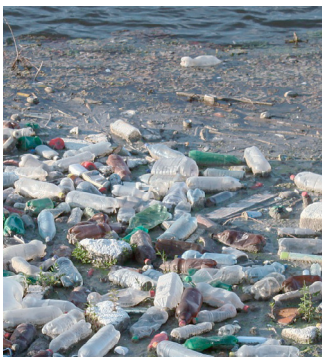

The Aquarium Conservation Partnership (ACP)

ACP Ocean & Freshwater Plastic Pollution Initiative

Background Report

About this Report

The Aquarium Conservation Partnership (ACP) is a two-year (2016-17) pilot project designed to increase the collective impact of aquariums on shared ocean and freshwater conservation goals. The primary goal of the ACP is to work together to reduce the sources of ocean and freshwater plastic pollution. This report summarizes scientific findings on the causes and impacts of ocean and freshwater plastic pollution. It also describes the ACP approach to advancing solutions to the problem of plastic pollution. All of the references included in this paper can be found in the ACP internal reference library: https://sites.google.com/site/acphomepage/resources. This library also includes the report from the 2016 Aquarium Plastic Pollution Symposium, which brought together nearly 150 aquarium leaders, scientists and other experts to share the latest information on ocean and freshwater plastic pollution and discuss solutions.[1] The ACP will continue to track new research as it emerges and make it available to ACP members.

The Scale of the Problem

Plastic pollution is a problem that affects waterbodies and wildlife across the country and around the world—from mountain streams,[2] to the Great Lakes,[3] to rivers running to the sea,[4] and throughout major ocean basins.[5] Over the past several years, a surge of research has focused on plastic pollution in the aquatic environment and its impact on wildlife and ecosystems, as well as human health effects. This section includes an overview of major findings on the scale of the plastic pollution problem.

For more information

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1 ACP Plastic Pollution Symposium report. https://sites.google.com/site/acphomepage/resources
2 M. Wagner et al., Microplastics in freshwater ecosystems: what we know and what we need to know, Env. Sci. Europe, 2014. https://doi.org/10.1186/s12302-014-0012-7
3 A.G.J. Driedger, H.H. Durr, K. Mitchell, P.V. Cappellan, *Plastic debris in the Laurentian Great Lakes: A review*, J. Great Lakes Res, 2015. http://dx.doi.org/10.1016/j.jglr.2014.12.020
4 Wagner et al.
5 D.K.A. Barnes, F. Galgani, R.C. Thompson, and M. Barlanz, *Accumulation and fragmentation of plastic debris in global environments*, Philos Trans R Soc Lond B Biol Sci., 2009. http://dx.doi.org/10.1098/rstb.2008.0205

As global plastic production rises, so does the amount of plastic pollution in the world's ocean and freshwater systems. Over the past 50 years, the global plastics industry has grown rapidly. During this time, the use of plastics increased twentyfold, with global production reaching 322 million tons in 2015.[6] Global plastic production is expected to double in the next 20 years, and almost quadruple by 2050.[7] Approximately 8.8 million tons of plastic enters the ocean each year.[8] Plastic debris can now be found in almost every marine habitat on Earth – from polar sea ice to major ocean gyres to the bottom of the deepest ocean trench.[9] If current practices continue, plastic input into the ocean is expected to double by 2025.[10] Plastic debris in lakes and rivers can be as high, or higher, than in oceanic gyres,[11] and about 22 million pounds of plastic flows into the Great Lakes each year.[12]

Plastic impacts aquatic wildlife and habitats around the world. Nearly 700 species of marine animals are known to be impacted by marine debris, most of which is plastic.[13] Plastic debris accounts for 92 percent of observed encounters between marine animals and debris.[14] All known species of sea turtle, 54 percent of all marine mammal species, and 56 percent of all seabird species have been affected by entanglement (mostly by plastic rope and netting) or ingestion (mostly by plastic fragments and microplastic) of marine debris, and the frequency of encounters have increased over time.[15] It's estimated that over 99 percent of all seabird species—and over 90 percent of individual seabirds—will have ingested plastic by 2050.[16] Entanglement impacts include drowning, suffocation, and lacerations, while ingestion has led to starvation due to gut obstruction, and reduced fitness.[17]

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We are learning more about the impact of plastic on the marine food web and human health. A further consequence of ingestion is that the chemical constituents of plastic, as well as the toxins they adsorb in the aquatic environment, can enter the bodies of marine organisms upon consumption,[18] where they may concentrate and climb the food chain, ultimately into

Approximately 8.8 million tons of plastic enters the ocean each year.[8]

6 *The New Plastics Economy: Rethinking the Future of Plastics*, World Economic Forum, 2016, http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf and *Plastics – The Facts 2016*, Plastics Europe, 2016, http://www.plasticseurope.org/Document/plastics---the-facts-2016-15787.aspx?FolID=2

7 World Economic Forum and Plastics Europe

8 J.R. Jambeck, R. Geyer, C. Wilcox, T.R. Siegler, M. Perryman, A. Andrady, R. Narayan, and K.L. Law, *Plastic waste inputs from land into the ocean*, Science, 2015. https://doi.org/10.1126/science.1260352 and World Economic Forum 2016

9 1. A. Lusher, *Microplastics in the marine environment: distribution, interactions and effects*, Marine Anthropogenic Litter, 2015. http://dx.doi.org/10.1007/978-3-319-16510-3_10; 2. Barnes et al.

10 Jambeck et al.

11 A.K. Baldwin, S.R. Corsi, S.A. Mason, *Plastic Debris in 29 Great Lakes Tributaries: Relations to Watershed Attributes and Hydrology*, Env. Sci. Tech., 2016, http://dx.doi.org/10.1021/acs.est.6b02917

12 Driedger et al.

13 S.C. Gall, R.C. Thompson, *The impact of debris on marine life*, Mar. Pollut. Bull., 2015, https://doi.org/10.1016/j.marpolbul.2014.12.041

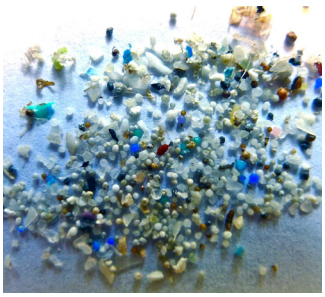
14 Gall and Thompson

15 Gall and Thompson

16 C. Wilcox, E. van Sebille, B.D. Hardesty, *Threat of plastic pollution to seabirds is global, pervasive, and increasing*, Proc. Natl. Acad. Sci., 2015. http://dx.doi.org/10.1073/pnas.1502108112

17 Gall and Thompson

18 1. C.M. Rochman et al. *Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress,* Sci Rep., 2013, http://dx.doi.org/10.1038/srep03263. 2. M.A. Browne et al. *Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity*, Curr Biol, 2013, http://dx.doi.org/10.1016/j.cub.2013.10.012. 3. E.M. Chua et al. *Assimilation of polybrominated diphenyl ethers from microplastics by the marine amphipod, Allorchestes compressa,* Environ Sci Technol, 2014, http://dx.doi.org/10.1021/es405717z. 4. K. Tanaka et al. *Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics*, Mar Pollut Bull, 2013, http://dx.doi.org/10.1016/j.marpolbul.2012.12.010. 5. Besseling E, et al. *Effects of microplastic on fitness and PCB bioaccumulation by the lugworm Arenicola marina (L.)*, Eviron Sci Technol, 2013, http://dx.doi.org/10.1021/es302763x 6. Thompson RC, et al. *Lost at sea: where is all the plastic?* Science, 2004, http://dx.doi.org/10.1126/science.1094559



humans.[19] A 2015 study found plastics of different concentrations and types in fish sold for human consumption,[20] and plastic has also been found in oysters and mussels.[21] As plastic pollution continues to increase, so does the need for more research on the impacts of plastic on aquatic populations and ecosystems, as well as human health.

Their small size enables microplastics to enter the food chain at the lowest trophic levels.[26]

The Pervasive Problem of Microplastics and Nanoplastics

Plastic fragments less than 5 millimeters in size are known as microplastics, which are either manufactured at this size (i.e., microbeads, capsules, fibers and pellets), or created when larger plastic pieces break down due to sunlight exposure, oxidation, and the physical action of waves, currents, and grazing by fish or birds.[22] Nanoplastics—defined as particles less than 100 nanometers—is probably the least known area of marine debris, but potentially also the most hazardous.[23] One study estimates that there are up to 51 trillion microplastic particles floating on the ocean's surface,[24] and deep sea sediments have been found to contain up to four times more microplastic particles than surface waters.[25] Their small size enables microplastics to enter the food chain at the lowest trophic levels,[26] and microplastics have been found in the digestive tracts of both marine and freshwater species,[27] where they may leach chemicals into the tissues of organisms.[28] Solutions for preventing microplastic pollution include reducing the input of all plastic waste into the ocean, and improving waste management systems to better capture small plastic particles.

19 S.L. Wright, R.C. Thompson, T.S. Galloway, *The physical impacts of microplastics on marine organisms: A review*, Env. Pollut., 2013. http://dx.doi.org/10.1016/j.envpol.2013.02.031

20 C. Rochman et al., *Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption*, Sci. Reports, 2015. http://dx.doi.org/10.1038/srep14340

21 Wright et al.

22 NOAA Marine Debris Program, *Microplastic Marine Debris,* https://marinedebris.noaa.gov/sites/default/files/MicroplasticsOne-Pager_0.pdf

23 A.A. Koelmans, E. Besseling, W.J. Shim, *Nanoplastics in the Aquatic Environment. Critical Review*, in: Marine Anthropogenic Litter, Springer, 2015, pp. 325e340. https://link.springer.com/chapter/10.1007%2F978-3-319-16510-3_12

24 1. Barnes et al.; 2. E. van Sebille et al., *A global inventory of small floating plastic debris*, Env. Res. Lett., 2015. http://doi.org/10.1088/1748-9326/10/12/124006

25 L.C. Woodall et al., *The deep sea is a major sink for microplastic debris*, Roy. Soc. Open Sci., 2014. https://doi.org/10.1098/rsos.140317

26 Cole et al., *Microplastic ingestion by zooplankton*, Environ Sci Tech, 2013. http://pubs.acs.org/doi/abs/10.1021/es400663f

27 1. W. Sanchez, C. Bender, J.M. Porcher, *Wild gudgeons from French rivers are contaminated by microplastics: preliminary study and first evidence*, Env. Res. 128, 2014. http://dx.doi.org/10.1016/j.envres.2013.11.004; 2. F.J. Biginagwa, B.S. Mayoma, Y. Shashoua, K. Syberg, and F. Khan, *First evidence of microplastics in the African Great lakes: Recovery from Lake Victoria Nile Perch and Nile tilapia*. J. Great Lakes Res., 2016. http://dx.doi.org/10.1016/j.jglr.2015.10.012; 3. Wright et al.

28 1. C.M. Rochman et al. 2. M.A. Browne et al. 3. E.M. Chua et al. 4. K. Tanaka et al. 5. Besseling E, et al.

The Scope of Solutions

Plastic pollution is an expansive, multi-faceted problem that has its root cause in a staple of our society. Solution strategies span the spectrum from local beach clean ups to creating a "circular economy". Unfortunately, there is no singular, comprehensive solution to this challenge. However, as the spotlight on this issue intensifies, so do efforts to design comparable responses. Today, solution strategies can be characterized as follows below.

Cleaning it up

Thousands of beach cleanups occur in the United States and around the world every year, including many sponsored by aquariums. Ocean Conservancy has led the International Coastal Cleanup for nearly three decades, and in 2015, this global effort resulted in more than more than 18 million pounds of trash collected by nearly 800,000 volunteers.[29] Beach cleanups are a great way to raise public awareness while making a positive impact on the local environment, if only short-lived. They also produce valuable data on the most littered plastic products in coastal areas.[30] Accumulations of plastic in global ocean gyres has also spurred interest in large-scale, ocean-based cleanup projects, which are still at early stages of development.[31]

In 2015, nearly 800,000 volunteers collected more than 18 million pounds of trash around the world.[29]

Preventing "leakage"

Plastic can "leak" from land to the aquatic environment as the result of poor waste management and littering. Five countries (China, Indonesia, Philippines, Vietnam, and Sri Lanka) account for 54 percent ocean plastic pollution.[32] In these places, improving waste collection, dumping and recycling systems could significantly help prevent plastic from getting to the ocean. Although the United States has relatively strong waste management, it is still 20th on the list of ocean plastic polluting countries, generating between 40 and 100 thousand tons of ocean plastic a year.[33] U.S.-based efforts to reduce the leakage of plastic trash into waterbodies include new trash-focused Total Maximum Daily Load (TMDL) programs under the Clean Water Act, improvements in stormwater capture systems, and innovations in catchment devices like booms and trash wheels.

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Recycling

Recycling—the process of using waste material to manufacture new, often lesser-value products—is a key way to reduce the chance that plastic waste will be leaked into the aquatic environment. However, recycling continues to lag significantly behind the rate of plastic production in the United States and around the world.[34] Of the over 33 million tons of

29 https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/volunteer/clean-up-locations/ Accessed May 10, 2017.
30 http://www.coastalcleanupdata.org/
31 https://www.theoceancleanup.com/
32 Jambeck et al.
33 Jambeck et al.
34 Plastics Europe 2015

plastic waste generated in the United States in 2014, only 9.5 percent was recycled, while 75.5 percent was sent to landfills.[35] Only 2.1 percent of nondurable plastic product waste (i.e., disposable plates and cutlery) was recycled, while 15 percent of plastic packaging waste was recycled.[36] Another 15 percent of total plastic waste in 2014 was burned for electricity.[37] Incineration and other emerging "waste to energy" technologies (i.e., fuel through pyrolysis and gas through gasification) are expected to grow in use,[38] but have associated concerns about environmental and human health impacts.

Reducing production

Today, the packaging industry is the biggest single market for plastic,[39] and growth in the global middle class is expected to increase the consumption of consumer goods,[40] one of the primary drivers of this industry.[41] As public awareness of the impacts of plastic pollution increases, so does demand for more-sustainable alternatives to plastic packaging, especially for consumer-facing goods like food, beverages, personal care products, and household items. This demand is spurring innovation in product design and materials science as ways to reduce the amount of non-degradable plastic in the production and waste streams. The developing field of "bioplastics"—plastics that are fully or partly bio-based, biodegradable, or both—is one source of innovation, but questions remain about the environmental and economic impacts of this approach.[42]

Only 9.5 percent of the over 33 million tons of plastic generated in the United States in 2014 was recycled.[35]

Today, the packaging industry is the biggest single market for plastic.[39]

Closing the loop

The concept of creating a zero-waste, "circular economy" continues to gain traction worldwide. Generally speaking, the aim of a circular economy is to reuse or upgrade materials for productive applications through as many life cycles as possible. This is in contrast to the traditional "linear economy" in which products are made, used, and disposed.[43] While the circular economy idea is still in its infancy, an increasing number of

The aim of a circular economy is to reuse or upgrade materials for productive applications through as many cycles as possible.

35 U.S. Environmental Protection Agency, *Advancing Sustainable Materials Management: 2014 Fact Sheet*, 2014, https://www.epa.gov/sites/production/files/2016-11/documents/2014_smmfactsheet_508.pdf

36 U.S. EPA 2014

37 U.S. EPA 2014

38 Grand View Research, *Waste To Energy (WTE) Market Analysis By Technology (Thermal (Incineration, Gasification, Pyrolysis), Biological) And Segment Forecasts, 2014 – 2024*, November 2016, http://www.grandviewresearch.com/industry-analysis/waste-to-energy-technology-industry

39 World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, *The New Plastics Economy — Rethinking the future of plastics* (2016). http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf

40 SPI: The Plastics Trade Industry Association, *2015 Global Business Trends*, December 2015. http://www.plasticsindustry.org/article/spi-plastics-industry-trade-association-releases-annual-global-business-trends-report-gps http://www.technavio.com/pressrelease/technavioannouncesglobalfmcgpackagingmarketworth557billion2020.

41 14. Lucintel, *Growth Opportunities in the Global Plastic Packaging Market: Trends, opportunities and forecast in this market to 2018 by various segment and region*, 2013. http://www.lucintel.com/reports/chemical_composites/plastic_packaging_market_2018.aspx

42 UNEP, *Valuing Plastic: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry*, 2014. http://wedocs.unep.org/handle/20.500.11822/9238

43 1. Waste and Resources Action Programme, http://www.wrap.org.uk/about-us/about/wrap-and-circular-economy, Accessed May 10, 2017; 2. McKinsey & Company, Moving Toward a Circular Economy, http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/moving-toward-a-circular-economy, Accessed May 30, 2017; 3. Ellen MacArthur Foundation, *What is a circular economy?* https://www.ellenmacarthurfoundation.org/circular-economy, Accessed May 10 2017; 4. M. Geissdoerfer,P. Savaget, N.M.P. Bocken, E.J. Hultnik, *The circular economy - a new sustainability paradigm?* J. Clean. Prod., 2017. http://dx.doi.org/10.1016/j.jclepro.2016.12.048

While plastic pollution is a global problem, our reputation as leading aquariums in the United States can help us achieve impact from the local to global scale.

industries, governments, and NGOs are coming together to develop circular economy-based practices and policies.[44] Extended producer responsibility, also known as EPR, is a current policy approach that reflects this concept by incentivizing producer investment in the full life cycle of its products, including the management of its waste.[45] Innovative product and systems design are also a hallmarks of the circular economy concept.[46]

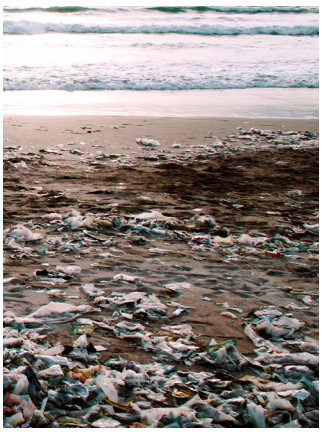
ACP Plastic Pollution Initiative

Using our Unique Assets

The ACP's priority conservation goal for the 2016-2017 pilot period is to reduce the sources of ocean and freshwater plastic pollution.[47] Tackling this challenge in a meaningful way takes the best science, as well as concerted action by consumers, industry, and government. ACP aquariums bring unique and powerful assets to both advancing our understanding of the problem of plastic pollution, and catalyzing action by each of these groups. Today we are raising awareness about the state of the science among the tens of millions of people who visit our institutions each year and follow us on social media. We are also leveraging our business relationships to catalyze market-based change. And we are using our credibility and influence with decision-makers to advance progress at the local, state, national, and even international levels.

While plastic pollution is a global problem, our reputation as leading aquariums in the United States can help us achieve impact from the local to global scale. U.S. consumers generate more plastic waste per person than any other top plastic polluting country.[48] The United States is also home to many of the top consumer brands that are packaging their products in plastic at an increasing rate.[49] These statistics represent significant challenges, but also tremendous opportunities to create positive change, especially since the United States is also a global leader in science and innovation. And we are trend-setters—solutions adopted by U.S. consumers, industry and government can ultimately become models for the rest of the world.

44 P. Lacy and J. Rutkvist, *Waste to Wealth - the Circular Economy Advantage* (2015) Palgrave Macmillan UK. http://www.palgrave.com/us/book/9781137530684
45 1. OECD, *Extended Producer Responsibility: A Guidance Manual for Governments*, 2001. http://ec.europa.eu/environment/waste/pdf/target_review/Guidance%20on%20EPR%20-%20Final%20Report.pdf; 2. European Commission - SG Environment, *Development of Guidance for Extended Producer Responsibility*, 2014. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/epoc/wgwpr(2005)6/final
46 Ellen MacArthur Foundation, *New Plastics Economy - Catalysing Action*, 2017. https://www.ellenmacarthurfoundation.org/assets/downloads/New-Plastics-Economy_Catalysing-Action_13-1-17.pdf
47 ACP Conservation Action Agenda
48 Jambeck et al.
49 16. OC&C, *Flat Footed: The OC&C Global 50 2015* (2015). http://www.occstrategy.com/insights/def/flatfooted_global502015



The ACP primary goal for 2016-17:

To work together to reduce the sources of ocean and freshwater plastic pollution through a mix of consumer, business, and policy strategies.

Three Main Strategies

ACP aquariums are working to achieve our goal to reduce the sources of ocean and freshwater plastic pollution in three ways:

1. **Consumer strategy:** Raise public awareness and increase consumer demand for alternatives to single-use plastic.

   In the summer of 2017, ACP aquariums will launch a coordinated consumer campaign to raise awareness among our audiences about the problem of aquatic plastic pollution, and to increase consumer demand for alternatives to single-use plastic.

2. **Business strategy:** Work with business partners to model change in our aquariums and accelerate innovation in the broader marketplace.

   In the summer of 2017, ACP aquariums will make a public commitment to reduce and eliminate single-use plastic in our retail and food service operations. To do this, we are working with our business partners to advance change inside and outside our aquariums.

3. **Policy strategy:** Promote science-based policies to reduce sources of aquatic plastic pollution.

   Over the past two years, ACP aquariums have supported local, state and federal policies to address aquatic plastic pollution, including actions to phase-out plastic microbeads and single-use plastic bags, and fund government programs to improve plastic pollution research and management.

Together, these three strategies represent a “theory of change” for how ACP aquariums can use our consumer, business, and policy assets to catalyze action by each of these groups, and help accelerate comprehensive solutions to the global ocean and freshwater plastic pollution challenge.