Florida Microplastic Awareness Project: A Citizen Science Initiative

Florida Microplastic Proyecto de Concientización: Una Iniciativa de Ciencia Ciudadana

Florida Microplastic Project de Vulgarisation: Una Iniciative Citoyenne de Science

MAIA P. MCGUIRE[1]* and R. LEROY CRESWELL[2]
[1]*University of Florida Sea Grant, 150 Sawgrass Road, Bunnell, Florida 32110 USA. *mpmcg@ufl.edu*
[2]*University of Florida Sea Grant, 2199 South Rock Road, Fort Pierce, Florida 34945 USA.*

ABSTRACT

Plastic pollution in the oceans is an increasing environmental and fisheries problem. Microplastics (plastic pieces smaller than 5 mm in size) are being found in fish and invertebrates. The Florida Microplastic Awareness Project aims to raise awareness about microplastics, in part by having citizen scientists collect and analyze coastal water samples for the presence of microplastics. Volunteers and others in the community are asked to reduce their consumption/disposal of plastics.

Sixteen coordinators around the state give presentations about microplastics to potential volunteers, then conduct hands-on trainings to show water collection and analysis techniques. Volunteers are asked to collect at least four samples during the year, filter them and observe the filters to count the number of pieces of plastic present. Data are used to populate a Google Map. People are asked to take a pledge to reduce their plastic waste.

Data from over 800 water samples show that 89% contain at least one plastic item. On average, there are 7.7 pieces of plastic in a liter of coastal water. 83% of the plastic items are fibers/filaments. On average, people are pledging to make 3.5 of the suggested eight behavior changes to reduce plastic waste. In follow-up surveys, people are reporting having made an average of three behavior changes.

People learning about microplastics are willing to take steps to reduce their contribution to the problem, but improvements in wastewater treatment plant filtration technology may be needed to address this issue.

KEYWORDS: Microplastics, citizen science, pollution, marine debris

INTRODUCTION

Microplastics, defined as pieces of plastic less than 5 mm in size (Arthur et al. 2009), are becoming ubiquitous in the marine environment (Andrady 2011, Cole et al. 2011, Eriksen et al. 2013, Browne et al. 2014, Desforges et al. 2014, Zhao et al. 2015). There are two main types of microplastics: secondary microplastics form from the degradation of larger pieces of plastic, while primary microplastics are deliberately manufactured. Many of the manufactured microplastics (e.g. polyethylene "microbeads") are ingredients in some toothpastes, many facial scrubs and body washes, as well as makeup products, deodorants and other personal care products (Household Products Database 2014). Wastewater treatment plants are not capable of removing these very small, floating plastics, so the plastics are discharged as part of the treated effluent (Eriksen et al. 2013, Leslie et al. 2013, Murphy et al. 2016).

In the ocean, plastics can serve as vectors for the transport of persistent organic pollutants (Mato et al. 2001, Teuten et al. 2007, Hirai et al. 2011, Engler 2012). Some of the chemicals used in the manufacture of plastics (bisphenol A, phthalates) are known to be weakly estrogenic (e.g. Jobling et al. 1995, Feldman 1997). However, the in vivo impacts of exposure to these chemicals are not well understood and may depend on the type of organism being studied (e.g. Vethaak et al. 2008).

Microplastics can be consumed by many marine organisms, including zooplankton (Setälä et al. 2014), corals (Hall et al. 2015), bivalves (Browne et al. 2008, Farrell and Nelson 2013, Van Cauwenberghe and Janssen 2014, Li et al. 2015, Rochman et al. 2015, Sussarellu et al. 2016), fishes (Boerger et al. 2010, Lusher et al. 2013, Costa and Barletta 2015. Rochman et al. 2015. Lönnstedt and Eklöv 2016), sea turtles and birds (Costa and Barletta 2015). Toxins, both those adsorbed to the plastic's surface and those contained within the plastic, can be found in the tissues of organisms that have consumed plastics (Browne et al. 2013, Rochman et al. 2013, Tanaka et al. 2013).

Jambeck et al. (2015) estimated that between 4.8 and 12.7 million metric tons of plastic entered the ocean (worldwide) in the year 2010. They further predict that this amount will increase by an order of magnitude by the year 2025. Since petroleum-based plastic does not biodegrade (rather, it breaks down into smaller and smaller fragments over time), plastic pollution, especially microplastics, is a growing concern among ocean scientists (

Many Florida residents are aware that plastic pollution in the ocean is a problem, but many associate this issue with the "Great Pacific Garbage Patch" and are unaware that plastics are also a problem in the Atlantic, much less in Florida's coastal waters. The Florida Microplastic Awareness Project (FMAP) is a citizen science effort (funded by a 2015 NOAA Marine Debris Program Outreach and Education Grant) that was designed to have people learn for themselves how prevalent plastics (specifically those less than 5 mm in size) are in Florida's marine environment. FMAP has two main goals:

i) To train citizen scientists to look for the presence of microplastics in Florida coastal waters, and
ii) To teach people ways to reduce their personal contribution to microplastic pollution (in part by selecting and using personal care products that do not contain polyethylene.)

METHODS

FMAP volunteers were organized by regional coordinators in sixteen locations around the state of Florida. These citizen scientists sampled and analyzed water from along the majority of the Florida coastline from Pensacola in the western panhandle, to Key West, to Amelia Island in northeast Florida (Figure 1). The methods for the collection and analysis of samples are based on those used by Adventure Scientists (Abby Barrows, pers. comm.).

Volunteers were asked to avoid wearing synthetic fabrics when collecting and analyzing samples to try and prevent contamination. They triple-rinsed a one-liter Nalgene bottle (and lid) at the sampling site, then filled the bottle with surface water, capping the bottle underwater. They recorded the GPS coordinates for the location, date and bottle number on their data sheet. It was found that samples were easier to filter if they were allowed to sit for at least a week (out of direct sunlight) after collection.

Filtered (0.45 µm) water was prepared and used to prerinse filtration equipment. Samples were vacuum filtered through gridded 0.45 µm mixed cellulose ester membrane filters. The filter holder was almost completely covered with a petri dish while the sample was being filtered to minimize contamination by airborne fibers. Filters were placed in covered petri dishes and examined at 20-40 times magnification using a dissecting microscope. Positive identification of plastic fibers was confirmed using a hot needle (Abby Barrows, pers. comm.) Plastic items seen on the filter were categorized as either fibers, fragments, microbeads, or film.

For the outreach component of the project, members of the public who attended educational events were asked to take a pledge (available online or in paper form at outreach events.) In the pledge, people could indicate if they already did a particular action, or if they were willing to do it. The actions are all ways of reducing one's personal contribution to plastic waste. The eight actions suggested were:

i) Read labels on personal care products and avoid products containing polyethylene,
ii) Use paper or reusable shopping bags instead of single use plastic ones,
iii) Avoid using plastic drinking straws,
iv) Bring my own water bottle instead of buying single-use plastic water bottles,
v) Bring my own washable coffee/hot drink cup instead of using foam,
vi) Use foil or a washable container as a "to go" box at restaurants, or for packing lunches,
vii) Recycle as many plastic items (those with the triangular recycle logo) as possible, and
viii) Choose more natural fabrics instead of microfiber, nylon, acrylic, polyester or polypropylene.

If people provided their email addresses, they were contacted within three months with a follow-up survey to assess which behavior changes they had made since learning about microplastics.

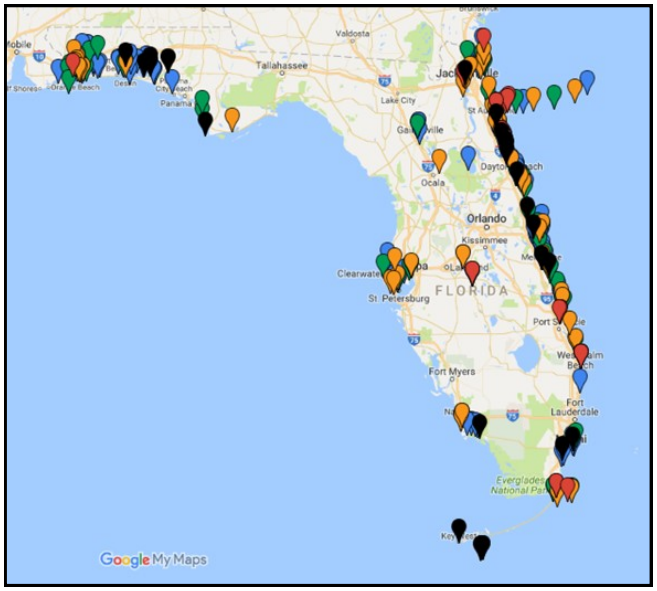

Figure 1. Map showing microplastic collection locations. Pin colors denote the number of plastic pieces found in 1 liter of water (black = 0; blue = 1-5; green = 6-10; orange = 11-20; red = 20+).

RESULTS

Between September 2015 and December 2016, 161 volunteers collected and analyzed 851 water samples from 311 locations around Florida. The majority of these water samples (89%) contained at least one piece of plastic. On average, there were 7.7 +/- 11.0 pieces of plastic per liter of water (Figure 2). The largest number of pieces of plastic in a single liter was 164. The plastic in the samples was primarily (83%) in the form of microscopic fibers (Figure 3). Microbeads (from facial scrubs and other personal care products) comprised only a small portion of the plastics found (6%). This number might be slightly high as it was discovered that some volunteers were mistaking planktonic diatoms for microbeads.

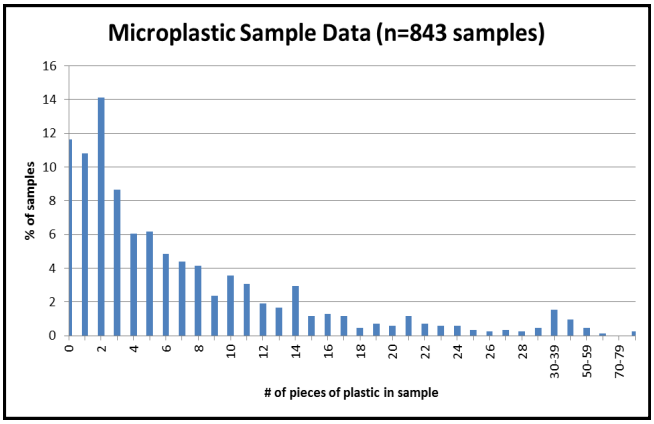

Figure 2. Graph showing frequency with which plastic was found in samples. One extreme (164 pieces of plastic) was omitted from the graph because of scale. That sample was collected a few days after the passage of Hurricane Matthew in northeast Florida.

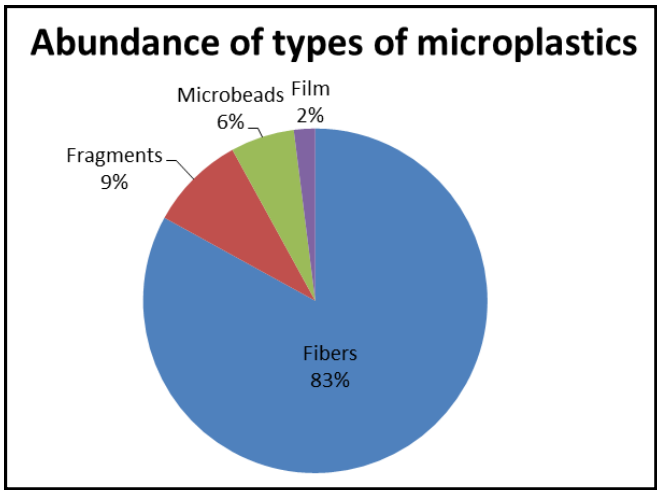

Figure 3. Relative abundance of the different groups of microplastics found in the Florida Microplastic Awareness Project samples.

A total of 893 people completed the Florida Microplastic Awareness Project's pledge. 29 people (3.2%) were already taking all eight suggested actions to reduce plastic waste. Eight people (0.9%) did not indicate a willingness to make any behavior changes to reduce their plastic waste. On average, people pledged to make 3.4 behavior changes.

39% of pledge takers provided valid e-mail addresses for follow-up surveys. 88 people responded to follow-up surveys. This was a response rate of 25%. 90% of respondents indicated that they had made at least one behavior change to reduce their plastic waste production. It is possible that some respondents were already using all of the suggested behaviors prior to the follow-up surveys. On average, people reported having made three behavior changes. 85% reported having shared information about microplastics with others.

From the original pledge data, most people (64%) indicated that they were willing to read labels on personal care products (like body wash, deodorant, toothpaste, facial scrub, makeup) and avoid products containing polyethylene. 55% were willing to bring their own foil or washable container to use as a "to go" box at restaurants, or pack lunch contents in reusable containers instead of single-use bags. 49% said they would avoid the use of plastic drinking straws and 39% said they would try to choose more natural fabrics rather than microfiber or other synthetic fabrics (acrylic, nylon, polyester, polypropylene).

In the follow-up pledge, 68% of people reported having read labels on personal care products (like body wash, deodorant, toothpaste, facial scrub, makeup) and avoided products containing polyethylene. Almost as many (61%) reported avoiding the use of disposable drinking straws. Other commonly-taken actions included:

i) Bringing their own reusable water bottle/cup instead of buying single-use plastic water bottles (44%),
ii) Recycling as many plastic items (those with the triangular recycle logo) as possible (44%),
iii) Use paper or reusable shopping bags instead of single use plastic ones (39%), and
iv) Bringing their own washable coffee/hot drink cup instead of using a disposable one (38%)

Other actions that people stated having taken included the following:

i) "Trying to be more aware of where I cut plastics such as PVC pipe and PVC sheets when I'm close to marine environments."
ii) "I have tried not to use plastic silverware."
iii) "I look closely for plastic at the beach and always pick it up."

CONCLUSIONS

It was somewhat surprising to find how common the microplastic fibers were (and how much more abundant than fragments, film and microbeads) in our Florida project. This methodology used differs from that used by ocean/Great Lakes researchers, who use manta trawls, typically with mesh sizes of 333 or 100 µm, that are towed over large areas (data are reported as number per km²). Our method samples a relatively small volume/surface area of water (one liter) but captures all microplastics on the 0.45 µm filter. As found by Barrows et al. (2017), we likely captured proportionally more fibers in our samples than the ocean studies, and were probably less likely to capture the larger plastic items (film, fragments and microbeads) in our bottles. The Florida Microplastic Awareness Project has revealed the abundance and distribution of microplastics around the Florida coastline.

The Florida Microplastic Awareness Project provides the first comprehensive set of data for microplastics in coastal Florida waters. The citizen science volunteers have often become passionate advocates for plastic waste reduction after seeing for themselves how much plastic is in their local waterways.

Responses to the pledge were very positive. Many people commented that they had never thought to do certain actions recommended in the pledge (and that is reflected in the actions that were most commonly pledged.) The results of the follow-up surveys were also positive, with people reporting having made almost as many behavior changes as had been pledged. The types of behavior changes reported did not completely match the types that were most commonly pledged. This could be because people are not faced with some of the actions (e.g. bringing foil or reusable containers to use as "to go" boxes, or choosing natural fabrics rather than synthetics) as frequently as others (e.g. refusing a drinking straw or using reusable water bottles or washable hot drink containers).

LITERATURE CITED

Andrady, A.L. 2011. Microplastics in the marine environment. *Marine Pollution Bulletin* **62**: 1596-1605.

Arthur, C., J. Baker, and H. Bamford. 2009. Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris. Sept 9-11, 2008. NOAA Technical Memorandum NOS-OR&R-30.

Barrows, A.P.W., C.A. Neumann, M.L. Berger, and S.D. Shaw. 2017. Grab *vs.* neuston tow net: a microplastic sampling performance comparison and possible advances in the field. *Analytical Methods* http://DOI: 10.1039/C6AY02387H.

Boerger, C.M., G.L. Lattin, S.L. Moore, and C.J. Moore. 2010. Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. *Marine Pollution Bulletin* **60**:2275-2278.

Browne, M.A., A. Dissanayake, T.S. Galloway, D.M. Lowe, and R.C. Thompson. 2008. Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, *Mytilus edulis* (L.). *Environmental Science &Technology* **4**2:5026-5031.

Browne, M.A., S.J. Niven, T.S. Galloway, S.J. Rowland, and R.C. Thompson. 2013. Microplastic Moves Pollutants and Additives to Worms, Reducing Functions Linked to Health and Biodiversity. *Current Biology* **23**:2388-2392.

Cole, M., P. Lindeque, C. Halsband, and T. Galloway. 2011. Microplastics as contaminants in the marine environment: A review. *Marine Pollution Bulletin* **62**:2588-2597.

Costa, M.F. and M. Barletta. 2015. Microplastics in coastal and marine environments of the western tropical and sub-tropical Atlantic Ocean. *Environmental Science Processes & Impacts* **17**:1868-1879.

Desforges, J.-P.W., M. Galbraith, N. Dangerfield, and P.S. Ross. 2014. Widespread distribution of microplastics in subsurface seawater in the NE Pacific Ocean. *Marine Pollution Bulletin***79**:94-99.

Engler, R.E. 2012. The complex interaction between marine debris and toxic chemicals in the ocean. *Environmental Science &Technology* **46**:12302-12315.

Eriksen, M., S. Mason, S. Wilson, C. Box, A. Zellers, W. Edwards, H. Farley, and S. Amato. 2013. Microplastic pollution in the surface waters of the Laurentian Great Lakes. *Marine Pollution Bulletin* **77**:177-182.

Farrell, P., and K. Nelson. 2013. Trophic level transfer of microplastic: *Mytelus edulis* (L.) to *Carcinus maenas* (L.). *Environmental Pollution* **177**:1-3.

Feldman, D. 1997. Editorial: Estrogens from Plastic—Are We Being Exposed? *Endocrinology* **138** (5):1777-1779.

Hall, N.M., K.L.E. Berry, L. Rintout, and M.O. Hoogenboom. 2015. Microplastic ingestion by scleractinian corals. *Marine Biology* **162**:725 http://DOI 10.1007/s00227-015-2619-7.

Hirai, H., H. Takada, Y. Ogata, R. Yamashita, K. Mizukawa, M. Saha, C. Kwan, C. Moore, H. Gray, D. Laursen, E.R. Settler, J.W. Farrington, C.M. Reddy, E.E. Peacock, and M.W. Ward. 2011. Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. *Marine Pollution Bulletin* **62**:1683-1692.

Household Products Database. U.S. National Library of Medicine. August, 2014. Web. 16 Dec. 2016.

Jambeck, J., R. Geyer, C. Wilcox, T.R. Siegler, M. Perryman, A. Andrady, R. Narayan, and K.L. Law. 2015. Plastic waste inputs from land into the ocean. *Science* **347** (6223):768-771. http://DOI: 10.1126/science.1260352.

Jobling, S., T. Reynolds, R. White, M.G. Parker, and J.P. Sumpter. 1995. A variety of environmentally persistent chemicals, including some phthalate plasticizers, are weakly estrogenic. *Environmental Health Perspectives* **103**(6):582-587.

Leslie, H.A., M.J.M. van Velzen, and A.D. Vethaak. 2013. Microplastic survey of the Dutch environment. *Novel data set of microplastics in North Sea sediments, treated wastewater effluents and marine biota*. Web. 16 Dec. 2016.

Li, J., D. Yang, L. Li, K. Jabeen, and H. Shi. 2015. Microplastics in commercial bivalves from China. *Environmental Pollution* **207**:190-195.

Lönnstedt, O.M., and P. Eklöv 2016. Environmentally relevant concentrations of microplastic particles influence larval fish ecology. Science **352** (6290):1213-1216. http://DOI: 10.1126/science.aad8828.

Lusher, A.L., M. McHugh, and R.C. Thompson. 2013. Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. *Marine Pollution Bulletin* **67**:94-99.

Mato, Y., T. Isobe, H. Takada, H. Kanehiro, C. Ohtake, and T. Kaminuma. 2001. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. *Environmental Science & Technology* **35**:318-324.

Murphy, F., C. Ewins, F. Carbonnier, and B. Quinn. 2016. Wastewater treatment works (WwTW) as a source of microplastics in the aquatic environment. *Environmental Science & Technology* **50**:5800-5808.

Rochman, C., E. Hoh, T. Kurobe, and S.J. Teh. 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. *Scientific Reports* **3**:3263. http://DOI:10.1038/srep03263.

Rochman, C.M., A. Tahir, S.L. Williams, D.V. Baxa, R. Lam, J.T. Miller, F.-C. Teh, S. Werorlangi, and S.J. Teh. 2015. Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Scientific Reports* **5**:14340. http://DOI: 10.1038/srep14340.

Setälä, O., V. Fleming-Lehtinen, and Maiju Lehtiniemi. 2014. Ingestion and transfer of microplastics in the planktonic food web. *Environmental Pollution* **185**:77-83.

Sussarellu, R., M. Suquet, Y. Thomas, C. Lambert, C. Fabioux, M. E. J. Pernet, N. Le Goïc, V. Quillien, C. Mingant, Y. Epelboin, C. Corporeau, J. Guyomarch, J. Robbens, I. Paul-Pont, P. Soudant, and A. Huvet. 2016. Oyster reproduction is affected by exposure to polystyrene microplastics *Proceedings of the National Academy of Sciences of the United States of America* **113** (9): 2430-2435

Tanaka, K., H. Takada, K. Mizukawa, M. Fukuwaka, and Y. Watanuki. 2013. Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics. *Marine Pollution Bulletin* **69**:219-222.

Teuten, E., S.J. Rowland, T.S. Galloway, and R.C. Thompson. 2007. Potential for Plastics to Transport Hydrophobic Contaminants. *Environmental Science & Technology* **41**:7759-7764.

Van Cauwenberghe, L. and C.R. Janssen. 2014. Microplastics in bivalves cultured for human consumption. *Environmental Pollution* **193**:65-70

Vethaak, A.D., J. Lahr, S.M. Schrap, A.C. Belfroid, G.B.J Rijs, A. Gerritsen, J. de Boer, A.S. Bulder, G.C.M. Grinwis, R.V. Kuiper, J. Legler, T.A.J. Murk, A. Peijnenburg, H.J.M. Verhaar, and P. de Voogt. 2005. An integrated assessment of estrogenic contamination and biological effects in the aquatic environment of The Netherlands. *Chemosphere* **59**:511-524

Woodall, L.C., A. Sanchez-Vidal, M. Canals. G.L.J. Paterson, R. Coppock, V. Sleight, A. Calafat, A.D. Rogers, B. E. Narayanaswamy, and R.C. Thompson. 2014. The deep sea is a major sink for microplastic debris. *Royal Society Open Science* **1**:140317. http://dx.doi.org/10.1098/rsos.140317.

Zhao, S., L. Zhu, and D. Li. 2015. Microplastic in three urban estuaries, China. *Environmental Pollution* **206**:597-604.