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FLUORESCENT SIGNATURES OF MICRO-PLASTICS CONTAINED IN SEDIMENTS FROM BEACHES OF SOUTHERN LAKE MICHIGAN

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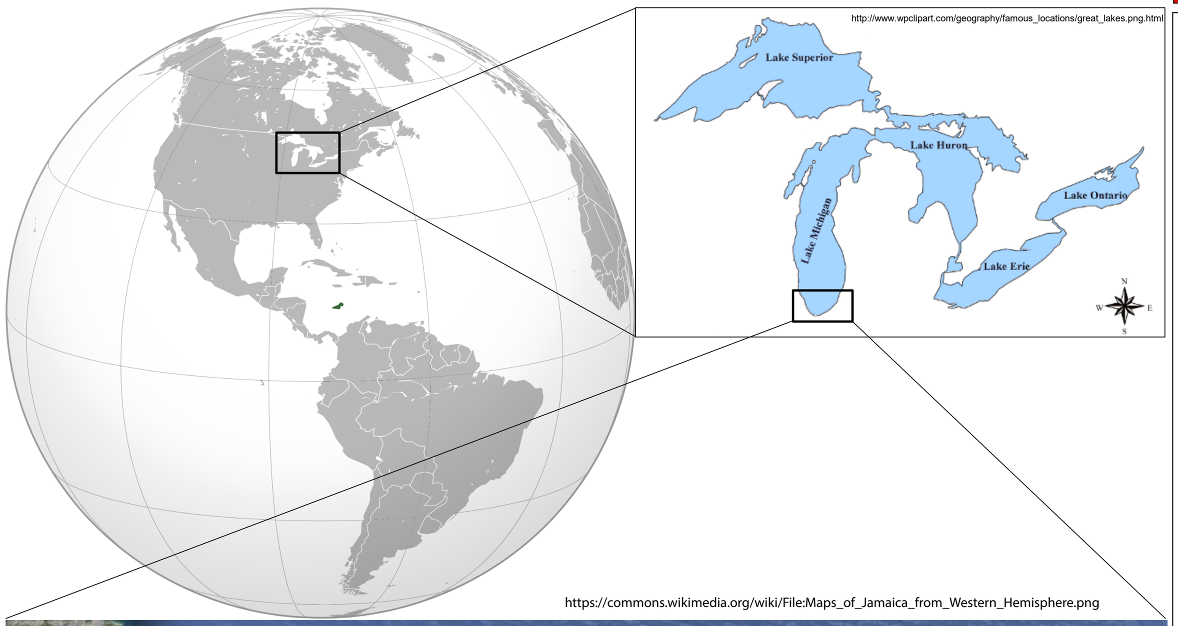


Study area along Lake Michigan, Indiana coastline. Beaches from lower left to right: Whihala, Marquette, Portage Lakefront, Porter, Dunbar and Central. Chicago is shown in upper left as point of reference.

ABSTRACT

Various plastic materials were the primary type of anthropogenic debris collected along strand line at Indiana beaches of southern Lake Michigan. We assume that this macro-plastics material will degrade into micro-plastics and mix with a natural beach sediment. In addition to this, some micro-plastics that is used in cosmetics and other industries is released into the environment. Examining sediment samples from beaches of southern Lake Michigan with a fluorescent microscope may help to determine if they contain micro-plastics. We examined small fragments (<2mm) of known plastics to determine their behavior under red (650nm), green (510nm) and blue (475nm) fluorescence. Plastic materials were ground to powder or cut in micro-particles (< 2 mm), mixed with sand and examined under microscope. This same material was made into thin sections and examined with microscope. Hard plastics such as that found in mouthpieces from swisher cigars have strongest green fluorescence. Disposable water bottles have strongest blue fluorescence. Styrofoam has a very weak fluorescent signal and is detectable under blue light. Most common waste, plastic bags, could not be detected with fluorescent light. Household products such as soaps that contain micro-plastics have strongest red fluorescence. Larger (2-3mm in diameter) recognizable plastic spherules also have a bright red signature under fluorescent light. Both cut and ground plastic have strong fluorescent signature. Plastic mixed with sediment in thin sections are not as obvious as in loose sample examination, probably due their loss during thin sectioning process. Once we established fluorescent signatures database of common plastics, we examined swash line beach sediment under the fluorescent microscope and found that in some areas up to 6% of fluorescent particles were present. When examined under plain light these particles did not differ from the rest of grains. We conclude that fluorescence microscopy is a very powerful tool in detecting micro-plastics in sediments that otherwise might look natural and environmentally clean. Our future work would include quantification of micro-plastics present in beach sediments during various seasons.

Macroanthropogenic material in strandline.

INTRODUCTION

Currents along Lake Michigan lead to the transportation and deposition of sand along the beaches of Indiana. These currents also carry contaminants such as plastic debris that is floating in the lake, and eventually settles on the lake bottom or accumulates on the beaches. Evidence of plastic debris can be found along the strand line after storms. Various plastic materials including bags, smoking related material, bottles, bottle caps, and personal hygiene items were the primary type of anthropogenic debris collected along strand line at five Indiana beaches (Whihala, Marquette Park, Portage Lakefront and Riverwalk, Porter, and Dunbar) of southern Lake Michigan during the initial phase of this study. We assume that this macro-plastics material will degrade into micro-plastics and mix with a natural beach sediment. In addition to this, some micro-plastics that is used in cosmetics and other industries is released into the environment. Certain materials have a particular fluorescent signature. By observing and recording the fluorescent behavior of plastics found along the strand line, it may be possible to create a visual catalog of microplastics that can help to identify micro-plastics contained within beach sediment.

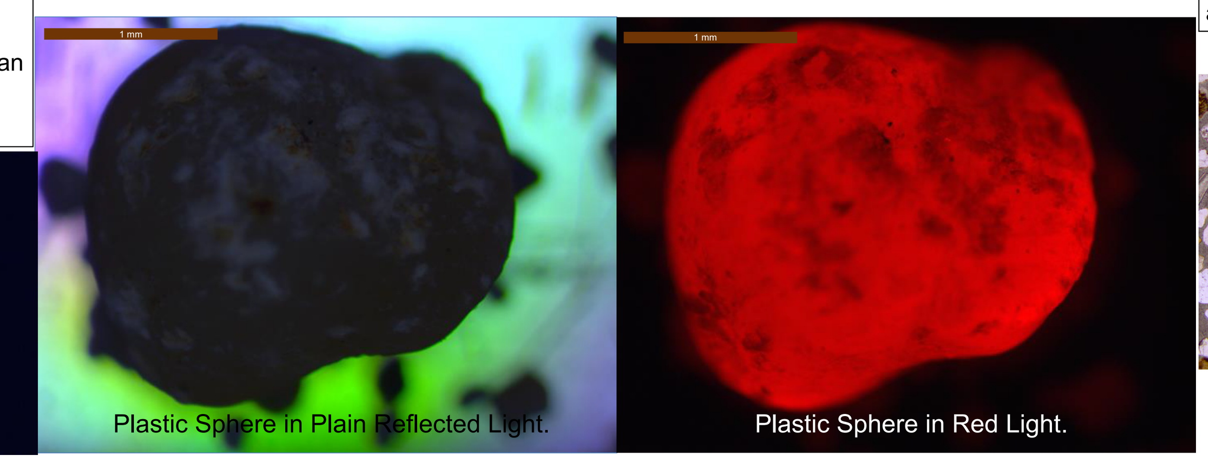
METHODS

This study began in September of 2014 by monitoring and collecting plastic debris on the southern Lake Michigan beaches. Five beaches were selected for the monitoring of strandlines following storms. In the initial phase of the study macro anthropogenic material was collected, as well as surficial (approx. 1 cm depth) sediment samples, sample collection was performed at specific five meter segments of each beach. The macro-plastics and sediment samples were placed into separate sealed bags. Once in the laboratory the macro-plastics where washed with clean tap water and then separated into eight different categories following classification by Laglbauer et al., 2014. Surficial sediment samples, were dried, weighed, and sieved through a series of screens ranging from 2mm to 0.06mm.
The second phase of the study has focused on locating micro-plastics within surficial sediment samples. Samples were obtained by two different methods. The first method continued to collect surficial sediment samples with a trowel along five meter long segments of the strandline after storm activity. In the second method surficial samples were obtained from three 30 cm^2 plots spaced equally between the strandline and water line. The second method was abandoned due to large amounts of sediment obtained with no additional information compared to our first method.

We used Cargille density liquid to separate natural sediment from micro-plastics. Microbeads from commercial cosmetic products were separated from solution, washed with distilled water, and dried. Sediments as well as known plastics were then studied with fluorescent microscope to determine their fluorescent signal. Scanning electron microscope (SEM) was used to make images of fluorescent materials found in sediment samples.

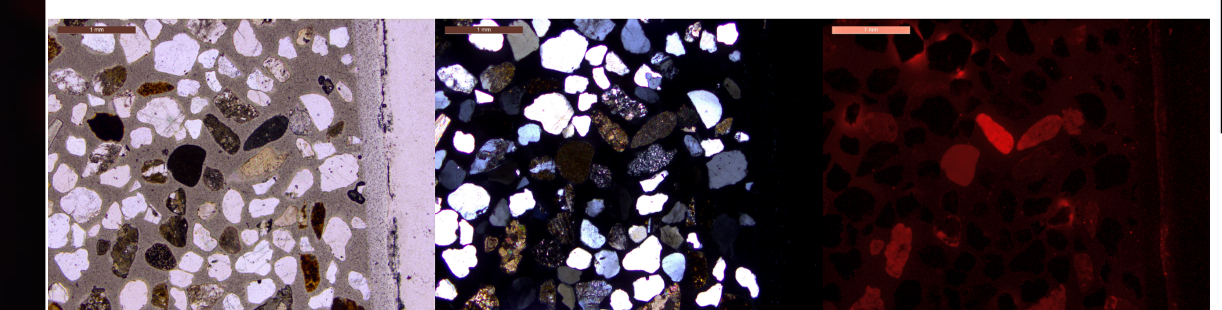
In the next phase of our study thin sections were created from shredded plastic products, which are common in the macro-plastics found along the strandline. The thin sections were produced by mixing clean sand with filed or cut plastic particles. Images in plain light as well as fluorescent light were obtained in order to develop visual catalog of microplastics characteristics.

Plastic spheres found along strandline, taken at Dunbar Beach on September 17th, 2015. These spheres, which have 2 - 3 mm average diameter, are easily found along the strandline on all of the beaches being studied.



Discussion

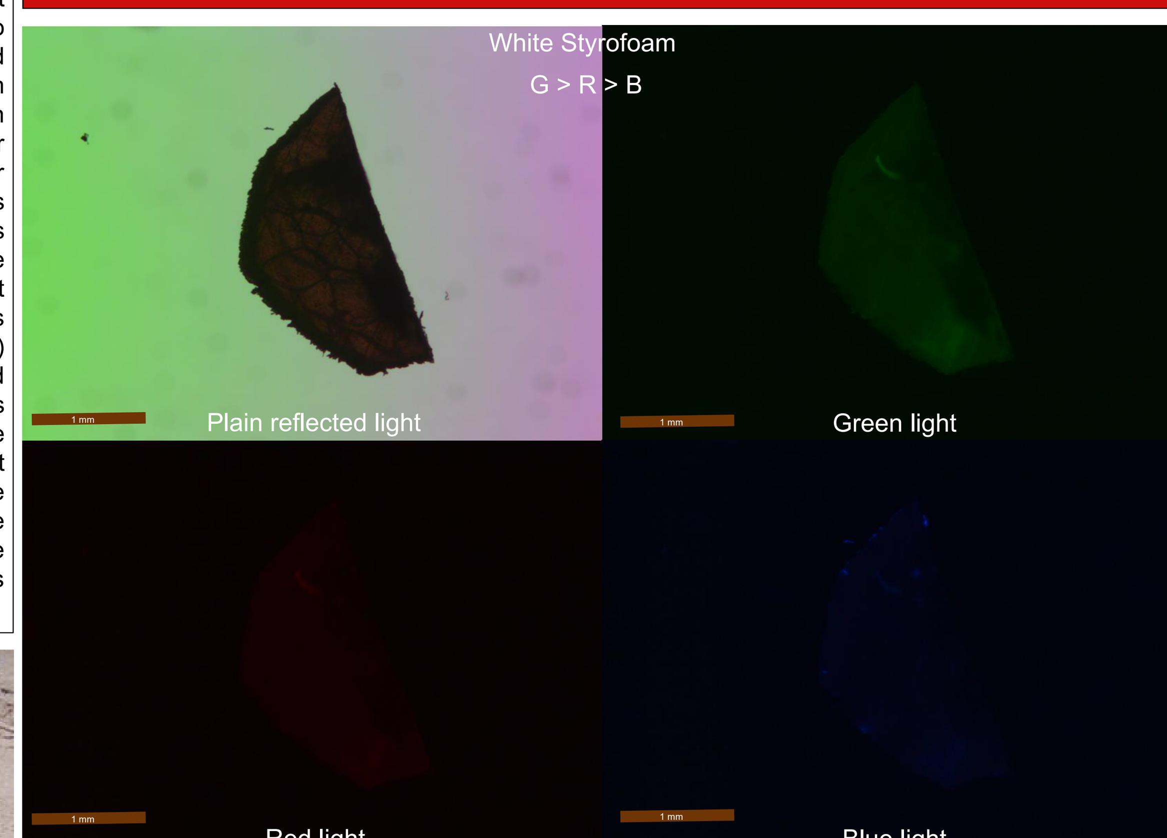
Lake Michigan longshore currents lead to the deposition of sediments at its southern end along the Indiana shoreline. Plastic floating in the lake is carried along with the sediments and can be found along the strandline. We believe that the macro-plastic in the lake will eventually wear down into micro-plastic and that these micro-plastics as well as those contained in various materials such as cosmetics will be deposited and accumulate along the shoreline. The hypothesis of this study is that by analyzing surficial sediment taken from the strandline after storm activity we may be able to determine the presence and possible amount of micro-plastic that is found along the shoreline, which may then be used to determine the amount of micro-plastic floating in the lake.
Cargille Heavy Liquids Density 2.2 ±0.005 gm/cc 23°C where originally used to try and separate natural clasts from anthropogenic material. This method was abandoned due to rafting of the natural clasts. Believing that fluorescent microscopy may provide a way of identifying micro-plastics within sediment samples, several samples from the strandline where placed under fluorescent microscope. About 6% of material was found to have fluorescent signature. Some of fluorescent material may be natural such as carbonates but when carbonates where placed alongside known micro-plastics under fluorescent microscope the micro-plastics were found to have brighter signal. Samples of fluorescent material where then later confirmed as non carbonates by using scanning electron microscope. Based on these findings we have gone on to try and compile a visual database of the fluorescent signature of the most common plastic items in our strandline study. Shredded plastic from these plastic items has been placed under the fluorescent microscope by itself, as well as mixed with natural sediment. Placing thin sections of the plastic/sediment mixes under fluorescent and petrographic microscope resulted in definite visible fluorescent signature. We believe that the fluorescent microscope provides a way to identify micro-plastic among natural sediment.

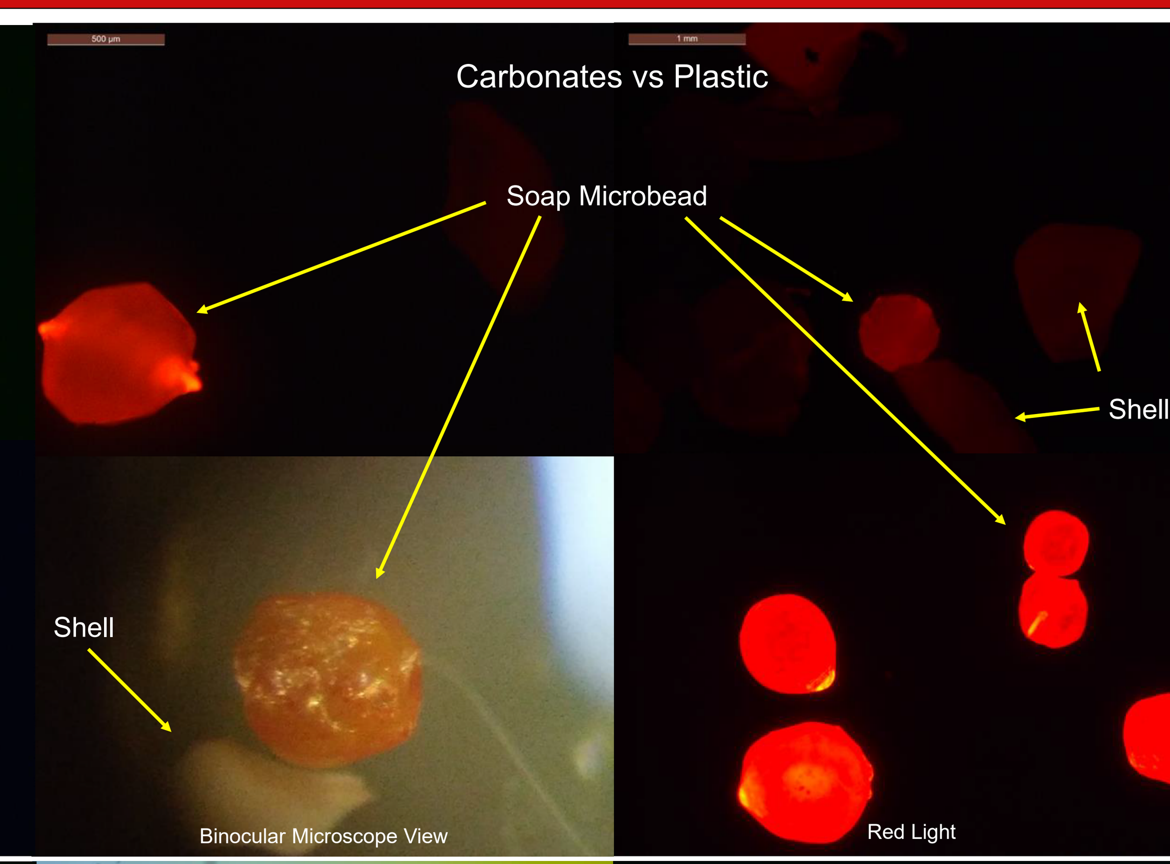


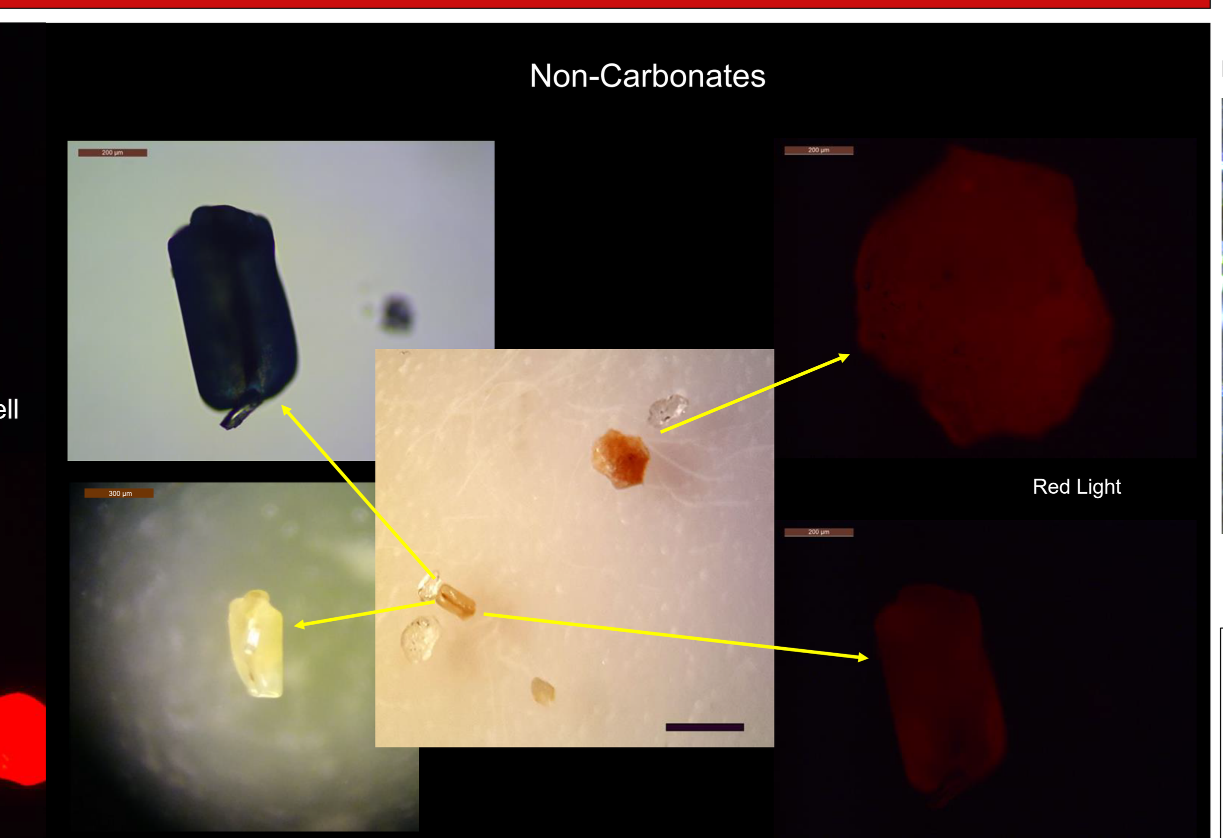
Thin section images of beach sediment in plain, x-polars, and red fluorescent light.

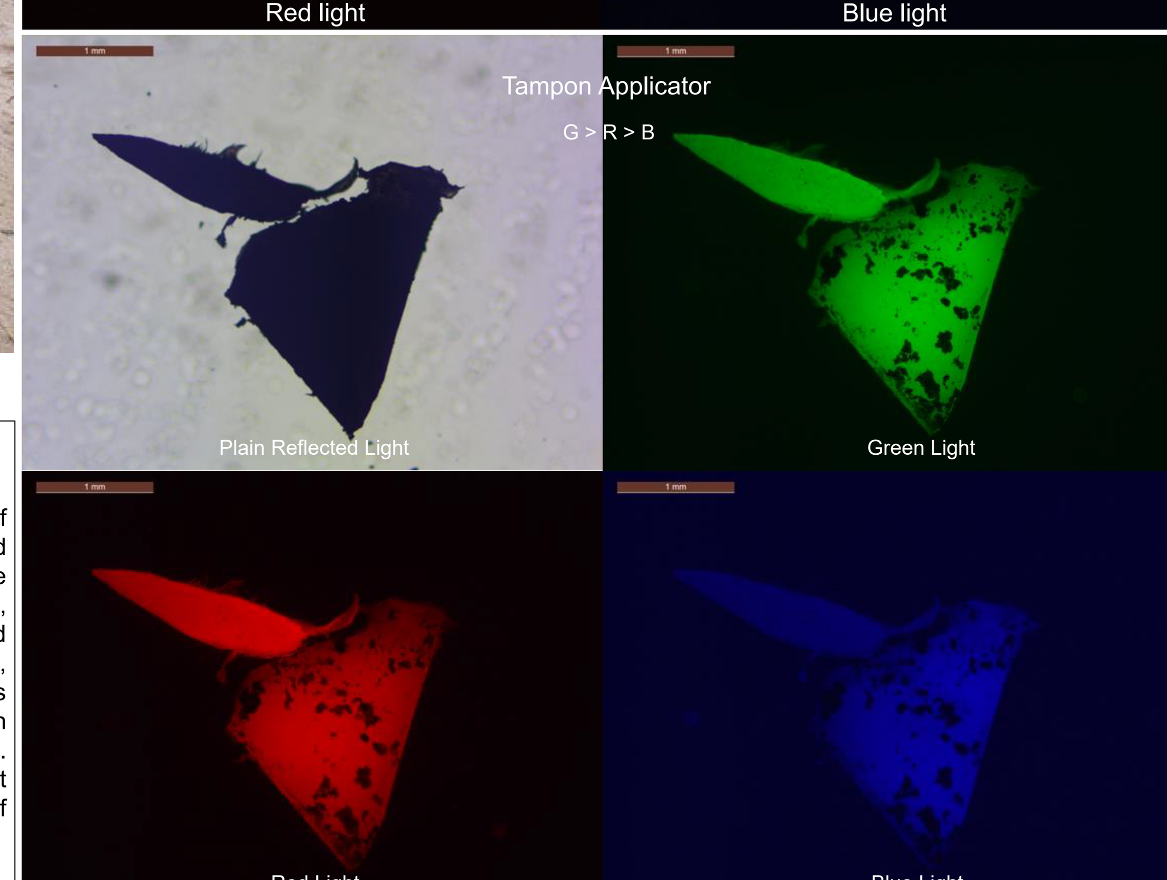
RESULTS

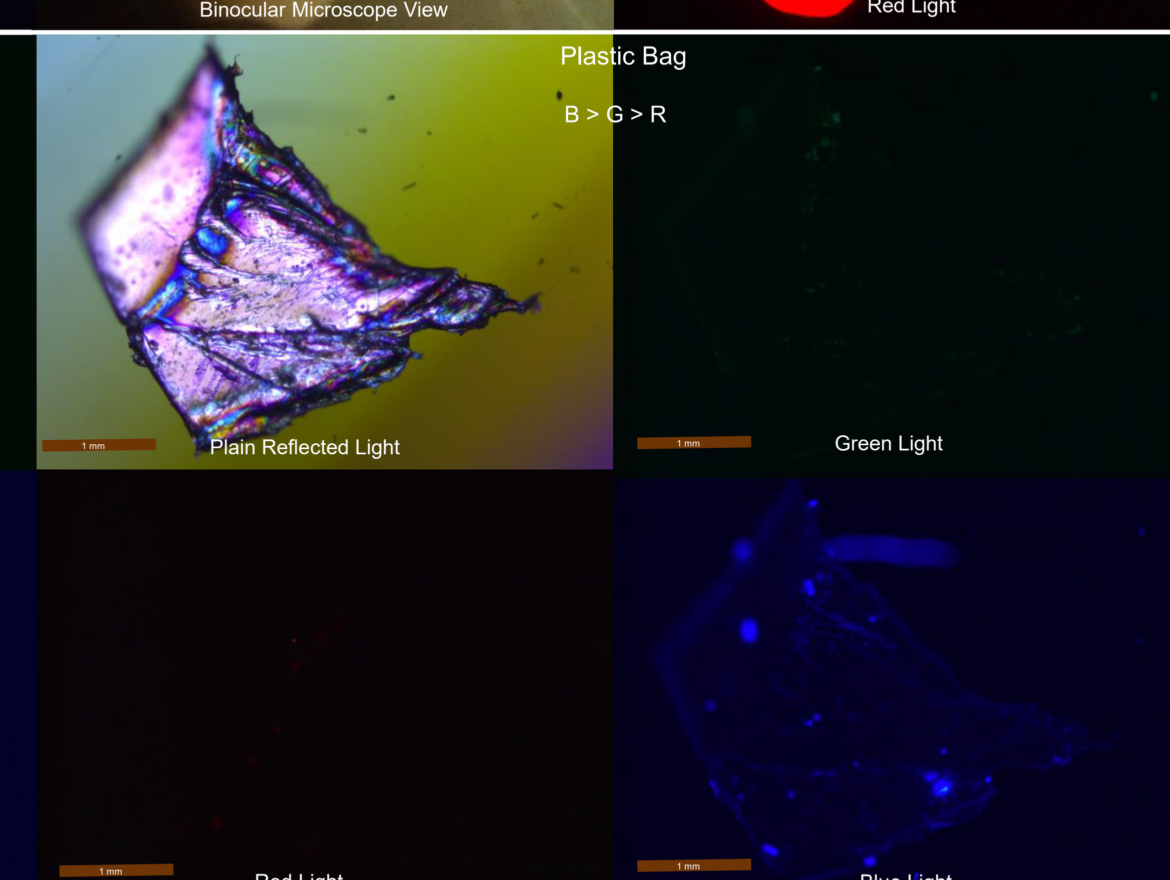
Visual Characteristics of Known Plastics Under Fluorescence

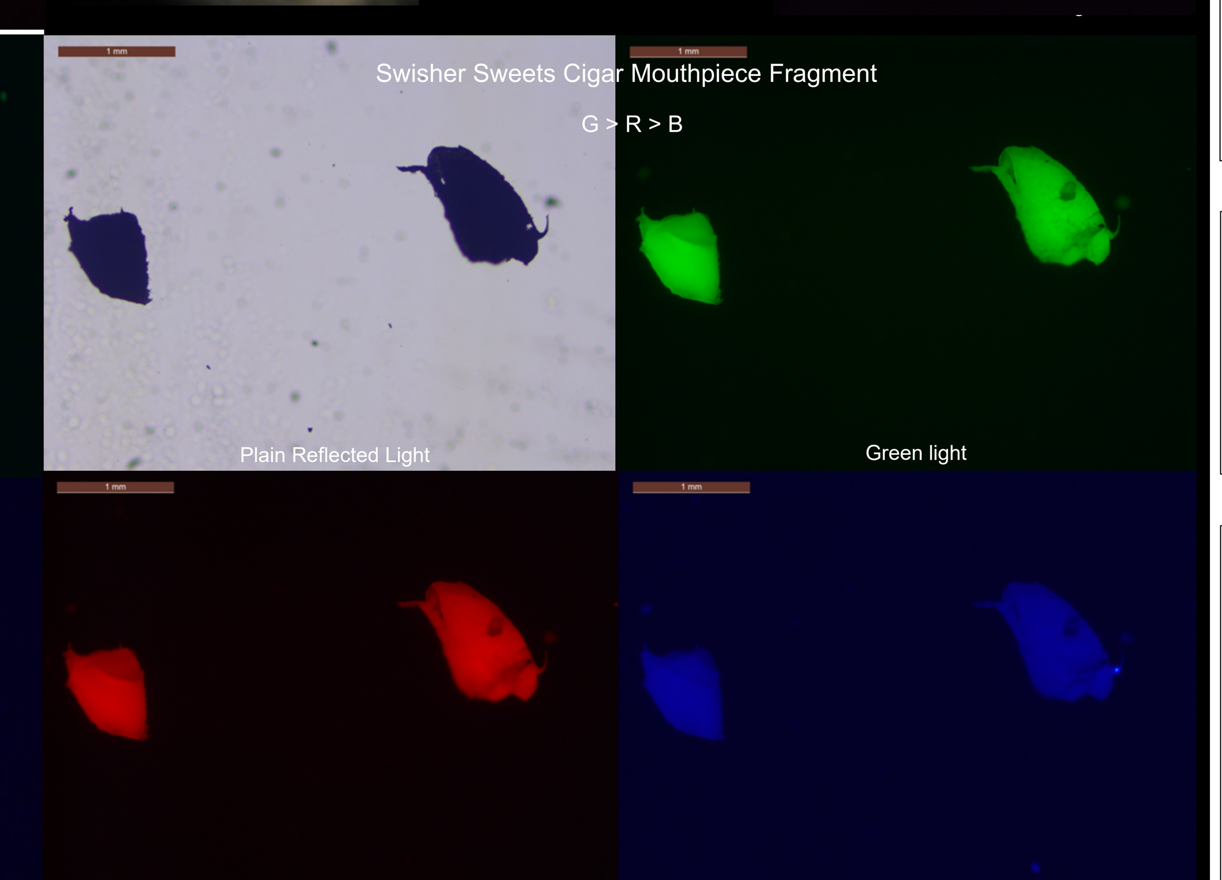


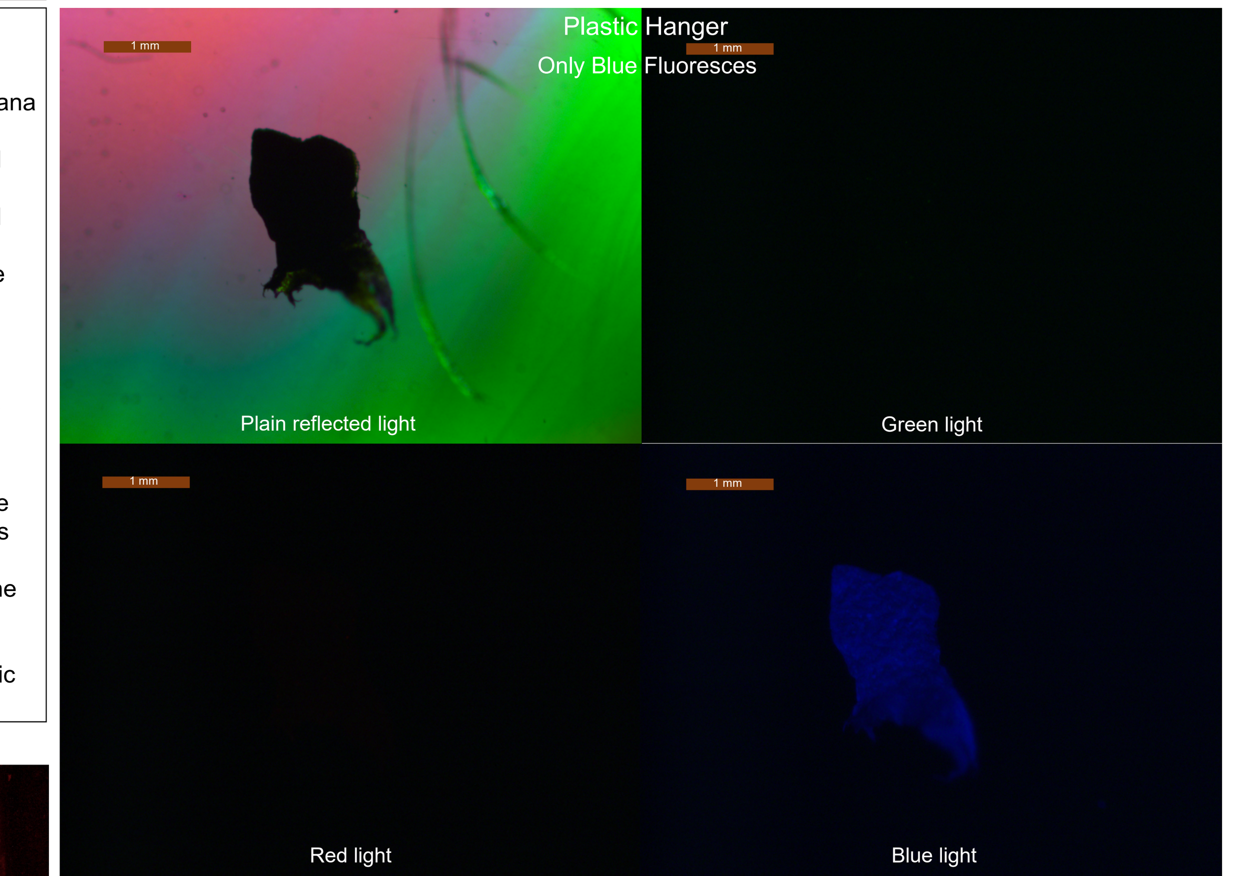


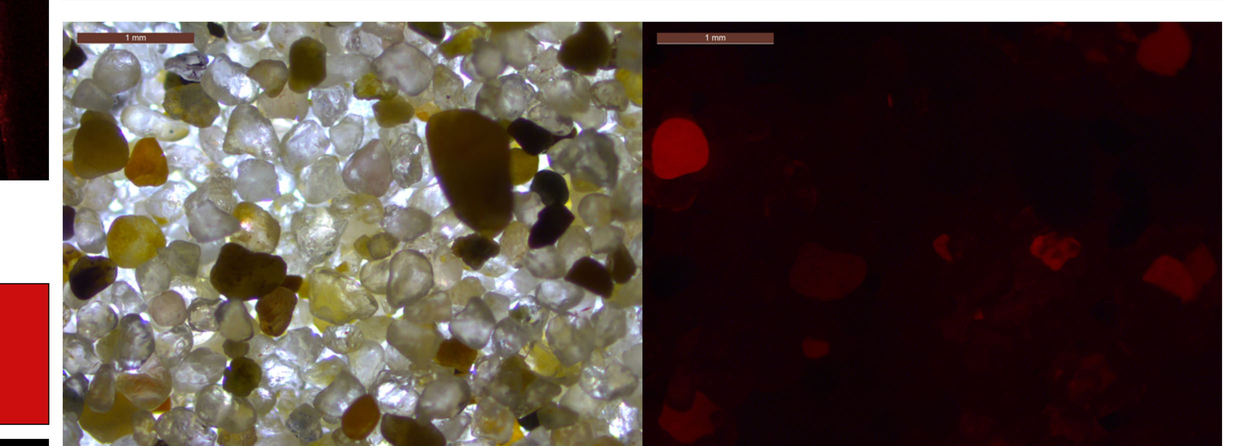




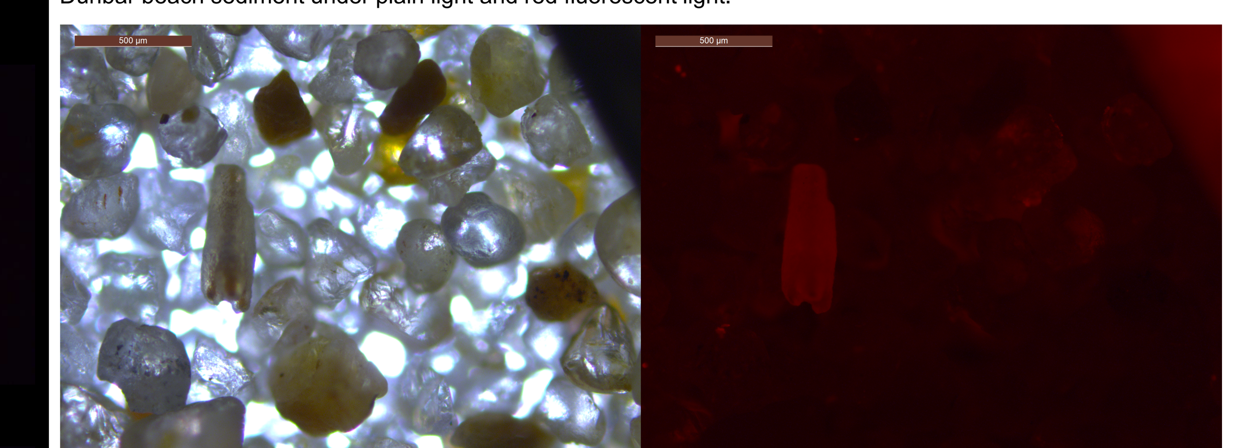








Dunbar beach sediment under plain light and red fluorescent light.



Marquette Beach sediment sample under plain light and red fluorescent light.

CONCLUSION

Fluorescence microscopy can be powerful tool in detecting micro-plastics in sediment that otherwise might look environmentally clean. Although some natural sediments such as carbonates have fluorescent properties their signature is different in intensity then that of micro-plastics. By identifying the fluorescent signature of the most common plastics it will be possible to identify them among natural sediment.
Future work would include: 1) Quantification of micro-plastics present in beach sediments during various seasons as well as following major storms. 2) The possible use of handheld UV light sources to detect micro-plastics on location at the beach. 3) The continued expansion of the fluorescent light signature database.

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