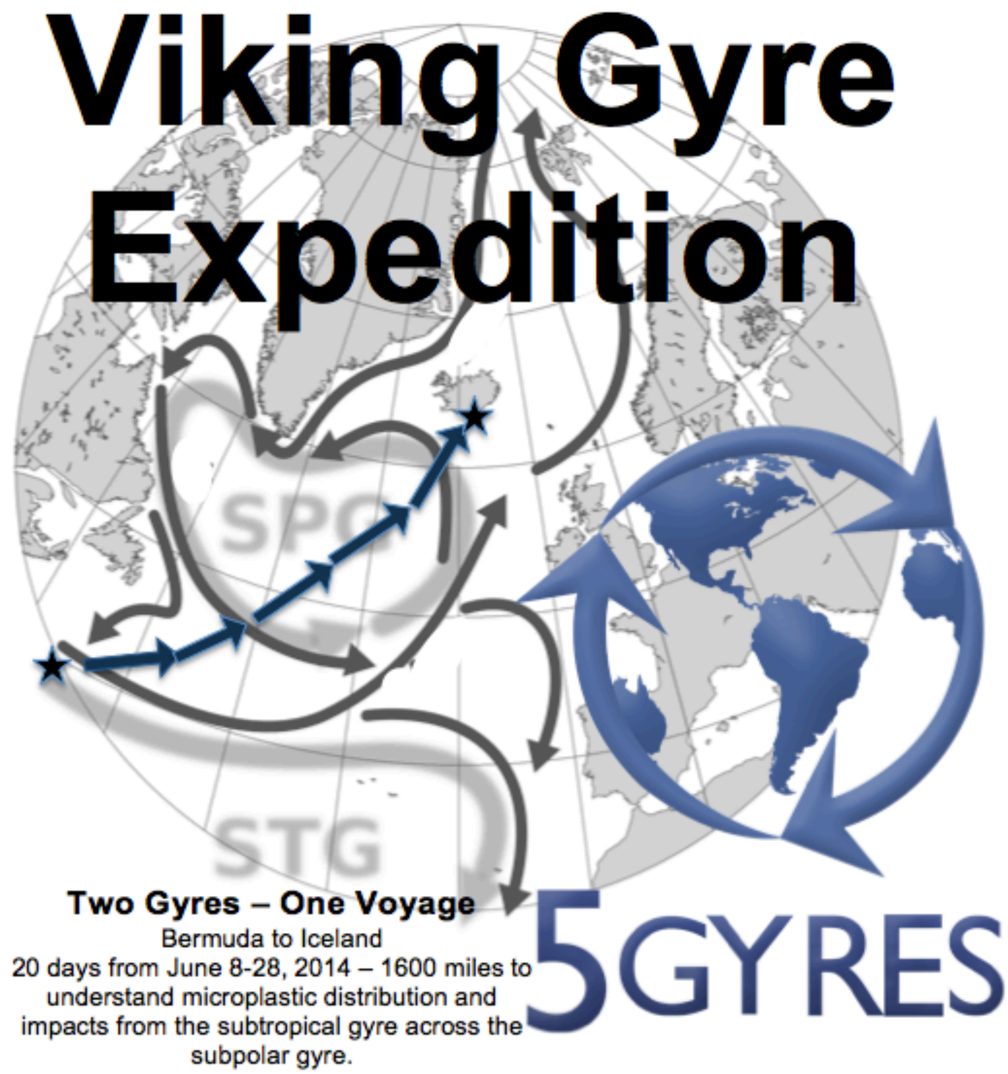
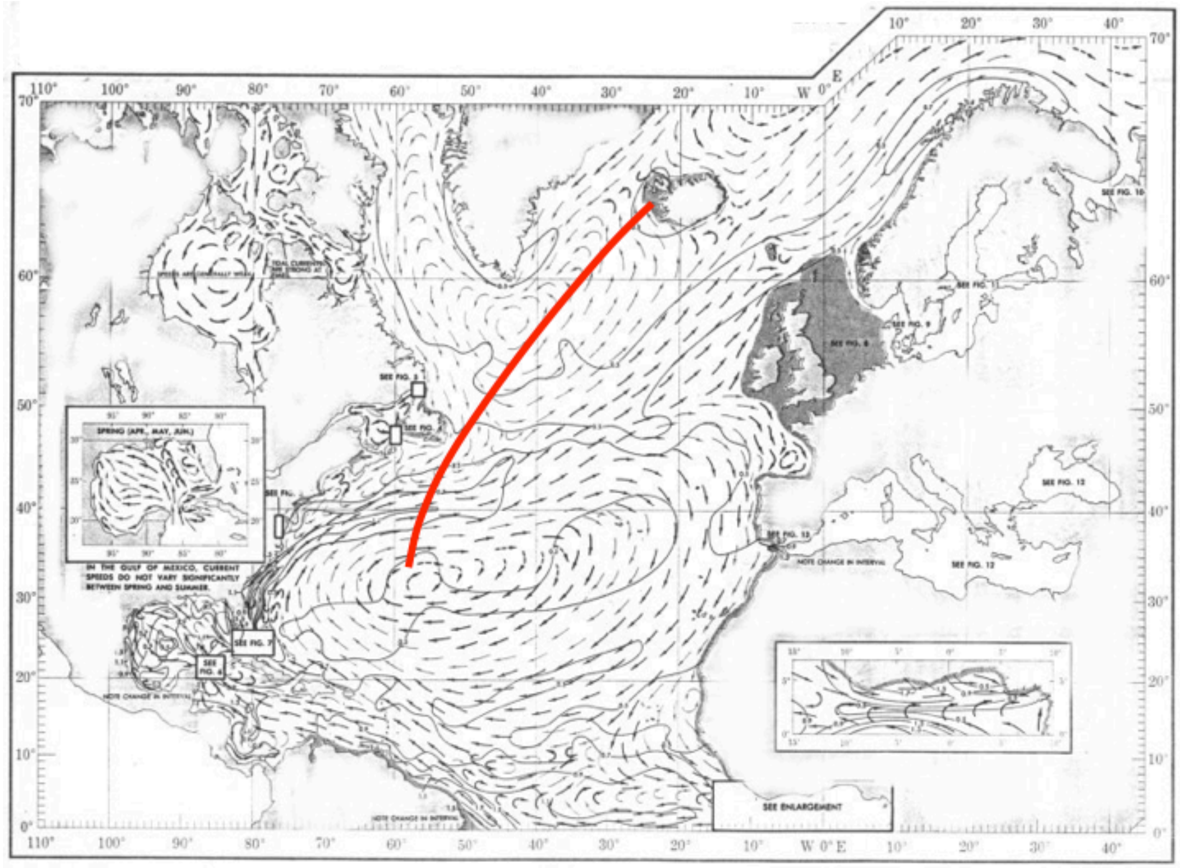
SUMMARY OF THE 2014 EXPEDITION
TO STUDY PLASTIC MARINE POLLUTION ACROSS THE SUBTROPICAL AND SUBPOLAR GYRES OF THE NORTH ATLANTIC



5GYRES

THE EXPEDITION ROUTE, VESSEL AND CREW

On June 9, 2014 the Sea Dragon found its weather window to depart Bermuda to begin a 3-week expedition across the North Atlantic Subpolar Gyre, starting from the subtropical gyre of the Sargasso Sea.



There were 14 crew on the expedition. Skipper Phil Taylor and First Mate John Wright (Disco John) sailed the Sea dragon safely from port to port. March Eriksen, PhD led the scientific work, collecting sea samples and oceanographic data for the 5 Gyres Institute. Stiv Wilson and Carolynn Box, also from 5 Gyres, managed crew logistics and communications. Our crew included Carolyn Roosevelt, (Green with) Tiffany Paige, Sergio Izquierdo, Brett (Mr. Eco) Edwards, Aly Tharp, Genivieve Abedon, Allison Scott, La Benida Hui, Ryan Martin.

We left St. George Harbor in Bermuda after a one-day weather delay. Clear sunny skies and calm seas were ahead of us for 4 days allowing for good trawling for plastic and settling into life at sea. The remaining 2 ½ weeks would prove the name "Subpolar" as we quickly donned gloves and boots for the remainder of the voyage.

The Sea Dragon (originally CB 37) and her sister-ships were built for the 2000/ 04 Global Challenge race- a "wrong way", upwind circumnavigation. She was designed to thrive in the Southern Ocean and safely handle the world's worst sailing conditions. The boats were also specifically set up for volunteer crew with limited sailing experience. At 72' (22m) and 90,000 lbs displacement she will carry up to 14 crewmembers for extended journeys. Her cruising speed of 12kts and capability make her true to the British MCA rating – she is "all oceans."

THE PLASTISPHERE – THE MAKING OF A PLASTICIZED WORLD

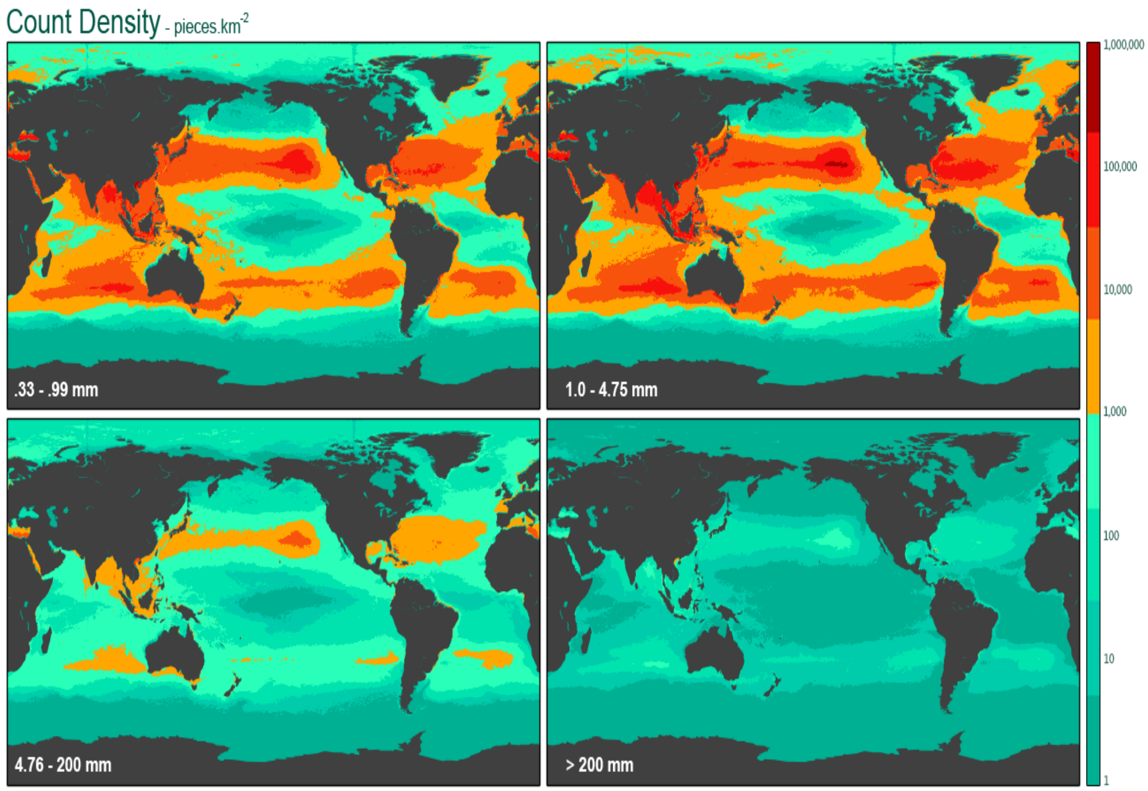
The utility of plastic in contemporary society is at a crossroads, where the perceived benefit of single-use products and packaging is outweighed by the true cost of persistent waste and fragmented microplastics in terrestrial and marine ecosystems. Plastic pollution is ubiquitous in aquatic environments, from the Mississippi River to the Great Lakes, and across all subtropical gyres in the global ocean. What Life magazine described as "Throw Away Living" in 1955 has led to considerable demand for plastic, from less than 2 million tons annually in the late-1950's to nearly 280 million tons in 2011[1]. Yet managing waste, innovations in environmentally harmless product design, and public awareness of ecological and human health impacts, are all lacking extensively, leaving even the most remote regions of the planet trashed.

How much plastic pollution is out there?

Once plastic is lost to the environment it becomes pollution, not the politically loaded terms of debris or litter. Some have suggested that synthetic polymers in the ocean be regarded as hazardous waste[2], a designation that would create new legal tools for mitigation. Plastic pollution is the dominant type of anthropogenic material found in the oceans[3,4]. Though other types of materials are found in the marine environment, such as glass floats, bottles, light bulbs and tubes, metal cans and derelict traps, and cut wood, 60-80% is estimated to be plastic from fossil fuels[5,6,7]. Through degradation by sunlight, biodegradation, chemical and mechanical degradation, plastics fragment and disperse globally, accumulating in massive circular currents called subtropical gyres, where wind and waves slow down toward the centers. Microplastics less than 5mm to macroplastics of all sizes above have been reported since the early 1970's in the subtropical gyres of the North Atlantic[8,9,10], South Atlantic[11], North Pacific[12,13], South Pacific[14], and outside the gyres in near shore environments.[15,16,17] They have also been found in estuaries[18], lakes[19], closed gulfs, bays and seas[20,21]. On land plastics dominate desert landscapes[22] and wind-driven micro and nanoplastic particles can reach distant terrestrial biomes, evidenced by the inadvertent collection of these particles by pollinating insects.[23]

In half a century of commercial use, plastic pollution has become ubiquitous in all environments. The widely accepted term to describe our geologic time, Anthropocene, or "Age of Man", can be defined stratigraphically by our uniquely manufactured index fossil, the synthetic polymer, plastic.

Placing a number on the magnitude of the problem is challenging. With substantial evidence of ocean pollution from the first series of expeditions to all accumulation zones in the five subtropical gyres, and the best ocean current models available, The 5 Gyres Institute has established a 2013 estimate of .269 million tons of plastic marine pollution worldwide from 5.25 trillion particles larger than 0.33mm. The majority of this debris accumulates in the subtropical gyres, or roughly 21% of the planet's surface[24].

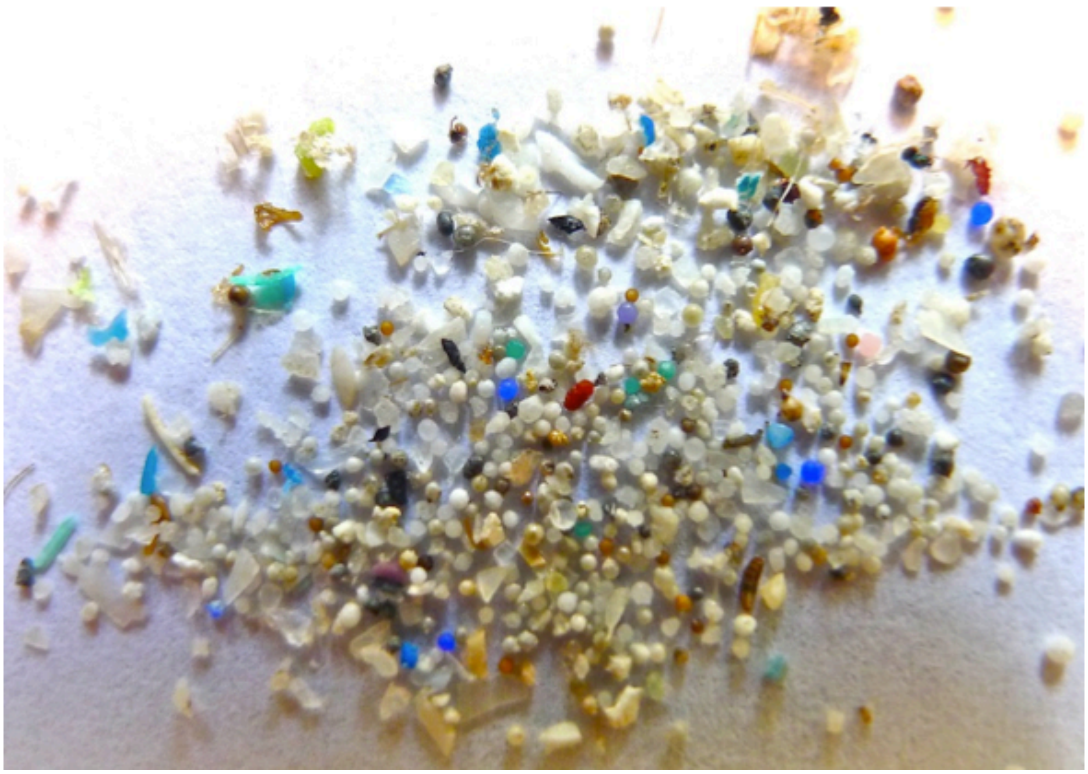


5 Gyres model estimate of plastic distribution worldwide in 4 size classes, totaling .269 million tons from 5.35 trillion particles.

Where does plastic pollution come from?
Plastic waste may enter waterways through storm water drainage, illegal dumping into near shore environs, lost fishing gear or other maritime activities, microplastics evading sewage treatment effluent or overflowing during high-volume rain events[25,26], or by blowing off beaches or developed structures, like docks and piers[27].

Looking offshore to the beaches of remote islands in the gyres, there's a preponderance of fishing industry related debris[28], including nets, buoys and line, surrounded by durable consumer goods, shoes, buckets and crates, bottles and caps, and other random hard plastic objects from toys to umbrella handles. These island surveys represent what survives over time at sea, favoring thick plastic buoys over thin plastic bags or foamed polystyrene. This varies widely from mainland coastal surveys, where the derelict fishing gear drops to 20%, leaving the majority of debris representing single-use throw away plastic items[29]. International Coastal Clean up day, harnessing the efforts of over 561,000 volunteers in 97 countries to pick up over 10 million pounds of pollution along 17,700 miles of shoreline, documents the top 10 pollutants found as cigarette filters, food wrappers, plastic bottles, plastic bags, lids and caps, plastic tableware, straws, glass bottles, cans, and paper bags[30]. These products, though globally represented, are most prevalent in developing nations with no infrastructure for waste management. The burning of waste, or discard to rivers or the edge of town, is the norm for many countries with limited alternatives.

In developed nations, where relatively less plastic is lost to the environment, a new threat of microplastics has recently been uncovered. A recent expedition across the Great Lakes in North America described a large abundance of 0.5mm spherical polyethylene particles, rivaling the counts of microplastics in most ocean samples[31]. A comparison revealed similarities in size, color, shape, and composition to microbeads commonly used in consumer facial cleansers as an exfoliant. Plastic microbeads in this application are intended to be washed into the sink and presumably captured by municipal waste water treatment facilities[32]. Yet many sewage treatment plants do not capture floating, non-biodegradable, particles of this size. Furthermore, when cities employ combined sewage overflow, which merges stormwater with raw sewage on heavy rain days, the microbeads flow directly into the aquatic environment[33]. Sewage effluent also contains microfibers from the washing of synthetic textiles from both laundry facility and household waste water [34].



Microbeads found on the surface of Lake Erie during the 2012 expedition

Increases in coastal population density, climate change, and the rapid growth of plastic production have led to catastrophic events like hurricanes, floods and tsunamis, leaving a legacy of plastic waste. A 2007 survey of the Mississippi River delta post-Katrina revealed abundant microplastics in waters around New Orleans, with highest counts in the Industrial Canal. The Mississippi and Atachafalaya rivers, Lake Pontchartrain and the Rigolets showed greater macroplastics than microplastics, typical of nearshore or inland environments where plastic degradation and accumulation is reduced. Beach surveys throughout the Mississippi Delta, including the Chandelieur Islands, Ship and Dauphine Islands yielded large macrodebris items from the hurricane, including household appliances and construction material, as well as items from fishing and petroleum industries, such as buoys, ropes and hard hats[35]. The United States Corps of Engineers (USACE) estimates 118 million tons of debris were created by Hurricane Katrina.[36] What remains at sea is unknown.

In a recent survey of marine impacts from the 2011 Japanese tsunami, researchers sailed from Tokyo to Hawaii through the sub-surface debris field. During the 28-day voyage, crew detected 820 objects during 41 non-consecutive hours of sea surface observations, of which 98% were plastic, representing bottles, shoes, combs, crates and buckets, toys, fishing gear, foam insulation attached to building materials, a truck tire and half of a fiberglass fishing boat[37]. This expedition across the Pacific Ocean after a natural disaster, much like the debris survey following Hurricane Katrina, demonstrates the persistence of plastic over all other materials, such as metal, wood and glass, washed into the environment.

What is the impact of plastic pollution on wildlife?

The Convention on Biological Diversity summarized that there are currently 663 species of marine life known to be impacted by marine debris[38]. A wide range of marine life is impacted by plastic pollution through entanglement or ingestion, including marine mammals, birds and reptiles[39,40]. One snapping turtle appeared on the doorstep of the New Orleans Audubon Zoo in the early 1990's with a plastic ring from the neck of a milk jug bound around its waist. The turtle, weighing over 3 pounds, was the size of a football. The constriction prevented the shell and vertebrate from fusing, resulting in an hour-glass shape of the carapace, earning her the moniker "Mae West". This deformity also demonstrated the durability of plastic. In the ocean, all sea turtle species are represented in hundreds of necropsy reports and observations of entanglement. Ecological impacts include the transportation of invasive species. Plastics ranging from the size of resin pellets to large derelict nets and vessels may transport microbial communities, invertebrates and larger organisms to non-native regions.[41,42]

Plastic pollution is not benign in the environment or when ingested, but has the potential to cause harm through desorption of chemicals on plastic. Several persistent organic pollutants (POPs) bind to plastic as it is transported throughout a watershed, buried in sediment or floating in the ocean[43,44,45]. A single pellet may attract up to one million times the concentration of some pollutants in ambient seawater[46], making those chemicals readily available to marine life. Food mimicry, based on color, shape or presence of biofilms, is one mechanism driving ingestion of plastics, as well as filter

Rainbow runner found in the N. Pacific Garbage patch with 17 fragments of microplastic in its stomach.

feeding and respiration. Once in the stomach POPs may desorb due to changes in PH, temperature, or the presence of surfactants[47].

Lab studies of ingested plastic nanoparticles have shown an uptake of particle sizes under 10μm into the circulatory system of mussels[48] that can bridge trophic levels into crustaceans[49] and other secondary consumers[50]. Some persistent pollutants, like polybrominated diphenyls (PBDEs), flame-retardant chemicals used in plastic product manufacturing, may transfer to birds after ingestion[51]. In laboratory experiments with lugworms ingesting plastic particles laden with PBDE's, the lugworms desorbed the chemical and resulted in a marked reduction in feeding response[52]. Polychlorinated biphenyls (PCBs), an environmentally persistent industrial chemical used as a thermal insulator, has been shown to transfer to lugworms through ingestion of microplastics[53], as well as in seabirds that ingest larger plastic items[54].

What is the impact of plastic and plasticizers on human health?

How plastic marine pollution affects human health is a long chain of cause and effect following the path of plastic waste through the watershed as it accumulates toxins, flows to the ocean, and degrades over time into fragments the size of fish food that desorb toxins into the marine organisms human harvest for food. Yet, before people even sit down to dinner, many plastic products we touch, wear, sit upon, drink or eat from or with leach synthetic compounds into our bodies. Many of the chemical building blocks of plastic, or the additives that give it varied properties, have adverse effects on humans and other mammals. Polymerization leaves some monomers unbounded and free to migrate from food containers, bottles, and utensils. Many plasticizers included as additives not bonded to the polymer. Some of these compounds bioaccumulate in our bodies.

Bisphenol A (BPA) - the building block of polycarbonates - and Phthalates - the plastic additive that turns hardened PVC into pliable vinyl, - are both known endocrine disruptors.[55,56] This is not surprising in the case of BPA, which was invented as a synthetic estrogen[57], yet proved to be more appealing as a plastic additive. Today BPA is ubiquitous in human body burdens of synthetic chemicals. Exposure ranges from the lining of metal cans for food storage[58], to CD's, DVD's, polycarbonate dishware, and receipt paper from cash registers. BPA has been linked to many developmental disruptions, including early puberty, increased prostate size, obesity, insulin inhibition, hyperactivity and learning disabilities[59].

Phthalates are similarly problematic as endocrine disruptors,[60] with effects including early puberty in females, feminization in males, and insulin resistance[61]. Different phthalates are found in paints, toys, cosmetics and food packaging, added for the purpose of increasing durability, elasticity, and pliability. In medical applications, such as IV bags and tubes, phthalates are prone to leaching after long storage, exposure to elevated temperatures, and as a result of the high concentration present - up to 40% by weight[62]. Although phthalates metabolize quickly, in a week or less, we are exposed continuously through contact with plastics, like vinyl and soft plastic products.

A large number of other additives and contaminants commonly found in consumer plastic products raise human health and ecological concerns. Most notable are polychlorinated biphenyls ("PCBs")[63], polyfluorinated compounds ("PFCs")[64,65,66], the pesticide/sanitizer triclosan[67,68] also used in over-the-counter drugs, anti-microbial hand soaps and some toothpaste brands, flame retardants, particularly PBDEs[69,70], and nonylphenols.

What is the fate of plastic pollution in the gyres?

There are multiple known and suspected pathways whereby the estimated 1.8 million tons of plastic pollution in the subtropical gyres will leave the ocean. Sea Education Association (SEA), based in the Woods Hole Oceanographic Institution, reassessed archived plankton net tows spanning 22 years, finding no significant increase in microplastics on the sea surface, regardless of well-documented increases in coastal inputs over the same time[71]. Islands in the gyres function as natural nets, with 1000's of miles of coastline receiving plastic pollution that washes ashore and requires substantial clean-up efforts. On Hawaii's Kamillo Beach an estimated 165 tons of plastic pollution were removed by volunteers in the decade since 2003.[72] We know that plastics degrade into microplastics and ever-smaller particles by photo and mechanical degradation[73], that microbial degradation of polyethylene happens slowly[74,75], and that some microplastics sink to the deep sea floor[76]. Microplastics have been found throughout the vertical water column, suspended beneath the sea surface, where most ocean sampling takes place. It may be that the ingestion of microplastic fragments by fish and zooplankton may package these particles in fecal pellets that are excreted and slowly sink. The ultimate fate of microplastics in the marine environment is poorly known.

Producer responsibility for plastic pollution in the 21st century

In 1971 Iron Eyes Cody was portrayed on television across the United States as the "Crying Indian" in public service advertisements designed to curtail litter along the new interstate highway system. The organization Keep America Beautiful, with significant funding from Philip Morris, Anheuser-Busch, PepsiCo and Coca-Cola, ran the ad with the tag line, "People Start Pollution. People can stop it." The focus was on consumer behavior as the principle source of litter, rather than a fair assessment of product design.

A focus on consumer behavior rather than product design has prevailed over decades of increasing plastic use and non-biodegradable waste, and in developing countries where waste management is non-existent, single-use plastic packaging is a pervasive pollutant. The appropriate ethic, demonstrated by the failure of "litter-focused campaigns" over the last four decades, is that producer responsibility must demonstrate successful recovery or environmental harmlessness. Responsibility for product end-life is now shifting to this ethic, albeit with resistance from many manufacturers of plastic and its products, based on the concept Extended Producer

Responsibility (“EPR”). Simply put, all products and packaging must demonstrate a successful recovery plan, either voluntary or incentive-based recovery schemes, or they must be environmentally harmless. ‘Benign by design’ is the new motto, evoking a plethora of green chemistry and product design solutions for efficient recovery, ease of repair, or biodegradable parts. The transition to EPR will require phase-outs of polluting products and packaging, which may occur voluntarily or by bans or assessed fees. Traditionally, tax-payer funded municipal waste management collects, transports, sorts, recycles, burns or buries plastic waste. EPR promises to reduce waste volume, while also reducing persistent waste in the environment.

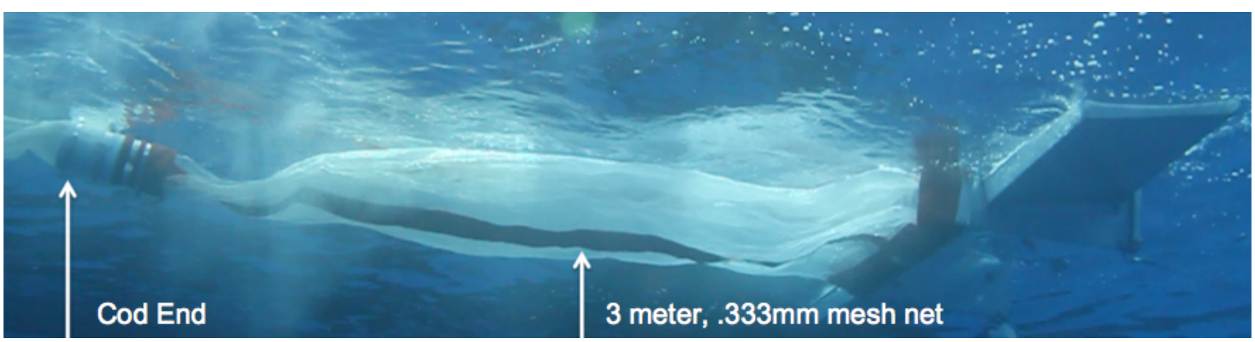
EPR does not absolve the public of responsibility for litter. Nor does it account for the millions of tons of plastic pollution in the gyres and leaving coastal watersheds daily. Though EPR is essential to curbing the creation of plastic pollution, many developing nations lack the waste management system necessary to deal with current waste. Without opportunities for recovery, the norm for much of the world is to burn or bury plastic. Two additional solutions apply here – build infrastructure for waste management in developing nations, and promote general public awareness about the ecological, economical and human health concerns about plastic pollution.

The future of research on this issue will focus on the ultimate fate of plastic pollution in all environments, and further defining the impacts of persistent chemicals from plastics on humans and other life forms. How do we mitigate the inputs, while we monitor the outputs? What will change how we view plastics is honest, science-based analyses of the true cost to society and the sea. But the ocean is not where solutions will begin. Despite the unfathomable mass of plastic pollution globally, it is challenging to mitigate the problem based on data from the gyres, where garbage patches are in international waters and the plastic is too degraded to assess blame or remedy. Effective solutions must begin upstream, to the behavior of the consumer and the design of the product. It is where we can assign responsibility, either through the good will of the producer, customer demand, or the legislative arm of governments. To save our synthetic seas we must take responsibility at the source of the problem.

EXPEDITION RESEARCH OBJECTIVES AND METHODS

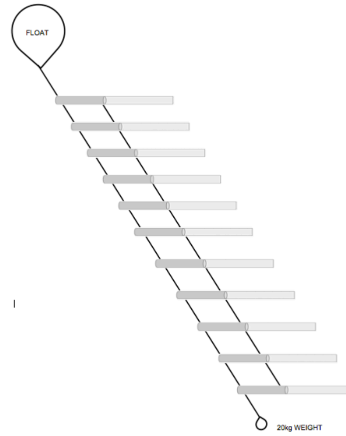
1. **Manta and hi-speed trawls:**
   Two trawls designed to capture plastics on the sea surface.
2. **Vertical distribution:**
   This trawl will help tell us how plastic is distributed vertically below the sea as the wave state increases.
3. **Visual observations:**
   Like the manta net, visual observations look for surface plastics, but in this case we look for what doesn't fit in the net.
4. **Fish/turtle Bite Survey:**
   There are fish biting plastic in the N. Atlantic, but we don't know which ones.
5. **iGyre: Plastic Ocean**
   Our citizen science program will use all trawl data to recalibrate our global model
6. **iGyre: Plastic Beach**
   Surveying micro and macroplastics in Bermuda and Iceland will show us differences in type, size and abundance.

Manta and mini hi-speed trawls.
Surface samples were collected using a manta trawl with a 0.6 x 0.15 m^2 rectangular opening manta trawl with a 3 m long, 333 micron net and a 30 x 10 cm^2 collecting bag. The mini hi-speed trawl has a 10 cm wide net opening and is .5 m tall. It is designed to capture surface plastics very quickly while under sail. Samples from both nets are preserved in isopropyl alcohol and sent to a lab to count and weigh particles in 3 size classes (.33-1mm, 1-5mm, >5mm). These data will be used to describe the distribution of microplastics across the North Atlantic gyres.



Vertical trawl.

Vertical distribution in varied sea states is not understood. What we do know is that debris does move downward. Mechanisms for vertical distribution may include sea state, fouling by heavier organisms, polymer type and shape, as well as the behavior of small particles as they respond to surface tension rather than buoyancy.



On this expedition we aimed to test the equipment and collect a few samples. By adjusting buoyancy and weights at the bottom of the trawl, we were able to successfully collect 3 samples in sea state 1.

Visual Observations.

Since we can't catch the big stuff in our nets, we sit on deck while the manta trawl is out and look for it. This creates a 4th size range of macroplastic data to go with our microplastic data.

Visual observations of large debris are essential to making a realistic assessment of the problem. From our global estimate we find that more than 90% of debris is macrodebris, leaving less than 10% of debris captured by our nets. This extreme bias is addressed by doing visual surveys.

Marine Debris Log

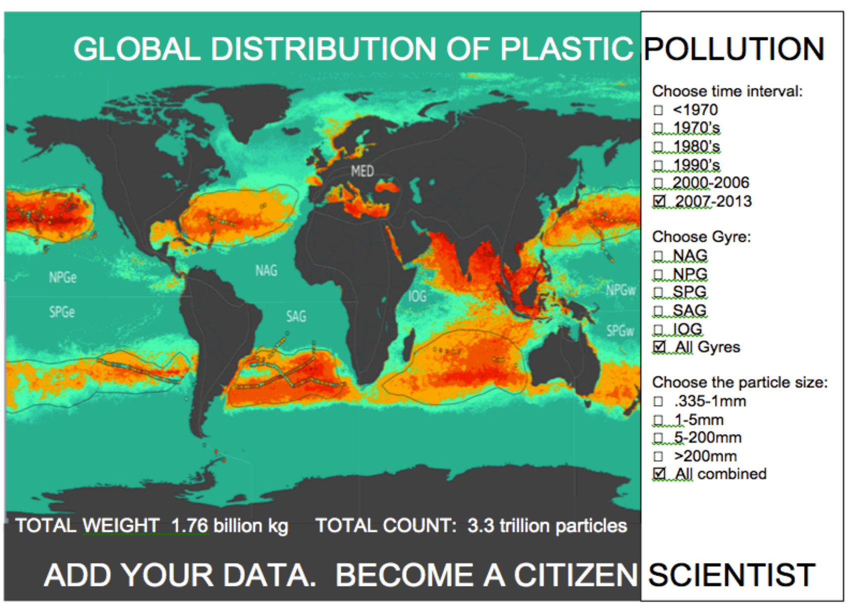
By recording debris sightings while you're trawling, we will be able to capture the full range of debris sizes, from the mesh size of the net to large debris items the net could never capture.

1. **Record your start time, latitude and longitude.**
2. **Sit on the side of the boat looking 20 meters out to sea. Your gaze should be perpendicular from the boat, scanning 90 degrees to the bow and back. You're trying to observe an arc from bow to beam.**
3. **Use tick marks to record each object in the appropriate column. Any object bigger than a bottle cap should be recorded. Write in descriptions of objects whenever possible.**

DATE	LAT/LONG START N,E	LAT/LONG END N,E	TOTAL DISTANCE	HEADING_Degrees	START_TIME	TOTAL TIME (minutes)	Buoys/Floats	Misc. Line	Misc. Nets	Plastic Fragment	Sheeting and Tarps	Plastic Bags	Bottles (Beverage)	Jugs/Buckets	Styrofoam	Other plastic items	Glass bottle	Other Glass Items	Other (Describe)	Wind spd	Boat spd	Weather	Cloud cover (%)	Sea State	# of observers
23	28.55,173.10	173.02,28.51		115	15:48	60					2		2		4	2				-	-	sun	80	3	4

Fish/turtle Bite Survey:
It's safe to say that most of the bottles found drifting in the N. Atlantic have fish bites, but which fish is the culprit? We'll collect plastic with bites, photograph them, and compare to fish and turtle skulls in the Bermuda Aquarium and Natural History Museum and at BIOS. During our time in Bermuda we were able to collect over 40 pieces of fish-bitten plastic from the beach, as well as photograph triggerfish and turtles in the aquarium collections.

iGyre: Plastic Ocean
Using data from all expedition trawls, we will recalibrate our current global model to determine a new estimate of the total weight and particle count of plastic pollution in the N. Atlantic. These data, along with other data from recent expeditions, will provide a new global estimate.



iGyre – Plastic Beach
On this expedition we are surveying microplastics on beaches in Bermuda and Iceland. Our intention is to collect data on micro and macroplastic distribution and abundance, sourced from two different gyre systems in the N. Atlantic. These comparisons will help us characterize what's at sea and where it is.
We are working with other NGO's, like NOAA and Scientificos de la Basura, to standardize protocols and make global comparisons.

5 Gyres Institute 3131 Olympic Blvd, Santa Monica, CA 90402, USA • www.5gyres.org • +1(310) 998-8616

PRELIMINARY RESULTS

During the expedition we accomplished 30 manta trawls, 8 mini hi-speed trawls, 3 vertical trawls, 8 beach transects and 40 visual observations. In the months ahead we'll process all samples with the intention of publishing a comparison of plastic type, size and abundance between the subpolar and subtropical gyres of the N. Atlantic.

EXPEDITION TALKING POINTS

1. Our primary objective of the expedition is to document plastics in both the subtropical and subpolar gyres of the N. Atlantic. We confirmed that microplastics are present in all trawls, even in extremely remote regions of the world.
2. The garbage patch in the North Atlantic does not have clear boundaries, and microplastics could arguably be explained as globally distributed with accumulation in regions where wind and current are absent.
3. Plastic pollution also occurs in hotspots where plastic is lost to the environment: dense coastal populations, river mouths, maritime activities.
4. The garbage patches, like others in the world, are not an island of trash. They are more akin to a soup of widely distributed plastic pollution in sizes ranging from microplastic dust to 1 ton tangled masses of nets. This reality is much worse than an island, because it makes clean-up a very impractical solution. This observation, and the global extent of it, lends more support to land-bases solutions over clean-up at sea.

CONCLUSION

The Sea Dragon safely carried 14 crew 2,400nm from Bermuda to Iceland. Our research goals were met despite cold and rain along the way. We arrived in Iceland after 21 days at sea after a true adventure. Crewmembers walk away with tools they can use to become ambassadors for ocean conservation, specifically on the plastic pollution issue. You each have a sample of microplastic collected from Tobacco Bay in Bermuda. With this, combined with shared research papers and presentations, and mostly your own experience, you can now make changes in your community. We have accomplished something great together.

Fair winds and following seas

[1] Plastics Europe, Plastics—the Facts 2012: An analysis of European plastics production, demand and waste data for 2011. http://www.plasticseurope.org/ Document/plastics-the-facts-

[2] Rochman, C., Browne, B., Halpern, B., Hentschel, B., Hoh, E., Karapanagioti, H., Rios-Mendoza, L., Takada, H., Teh, S., Thompson, R., 2013. Classify plastic waste as hazardous. Nature 494, 169–171.

[3] Barnes, D., Galgani, F., Thompson, R.C., Barlaz, M., 2009. Accumulation and fragmentation of plastic debris in global environments. *Phil. Trans. R. Soc. B*. 364, 1985-1998.

[4] Gregory, M.R., Ryan, P.G., 1997. Pelagic plastics and other seaborne persistent synthetic debris: a review of Southern Hemisphere perspectives. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris – Sources, Impacts and Solutions. Springer-Verlag, New York, pp.49-66.

[5] Derraik, J.G.B., 2002. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin 44, 842–852.

[6] Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D., Russell, A.E., 2004. Lost at Sea: where is all the plastic? Science 304, 838.

[7] Browne, M. A., Crump, P., Niven, S. J., Teuton, E., Tonkin, A., Galloway, T., Thompson, R. C., 2011. Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks. Environmental Science and Technology 45, 9175-9179.

[8] Carpenter, E.J., Smith, K.L., 1972. Plastics on the Sargasso sea surface. Science 175, 1240–1241.

[9] Colton, J.B., Knapp, F.D., Burns, B.R., 1974. Plastic particles in surface waters of the northwestern Atlantic. Science 185, 491–497.

[10] Law, K.L., Morét-Ferguson, S., Maximenko, N., Proskurowski, G., Peacock, E E., Hafner, J., Reddy, C.M., 2010. Plastic accumulation in the North Atlantic Subtropical Gyre. Science 329, 1185-1188.

[11] Ryan, P. G., 2013. Litter Survey detects the South Atlantic 'Garbage Patch'. Marine Pollution Bulletin. (in Press).

[12] Day, R.H., Shaw, D.G., Ignell, S.E., 1990. The quantitative distribution and characteristics of neuston plastic in the North Pacific Ocean, 1984-1988. In R. S. Shomura and M. L. Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, Hawaii. U. S. Department of Commerce, NOAA Technical Memorandum. NMFS, NOAA-TM-NMFS-SWFC-154. pp. 247-266.

[13] Moore, C.J., Moore, S.L., Leecaster, M.K., Weisberg, S.B., 2001. A comparison of plastic and plankton in the North Pacific Central Gyre. Marine Pollution Bulletin 42, 1297–1300.

[14] Eriksen, M., Maximenko, N., Theil, M., Cummins, A., Lattin, G., Wilson, S., Hafner, J., Zellers, A., Rifman, S., 2013. Plastic Pollution in the South Pacific subtropical gyre. Marine Pollution Bulletin 68, 71-76.

[15] Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D., Russell, A.E., 2004. Lost at Sea: where is all the plastic? Science 304, 838.

[16] Hinojosa, I.A., Thiel, M., 2009. Floating marine debris in fjords, gulfs and channels of southern Chile. Marine Pollution Bulletin 58, 341-350.

[17] Dubaish, F. and Liebezeit, G., 2013. Suspended Microplastics and Black Carbon Particles in the Jade System, Southern North Sea. Water Air Soil Pollution 224, 1352.

[18] Browne, M. A., Galloway, T. S., Thompson, R. C., 2010. Spatial Patterns of Plastic Debris along Estuarine Shorelines. Environmental Science and Technology 44, 3404-3409.

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

[20] Ryan, P.G., 2013. A simple technique for counting marine debris at sea reveals steep litter gradients between the Straits of Malacca and the Bay of Bengal. Marine Pollution Bulletin 69, 128–136.

[21] Collignon, A., Hecq, J., Glagani, F., Voisin, P., Collard, F., Goffart, A., 2012. Neustonic microplastic and zooplankton in the North Western Mediterranean Sea. Marine Pollution Bulletin 64, 861-864.

[22] Zylstra, E.R., 2013. Accumulation of wind-dispersed trash in desert environments. Journal of Arid Environments 89, 13-15.

[23] Liebezeit, G. and Liebezeit, E., 2013. Non-pollen particulates in honey and sugar. Food Additives & Contaminants: Part A, DOI: 10.1080/19440049.2013.843025

[24] 5 Gyres Institute, 2013. The global abundance of plastic marine pollution. Unpublished manuscript.

[25] EPA, 2007. Report to Congress: Combined Sewer Overflows to the Lake Michigan Basin, EPA-833-R-07-007.

[26] Browne, M.A., Crump, P., Niven, S.J., Teuton, E., Tonkin, A., Galloway, T., Thompson, R.C., 2011. Accumulation of microplastic on shorelines woldwide: sources and sinks. Environmental Science and Technology 45, 9175–9179.

[27] Ryan, P.G., Moore, C.J., van Franeker, J.A., Moloney, C.L., 2009. Monitoring the abundance of plastic debris in the marine environment. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences 364, 1999–2012.

[28] Dameron O.J., Parke M., Albins, M.A., Brainard, R., 2007. Marine debris accumulation in the Northwestern Hawaiian Islands: an examination of rates and processes. Marine Pollution Bulletin 54, 423-433.

[29] Sheavly, S. B., Register, K. M., 2007. Marine Debris and Plastics: Environmental Concerns, Sources, Impacts and Solutions. Journal of Polymers and the Environment 15, 301-305.

[30] Ocean Conservancy, 2013. International Coastal Clean Up. http://www.oceanconservancy.org/our-work/international-coastal-cleanup/

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

[32] Fendall, L.S., Sewell, M.A., 2009. Contributing to marine pollution by washing your face: microplastics in facial cleansers. Marine Pollution Bulletin 58, 1225–1228.

[33] EPA, 2007. Report to Congress: Combined Sewer Overflows to the Lake Michigan Basin, EPA-833-R-07-007.

[34] Browne, M. A., Crump, P., Niven, S. J., Teuten, E. L., Tonkin, A., Galloway, T., Thompson, R. C., 2011. Accumulations of microplastic on shorelines worldwide, sources and sinks. Environmental Science and Technology 45, 9175–9179.

[35] Eriksen, M., 2007. Survey of marine debris after Hurricane Katrina. Unpublished raw data.

[36] U.S. Executive Office of the President, 2006. The Federal Response to Hurricane Katrina: Lessons Learned. ISBN 13:9780160756009.

[37] 5 Gyres Institute, 2012. Tsunami Debris Field Expedition. Unpublished raw data.

[38] Convention on Biological Diversity (CBD), 2012. Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel—GEF (2012). Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions, Montreal, Technical Series No. 67. http://www.cbd.int/doc/ publications/cbd-ts-67-en.pdf,

[39] Laist, D.W., 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. Marine Pollution Bulletin 18, 319–326.

[40] Van Franeker, J.A., Blaize, C., Danielsen, J., Fairclough, K., Gollan, J., Guse, N., Hansen, P.L., Heubeck, M., Jensen, J.K., Le Guillou, G., Olsen, B., Olsen, K.O., Pedersen, J., Stienen, E.W.M., Turner, D.M., 2011. Monitoring plastic ingestion by the northern fulmar Fulmarus glacialis in the North Sea. Environmental Pollution 159, 2609–2615.

[41] Gregory, M.R., 2009. Environmental implications of plastic debris in marine settings--entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Phil. Trans. R. Soc. B*. 364, 2013-2025.

[42] Barnes, D., 2002. Invasions by marine life on plastic debris. *Nature* 416, 808-809.

[43] Teuten, E.L., Rowland, S.J., Galloway, T.S., Thompson, R.C., 2007. Potential for plastics to transport hydrophobic contaminants. Environmental Science and Technology 41, 7759–7764.

[44] Teuten, E.L., Saquing, J.M., Knappe, D.R.U., Barlaz, M.A., Jonsson, S., Björn, A., Rowland, S.J., Thompson, R.C., Galloway, T.S., Yamashita, R., Ochi, D., Watanuki, Y., Moore, C., Viet, P.H., Tana, T.S., Prudente, M., Boonyatumanond, R., Zakaria, M.P., Akkhavong, K., Ogata, Y., Hirai, H., Iwasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Saha, M., Takada, H., 2009. Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society of London Series BBiological Sciences 364, 2027–2045.

[45] Rios, L.M., Joes, P.R., Moore, C., Narayan, U.V., 2010. Quantification of persistent organic pollutants adsorbed on plastic debris from the Northern Pacific Gyre's ''eastern garbage patch''. Journal of Environmental Monitoring 12, 2226–2236.

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

[47] Bakir, A., Rowland, S. J., Thompson, R. C., 2014. Enhanced desorption of persistent organic pollutants from microplastics under simulated physiological conditions. Environmental Pollution 185, 16-23.

[48] Browne, M.A., Dissanayake, A., Galloway, T.S., Lowe, D. M., Thompson, R.C., 2008. Ingested microscopic plastic translocates to the circulatory system of the mussel *Mytilus edulis* (L.). *Environ. Sci. Technol.* 42, 5026–5031.

[49] Farrell, P., Nelson, K., 2013. Trophic level transfer of microplastic: *Mytilus edulis* (L.) to

Carcinus maenas (L.). *Environ.l Pollut.* 177, 1-3.

[50] Setälä, O., Fleming-Lehtinen, V., Lehtiniemi, M., 2014. Ingestion and transfer of microplastics in the planktonic food web. Environmental Pollution. 185, 77-83.

[51] Tanaka, K., Takada, H., Yamashita, R., MIzukawa, K., Fukuwaka, M., Watanuki, Y., 2013. Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics. Mar. Pollut. Bull. 69, 219–222.

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

[53] Besseling, E., Wegner, A., Foekema, E., Van Den Heuvel-Greve, M. & Koelmans, A. A. Effects of microplastic on fitness and PCB bioaccumulation by the lugworm Arenicola marina (L.), 2013. Environ. Sci. Technol. 47, 593–600.

[54] Yamashita, R., Takada, R., Fukuwaka, M. & Watanuki, Y., 2011. Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, Puffinus tenuirostris, in the North Pacific Ocean. Mar. Pollut. Bull. 62, 2845–2849.

[55] Bonefeld-Jorgensen E.C., Long M., Hofmeister M.V., Vinggaard A.M. 2007. Endocrine-disrupting potential of bisphenol A, bisphenol A dimethacrylate, 4-n-nonylphenol, and 4-n-octylphenol in vitro: new data and a brief review. *Environ. Health Perspect.* 115, 69–76

[56] U.S. Environmental Protection Agency. Bisphenol A Action Plan; 29 March 2010

[57] Dodds E.C., Lawson W.,1936. Synthetic estrogenic agents without the phenantthrene nucleus. *Nature* 137, 996

[58] Brotons J.A., Oleaserrano M.F., Villalobos M., Pedraza V., Olea N., 1995. Xenoestrogens released from lacquer coatings in food cans. *Environ. Health Perspect.* 103, 608-612

[59] vom Saal F.S., Hughes C., 2005. An extensive new literature concerning low-dose effects of bisphenol A shows the need for a new risk assessment. *Environ. Health Perspect.* 113, 926–933

[60] Meeker J.D., Sathyanarayana S., Swan S.H., 2009. Phthalates and other additives in plastics: human exposure and associated heatlh outcomes. *Philos. Trans. R. Soc. London Ser. B* 364, 2097–2113

[61] Stahlhut R.W., vanWijngaarden E., Dye T.D., Cook S., Swan S.H., 2007. Concentrations of urinary phthalate metabolites are associated with increased waist circumference and insulin resistance in adult US males. *Environ. Health Perspect.* 115, 876–882

[62] Buchta C., Bittner C., Heinzl H., Hocker P., Macher M., 2005. Transfusion-related exposure

to the plasticizer di(2-ethylhexyl)phthalate in patients receiving plateletpheresis concentrates. *Transfusion* 45, 798–802

[63] Herbstman J.B., Sjoedin A., Apelberg B.J.,Witter F.R., Patterson D.G., 2007. Determinants of prenatal exposure to polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in an urban population. *Environ. Health Perspect.* 115, 1794–1800

[64] Fromme H., Tittlemier S.A., Volkel W., Wilhelm M., Twardella D., 2009. Perfluorinated compounds—exposure assessment for the general population in Western countries. *Int. J. Hyg. Environ. Health* 212, 239–270

[65] Giesy J.P., Kannan K., Jones P.D., 2001. Global biomonitoring of perfluorinated organics. *Sci. World J.* 1, 627–629

[66] Kovarova J., Svobodova Z.. 2008. Perfluorinated compounds: occurrence and risk profile. *Neuro. Endocrinol. Lett.* 29, 599–608

[67] Ahn K.C., Zhao B., Chen J., Cherednichenko G., Sanmarti E., 2008. In vitro biologic activities of the antimicrobials triclocarban, its analogs, and triclosan in bioassay screens: receptor-based bioassay screens. *Environ. Health Perspect.* 116, 1203-1210

[68] Chalew T.E., Halden R.U., 2009. Environmental exposure of aquatic and terrestrial biota to triclosan and triclocarban. *J. Am. Water Resour. Assoc.* 45, 4–13

[69] Costa L.G., Giordano G., Tagliaferri S., Caglieri A., Mutti A., 2008. Polybrominated diphenyl ether (PBDE) flame retardants: environmental contamination, human body burden and potential adverse health effects. *Acta Biomed.* 79, 172–183

[70] Yogui G.T., Sericano J.L., 2009. Polybrominated diphenyl ether flame retardants in the U.S. marine environment: a review. *Environ. Int.* 35, 655–666

[71] Law, K.L., Moret-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., Reddy, C.M., 2010. Plastic Accumulation in the North Atlantic Subtropical Gyre. Science 329, 1185-1188.

[72] Hawaii Wildlife Fund. Personal communication with executive director. http://wildhawaii.org/projects.html

[73] Andrady, A.L., 2011. Microplastics in the marine environment. Marine Pollution Bulletin 62, 1596-1605.

[74] Harshvardhan, K., Jha, B., 2013. Biodegradation of low-density polyethylene by marine bacteria from pelagic waters, Arabian Sea, India. Marine Pollution Bulletin 77, 100-106.

[75] Zettler, E., Mincer, T., Amaral-Zettler, L., 2013. Life in the “Plastisphere”: Microbial communities on plastic marine debris. Environmental Science and Technology 47, 7137-7146.

[76] Cauwenberghe, L.V., Vanreusel, A., Mees, J., Janssen, C.R., 2013. Microplastic pollution in deep-sea sediments. Environmental Pollution 182, 495-499.