Plastic Eating Device For Rocky Ocean Coasts (P.E.D. R.O.C.) 3.0: A passive sampling instrument for monitoring shoreline plastics on rocky coasts

Technology Report

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The P.E.D. R.O.C. 1.0 was developed by Cian Kavanagh, Colin Grenning & Nicolas Brouard-Ayres (2015)
The P.E.D. R.O.C. 2.0 and 3.0 (this version) was developed by Will Glatt, with Colin Grenning (2016)
Both versions were developed under the supervision of Max Liboiron

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Summary

This report summarizes the Plastic Eating Device for Rocky Ocean Coasts (P.E.D. R.O.C.) project, which has been ongoing since the winter of 2015. Initially undertaken by Cian Kavanagh, Colin Grenning & Nicolas Brouard-Ayres, students enrolled in SOC 4107 Feminist Technologies taught by Dr. Max Liboiron, the goal was to enable both accredited and citizen scientists with the technological means to conduct marine microplastic studies on rocky and pebble beaches. The initial technology (V 1.0) proved promising and was funded for further development outside of the course. Now as a part of the Monitoring Marine Plastics in Canada's North, Marine Environmental Observation and Response (MEOPAR) project grant awarded to Dr. Liboiron, the current P.E.D. R.O.C. design team, lead by William Glatt, has improved the design and produced a capable technology and methodology for conducting marine plastic shoreline studies in Canada's North (V 3.0).

Marine microplastics are defined as plastics smaller than 5 mm in size. Micoplastics account for 93% of all marine plastics in the world's oceans. These plastics are found in marine environments globally and threaten many species that ingest them, as well as reduce oxygen transfer in sediments when they accrue in benthic environments. Currently government organizations in the United States as well as the European Union have developed methods for monitoring marine microplastics on sandy beaches. These methods are inapplicable to rocky coastlines like those found in Newfoundland and much of northern Canada. The P.E.D. R.O.C. overcomes the challenges of a kinetic and caustic environment.

The P.E.D. R.O.C. prototype was successful in detecting marine microplastics and surviving a short period of deployment on Topsail Beach, Newfoundland. After processing the

results, several conclusions have been made. First, the rock entrapment methodology functions and captured microplastics that were characteristics of the area, though will require further validation in order to begin producing usable data. Secondly, the test helped to identify weaknesses in the design, particularly in accessing and processing the plastics collected. Future work should focus on finalizing the technology in such a way that incorporates laboratory processes for extracting plastics from the device.

Note that this current version has been tested by not validated, meaning that it successfully collects microplastics, but we have not determined whether and how it can be compared to other methods of shoreline study.

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1.0 Introduction

1.1 Purpose

The purpose of this technical report is to summarize and analyze the design of a technology for monitoring marine microplastics. The technology developed is the Plastic Eating Device for Rocky Ocean Coasts (P.E.D. R.O.C.). Its aim is to collect samples of marine microplastics (<5mm) while deployed in a rocky coastal environment, as no current monitoring protocol anticipates rocky shorelines. All standardize protocols (NOAA, UN TSG-ML) assume sandy beaches. The P.E.D. R.O.C. development will contribute to Monitoring Marine Plastics in Canada's North, the Marine Environmental Observation Prediction and Response (MEOPAR) project led by Dr. Max Liboiron.

1.2 Background on microplastics

According to marine scientist Richard Thompson, "[m]icroplastics is used as a collective term to describe a truly heterogeneous mixture or particles ranging in size from a few microns to several millimeters in diameter; including particles of various shapes from completely spherical to elongated fibers" (2015, p.186). Though a myriad of sources of microplastics exist, they can be grouped into two categories: primary and secondary. Primary sources are small particles released directly into the ocean, such as microbeads from personal care products or microfibers from clothing, whereas secondary sources are fragments of larger items broken down in the ocean due to wave action or stress from sunlight (Hidalgo-Ruz et al., 2012; Thompson, 2015). Regardless of the source, microplastics saturate the world's oceans and can be found in all marine environments including arctic sea ice (Rochman et al., 2015, p.3).

These small plastic particles pose a threat to marine ecosystems. Because of microplastics' size and variety, marine organisms often ingest them and thus the toxicants often associated with these plastics are able to enter the food web and accumulate in the animal, and then biomagnify up food webs (Hidalgo-Ruz et al., 2012; Loder & Gerdts, 2015; Rochman et al., 2015; Thompson, 2015). Multiple studies have been conducted examining both the real and perceived impacts of microplastics on the marine environment, however Rochman et al., (2015) found that: "There is pressing need for robust, quantitative information to predict ecological impacts to species of wildlife that are considerably contaminated with marine debris. The presence, sizes, frequencies and nature of ecological impacts are currently largely unknown" (Rochman et al., 2015, p.16). The P.E.D. R.O.C. is designed to increase our capacity to understand these threats in rocky shore landscapes.

An increasing number of studies are being published examining accumulation of marine plastic debris (Hidalgo-Ruz et al., 2012; Loder & Gerdts, 2015; Rochman et al., 2015; Thompson, 2015). Standards are emerging addressing methodologies for shoreline studies and trawl (surface water) studies, however, there is yet to be a standardized methodology for quantifying marine plastics in sediment: This need for standardized methodology is a common theme across multiple studies (Gerdts & Loder, 2015; Hidalgo-Ruz et al., 2012; Rochman et al., 2015; Thompson, 2015):

> One of the main problems of large-scale spatial and temporal comparisons is the fact that a wide variety of approaches have been used to identify and quantify microplastics. For meaningful comparisons and monitoring, it is thus important to define specific

> methodological criteria to estimate abundance, distribution and composition of microplastics. (Hidalgo-Ruz et al., 2012, p.3060)

Currently there is a protocol developed by the National Oceanic and Atmospheric Administration (NOAA) as well as by the European Union (EU) Technical Subgroup on Marine Litter (TSG-ML) for the quantification of microplastics on sandy coastlines. However, these protocols cannot be applied to rocky and icy coastlines like that of Newfoundland for several reasons. Shoreline studies on sandy beaches involve scooping up volumes of sand and mixing them with water to separate plastics that are entrapped. Rocky shores do not afford researchers that same ease of sampling due to weight and difficulty capturing the medium, and microplastics tend to disappear between rocks, making them inaccessible to monitoring. This unique challenge is the crux of the technology being developed. A standardized and robust method of sampling ocean microplastics on rocky shores is essential to future research in anthropogenic plastic pollution studies in Canada's north, and similar rocky coastlines.

1.3 Scope

This technical report analyzes and proposes a technology and methodology to collect samples of ocean microplastics while deployed in a rocky coastal environment. Both accredited researchers as well as citizen scientists (everyday people looking to collect data) will be able to use the proposed technology in order to begin quantifying marine plastics in Canada's north, an area characterized by rocky coasts.

The Primary areas investigated in the report are as follows:

- Examination of current microplastic sampling methods

  - Comparison of standards set out by NOAA and the EU TSG-ML
  - Analysis of whether they are applicable in Canada's North
- Accessibility of building materials in out port (rural) Newfoundland
  - Examination of what types of materials are available
  - Determination of what materials will survive a dynamic ocean environment
- Technology accessibility and methodology
  - Design to meet the needs of both researchers and citizen scientists
  - Examination of the criteria required for both user groups
- Technology testing
  - Design tests to authenticate and prove the technology constructed can fulfill its purpose
  - Determine the ability of the P.E.D. R.O.C. to capture ocean microplastics

Based on the analysis conducted, recommendations have been developed to create a streamlined protocol for sampling microplastics on rocky shores like those found in Canada's north.

1.4 Methodology

1.4.1 Design Rationale

The integral value of the technology is the goal of engaging "participatory sensing" through citizen scientists. Citizen Science allows people to sense their environment using low-cost sensors and Do It Yourself (DIY) hardware with or without partnerships with professional scientists. Because of the relative isolation of some communities in the north, it is important that they can begin to monitor their coastal environments and contribute to the quantification of ocean microplastics, since they are often unable to be included in traditional scientific studies because of expensive infrastructure and lack of partnerships with universities or scientists. This technology in particular is being developed to be able to engage high school students living in coastal communities in Newfoundland and Labrador. However, the technology must also prove effective for accredited scientists and researchers.

One of the tenets embedded in the development of the P.E.D. R.O.C. is acknowledging the inherent politics and power in technology. In his paper *Do Artifacts Have Politics?* (1980) science and technology scholar Langdon Winner analyses the specific forms of power and authority inherent in the technical systems and structures of modern society. Winner states:

> In the processes by which structuring decisions are made, different people are differently situated and possess unequal degrees of power as well as unequal levels of awareness. By far the greatest latitude of choice exists the very first time a particular instrument, system, or technique is introduced. (p.127)

By acknowledging these inequalities in accessibility and application of the P.E.D. R.O.C., the goal to develop a technology that is versatile and adaptable to a wide range of users, with an emphasis on citizen scientists in rural Newfoundland.

The plurality of its application requires design criteria that include the ability to quantify marine plastics on rocky shores comparable to transect methods for sandy shores. Additionally the technology needs to be accessible to out port citizen scientists, meaning a device that is affordable, simple to build, and straightforward to use as well as troubleshoot. Finally the device must be a robust and effective tool that will enable accredited researchers to collect data efficiently and reliably.

1.4.2 Research Tasks

Materials Research

This was primary research conducted to see what is available in an example of an out port community likely to use the technology. This task was completed in Fogo, NL and consists of documentation of the materials available in hardware and building supply retailers.

Primary Field Research

This project required the collection of both primary and secondary research. The primary field research conducted consists of the multiple tests that the P.E.D. R.O.C. underwent (see above). This included testing the plastic entrapment ability of the P.E.D. R.O.C. as well as the adaptable anchoring methods. They consisted of tank testing as well as environmental testing at sites listed in the primary research section.

Secondary Literature Review

Additionally a systematic literature review has been conducted. Utilizing a peer reviewed article database a keyword/title/abstract search for all studies for shoreline microplastics has been evaluated to investigate the number of studies examining rocky shores. A handful did, but their methodologies were either not remarked upon, or they did not systematically search rocky landscapes for plastics in a way that is comparable to current protocols for sandy shores. This provided firm evidence of a need for the P.E.D. R.O.C. 2.0.

1.5 Resource Requirements

1.5.1 Partnerships

In order to fulfill the needs of this research project, access to key resources were required. The partnerships involved in this project were essential to its success. Within the grant Monitoring Marine Plastics in Canada's North, a funded MEOPAR project, a team of two undergraduate students worked on development of the P.E.D. R.O.C. during the Fall 2015 semester under the supervision of Dr. Max Liboiron in concert with Memorial's Undergraduate Career Experience Program (MUCEP). In the Winter 2015 semester, development was solely the responsibility of the first author, William Glatt. This report is written by Glatt with editing by Liboiron.

1.5.2 Facilities

Work space and prototype testing needs for the P.E.D. R.O.C. did not require specialized facilities, especially when considering its goal of accessibility. Access to the School of Ocean Technology workshop at the Marine Institute ensured that hand tools were available and storage space is convenient for the development team.

During initial testing and prototyping microplastic capture, bathtubs at the homes of the development team sufficed. When testing the anchoring methods, suitable locations with varying sedimentation and stratigraphy were selected. This was to ensure that the test sites are relevant for deployment of the P.E.D. R.O.C., i.e. plastics are found on these beaches, as well as accessible to the development team based out of St. John's, NL. The sites selected were Quidi Vidi Lake and Topsail Beach in Conception Bay South (CBS).

The research portion of the project was conducted using resources available to students and faculty of Memorial University. Online databases and scientific journals were accessed through Memorial University's Queen Elizabeth the second Library as well as the Marine Institute's Barrett library.

2.0 Literature Analysis

2.1 Analysis of Current Marine Debris Survey Methods

The following sections outline two separate sampling methodologies published by the National Oceanic and Atmospheric Administration (NOPAA) as well as the European Union's Technical Subgroup on Marine Litter (UN TSML). Both were published in 2013 with the goal of formulating a standardized method for surveying beaches for microplastics. Following is an comparison of methods and an analysis of their feasibility for rocky shores such as those in Newfoundland.

2.1.1 NOAA sampling methodology

The most recent NOAA marine debris document with sampling methodology was published in 2013, titled "Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment." Published by the Marine Debris Program, its goal is to standardize shoreline surveys to allow for greater data comparisons, while enabling evaluation of implemented policies and cleanup strategies.

The section on sampling Meso (>5mm) and Micro-debris (<5mm) provides a methodology for collecting random samples from sandy beaches. The process involves implementing a random number table to select the placement of a 1-m^2 quadrat. The purpose of randomizing the sample location is that the process can be applied over larger spatial scales. However, as stated in the document "[p]revious studies have suggested sampling along the wrack line, where less re-suspension and thus higher debris concentrations are expected to occur, and to avoid the effect of tidal height on the deposition of debris of various sizes and densities" (Browne et al., 2010). Once the randomized location has been selected, all debris larger than 2.5 cm is removed from the quadrat. Then the top 3 cm of sand is collected using a shovel from 1/16th of the quadrat at a time. The sand is then sifted through a 5mm mesh to separate macro and micro debris, and then transferred to sample containers for analysis later in a laboratory.

2.1.2 EU Sampling Methodology

The European Union Technical Subgroup for Marine Litter also published a document in 2013 titled, "Guidance on Monitoring of Marine Litter in European Seas". This document is a much more thorough analysis than the one published by NOAA. It analyzes the state of the field in microplastic studies, helping to identify the shortcomings of the current lack of standardized methods while acknowledging the contributions that previous studies have made in paving the way to developing a standard.

The section dealing with sampling intertidal sediments makes several recommendations based on evaluation of previous published studies. First, they recommend that microplastics should be monitored on the top of the shore (strand line/ wrack line), where possible on sandy shores. Next, it is suggested that separate samples be collected to monitor each of two sizes of debris (1-5 mm and 1 mm- 20 um). This is done so that potential contamination is minimized.

These samples should be replicated a minimum of five times and each replicate should be separated by at least 5m. They can be distributed in a randomized manner in order to be representative of an entire beach.

Microplastics 1 mm- 20 um should be collected first, collecting the top 5 cm of sand using a metal spoon. The sample can be collected by kneeling on the strand line and collecting a series of scoops at arm's length intervals within an arc area to the front. Standardizing the sampling by volume helps reduce variance caused by the water content of sediment; a 250 ml sample is recommended. Samples should then be stored in metal or glass (not plastic) containers for later analysis in the lab.

When sampling microplastics 1-5 mm, it is recommended that this is done independently and after the other samples are taken. The sediment can be collected with a spoon or trowel, collecting the top 5cm of sand from the area within a 50 cm^2 quadrat. The sample is then passed through a 1mm screen mesh and stored in a metal or glass container.

2.1.3 Sampling analysis and comparison

When comparing the two published methods it is evident that discrepancies exist between the protocols. Firstly, NOAA methodology samples microplastics in a randomized pattern, allowing for application over large spatial scales. In comparison the EU TSG-ML recommends sampling at the wrack line, even if transects are randomized along it. Secondly, the EU suggests that samples be collected and analysed separately for plastics ranging from 20 um -1 mm and 1-5 mm, while the NOAA protocols define and sample all microplastics in the same size range of <5 mm. Finally, the depth of the sediment sample collected is different, with NOAA recommending a 3 cm depth while the EU methodology requires 5 cm depth.

The sampling methodology between the two is not directly comparable. This limits temporal and spatial comparisons between studies in the United States and in European countries. Neither of these protocols are applicable to rocky or cobble beaches, which present a unique set of challenges, especially if we wish to compare them to sandy shorelines. It is evident that the difference between the two agencies will cause a divergence of future studies to be published and limit their comparison globally. Though both of these methods for sediment studies are applicable for use on sandy shores in Canada, a need still exists for sampling methods to be developed for rocky and cobble beaches. However, these two methods provide insight as to how the P.E.D. R.O.C. protocol can be developed.

2.1.4 Issues monitoring microplastics on rocky shores

In a literature review of shoreline surveys conducted by Thiel et al (2013), of thirty-nine shoreline plastic studies conducted between 1987 and 2012, only three included rocky shores (Vauk and Schrey 1987, Slip and Burton 1990, and Nakashima 2011). Of these, Vauk and Schrey (1987) do not mention their collection protocol at all; and Slip and Burton state that "the rocky nature of much of the coastline precluded sampling of items smaller than 10mm in length. Searches for small items, particularly plastic industrial pellets and polystyrene beads, were made on small areas of sandy beach" (1991, 250). Nakashima et al (2011) use aerial photographs taken by a digital camera attached to a helium balloon to estimate anthropogenic items larger than 10 cm x 10 cm, the maximum resolution of the camera (762). However, because research has found that ninety-two percent of marine plastics are microplastics smaller than 5mm (Eriksen et al 2014), this method misses the most plentiful genre of anthropogenic marine debris. Finally, Thiel et al (2013) conducted their own rocky shore survey, but focused only on the wrack line which often includes seaweed that entangles debris. This protocol diverges from NOAA's recommended shoreline methods that consider entire beaches (Opfer et al 2012, Lippiat et al 2013).

Microplastic studies on rocky shores are crucial for understanding marine debris trends. First, some geographical areas, such as Canada's far north, are characterized by rocky and cobble shores and contain key ecological areas that need to be monitored. Secondly, rocky shores include environmental dynamics important for understanding larger trends of marine plastics and their effects on scientific protocols.

Complicating quantification even further, studies show that debris that is buried (in rocks or sand) can be later exhumed by wind and wave power (Kusui and Noda 2003, Thompson et al 2004, Smith and Markic 2013). This is particularly acute with rocky shores. Williams and Tudor (2001) found that while objects larger than surrounding cobbles were likely to work their way up to the surface while smaller items stayed buried, potentially skewing data designed to record shoreline debris as an indicator of overall marine debris in an area. Moreover, several studies suggest that rocky shores may serve as "grinding mills" that batter larger marine debris and accelerate the creation of microplastics (<5mm) from macroplastics (>5mm), which are then pulled back into the ocean (Eriksson and Burton 2003, Debrot et al 1999). Beach characteristics are thus important factors in determining how anthropogenic marine debris, and particularly plastics, circulate in environments and potentially confound quantitative studies of rocky areas.

3.0 Findings and Analysis

The dominant task for the project was creating the P.E.D. R.O.C. itself. This process involved multiple rounds of design, construction, testing, and revision. In order to meet the goal of accessibility to a wide range of users, the materials and methods of construction needed to be available to as many users as possible. Therefore, evaluating the materials available to potential technology users was crucial. The design rationale goals of restricting the use of plastic (to avoid contamination as well as to not contribute to the plastic problem) as well as keeping down the costs (for accessibility) further confined the scope of what was viable for use. Additionally, the technology is required to function in a hostile environment characterized by high waves, strong wind, ice, and rocks. Designing a functional technology within these constraints proved to be the most challenging aspect of the project.

3.1 Materials Survey

During the first phase of the project, materials research was conducted at Walbourne's General Store in Fogo, Newfoundland. A photo inventory—photographs of all available materials—was made by Dr. Liboiron so that the P.E.D. R.O.C. design team could assess the range of the materials available in rural communities. The data collected is shown in Appendix A of the report.

This method gave excellent insight into the types of materials found in one community, but it could not be assumed that access to those materials would be uniform across all rural communities. Furthermore, because of the design team's base of operations was St. John's, it proved challenging to limit the scope of materials to only those available in out port

Newfoundland. This led to the decision that the design team would prototype using materials available in both St. John’s and once a viable prototype was established, alternatives would be possible using materials on Fogo Island and other rural locations. Because the P.E.D. R.O.C. would be shared under an open source hardware licence, adopters are able to modify and enhance the design using the materials available to them. These solutions helped to overcome a major design hurdle while broadening the scope of materials to be used in the construction.

Figure 1. P.E.D. R.O.C. 1.0 deployed in Quidi Vidi. Winter 2015

3.2 Shoreline Anchoring Strategies

The coastline, particularly in Newfoundland, is a powerful and rough environment requiring a device that is capable of surviving a battery of wind and waves. Anchoring the device in such a dynamic environment proved difficult. Initially the P.E.D. R.O.C. 1.0 and 2.0, undergoing their sea trials, were buried under water and rocks at the low tide mark and were difficult to retrieve.

The design team wanted to move away from this method of deployment because of the volatility of the device. P.E.D. R.O.C. 1.0 was lost in the Quidi Vidi gut and never recovered.

Figure 2. P.E.D. R.O.C. 2.0 under development deployed in Quidi Vidi. Summer 2015

An anchoring method was required to function on different types of cobble beaches common in Newfoundland, both large rocks such as those found in the Quidi Vidi gut and small pebbles like Topsail beach. The anchoring method also could limit the range of users, by being too heavy, or prohibitively expensive. Two different methods were experimented with at both Topsail and Quidi Vidi. The first was inspired by a traditional Newfoundland anchoring device called a Killick. A Killick is an improvised anchor comprised of lumber, rope and a large rock. The design team streamlined this idea with the Bag of Rocks (BOR) anchor. Four reusable bags made of non-synthetic material could be fastened to each of the corners of the P.E.D. R.O.C..

Figure 3: BOR Anchor System deployed in Quidi Vidi. Fall 2015

Figure 4 BOR anchor system deployed at Topsail Beach. Fall 2015

The bags were then filled with rocks taken off of the beach and splayed out to limit the amount of motion the P.E.D. R.O.C. was subject to. Since the P.E.D. R.O.C. was still under development, anchor tests were conducted using milk crates for simulation.

In addition to the BOR anchors, some beach stratigraphy allowed for the device to be staked. For this, 3 foot sections of steel rebar with a corrosion resistant epoxy coating was used. An experiment testing the BOR Anchor, rebar staking, and a combination of both methods side-by-side was conducted at Topsail Beach. After three days of deployment in medium to heavy weather, all three anchor methods failed, only leaving scraps of material behind. It became clear that deploying the device at the low tide mark was not feasible.

The decision was made to deploy the P.E.D. R.O.C. at the wrack line, or the point of highest tide. This decision meshed with the quantification protocols outlined by both the EU TSG ML and NOAA. However, in order to ensure that the device's opening has enough exposure to the water but was secure enough that it would not be destroyed, it would need to be buried so that the top of the device was flush with the surface of the beach. A test was conducted, and not only did it prove easy to dig a large enough hole to deploy the device, but the simulated P.E.D. R.O.C. survived several days of harsh weather deployed as such.

After several tests, it was determined that burying the P.E.D. R.O.C. was the best way to ensure a consistent location and opening for water and plastics. However, in some environments, the anchoring system may still be preferable and is here for reference.

3.3 Marine microplastic entrapment

The P.E.D. R.O.C. 1.0, as seen is figure 4.1, only used a single layer of chicken wire to entrap plastic. This was an ineffective method because the majority of microplastics could easily escape by floating as the device filled with water. Since trapping marine microplastics is the primary function of the P.E.D. R.O.C., two approaches were taken with P.E.D. R.O.C. 2.0 and 3.0 to correct this. The approach initially had the design team purchase and test prefabricated and inexpensive trap doors or screens that could perform this task. This process proved fruitful in

Figure 5 P.E.D. R.O.C. 1.0 Detail. Winter 2015

identifying designs that showed promise for further development. However, all of the potential products that could have been used were made of plastic. This conflicted with one of the design criteria decided at the outset of the project which the design team was unwilling to compromise.

The second approach taken was to construct a trap similar in design to the prefabricated trap doors. This was done utilizing environmentally friendly materials such as wood and aluminum. Such a design was applied to P.E.D. R.O.C. 2.0 as seen in figures 5.1 and 5.2 in June of 2015.

Figure 6 P.E.D. R.O.C. 2.0 with wooden slats that closed when water rose. The problem with this design is that the wood could swell. Summer 2015.

Though the prototype was marginally successful, several flaws were identified requiring an entirely different approach to plastic entrapment. First, the wooden construction of the device was prone to expansion when swollen with water. This led to the trap door to jam whenever the wood was wet. Secondly, the construction was too complex and would inhibit potential users who did not have strong carpentry skills. Thus, this approach was abandoned.

Due to the limitations of the previous two concepts, a distinct new method was devised. Because the P.E.D. R.O.C. was attempting to monitor the amount of marine microplastics deposited on the shore, inspiration was drawn from the environment itself. Anthropogenic marine debris from the shore or sea has been shown to move from the shoreline and back into the sea by waves, run off, or winds (Nagaelkerken et al 2001), but this may be reduced on rocky shores, giving plastics a longer life on shore in rocky areas compared to sandy beaches (Eriksson et al 2013). The design premise evolved to simulate a cross section of the shoreline *within* the P.E.D. R.O.C.. By filling the device with layers of rocks decreasing in size towards the bottom, the plastics would naturally entangle themselves within, mimicking a shoreline.

Figure 7. P.E.D. R.O.C. 3.0 being deployed on Topsail Beach

3.4 Field Testing

Environmental testing of P.E.D. R.O.C. 3.0 began March 12, 2016 at Topsail Beach, CBS, Newfoundland. The rock tray was filled with rocks from the surface layer of the beach and then the top screen was replaced and secured. Then a hole large enough for the P.E.D. R.O.C. was dug and the device was buried so that the top screen layer was flush with the surface of the beach.

Figure 8. P.E.D. R.O.C. 3.0 Deployed. Summer 2016.

The device was buried at the point of highest tide which was obvious from the concentrated distribution of marine debris. After being buried in-situ for 24 hours, the P.E.D. R.O.C. was recovered and processed for plastics.

The processing protocol involved several steps attempting to extract all of the small pieces of plastic that had been captured among the rocks. First the top screen was removed and inspected for any plastics that may have been lodged in the mesh. Next, small amounts of rocks were scooped out of the rock tray and rinsed under fresh water into sieves with 0.5 mm mesh. The sieves separated out the larger pieces, leaving only particles approx. 0.5mm or larger in diameter in the finest mesh. These were then sorted through using tweezers and potential plastics were identified and placed in a petri dish. The petri dish contents evaluated under microscope by Dr. Liborion in order to classify what was found.

Figure 9. Marine Microplastics, organic materials, and contaminants Collected.

This image illustrates both the successes and some short comings of the P.E.D. R.O.C. 3.0. The P.E.D. R.O.C. succeeded in collecting evidence of marine microplastics. The plastics found included fragments of green fishing gear, fiberglass cigarette filters, a thin white plastic thread and several small pieces of dryer lint. This is characteristic of plastics found in sewage effluent, which aligns with the type of macro plastics found on Topsail Beach (Bell Island's sewage often washes ashore there). Additionally, several contaminants were found to have been introduced to the sample. The large shiny piece in the top left hand side of the image is a piece of aluminum that has been shed by the P.E.D. R.O.C. itself. To the right there is a black thread whose presence was caused by the accidental use of a plastic scrub brush while rinsing the rocks. In the future these contaminants will be avoided through more thorough cleaning and precaution when deploying, retrieving and processing samples.

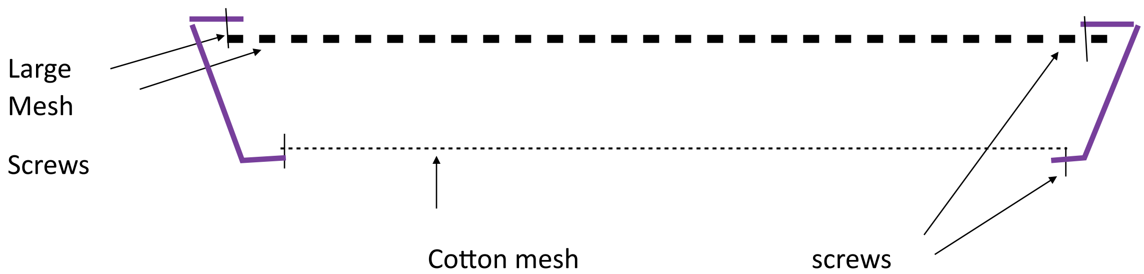
4.0 How to Build a P.E.D. R.O.C. 3.0

Materials

The following material list references both what was used in the final design of the 3.0, as well as characteristics of those materials so that local adaptations can be made.

- Chicken wire or other large mesh wire
- Cotton— preferably white (t-shirt is fine)
- Metal body (dryer venting, stove top guard)
- Screws
- Rocks (obtained at shoreline where the P.E.D. R.O.C. will be deployed)
- Tools: screwdriver or power drill, bits, wire snips, pliers,
- shovel (for deployment)ton

Construction



Fill centre with rocks at deployment site

Figure 10: Diagram of PED ROC from the side.

1. Either find a metal base with a hole in the top and bottom (like a metal stove guard), or cut a hole in the bottom of the metal base. The hole at the top is for the large wire mesh, and the hole in the bottom is for the cotton so that water can pass through. There should be a lip on both the top and bottom areas of the metal body (see top lip in diagram above)

2. Cut the wire mesh with the wire cutters so it fits inside the top mouth of the metal body. Look out for sharp edges. You may want to double up on the mesh or create two layers if the rocks at your deployment site are smaller pebbles. Screw or clamp down the mesh to the metal body. These screws/clamps need to be removable.

3. Cut the cotton so it fits in the bottom of the body with significant overlap on the sides (this overlap is so any plastics do not escape where the cotton meets the metal— it is also so that you can “scoop” the entire cotton up like a sack and take it back to the lab/classroom/home for analysis). Screw or clamp down the cotton to the metal body. These screws/clamps need to be removable.

4. In the field, shovel a hole at the high tide line to place the P.E.D. R.O.C. within. Remove the top mesh of the P.E.D. R.O.C. and shovel rocks inside. Replace the top mesh, and place the rock-filled device in the hold. Cover the device with a thin layer of rocks to keep it place. Use GIS or landmarks to ensure you can find the device later.

Figure 11: Opening the top mesh of the PED ROCK to shovel rocks into the center. Note the hole is already dug in this photo.

Figure 12 (above): Covering the PED ROC with a thin layer of rocks at the end. Many of these rocks will cover the device even more during wave action, so be sure to indicate where you've buried the device! We found that flags and lines were often buried, so we recommend triangulating landmarks and/or using GIS.
Figure 13 (below): Detail of the double mesh on the PED ROC and the rocks filled in.

5.0 Conclusion

The P.E.D. R.O.C. project has been under development since January of 2015, and over the past year the technology has evolved into the refined and accessible device described in the report. Through multiple cycles of design, testing, and revision, a successful technology has been developed while remaining true to the core ethical values established at the outset of the project. There are two further developments required:

1. Ensuring the P.E.D. R.O.C. 3.0's design includes ease of processing. Currently the rocks inside have to be rinsed and checked, which is time consuming, and the debris caught by the cotton has to be examined in details. This is a small and surmountable alternation.

2. The P.E.D. R.O.C. 3.0 must be validated in a controlled setting to ensure that it is taking a reliable sample of a known quantity of plastics. This will be conducted by CLEAR in the next 12 months, and this report will be updated. In the meantime, P.E.D. R.O.C. 3.0 is able to reliable retrieve marine microplastics from the rocky shore environment, and can provide qualitative data on the types of plastics present and their relative ratios.

The importance of accessibility and sustainability being built into the device will help to ensure the P.E.D. R.O.C.'s continued development and use by a range of potential users. Indeed, we invite users to send us details of their alterations and experiences to mliboiron@mun.ca. This device is designed to fill the vacuum that exists currently in quantification methodology for sedimentation studies on rocky or pebble coastlines. Though some protocols exist, they are not applicable to the rocky coasts typical in Newfoundland, though they have influenced the methodologies developed.

In summary, the development of the P.E.D. R.O.C. will enable researchers and citizen scientists alike to begin quantifying ocean microplastics in Canada's north and similar rocky shorelines. With clear design rationale and methodology, the project has produced notable findings. These findings are quintessential to the further development and creation of technologies used to monitor marine anthropogenic litter. This technology is crucial to the quantification of ocean microplastics, and without it shoreline studies in Canada's north will be difficult to conduct and standardize.

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Appendix A: Materials Survey Documentation


GYPROCK SCREWS
GYPROCK SCREWS
2" GYPROCK SCREWS


TOPLINE CANADA
BIKE TIRE REPAIR KIT
ENS.REPARATION DE PNEU
RED SUN
MADE IN USA
FULLER
FULLER
FULLER
FULLER
FULLER
MIBRO
Chrome Vanadium Steel
RECIPROCATING BLADES
6 TPI
SUPER


LEVOLOR
Push Broom
vileda
Mastercraft
Mastercraft
Mastercraft


Strata
Rotating sprinkler
Arrosoir rotatif
RCR
No. 99621
Garden Shed
Hose Nozzle Spray
Bec de tuyau
FORCE
SUPERSWEEP
Brosse à ramoner
7"


Lysol
CLOROX
ORIGINAL
2½ Siding NAILS
DUCHESNE
Grip Rite
Breezy


BKT2BW
FUSE
335


1½" x 1½" Hub
Abs
1½" x 1¼" Hub
1½" Abs
S TRAP
6" x 12" BM PIPE
Half Joint Pipe
BM0102


71449
BBB
$1.59
3/16 X 3
TOGGLE BOLT
marr
FUSE
Honeywell
MASTER
CONNECTEUR DE FILS
HEAVY DUTY
UTILITY HOOK


WH-2008
COLLETS POUR BOYAUX


MAITRE
MASTER
CEILING HOOK
WH-200S
COLLETS POUR BOYAUX
HOSE CLAMPS