but fails to identify a number of common plastics types (Shim et al., 2017). Additionally, this method requires expensive equipment and is destructive to the sample.

RESEARCH APPROACH

METHODS USED

The goal of our project was to gauge WPI Project Center Directors' interest in collaborative research through a microplastics pilot. Additionally, this project contributed to WPI's microplastics research by creating a microplastics sampling system for water samples that can be used at all of WPI's project centers.

To accomplish this, we surveyed and interviewed Project Center Directors to evaluate the feasibility of connected microplastics research through project centers. In addition, we used these interviews and survey results to understand how to engage Project Center Directors in connected research. Next, we established a microplastics sampling system through interviews with microplastics experts and comparing currently established methods. We ensured that this method would be feasible for use at WPI's global project centers. Lastly, we created a webpage on the Global Lab website to host a collection of previous microplastic IQPs curated into a storytelling experience. A schematic of our goal, objectives, and methods is presented in Figure 15.

PERSPECTIVES ON COLLABORATIVE RESEARCH

To gauge general perspectives on collaborative research in WPI's Global Project Program, we conducted a survey of Project Center Directors (Appendix A). The survey questions were divided into two groups: the respondents' perspectives on collaborative research in general, and the respondents' interest in a collaborative microplastics project. We used questions about the potential for a collaborative microplastics project to gauge the ability and interest in engaging in microplastics research among Project Center Directors. We sent the survey to 55 Project Center Directors by email along with a brief description of our project. Of those 55, we received 19

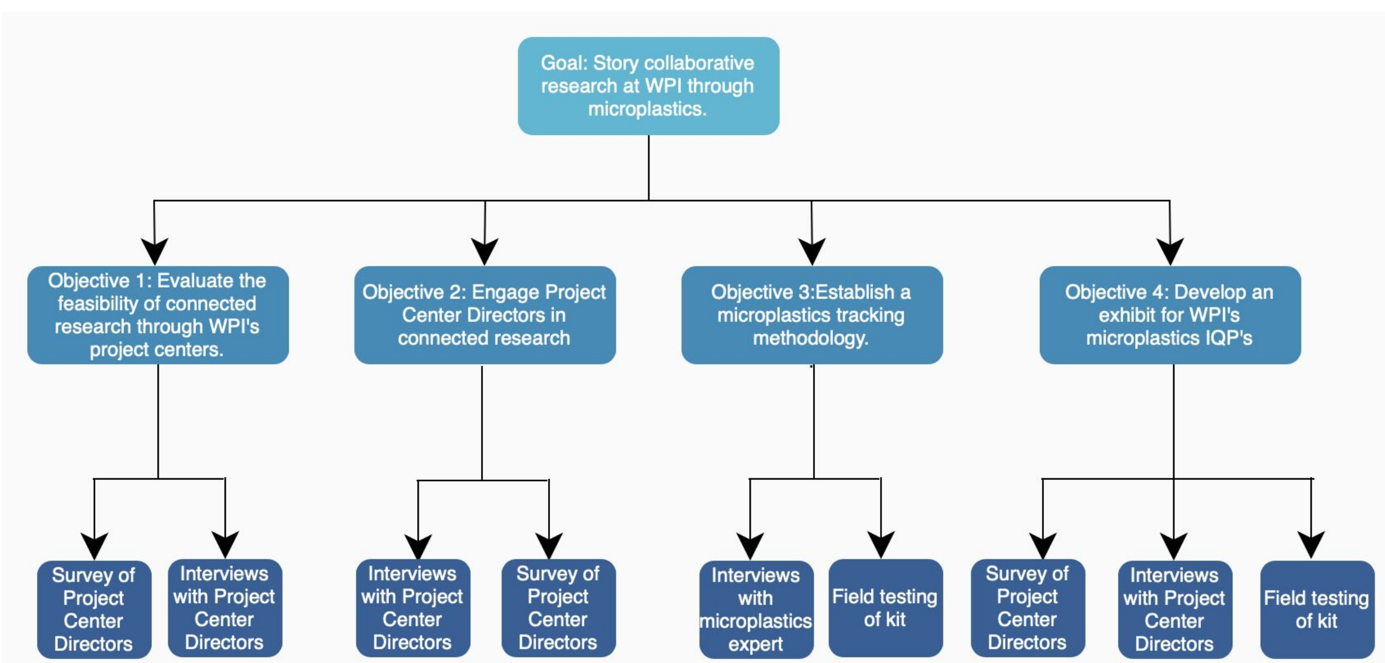

Figure 15: Flow chart of objectives and methodologies

Figure 16: Locations of Project Center Directors surveyed

responses. As some respondents direct multiple centers, these 19 responses represent 22 of 57 unique project centers (Figure 16). To understand the perspectives of Project Center Directors in depth, we conducted eight interviews (Appendix B). We conducted these interviews in a semi-structured manner so that we could probe deeper into topics that each particular interviewee was interested in. The specific questions asked varied by interview, but we generally asked questions about the logistical ability of Project Center Directors to travel and use a microplastics sampling kit, their perspective on collaborative research, potential barriers to collaborative research, and how to better engage Directors in collaborative research. The questions were similar to our survey questions because we wanted to gain in depth answers to these questions that we did not obtain from the survey. We selected interviewees from our pool of survey respondents. When selecting interviewees, we ensured that we included Project Center Directors with a variety of interests. We interviewed two Directors who responded on the survey that they did not have access to the ocean and three Directors who responded that they did not have previous experience with microplastics.

MICROPLASTICS IN ICELAND

To learn about the state of microplastics research in Iceland, we interviewed Valtýr Sigurðsson (Appendix C), a biologist and researcher for Biopol (Skagaströnd, Iceland), a biotechnology company that leads Iceland's microplastics research. In this interview, we asked questions about the history of his research, the effects microplastics have on Iceland, and the methodologies used in his research. We conducted this interview in a semi-structured manner.

MICROPLASTICS SAMPLING KIT

We conducted field testing to develop a user-friendly microplastics sampling kit. Our prototype kit design consisted of a 12-inch diameter, 100-micrometer stainless steel mesh, a 235-millimeter funnel, and a five-liter bucket. The mesh was purchased online from USA Labs (Livonia, Michigan), and the funnel and bucket were purchased at BYKO, a local hardware store in Reykjavík. We did our testing at Nauthólsvík Geothermal Beach in Reykjavík. Our testing consisted of placing the mesh in the funnel such that the bottom of the funnel is completely covered, as seen in Figure 16. Then, we waded approximately 15-feet from shore to minimize the sand floating in the sample. We filled our five-liter bucket with surface water, brought it to shore, and poured the water through the funnel and mesh. We repeated this process ten times to obtain a 50-liter sample size. We then folded the mesh twice and stored it in a ziplock bag for storage and shipment back to WPI.

STORYING MICROPLASTICS RESEARCH

We designed a website that stories student-conducted microplastics research. This site will be hosted on the Global Lab website (https://global-lab.wpi.edu/) to ensure it is easily accessible to the WPI Project Center Directors. We worked with Global Lab Co-Director Professor Leslie Dodson and Global Lab Production Manager Jeremiah Valero who agreed to create and host the webpage from our fully developed design. To create the website design, we used Canva, an online design tool. The webpage contains general information about microplastics, as well as summaries of student conducted microplastics projects from the executive summaries of reports retrieved from the Digital WPI website (https://digital.wpi.edu/). The summaries also contain assets and visuals both created by the original authors and by us based on the findings of the reports. The full design of this webpage can be found in Appendix D.

Use of human subjects in our research has been approved by the WPI Institutional Review Board, IRB-21-0628.

Figure 17: Mesh filter lining funnel

RESULTS

RESULTS

Through our research, we found that undergraduate, project center based collaborative research at WPI is limited. Despite this, all the Project Center Directors surveyed indicated that they would like to participate in more collaborative research. Three main barriers to collaborative research were identified: organizational challenges, time constraints, and communication challenges.

COLLABORATIVE RESEARCH - AN UNTAPPED OPPORTUNITY

To understand the current state of collaborative research at WPI, we surveyed WPI Project Center Directors. We were specifically interested in determining how often their project center conducted collaborative research. In total, we received responses from 19 individual Project Center Directors representing 22 unique project centers around the world. From the survey, we found that most project centers do not participate in collaborative research (Figure 18). Out of the 19 Project Center Directors surveyed, 14 responded that their center seldom or never participated in collaborative research across multiple centers. Only one Project Center Director responded that they frequently participated in collaborative research. This response was from Professor Ingrid Shockey, who launched the Storying Climate Change project at WPI. The success of this project highlights the fact that successful collaboration between project centers is possible despite the current lack of widespread collaboration between centers.

A DESIRE TO COLLABORATE

Once we understood the current state of collaborative research at WPI, we wanted to know if a desire for collaborative research exists. Our survey results show that all of the Directors who responded had a desire to participate in more collaboration between project centers. As a follow up question, we also asked what topics Directors would be interested in collaborating on.

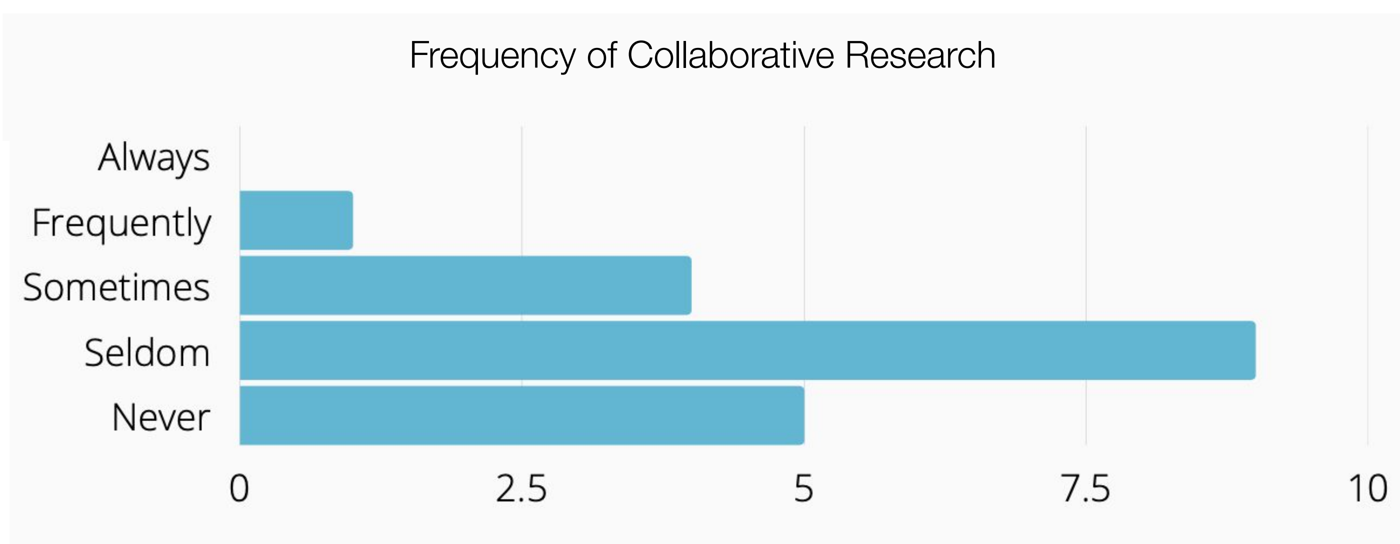

Figure 18: Frequency of collaborative research

Figure 19: Collaborative research topics

By far the most recurrent topics mentioned in the survey responses were those dealing with climate change, clean energy, water quality, pollution, and refugee issues. This shows that Project Center Directors not only want to participate in collaborative research but that they want to broaden the range of topics it is applied to.

INTEREST IN MICROPLASTICS

To understand the likeliness of Project Center Directors to support our project, we needed to gauge their interest and understanding of microplastics. To do this we asked in our interviews if a student would be able to take our kit with them and collect a microplastics sample on location. Out of the eight interviews we conducted, all eight interviewees stated that they would be willing to take a kit with them to their project center. Professor John-Michael Davis said "that seems feasible to me, to carry [it] in luggage…" Additionally all eight of the Directors interviewed stated that students would have time to collect a microplastics sample. In our interview with Professor Courtney Krulanska, she stated "That would definitely be an easy thing to do. There's literally four [rivers] that run through the city [Cuenca]". This data shows that there is interest in conducting microplastics research among Directors. In addition to this, we felt our project could gain support from Directors if they understood the severity of the microplastics issue. To gauge Project Center Directors' understanding on the topic of microplastics we surveyed them asking the following question: How significant do you think the problem of microplastics is? From this question we found all nineteen respondents believe microplastics are at least a moderate problem, and eleven thought the significance of the problem was very high.

BARRIERS TO COLLABORATION

To make collaborative research a more frequent occurrence, we then identified barriers that prevented Project Center Directors from engaging in collaborative research. In the survey of Project Center Directors, we asked the following question: Which of the following factors do you think are barriers to collaboration between project centers? Survey respondents were asked to select all that applied (Figure 20).

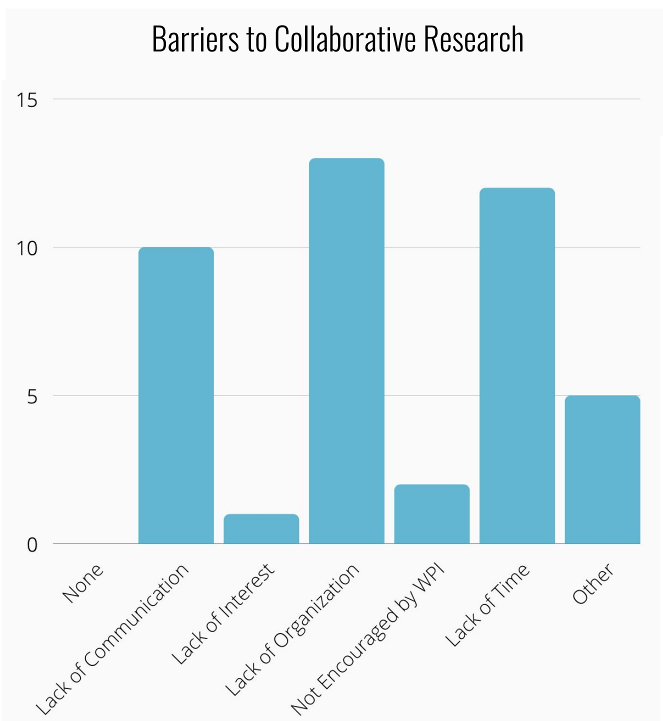

Figure 20: Barriers to collaborative research

We found that the top three barriers limiting collaborative research were a lack of organization, time, and communication. Out of the 19 Project Center Directors surveyed, 5 agreed that a lack of organization, time, and communication were all barriers and 16 cited at least one of the three.

This data shows that there is no single barrier that needs to be overcome. Instead, there are many, with the Directors surveyed generally agreeing on them.

EVALUATION OF THE MICROPLASTICS SAMPLING KIT

We tested our kit at the Nauthólsvík Geothermal beach, specifically the location at coordinates 64.121174, -21.927736 which is a suburban area of Reykjavik, Iceland. Including components bought locally, the kit cost $30. We took our sample from the top layer of the water column during low tide on October 5th at 11:51 AM. In total it took us 14 minutes to collect and filter a 50 liter sample of ocean water. After we finished filtering our sample we examined the mesh visually and found three microplastics (Figure 21). This verified that the sampling method did work and means that the microplastics concentration at the beach was at least 0.06 microplastics per liter. We also documented our sampling process by creating an instructional video and written directions, which can be found in Appendices E and F, respectively.

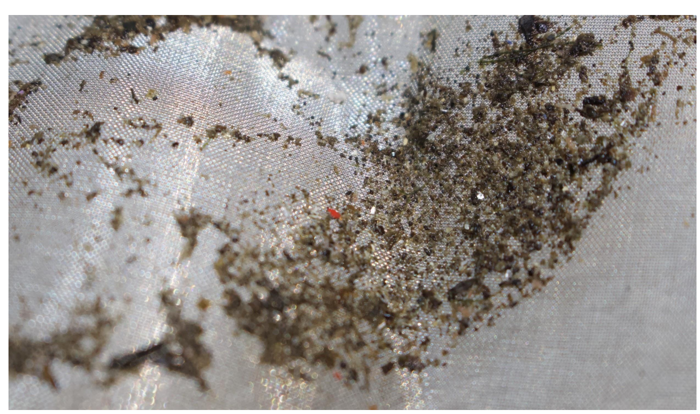

Figure 21: Red microplastic in mesh

CONCLUSIONS

CONCLUSIONS

From our survey of Project Center Directors, we found that there is currently a lack of collaborative research at WPI. However, all survey respondents answered that they would like to participate in more collaborative research. Additionally, Project Center Directors gave many topics that they would like to see utilize collaborative research, such as water quality, clean energy, and pollution. In our surveys and interviews, we investigated what barriers may exist that cause the discrepancy between the state of collaborative research and desire for it. We found that there are three primary barriers limiting collaborative research: lack of organization, lack of time, and lack of communication. Through our survey, we found that Project Center Directors are interested in participating in a microplastics collaborative research pilot. Additionally, Project Center Directors generally believe that microplastics pose a severe threat to our environment. We tested a microplastics sampling kit as a pilot collaborative research project. The sampling process took 14 minutes to complete and cost $30, showing that is time and cost effective. Our trial found a concentration of 0.06 microplastics per liter, which shows the kit is capable of collecting microplastics.

DELIVERABLES

MICROPLASTICS SAMPLING KIT AND INSTRUCTIONAL MATERIAL

To allow continued use of our sampling methodology, we developed a microplastics sampling kit. Our prototype kit consisted of a 100-micrometer, 12-inch diameter stainless steel mesh, a nine inch diameter funnel and a five liter bucket. In addition to the kit we created an instructional video. This is to ensure that different surveyors complete the sampling in a similar manner. We also included a written visual instructional manual to allow for users to print the directions if an internet connection is not available on site. The instructional video and written directions can be found in Appendices E and F respectively.

STORYING MICROPLASTICS WEBSITE

To engage Project Center Directors in collaborative research, we designed a webpage that will be hosted on the Global Lab website. The home page of this website features icons representing projects that have participated in microplastics research along with a map of the location of these centers. Each of the icons on this website leads to a webpage dedicated to that project. The home page also introduces the concept and problem of microplastics in an easily viewable format. The user is presented with options to learn more about either the types or sources of microplastics, each of which have dedicated pages with more information on the topic.

To date there are a total of eight projects that have contributed to microplastics research at WPI and each of these has a dedicated webpage. At the top of the page there is a link to the full project report so that it can be easily accessed. This is then followed by the project's intended goal along with descriptions of the project from the project report’s abstract and executive summary. Along with these descriptions are data visualizations and images from the project reports. Lastly, some projects included promotional, instructional, or educational material which can be found at the bottom of most project webpages. Some data visualizations were created by us based on the data in project reports. The designed website layout can be found in Appendix D.

RECOMMENDATIONS

1. REVISING SAMPLING TECHNIQUES

Our methodology for sampling microplastics can be improved. This can be done through further research on creating a sampling method that can retain microplastics smaller than 100-micrometers, is easier to use, and is less expensive. A future IQP team could work on improving optimal locations for where sampling should take place to maximize effectiveness. For example, depth of sample collection, where along a shoreline the sample is collected, and freshwater versus saltwater areas are all criteria that could affect the amount of microplastics per sample and could improve data obtained. Additionally, teams could expand on the existing data set, collecting samples from fresh waters and glaciers.

2. RESOURCES FOR CONTINUOUS SAMPLE ANALYSES

As students and faculty from WPI’s global project centers collect microplastics samples, they will need to be analyzed in a lab to obtain useful data on concentration, plastics type, and particle size. A future team of MQP students could use the collected samples to characterize the microplastics and compare prevalence of microplastics between different sampling locations around the globe. The samples may also provide a useful resource to develop new methods for characterization of microplastics, or explore ways to degrade different types of plastics by biological or chemical means. Additionally, establishing a continuous program to analyze these samples as they are received from project centers would facilitate robust and continuous data collection.

3. ACT ON DATA COLLECTED

By characterizing microplastic samples collected around the world, a comprehensive and interactive database can be developed and housed through the Global Lab website. Once sufficient data has been collected, future projects will be able to analyze the data and continue contributing to the database. The database could then be shared with an already existing effort such as NOAA's National Centers for Environmental Information (https://www.emc.ncep.noaa.gov/emc_new.php). Utilizing the data analysis, we propose that future WPI IQPs and MQPs could take additional directions, such as working on solutions to limit microplastic pollution, developing educational materials, influencing environmental policy, or improving understanding of how ocean currents move microplastics around the globe.

4. STORYING COLLABORATIVE RESEARCH

In order to ensure that projects are able to connect across project centers it is paramount to have a central repository of information that they can contribute to and draw upon. This is why we recommend that Project Center Directors conduct IQP projects in the future focused on storying WPI's research in common topics of community science. Through coordination with the WPI Global Lab, students have a means to create virtual project exhibits that story WPI's efforts on social topics and IQP projects. These repositories can act as a way to inspire future projects to perform collaborative research.

LIMITATIONS

Our methods had several limitations. Our survey was sent by email to all Project Center Directors with a subject line mentioning microplastics and connected research. It is possible that Project Center Directors who have an interest or past experience working with collaborative research or microplastics were more inclined to fill out our survey. As such, this survey may not be representative of the Directors as a whole, but rather skewed towards those who had an interest in our project themes.

To select which Project Center Directors we contacted for an interview, we used our survey results. This means that our interviews have the same sampling bias as the survey, in which Project Center Directors who are most interested in our project are more likely to complete the survey and agree to an interview.

In addition to interviewing Project Center Directors, we interviewed an Icelandic microplastics expert, Valtýr Sigurðsson, who conducted research on microplastics sampling in Iceland. Our project was limited by only having one expert's perspective on microplastics research.

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APPENDICES

APPENDIX A: Project Center Director Survey Questions

Question 1: Which project center(s) do you direct?

Question 2: How often does your center participate in projects which span multiple project center?

Question 3: Would you like to participate in more collaboration between project sites such as shared research, practices, and community engagement material?

Question 4: Which of the following factors do you think are barriers to collaboration between project centers?

Question 5: Which types of projects or issues do you think could benefit from research that spans multiple project centers?

Question 6: How significant do you think the problem of microplastics is?

Question 7: Do students at your project center(s) have access to the ocean?

Question 8: Has your project center conducted research, community engagement, or collaborations related to microplastics in the past?

Question 9: Would your project center be interested in participating in a global microplastics data collection project?

Question 10: Would you like your name and answers to be kept anonymous?

Question 11: Would you like to receive a copy of the results of this survey?

Question 12: Can we contact you about an individual interview to discuss this project in more detail?

APPENDIX B: Project Center Director Interview Questions

The first step of each interview was to explain our project as a whole and clarify any questions our interviewee may have had about our project. After this we were able to ask questions in a semi-structured manner, changing the order of questions depending on the flow of conversation.

Question 1: Would students be available to take a microplastics sample at some point during their IQP term?

- What kind of body of water would be available for testing?
- What does a students typical schedule look like?
- Would it be reasonable to ask for them to allocate an hour to take a sample?

Question 2: Would it be reasonable to travel with a sampling kit such as we have described to you?

- What would be the maximum size or weight you think would be reasonable?
- Do you have any concerns with the feasibility of this part of the project?

The other part of our project is introducing the concept of interconnected research on IQPs in hopes of making collaboration between project centers more common.

Question 3: Do you have experience with interconnected IQPs?

Question 4: What do you think are potential barriers to collaboration between project centers?

Question 5: How do you think we can address these barriers to get more people involved?

Question 6: Are there any specific projects that you think would benefit from collaboration between project centers?

Question 7: How can we get more people/Project Center Directors involved in this project/future collaborative IQPs?

APPENDIX C: Microplastics Expert Interview Questions

Question 1: How did you start in the field of microplastics?

Question 2: Where did you begin your career?

Question 3: How did you end up working with microplastics?

Question 4: How does the problem of microplastics affect Iceland?
- Specifically ecosystem impacts and human impacts

Question 5: In past microplastics research you have conducted how it was decided where samples would be taken?
- How far offshore were samples collected?
- Were samples collected near populated areas?
- Did they try to sample near a densely populated area to see the effects of being near a city?

Question 6: Why was the sampling methodology used chosen?

Question 7: Were you able to determine if microplastics were a severe problem at any locations tested?

Question 8: If sampling showed that microplastics were not prevalent could this be because of limitations of the methods used underestimating the microplastics count?

Question 9: What role do ocean currents play in the amount of microplastics in Icelandic waters?

APPENDIX D: WEBSITE

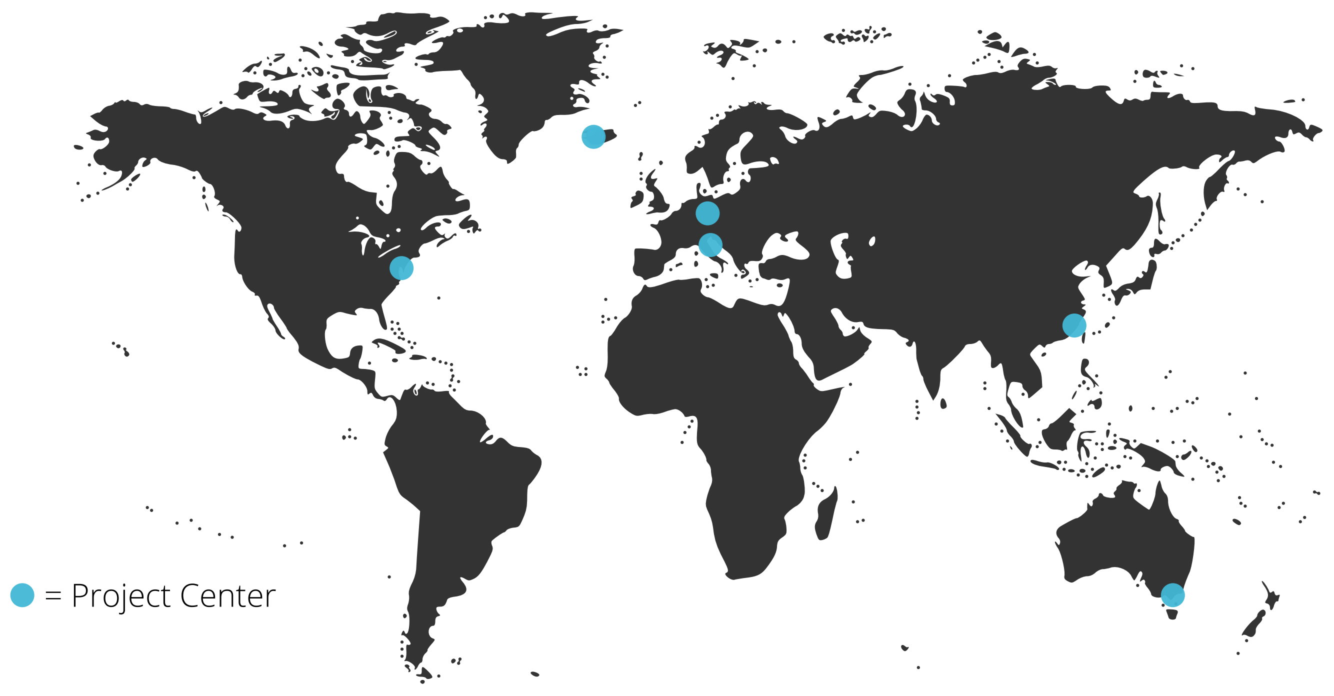
Microplastics Around the World

Showcasing student work that advances microplastics research

Download Data | Upload Data

WPI Microplastics Around the World

Project Centers that have conducted microplastics research



WHAT ARE MICROPLASTICS AND WHERE DO THEY COME FROM?

Microplastics can be categorized into three types: microfibers, microbeads, and shards, each with a variety of sources.

LEARN MORE

MICROPLASTICS RESEARCH

A showcase of student work that advanced microplastics research

BERLIN
A Citizen Science Approach to Measuring Microplastics in Berlin's Water
March 2019

HONG KONG
Microplastic Pollution in Littoral Environments
March 2015

MELBOURNE
A Pump-Based Method to Sample Midwater Microplastic Pollution
December 2019

MELBOURNE
A Citizen Science Platform for Long-Term Monitoring of Microplastic Pollution in Port Phillip Bay
May 2017

REYKJAVIK
Developing a System to Monitor Microplastics on Icelandic Shores
October 2018

REYKJAVIK
Leveraging WPI Project Centers for Collaborative Microplastics Research
Orctober 2021

VENICE
Plastic-Free Venice: Quantifying and Mapping Plastic Pollution
December 2019

WORCESTER
Strategies for Mitigating the Proliferation of Microplastics in Worcester (Massachusetts) Waterways
March 2019

Worcester

Strategies for Mitigating the Proliferation of Microplastics in Worcester Waterways

Kelly Perfetto | Alyssa Richardson | Shawn Salvatto | Evan Sauter

See Report

The goal of the project was to determine the concentration of Microplastics in Worcester waterways and make recommendations based on those findings.

We partnered with the Worcester Department of Public Works (DPW) to conduct an inaugural series of microplastics testing in Worcester. Ours tests could not determine if there were microplastics exiting the Middle River; however, there were larger plastics. Utilizing the information we gained from our tests and outreach we recommend that the Worcester DPW&P begin to conduct microplastics testing and regularly survey Worcester residents' opinions regarding plastics. Additionally, we recommend that WPI create projects pertaining to Worcester's microplastics.

We partnered with Jacquelyn Burmeister, the senior environmental analyst of the Worcester Department of Public Works & Parks(DPW&P) to determine the presence and concentration of microplastics in Worcester waterways, specifically within the Middle River. To achieve this goal, we first developed a sampling methodology based on a similar study conducted in western Lake Superior (Hendrickson et al., 2018). We then contracted a third party lab to conduct microscopic analysis on the samples we collected. The results we received from the lab were unable to accurately determine the concentration of microplastic particles in the Middle River. The lab report from ALS did identify two large plastic fibers that, while larger than our definition of microplastics, indicate the presence of at least some form of degraded plastics in the Middle River. It is unclear whether the error appeared due to our sampling methods or the testing methodology used by ALS. Despite the lack of conclusive data on microplastics, we observed that there were larger plastics within the sampling area that could still harm the environment. We later created and then presented a set of phased recommendations tailored for the City of Worcester's DPW&P. Our recommendations offered a set of strategies to mitigate plastics and microplastic proliferation in Worcester waterways. In order to accurately construct the set of recommendations we created a three phased approach. First, we chose to benchmark cities within New England to determine what cities similar to Worcester have or have not accomplished in order to combat plastic pollution. Once these cities and their methods had been identified, we conducted interviews with various municipal representatives, from both within and outside of Worcester, to more accurately understand their approaches to environmental problems and how to tailor them to Worcester and its residents. Finally, we conducted a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis with various Worcester representatives from the department of Health and Human Services and the DPW&P in order to further refine our recommendations.

> "We learned from councilman Gale the importance of introducing change gradually to residents."
>
> "We gained insight from councilman Sullivan as to how influential funding from grants can be towards the implementation of a program."
>
> "We learned councilman Rose importance of being aware of the demographics and cultural and political values of residents within a city."

"The inconclusively of our results is an effect of the limited research that has been conducted on microplastics in freshwater systems."

Berlin

A Citizen Science Approach to Measuring Microplastics in Berlin's Water

Adam Strohm | Allison Smith | Andrew Panneton | Sebastian Tomassi

See Report

The goal of this project was to increase awareness of the risk of microplastics to elementary students in the Treptow-Köpenick district of Berlin.

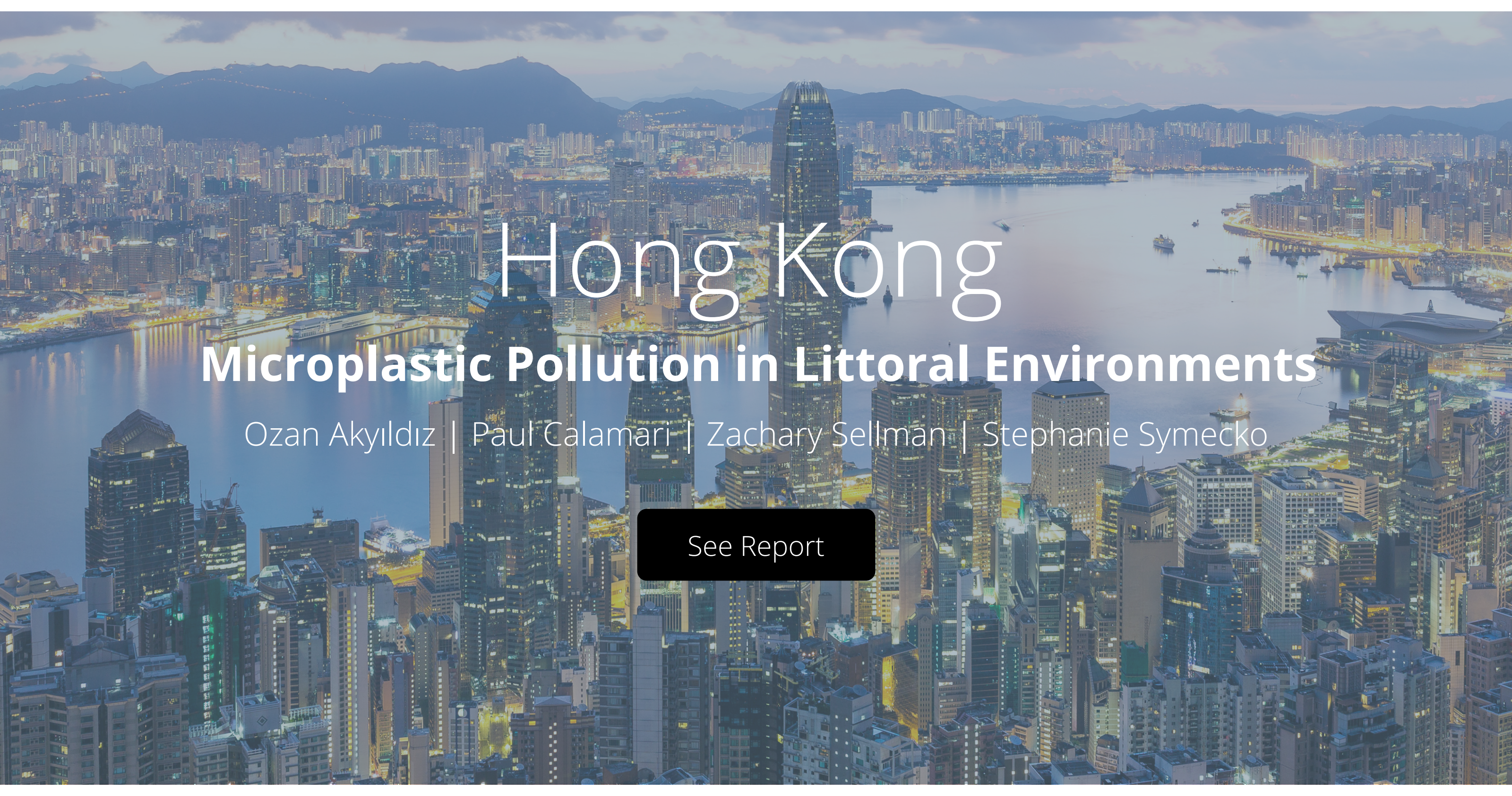
Microplastic and nanoplastic pollution is a continuously growing threat to our environment. The goal of our project was to increase awareness of this risk in elementary students in the Treptow-Köpenick district of Berlin. Through our partnership with Leibniz-IGB and other district affiliates, we developed a lesson plan containing a student experiment, a presentation, infographics, and reflection materials to teach students about the problem. Increasing awareness in younger generations is an important step in hopes of attaining a more sustainable future.

In order to compile information, we used various credible sources that examine saltwater and freshwater, including studies done by Leibniz-IGB. We gathered information on potential dangers caused by microplastic and nanoplastic pollution from these sources and presented the material as a literature review. We also organized an annotated bibliography of these sources. The research conducted on microplastic and nanoplastic pollution enables us to begin informing the next generations of their presence and the threats they pose to the planet's health.

In order to design an experiment suitable for the students, we researched and performed several collection and detection methods from previously published studies. We performed two distinct experimental methods, one being a density separation method for sand samples and the other being a filtration method for water samples. We modified these methods to be suitable and cost-effective for a 5th and 6th-grade student experiment.

Our team created a low-cost, student experiment to introduce 5th and 6th grade German students to a problem their community faces. We enhanced the students' learning outcomes of the experiment by producing a lesson plan that TJP can use to engage and enable them to make a difference in their community. The lesson plan involved informational material on microplastic and nanoplastic to help students understand their dangers. It also contained several experiments to help introduce students to laboratory techniques and get themto actively participate outside of the classroom.

> "As we continue to address the problem of plastic pollution, whether macroplastics, microplastics, or nanoplastics, we must consider that it is our responsibility to protect, mitigate, and manage the health of our planet and surrounding ecosystems."



Hong Kong

Microplastic Pollution in Littoral Environments

Ozan Akyıldız | Paul Calamari | Zachary Sellman | Stephanie Symecko

See Report

The main goal of this project was to accurately obtain the information that is needed to propose solutions to the microplastic problem.

The invention of plastic has revolutionized the way we package and manufacture goods. The reality of plastics can be summed up by the fact that they are inexpensive, easy to manufacture, and do not degrade naturally in the environment. The problem, most importantly, is that they do not break down chemically, but will keep breaking into smaller and smaller pieces. This breakdown happens when plastics get into bodies of water and are subject to mechanical erosion and photodegradation. This results in very small pieces of plastic of the order of millimeters, which scientists call microplastics. These microplastics have the potential to harm the environment they exist in because of their small sizes that allow ingestion and the ability to adsorb persistent organic pollutants (POPs). POPs are known to be harmful chemicals that can eventually cause cancer as well as other health problems after prolonged exposure to them. Microplastic pollution is a problem that needs to be addressed for exactly this reason.

The main reason behind the lack of action towards limiting microplastic pollution is the fact that there is not a lot of information on the subject. The only known preventive measures have been limiting to those preventing plastic microbeads from being used as an ingredient in health and beauty products. This happened when research was done showing the extent of the microbead pollution in the Great Lakes region of the US and Canada. However, this kind of successful action is not a global norm as the actual extent of microplastic pollution is unknown. Therefore, more information needs to be known about the severity of microplastic pollution.

82%
of students surveyed had never heard of microplastics

The main goal of this project was to accurately obtain the information that is needed to propose solutions to the microplastic problem. Our first objective was to sample enough of the Hong Kong coastline to accurately quantify the extent of the microplastic pollution there. By sampling the beaches in Hong Kong, we were able to completely analyze the beach samples to identify what plastics can be found on Hong Kong's shores. We also obtained information on the public's perceptions of microplastics by using a survey to gauge the public's awareness of this problem.

Our data indicated that microplastic pollution was more severe on the beaches nearest to the Pearl River Delta. We determined that the majority of the microplastics were in the form of expanded polystyrene (EPS). Comparing our results which were obtained in the winter season to the results that were obtained by other researchers in the summer, we found that many more microplastics were present on the beaches in the summer than in the winter. From our survey results, we were able to conclude that not many people had heard of microplastic pollution nor were they aware that it was a problem.

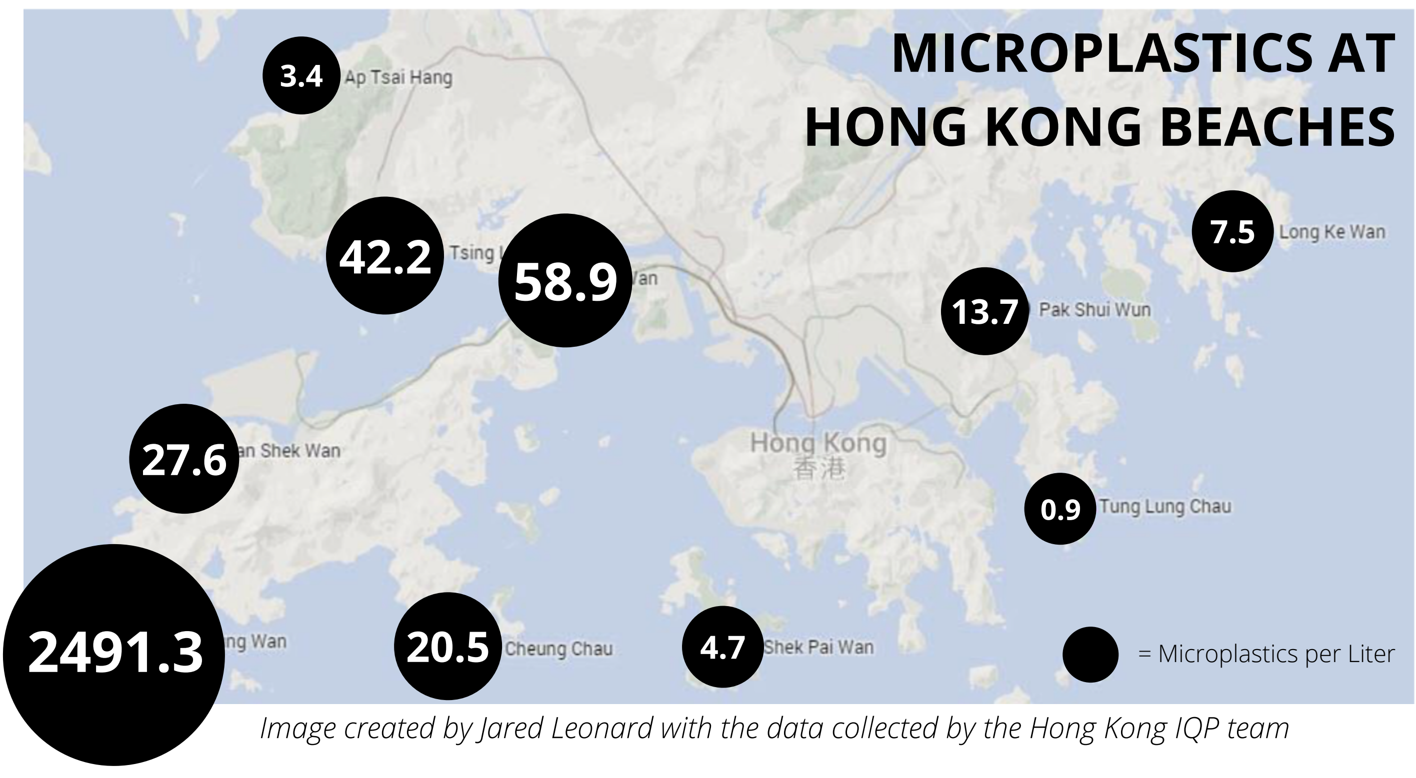
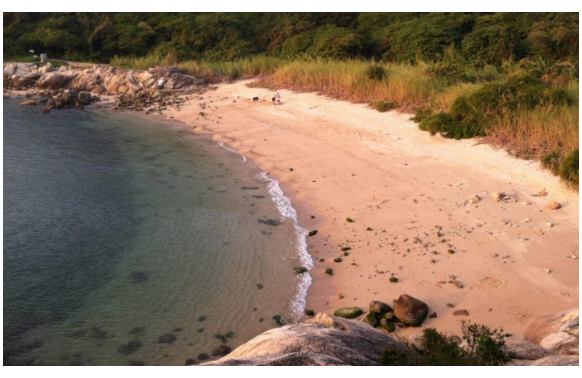


Image created by Jared Leonard with the data collected by the Hong Kong IQP team

Our final objective was to identify ways to change how plastics are handled in Hong Kong. We have concluded first that awareness of microplastic pollution needs to be raised throughout Hong Kong to show the dangers of this type of pollution. The awareness campaign can also show the extent of microplastics in the environment and show how people can contribute towards preventing this spread. This campaign could also encourage people to recycle EPS and to create ways to prevent microplastics from entering the waters around Hong Kong. A comprehensive awareness campaign would be the obvious start to effective action mitigating microplastic pollution.

Our project was successful in quantifying the extent of microplastic pollution in Hong Kong and in studying the perceptions of the people living there. Our recommendations can bring about change that is needed to limit the amount of microplastic pollution in the waters around Hong Kong. We hope our project is the first of many to bring about increased global action towards creating solutions to the problem of microplastic pollution.



"The levels of microplastic pollution are only going to go up as they do not ever cease to exist. Our data show that microplastic pollution is a problem here in Hong Kong and mitigation efforts are limited. We believe that change can happen when enough awareness is achieved and enough support is garnered."

Melbourne

A Citizen Science Platform for Long-Term Monitoring of Microplastic Pollution in Port Phillip Bay

Andrea Bayas| Maura Buckley | Cierra Ford | Javier Lawes

See Report

This project was intended to help the Port Phillip EcoCentre establish a long-term monitoring program to track microplastic pollution in Port Phillip Bay.

Microplastic pollution is an emerging global concern; therefore, there is a lack of knowledge and awareness surrounding the topic. Nevertheless, some communities, including the Port Phillip Bay area, have taken initial steps to address microplastic pollution. Port Phillip Bay is located in the southern part of the Australian state of Victoria. The bay is surrounded by four main catchments and multiple sub-catchments, which are home to two-thirds of Victoria's total population. There are several rivers and creeks that run through these catchments and discharge into the bay. These waterways play an important role in providing the Port Phillip Bay area with aesthetic appeal, recreational opportunities, tourism, ecosystem foundations, and wildlife habitat. However, these rivers and creeks also serve as a path for litter to travel from the catchments into the bay. The litter that enters Port Phillip Bay circulates the bay with the clockwise current for an estimated 1.65 years before it is released into the open ocean through Bass Strait.

Neil Blake, the Port Phillip Baykeeper, as part of Waterkeeper Alliance, strives to keep the bay clean by taking action, educating the community, and promoting the cause through a variety of projects. Neil developed the Baykeeper Beach Litter Audit to address microplastic pollution in Port Phillip Bay. It is a systematic method for collecting and recording litter at beaches around the bay. It focuses on microplastics unlike other methods to collect and sample debris from the marine environment. Due to the complexity of the microplastic pollution issue, citizen science is an appropriate approach to get more people

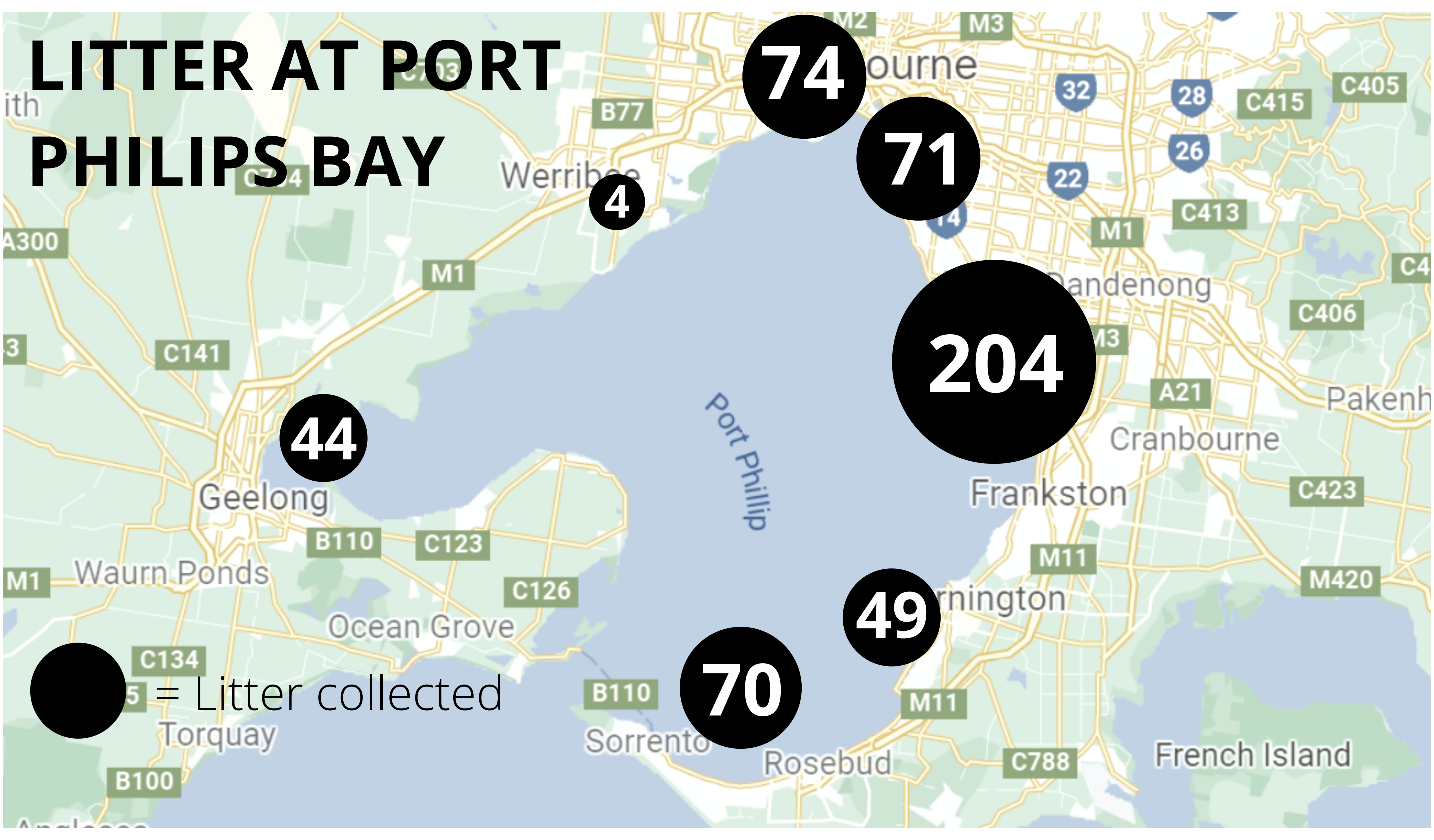
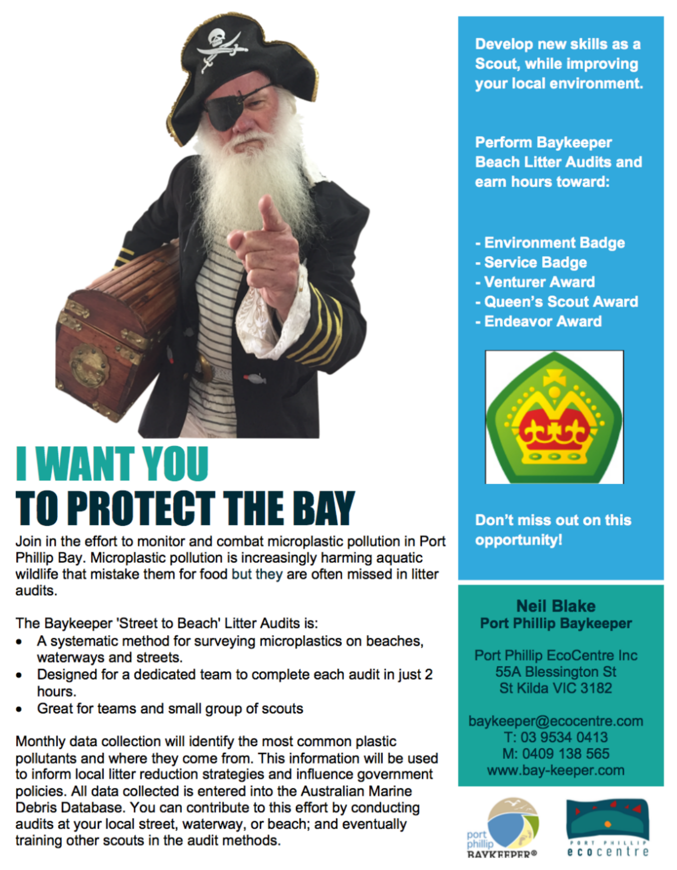


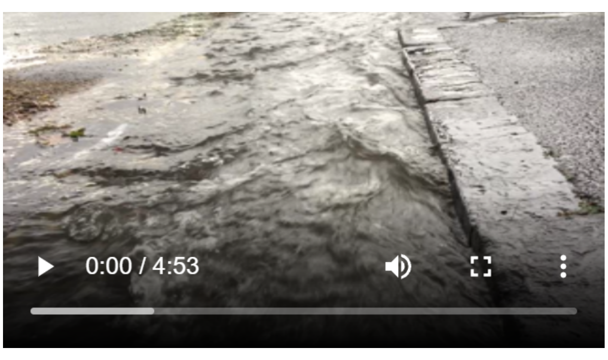
Image created by Jared Leonard with the data collected by the Melbourne IQP team

The study area consisted of nine pre-selected sites around the bay. This selection was based on the locations of waterway entries from rivers and creeks into the bay, the clockwise movement of the current around the bay, and wind patterns. We validated the suitability of each pre-selected site by determining any factors that might prevent volunteers from performing the audit at the site. This included noting each site's accessibility, such as proximity to car parks, and observing hazards, such as the need to cross bike paths to access the beach. We determined that one pre-selected site, Wader Beach, was not appropriate for implementing the audit due to access difficulties and the danger of tiger snakes in the area.

To understand the different perspectives on microplastic pollution in Port Phillip Bay, we conducted in-person surveys with individuals that visited St. Kilda Beach, including tourists, locals, beach goers, and fishermen. Out of 102 total surveys, 48% of the individuals were not aware of the existence of microplastics. Once we explained to the respondents what microplastics were, only 37% could provide possible sources of microplastic pollution. This lack of awareness within the community reveals an obstacle for the citizen science program because it shows the current lack of understanding of the issue within the community, but it also presents the opportunity for growth in this area.



Our team developed outreach and promotional materials necessary to establish a long-term monitoring program for citizen scientists. We produced an instructional video demonstrating how to perform the Baykeeper Beach Litter Audit, to provide volunteers with a visual representation of the written instructions. We also developed informational sheets for the audit sites explaining the specifics on each beach so that future auditors could easily retrieve the necessary information to perform the audits. Lastly, we designed a promotional flyer that targets Scout groups in the Port Phillip Bay area



"Preliminary findings are important to the success of citizen science projects because they provide a foundation for community members to build upon and obtain valuable information from over time"

Melbourne

A Pump-Based Method to Sample Midwater Microplastic Pollution

Kathleen Donovan | Spencer Hoagland | Thomas Lipkin | Eric Stultz

See Report

The goal of our project was to develop a means to quantify microplastic pollution at various depths, between 0.2 to 2 meters below the surface of the waterways that flow into Port Phillip Bay.

Microplastics, plastic pieces less than 5mm in diameter, are a threat to marine ecosystems. The Port Phillip EcoCentre quantifies surface level microplastics entering Port Phillip Bay in order to advocate for policy to mitigate microplastic pollution in Australia. We worked with this organization to develop a method to collect micro plastics at greater depths, between 0.2 to 2 meters below the water's surface. We designed and tested a portable pump and created a how-to video and an instructional manual for its use. We also created an animation to show the consequences of microplastics and the importance of our project to the public

We worked with the Port Phillip EcoCentre (hereinafter referred to as the 'EcoCentre'), an environmental hub in Melbourne that performs research to quantify the effects and abundance of microplastics in the Bay (Charko et al., 2018).Through sampling research, the EcoCentre aims to make evidence-based recommendations to policymakers in order to reduce microplastic pollution. This research is vital, because an Australian Senate Inquiry into the threat of marine plastic pollution concluded that "further research is required to identify effective mitigation and prevention strategies to stop plastic debris from entering the marine environment" (Urquhart, 2016, p. 62).

LOCATION	DATE	TIME PUMPED (MINUTES:SECONDS)	VOLUME (LITERS)	DEPTH (METERS)	MICRO-PLASTICS	CATEGORIES	CONCENTRATION (MICROPLASTICS PER M^3)
St. Kilda Pier (extends into Port Phillip Bay)	15-11-2019	34:34.24	242.2	1.00	2	1 hard plastic <2mm, 1 cellophane <5mm	8.26
The Main Yarra Trail near the McConchie Reserve	22-11-2019	48:38.29	250.0	1.00	4	4 hard plastics <2mm	16.00
The Main Yarra Trail near the McConchie Reserve	22-11-2019	52:53.26	250.0	1.75	4	2 hard plastics <2mm, 1 soft plastic <5mm, 1 cellophane <5mm	16.00
The Docklands	06-12-2019	52:39.95	250.0	2.00	3	1 hard plastic <2mm, 1 hard plastic 2-5mm, 1 cellophane <5mm	12.00

Through the use of our device and implementation of our recommendations, we hope that the EcoCentre will be able to collect meaningful data regarding the concentration of microplastics in the midwater in and around Port Phillip Bay. This data can stop microplastics from ever entering the waterways, since concrete numbers can be used to advocate for policy changes that address microplastic pollution.

- Produces accurate data
- Is replicable by others
- Allows for comparison to previous data collected
- Is portable, convenient, and inexpensive
- Is integrable into their current methods

OFFICE LOCATION
Innovation Studio, 2nd Floor
OPEN HOURS
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EMAIL
GR-GLOBAL-LAB@WPI.EDU

Reykjavík

Developing a System to Monitor Microplastics on Icelandic Shores

Tyra Alexander | Alexis Buzzell | Cecilia Schroeder | Jason Strauss

See Report

The goal of this project was to produce a beach monitoring method that can help community groups in Iceland track changes in microplastic pollution.

Microplastics are a growing problem worldwide, and their effects are only starting to be understood. Our goal was to produce a beach monitoring method that can help community groups in Iceland track changes in microplastic pollution. We tested multiple methods from previous studies and combined aspects into one method that is time efficient, simple, and low cost. We also developed an easy to use, consistent verification test. The final method is an ideal way for community scientists to monitor microplastics in beach sand. To keep Iceland's shores clean and marine ecosystems healthy, monitoring microplastics will be the first step in understanding plastic pollution.

Identification of microplastics by eye proved to be difficult because they blended in with pebbles and shells. For this reason, we tested methods to separate microplastics from other materials. One method was sieving, but larger pieces of shell or rock were incapable of being sieved from the sample. Picking microplastics by hand was the least time consuming method, but we could not conclude all microplastics were gathered or that the gathered sample was composed only of microplastics. To increase accuracy from hand picking or sieving, we used density separation tests. We found that salt water and ocean water do not have densities high enough for many plastics to float. Corn syrup, however, has a density of 1.4 grams per milliliter, which is higher than most plastics, but lower than rocks (Science Buddies, 2016). Corn syrup was most effective in separating plastics from sand, rocks and shells. Additionally, corn syrup is a low cost, readily available, and feasible analysis to help count microplastics from within collected samples. For this reason, we decided corn syrup would serve as the analysis for the final method.

Why are Microplastics a Problem

Microplastics Methodology

"Our project has potential to create baseline data that can bring awareness to the prevalence of microplastic pollution and the damage it causes not only in the marine environment, but in humans as well."

OFFICE LOCATION
Innovation Studio, 2nd Floor
OPEN HOURS
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Reykjavík

Leveraging WPI Project Centers for Collaborative Research Through Microplastics

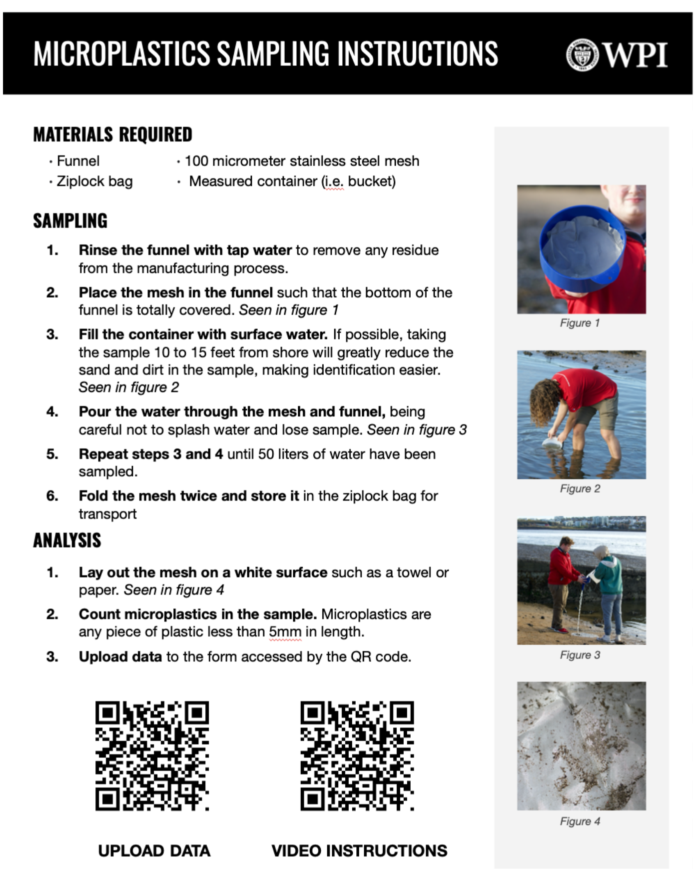
Aaron Boyer | Billy Garvey | Patrick Hyland | Jared Leonard

See Report

Our project engaged WPI Project Center Directors in collaborative research through a microplastics pilot.

We conducted interviews and surveys of Project Center Directors which revealed the discrepancy between the desire for collaborative research at WPI and its current state, as well as the barriers causing it. We also interviewed an Icelandic microplastics expert and conducted field research to develop a microplastics sampling kit as a pilot collaborative research project. Lastly, to engage Project Center Directors in collaborative research, we created this website that showcases student microplastics research projects.

Our microplastics pilot project consisted of a microplastics sampling kit that students can bring with them to their project centers to collect samples from around the world. We researched existing microplastics tracking methodologies and evaluated them for several factors according to our Project Center Director interviews. On the basis of the need for a simple sampling kit that was easy to travel with, we decided that a water based sampling methodology was most effective for our needs. We tested our sampling kit on Nauthólsvík Geothermal Beach in Reykjavík. In our 50 liter sample, we found three microplastics, showing that this method has potential in microplastics sampling.



MICROPLASTICS SAMPLING INSTRUCTIONS WPI

MATERIALS REQUIRED
- Funnel
- Ziplock bag
- 100 micrometer stainless steel mesh
- Measured container (i.e. bucket)

SAMPLING
1. **Rinse the funnel with tap water** to remove any residue from the manufacturing process.
2. **Place the mesh in the funnel** such that the bottom of the funnel is totally covered. *Seen in figure 1*
3. **Fill the container with surface water.** If possible, taking the sample 10 to 15 feet from shore will greatly reduce the sand and dirt in the sample, making identification easier. *Seen in figure 2*
4. **Pour the water through the mesh and funnel,** being careful not to splash water and lose sample. *Seen in figure 3*
5. **Repeat steps 3 and 4** until 50 liters of water have been sampled.
6. **Fold the mesh twice and store it** in the ziplock bag for transport

ANALYSIS
1. **Lay out the mesh on a white surface** such as a towel or paper. *Seen in figure 4*
2. **Count microplastics in the sample.** Microplastics are any piece of plastic less than 5mm in length.
3. **Upload data** to the form accessed by the QR code.

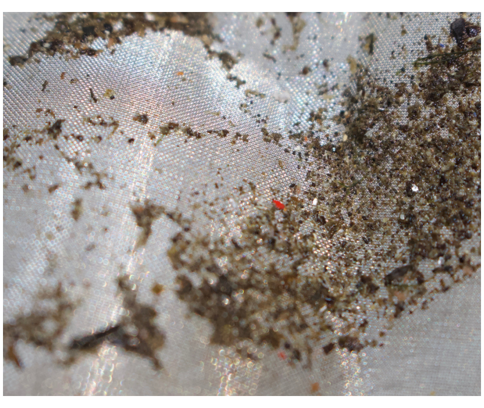
UPLOAD DATA   VIDEO INSTRUCTIONS

Figure 1

Figure 2

Figure 3

Figure 4



To help future groups consistently take these samples, we created an instructional video and document on the testing methodology. We also created a form for this data to stored, which can be accessed from the top of the home page of this website. We created this website showcasing students' microplastics research. Through showing how student work can come together to create a larger, global effect, we hope to engage Project Center Directors in collaborative research and allow for future collaborative projects to be done that leverage WPI project centers to their full potential.

Venice

Quantifying and Mapping Plastic Pollution

Shanna Bonanno | Alexander Hagedorn | Troy Howlett | Vivian Nguyen

See Report

The goal of this project is to contribute to the development of a strategic plan to reduce the build up of plastic pollution in Venice.

Venice has a dense population that consists of 270,000 citizens on the mainland of Venice while about 53,000 residents live in the historical center (Municipality of Venice, 2018). In addition to residents, many people commute to the historical center every day to work, as well as the approximately 36 million tourists who visit Venice each year. With such a diverse population there are many potential contributors to plastic pollution. The distinct geography of the Venice Lagoon also contributes to the plastic pollution in the city and amplifies the visibility of the issue. There are 10 rivers that flow into the Lagoon bringing in plastic waste from surrounding cities. In turn, there are only 3 passages from the Lagoon to the Adriatic Sea trapping much of the waste within the Lagoon. Within the historical city itself, Venice has many narrow streets running adjacent to a system of canals. The close proximity of human activity to the marine ecosystem makes it easy for general waste and plastic to enter and move around the environment.

> **"Selected accumulation sites were on the perimeter of the city where land is exposed during low tide and cleanups by organizations have previously been performed"**

Image created by Jared Leonard with the data collected by the Venice IQP team

North Tronchetto Site

To understand the accumulation of plastic pollution in Venice we did the following: located places where the plastic was accumulating, collected the accumulated pollutants, sorted what we had collected, quantified what we had sorted and analyzed our results. To locate potential accumulation points we worked with our advisors and sponsors to map out known locations in addition to what we had discovered as we traveled throughout the city.

Giardini (Partigiana) Site

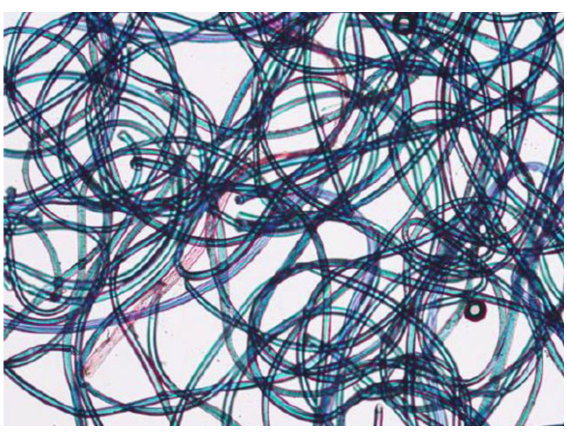
Taking into consideration the time constraints we had, weather, tides and our resources, we selected three locations to cleanup and collect data. These locations included the exposed land adjacent to the S. Alvise boat stop with an area of 310 square meters, the exchange location on Northern Tronchetto with an area of 160 Square meters, as well as the area directly behind Monumento alla Partigiana on Giardini with an area of 60 square meters.

South Alvise Site

We performed two cleanups at each of the three locations. At S. Alvise our collections were 13 days apart on 11/20/19 and 12/03/19. On Northern Tronchetto our collections were 12 days apart on 11/21/19 and 12/03/19. On Giardini (Partigiana) our cleanups were 9 days apart on 11/25/19 and 12/04/19. Once accumulated pollution was collected, we sorted it first into material categories and then into item types. The categories included plastic, glass, metal, rubber and others. The types were individual items branching from the categories. To quantify each of the types we measured the quantity in pieces and then the mass in kilograms to show a comprehensive view of the issue as each type has unique material characteristics and densities.

What are Microplastics?

Microplastics are any piece of plastic that is less than five millimeters in length. They can be classified into three distinct categories: microfibers, microbeads, and shards.



MICROFIBERS

Microfibers are synthetic fibers that end up in wastewater streams when synthetic clothes are washed. These fibers are often too small to be filtered out by wastewater treatment plants, and thus ultimately are washed into the ocean. Synthetic fibers are the largest contributor to microplastic pollution, making up 35% of all microplastics in the ocean.

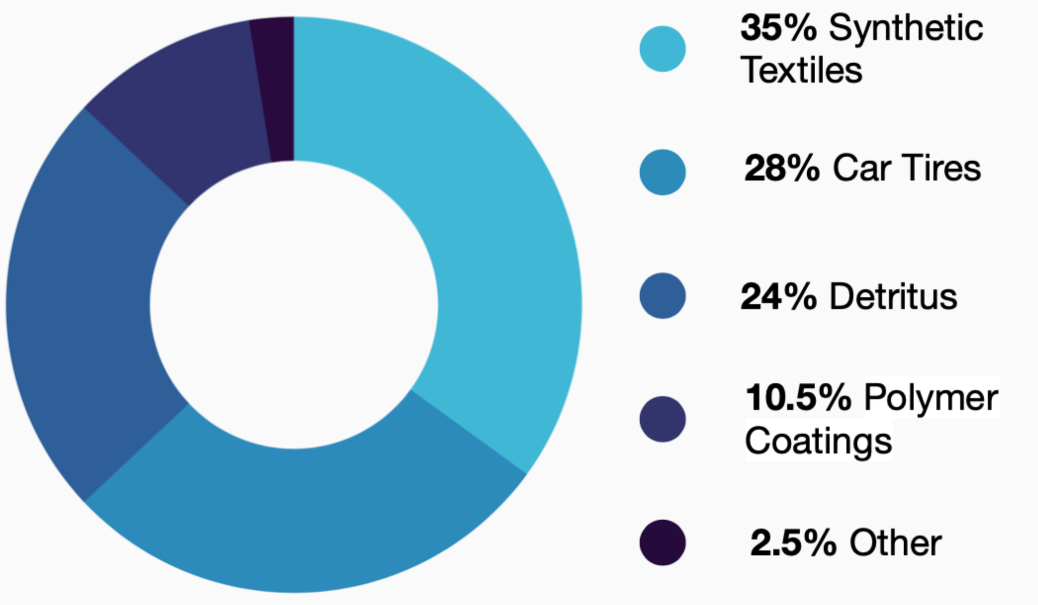
MICROBEADS

Microbeads are the second type of microplastic. These are small plastic beads that are added to certain personal care products such as face scrubs and toothpastes. Much like microfibers, these beads go down the drains of showers and sinks and are unable to be filtered out of wastewater streams. However, microbeads make up a small amount of microplastic pollution at less than 2.5%. Some countries have taken legislative action against this type of microplastic. The United States banned products with microbeads in 2015, and the United Kingdom banned these products in 2018.

SHARDS

The final category of microplastic is shards. Shards are formed by larger plastic waste breaking down over time. The second largest contributors to microplastics pollution as a whole are car tires. Car tires break down from use and end up in oceans, making up 28% of all oceanic microplastic pollution. Additionally, polymer road markings and coatings of marine vessels, other types of shards, make up 10.5% of microplastic pollution. The last large contributor to microplastic pollution in the ocean is detritus. This consists of particles from many synthetic common household items, such as rubber soles from shoes and plastic cutlery.

SOURCES OF MICROPLASTICS



APPENDIX E: Instructional Video

Our Instructional video can be accessed by scanning the QR code below or using the URL.

https://youtu.be/Wg_mWmstjO4

MICROPLASTICS SAMPLING INSTRUCTIONS

MATERIALS REQUIRED

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6. **Fold the mesh twice and store it** in the ziplock bag for transport

ANALYSIS

1. **Lay out the mesh on a white surface** such as a towel or paper. *(Figure 4)*
2. **Count microplastics in the sample.** Microplastics are any piece of plastic less than 5 millimeters in length.
3. **Upload data** to the form accessed by the QR code.

UPLOAD DATA

VIDEO INSTRUCTIONS


Figure 1


Figure 2


Figure 3


Figure 4