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PETITION FOR WATER QUALITY CRITERIA FOR PLASTIC POLLUTION UNDER THE CLEAN WATER ACT, 33 U.S.C. § 1314

Photo: NOAA Marine Debris Program

BEFORE THE ENVIRONMENTAL PROTECTION AGENCY

AUGUST 22, 2012

CENTER for BIOLOGICAL DIVERSITY

Because life is good.

Petitioner

The Center for Biological Diversity is a nonprofit environmental organization dedicated to the protection of imperiled species and their habitats through science, education, policy, and environmental law. The Center has over 375,000 members and online activists. The Center submits this petition on its own behalf and on behalf of its members and staff.

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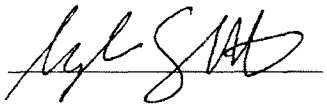
Respectfully submitted,



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Right to Petition

The right of an interested party to petition a federal agency is a freedom guaranteed by the first amendment: "Congress shall make no law ... abridging the ... right of people ... to petition the Government for redress of grievances." U.S. Const., Amend I. See also United Mine Workers v. Illinois State Bar Ass'n, 389 U.S. 217, 222 (1967) (right to petition for redress of grievances is among most precious of liberties without which the government could erode rights).

Under the Administrative Procedures Act (APA), all citizens have the right to petition for the "issuance, amendment, or repeal" of an agency rule. 5 U.S.C. § 553(e). A "rule" is the "whole or a part of an agency statement of general or particular applicability and future effect designed to implement, interpret, or prescribe law or policy." 5 U.S.C. § 551(4). Here, the Center for Biological Diversity seeks issuance of a new rule containing water quality criteria for plastic pollution and guidance on protecting waters from plastic pollution. The EPA is required to respond to this petition: "Prompt notice shall be given of the denial in whole or in part of a written application, petition, or other request of an interested person made in connection with any agency proceeding." 5 U.S.C. § 555(e).

The issuance of new criteria under section 304 is a non-discretionary duty under the Clean Water Act. Section 304(a)(1) and 304(a)(2) of the Clean Water Act, under which the Center for Biological Diversity is seeking EPA rulemaking, state that the EPA "shall" develop, publish, and revise water quality criteria and protection information. 33 U.S.C. § 1314(a)(1),(2). See Forest Guardians v. Babbitt, 174 F.3d 1178, 1187 (10th Cir. 1998) ("[W]hen a statute uses the word 'shall,' Congress has imposed a mandatory duty upon the subject of the command"). This petition is enforceable under the citizen suit provision of the Clean Water Act. 33 U.S.C. § 1365. The federal district courts of the United States have jurisdiction over a claim that the Administrator of the EPA has failed to perform a non-discretionary duty. 33 U.S.C. § 1365(a)(2).

The APA provides for judicial review of a final agency action. 5 U.S.C. § 704. The scope of review by the courts is determined by section 706 of the APA. 5 U.S.C. § 706. The APA also permits courts to compel agency action unlawfully withheld or unreasonably delayed. 5 U.S.C. § 706. The provisions of this Petition are severable. If any provision of this Petition is found to be invalid or unenforceable, the invalidity or lack of legal obligation shall not affect other provisions of the Petition.

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I. Executive Summary

Plastic pollution in the ocean is harmful, even deadly, to wildlife. Every year, it is estimated that hundreds of thousands of marine mammals and sea birds die after being entangled in or ingesting plastic.[1] Plastic is a principal threat to ocean water quality. Plastic pollution covers our ocean's surface, floor, and permeates shore sediment and the water column, even outnumbering plankton in certain areas.

The Center for Biological Diversity formally requests that the EPA initiate a rulemaking pursuant to the Clean Water Act to address threats posed specifically by plastic pollution. This Petition requests that the EPA:

1. Establish national water quality criteria pursuant to section 304(a)(1) to address plastic pollution, and

2. Publish information pursuant to section 304(a)(2) to guide states in monitoring and preventing harm to waters from plastic pollution.

Under the Clean Water Act, EPA has a duty to periodically update water quality criteria to reflect the latest scientific knowledge. 33 U.S.C. § 1314(a)(1). The national water quality criteria are the basis for state water quality standards and pollution controls; thus, they can be critical in protecting our waters and wildlife from the hazards of plastic pollution.

Because plastic particles are prevalent and often very small, marine animals such as sea birds, fish, and sea turtles mistake plastic particles for food. When these animals eat plastic, it can seriously injure or kill them by blocking their esophagus or breathing tube or inducing a false satiation of hunger. Larger plastic debris also entangles and traps marine mammals, including threatened and endangered species. Curious seals get plastic straps, rubber bands and rope wrapped around their necks or flippers, which can cut into their flesh or asphyxiate them. Lost fishing nets, traps, and lines made of plastic are a pervasive problem because they haunt the oceans capturing and drowning marine species. Plastic pollution is also known to attract and concentrate toxic chemicals. These chemicals can further accumulate as they pass up the marine food chain.

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[1] Wallace, N. "Debris Entanglement in the Marine Environment: A Review." Proceedings of the Workshop on the Fate and Impact of Marine Debris. Eds. R.S. Shomura, H.O. Yoshida. U.S. Department of Commerce: NOAA Technical Memorandum. NMFS, NOAA-TM-NMFS-SWFC-5, pp. 259-277.

Plastic pollution is ubiquitous in our oceans—but it does not belong there. Plastic pollution makes up 50 to 80 percent of beach litter, floating marine debris, and trash on the ocean floor.[2] Researchers report that there is a huge "garbage patch" of floating plastic debris in the North Pacific Ocean where currents form a gyre that collects plastic pollution. There are other smaller ocean gyres, including one in the North Atlantic, where plastic is also accumulating. Plastic pollution has been increasing exponentially with the widespread use of commercial and consumer plastics. In 2009, the global production of plastics reached 230 million tons per year.[3] The amount of plastic produced between 2000 - 2010 exceeds the amount produced during the entire last century.[4]

Because plastic pollution is a primary threat to marine life and water quality, it must be addressed separately from other wastes or pollutants. Doing so will allow decision makers to make more informed and more specific policy choices. Accordingly, this Petition seeks water quality criteria aimed at reducing plastic pollution in our waters and protecting wildlife from plastic waste.

This petition marks the first step toward a national approach to reducing and reversing the damaging effects of plastic on our oceans and wildlife. Due to plastic's resistance to degradation and its ubiquitous production, only a concerted national effort will solve this growing problem. The Clean Water Act mandates that the EPA protect the nation's water quality, and the EPA must act promptly to address the threats of plastic pollution.

II. Plastic Pollution Threatens Water Quality

The need to address plastic pollution in our oceans arises from the harm it presents to wildlife and uses of our oceans. The latest scientific information demonstrates that plastic pollution injures and kills marine mammals, sea birds, sea turtles, coral reefs, and fish.[5] The problem is significant, and it is daily growing more severe. The EPA has a duty to curb plastic pollution in order to protect the biological integrity of our nation's waters and to ensure that they

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[2] Barnes, D.K.A. et al. 2009. Accumulation and fragmentation of plastic debris in global environments. Phil. Trans. R. Soc. B, 364 (1526), 1985. http://nora.nerc.ac.uk/10804/1987.

3 Hirai, H., et al. 2011. Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. Mar. Pollut. Bull. doi:10.1016/j.marpolbul.2011.06.004

[4] Thompson, R.C., et al. 2009. "Plastics, the environment and human health: current consensus and future trends." Philosophical Transactions of the Royal Society B-Biological Sciences. 364.1526, 2153-2166.

[5] Laist, D. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. SPRINGER SERIES ON ENVIRONMENTAL MANAGEMENT.

support beneficial wildlife, fishing, and recreational uses, consistent with the goals of the Clean Water Act.

a. Plastic Pollution Defined

To adequately address the problem of plastic marine debris, it is essential to understand what it is and where it comes from. There are primarily two categories of plastic, user plastic and pre-production plastic. "User plastic" is the material found in common commercial goods, such as plastic bags, bottle caps, fishing gear, and clothing.[6] Waves and chemical processes break user plastic into smaller pieces, which makes it extremely difficult to clean up.[7] Estimates say that 80 percent of marine debris comes from land based sources.[8] These land based sources include urban runoff, combined sewer overflows, beach visitors, inadequate waste disposal and management, industrial activities, construction, and illegal dumping.[9] Of these, urban runoff is the primary contributor of marine debris, which is transported either by storm drains, wind, or direct dumping.[10] The primary type of pre-production plastic consists of plastic resin pellets, also called "nurdles," which are small granules, generally cylindrical or disk-shaped, with a diameter of a few millimeters.[11] These plastic particles, commonly polyethylene or polypropylene, are industrial raw material transported to manufacturing sites where "user plastic" is made by remelting and molding the resin pellets into final products.[12] Nurdles are often found floating on coastal and ocean waters or embedded in the sand of beaches and are lost during loading and transportation, both on land and at sea, and during their handling at plastic factories.[13] Older pellets exhibit signs of yellowing, cracking, and abrasion.[14] Due to their buoyancy and durability, lost pellets may be transported considerable distances in the oceans before becoming temporarily or permanently stranded.[15]

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[6] Barnes, supra note 3.

[7] Gordon, Miriam, Eliminating Land-Based Discharges of Marine Debris in California: A Plan of Action from The Plastic Debris Project, CALIFORNIA COASTAL COMMISSION, 1, 3 (2006) available at http://www.plasticdebris.org/CA_Action_Plan_2006.pdf

[8] Id.

[9] Id. at 14.

[10] Id. at 15.

[11] Mato, Y. et al. 2001. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment, ENVIRONMENTAL SCIENCE TECHNOLOGY, 35 (2), 318-324, http://www.ncbi.nlm.nih.gov/pubmed/11347604.

[12] Id.

[13] Ashton, K., Holmes, L. & Turner, A., Association of metals with plastic production pellets in the marine environment, MARINE POLLUTION BULLETIN, 60 (11), 2050-2055. http://www.ncbi.nlm.nih.gov/pubmed/20696443.

[14] Id.

[15] Id.

These types and sources of water pollution present unique challenges because they are widespread, and plastic is durable and resists degradation in the marine environment.

b. Oceans Are Heavily Polluted With Plastic

Due to plastic's special characteristics, it poses significant and unique risks to us and our environment. As the EPA has noted, "except for the small amount that's been incinerated... every bit of plastic ever made still exists."[16] In addition to its persistence, plastic pollution also contains concentrated toxic chemicals and harms wildlife and habitats. Plastic can also interfere with our enjoyment of oceans and coasts, diminishing recreational activities, aesthetics, and can have adverse economic impacts and even health effects.

The plastic pollution problem is vast and accelerating. The global production of plastic has increased from 1.5 million tons in 1950 to 230 million tons in 2009, with an average annual growth of around 9%.[17] Between 2000 and 2010, there was more plastic produced than in the entire previous century.[18] Plastic makes up over 12 percent of the municipal solid waste stream, but only seven percent of total plastic items are recycled.[19] While the recycling rate for some forms of plastic is much higher—in 2009, nearly 30 percent of percent of plastic bottles were recycled—these products are, in realty, simply down-cycled into other products like doormats, textiles, and other products, which do not reduce the need for more virgin plastic.[20] Accordingly, despite improvements in plastic recycling, the demand and manufacture of plastics is growing and plastic pollution is becoming more severe.

Plastic debris comprises 50 to 80 percent of beach litter, floating marine debris, and trash on the ocean floor.[21] Most shoreline litter has urban sources, which reflects current inadequate disposal practices as well as waste from recreational visitors.[22] In the Los Angeles watershed alone, every three days 2.3 billion plastic fragments, or approximately 30 metric tons, are carried

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[16] Casey, B.S. & Segal, G., Our oceans are turning into plastic ... are we?, BEST LIFE MAGAZINE, 1, 1, (2007) http://www.enviroplumbing.com/pdf/Plastic_Oceans_.pdf.

[17] Hirai, H., et al. Organic micropollutants in marine plastics desbris from the open ocean and remote and urban beaches, Mar. Pollut. Bull. (2011), doi: 10.1016/j.marpolbul.2011.06.004

[18] Thompson, R.C. "Plastics, the environment and human health: current consensus and future trends." *Philosophical Transactions of the Royal Society B-Biological Sciences.* 364.1526 (2009):2153-2166.

[19] Plastics, EPA, http://www.epa.gov/wastes/conserve/materials/plastics.htm (last visited October 26, 2011)

[20] Plastic Pollution Coalition, Common Misconceptions, (2010), http://plasticpollutioncoalition.org/learn/common-misconceptions/

[21] Barnes, supra note 3.

[22] Gregory, M.R. 1999. Plastics and South Pacific island shores: environmental implications. *Ocean and Coastal Management* 42(6-7):603-615.

into the Pacific Ocean from land.[23] Oceans provide particularly poor conditions for plastic degradation because of sea water's low temperature and high salinity.[24]

Top Ten Items Over 25 Years

RANK	DEBRIS ITEM	NUMBER OF DEBRIS ITEMS	PERCENTAGE OF TOTAL DEBRIS ITEMS
1	CIGARETTES/CIGARETTE FILTERS	52,907,756	32%
2	FOOD WRAPPERS/CONTAINERS	14,766,533	9%
3	CAPS, LIDS	13,585,425	8%
4	CUPS, PLATES, FORKS, KNIVES, SPOONS	10,112,038	6%
5	BEVERAGE BOTTLES (PLASTIC)	9,549,156	6%
6	BAGS (PLASTIC)	7,825,319	5%
7	BEVERAGE BOTTLES (GLASS)	7,062,199	4%
8	BEVERAGE CANS	6,753,260	4%
9	STRAWS/STIRRERS	6,263,453	4%
10	ROPE	3,251,948	2%
	TOP TEN TOTAL DEBRIS ITEMS	**132,077,087**	**80%**
	TOTAL DEBRIS ITEMS WORLDWIDE	**166,144,420**	**100%**

SOURCE: OCEAN CONSERVANCY'S INTERNATIONAL COASTAL CLEANUP

Figure 1. Data collected over 25 years of coastal clean-up projects world-wide reveals that the most common items are made of plastic. Source: Ocean Conservancy. Tracking Trash: 2011 Report.

Plastic pollution is particularly ubiquitous in an area commonly known as the Great Pacific Garbage Patch, which covers an area of ocean roughly twice the size of Texas.[25] The Garbage Patch is an ocean convergence zone that accumulates debris from the entire North Pacific.[26] In 1999, plastic pollution in the area outweighed zooplankton by a ratio of 6:1 and averaged over 300,000 pieces per square kilometer, making it difficult for fish to distinguish between plastic and their natural food.[27] These gyres, areas where currents converge and collect plastics, are also areas with abundant marine life. Plastic pollution fragments into smaller pieces as it circulates within ocean currents, which increases buoyancy and the potential for ingestion

[23] Moore, C.J., et al. 2011. Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California. *Journal of Integrated Coastal Zone Management*, 11 (1), 65-73.
[24] Id. at 1986.
[25] Casey, supra note 16 at 1-2.
[26] Auman, H.J. et al. 1997. Plastic ingestion by Laysan albatross chicks on Sand Island, Midway Atoll, in 1994 and 1995, ALBATROSS BIOLOGY AND CONSERVATION, 239, 42.
[27] Id.; Moore, C., Moore, S., & Leecaster, M. (2001). A comparison of plastic and plankton in the North Pacific central gyre. *Marine Pollution Bulletin, 42*(12), 1297–1300; Zarfl, C. & Matthies, M. 2010. Are marine plastic particles transport vectors for organic pollutants to the Arctic?, MARINE POLLUTION BULLETIN, 60 (10), 1810, 12, http://www.ncbi.nlm.nih.gov/pubmed/20579675.

by smaller marine organisms.[28] The Garbage Patch is only one of five such convergence zones, which in total cover 40 percent of the ocean—or 25 percent of the earth's surface—so, in the words of one article, "25 percent of our planet is a toilet that never flushes."[29]

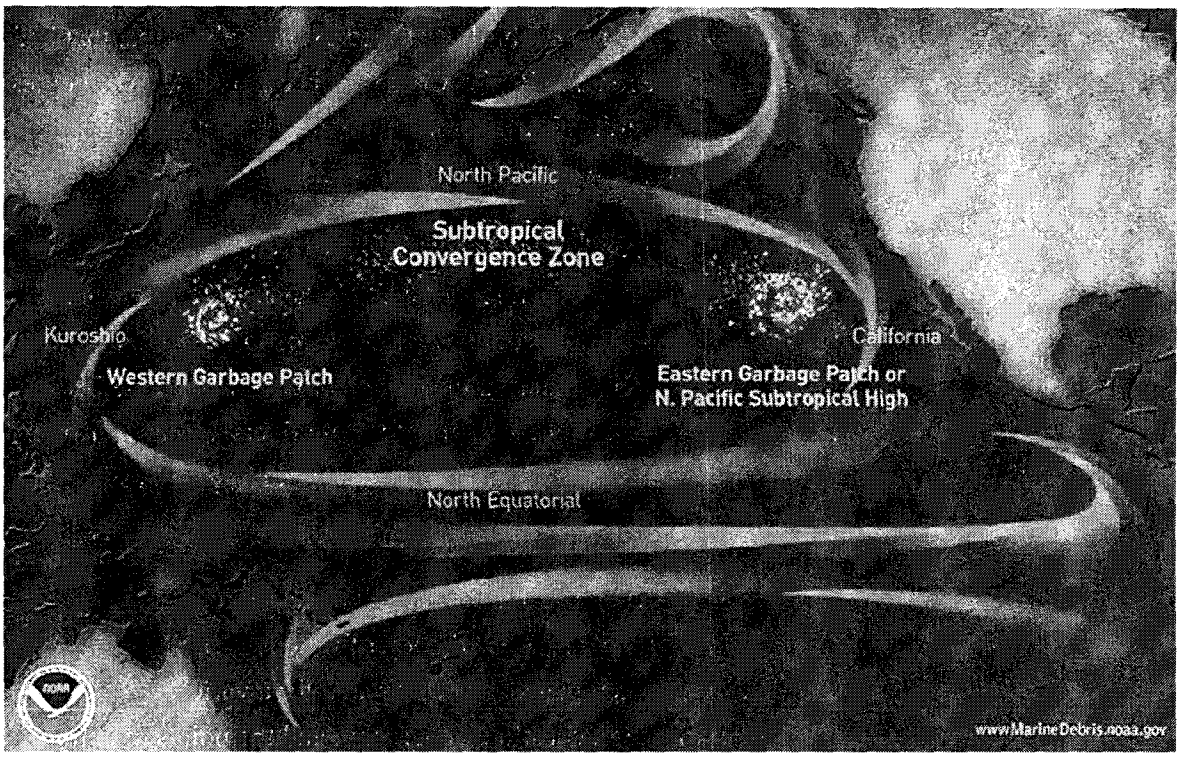

Figure 2. Marine debris accumulation locations in the North Pacific Ocean. (NOAA Marine Debris Program)

Studies initiated in the 1980s and 1990s indicate that the rate of marine plastic pollution show a sustained and considerable increase over time.[30] Similarly, the amount of macro-plastics associated with wildlife has also dramatically increased. For example, plastic ingestion in albatross chicks, whose parents feed them plastic particles mistaken for food, suggest that the amount of plastic in the Garbage Patch is increasing.[31] In 1966, 74 percent of albatross chicks

[28] Auman, supra note 24.
[29] Casey, supra note 16 at 5.
[30] Ribic, C.A., et al. 1997. Distribution, type, accumulation, and source of marine debris in the United States, 1989-1993. In *Marine Debris: sources, impact and solutions* (eds J.M. Coe & D. B. Rogers), pp. 35-48. New York, NY: Springer Verlag.
[31] Auman, supra note 24; Teuten, E.L. et al., 2009. Transport and release of chemicals from plastics to the environment and to wildlife, PHI. TRANS. R. SOC. B, 364(1526), 2027, 37, http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873017&tool=pmcentrez&rendertype=abstract.

sampled at Pearl and Hermes Reefs in the Northwest Hawaiian Islands contained an average of 1.87 grams of plastic, which increased to 97.6 percent in 1994-1995 and over 18 grams on average.[32] Another study of ingestion of plastic by birds found that birds near the Garbage Patch, on Kure Atoll, had ten times more plastic in their bodies than chicks from Oahu.[33] One recent study found over 90 percent of dead northern fulmars, birds that feed exclusively at sea, that had washed up on the coasts of Washington, Oregon and British Columbia had plastic in their bellies and an average of 36.8 pieces of plastic per bird.[34] These results compared to earlier studies indicated a 34 percent increase in plastic ingestion over the past 40 years.[35]

Surveys from around the globe also indicate that plastic pollution is increasing throughout the world's oceans. Off Japan's coast, floating particles of plastic debris increased ten fold from the 1970s through 1980s, and then ten fold again every 2-3 years in the 1990s.[36] In the Southern Ocean, plastic debris increased 100 times during the early 1990s.[37] Around the British Isles, surveys have shown a 3-to 4-fold increase in the volume of plastic fibers in seawater from the 1960s to the 1990s.[38] The increase occurred during a worldwide quadrupling of plastic fiber production.

Plastic pollution does not evenly distribute within water, and the effects of plastic pollution may be greater or lesser within parts of an affected body of water depending on local concentrations. In oceans, plastic debris is heterogeneously distributed for a variety of reasons, including current wind conditions (e.g. El Nino), coastline geography, and the points of entry into the system such as urban areas and trade routes.[39] For example, stranding of larger size plastic pollution is between one and two orders of magnitude less on remote shores, as abundance correlates very strongly with human population centers.[40] Studies provide highly variable estimates of marine debris density in the near-surface zone and encompass five orders of

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[32] Auman, supra note 24 at 300.
[33] Young, L.C. et al., 2009. Bringing Home the Trash: Do Colony-Based Differences in Foraging Distribution Lead to Increased Plastic Ingestion in Laysan Albatrosses? PLoS ONE, 4(10), 3. (2009) http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2762601&tool=pmcentrez&rendertype=abstract
[34] Avery-Gomm, S., et al. 2012. Northern fulmars as biological monitors of plastic pollution in the Eastern North Pacific. Mar. Poll. Bull. http://dx.doi.org/10.1016/j.marpolbul.2012.04.017
[35] Id.
[36] Ogi and Fukimot (2000) Fisheries Bulletin
[37] Copello and Quintara (2003) Mar Poll Bull
[38] R. Thompson, et al (2004) Science
[39] Barnes, supra note 3.
[40] Id.

magnitude (from less than one item per square kilometer to as many as 332,556 items per square kilometer).[41]

Marine debris originates predominantly from land-based sources and is carried primarily by rainfall to oceans.[42] The Los Angeles River is just one example of the abundance of plastic in local waters and collects a significant amount of debris from the surrounding environment. From 1998-1999, a Continuous Deflective Separation (CDS) unit installed in Calabasas, California collected 2,000 gallons of sludgy water and a 64 gallon bag two thirds full of plastic wrappers.[43] Presumably, paper products had decomposed during the nine months of collection, highlighting one of the unique problems of plastic pollution: resistance to degradation.[44] In Long Beach, California the weight of the amount of trash collected over different years from storms ranged from over 1,800 to 12,250 tons over a ten year period.[45] In the Northwest Hawaiian Islands, the annual debris accumulation, of which plastic is a principal component, is estimated at over 50 tons.[46]

Plastic debris is also common on the U.S. East Coast and in the North Atlantic.[47] Sixty-two percent of all surface tows in the western North Atlantic Ocean and Caribbean Sea from 1986 to 2008 contained detectable plastic. [48] In the area of highest concentration, the North Atlantic subtropical gyre, there was on average over 20,000 plastic pieces per square kilometer.[49] Based on the density of sampled surface plastics, 47 percent were likely polypropylene, low density polyethylene, and high density polyethylene, which compromise more than 50 percent of total discarded plastics in U.S. municipal solid waste.[50]

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[41] National Research Council Committee on the Effectiveness of International and National Measures to Prevent and reduce Marine Debris and Its Impacts). 2008 *Tackling Marine Debris in the 21st Century*, National Academes Press: Washington, D.C.

[42] Gordon, supra note 12 at 14.

[43] California Regional Water Quality Control Board, Los Angeles Region, Trash Total Maximum Daily Loads for the Los Angeles River Watershed, 1, 18 (2007), http://www.epa.gov/waters/tmdldocs/34863-RevisedStaffReport2v2.pdf (last visited October 26, 2011)

[44] Id.

[45] Id. at 19-20

[46] Dameron, O.J., et al. 2007. Marine debris accumulation in the Northwestern Hawaiian Islands: An examination of rates and processes. Mar. Poll. Bull. 54, 423-433.

[47] Law, K. et al. 2010. Plastic Accumulation in the Atlantic Subtropical Gyre. Science. 329, 1185-1188.

[48] Id.

[49] Id.

[50] Morét-Ferguson, S. et al. 2010. The size, mass, and composition of plastic debris in the western North Atlantic Ocean. Mar. Poll. Bull. 60, 1873-1878.

Commercial whale watching vessels in the southern Gulf of Maine in the summer of 2011 noted 2,574 pieces of debris and 4,660 whale sightings (a ratio of 1:2), with plastic the most common type of debris and balloons the most common item.[51] Current data sets of surface plastics may underestimate abundance; in 2012 Kukulka et al. concluded that plastic concentrations are likely two and a half times greater than what it is visible at the surface, because plastic pieces are vertically distributed in the mixed layer due to wind-induced mixing.[52]

Despite their longevity, plastic items fragment into the marine environment as a consequence of prolonged exposure to UV light and physical abrasion. As plastic objects fragment, they have the potential to be ingested by a much wider range of organisms than larger items of debris.[53]

Microplastic, defined here as items that are less than 5 millimeters, are increasingly becoming a problem in marine waters. The most abundant forms of plastic marine debris in the North Atlantic Ocean surface are fragments of consumer plastics between two and six millimeters.[54] A study by Moore et al. (2011) of plastic particles flowing from two rivers into coastal areas and beaches in southern California found that plastic particles less than five millimeters in size were 16 times more abundant and had a cumulative weight three times greater than larger particles.[55] Another common source of microplastics is plastic pellets, or nurdles, that are used to manufacture plastic products.

Small and microscopic plastic fragments present a likely route for the transfer of toxic chemicals because they have a much greater surface area to volume ratio, allowing for an increased update of contaminants, and because of microscopic plastics' size they are available to a wider range of organisms, including deposit feeders such as the lug worm that feed by stripping organic matter from particulates.[56] Mussels ingest microscopic plastic of less than 1 mm,

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[51] Asmutis-Silvia, R. et al. High risk of marine debris ingestion by large whales in the Southern Gulf of Maine, U.S.A. IWC/SC64/E13 (2012) available at http://iwcoffice.org/cache/downloads/8s3027w9v74sgs044o0sgcwkw/SC-64-E13.pdf (last visited August 20, 2012).

[52] Kukulka, T. et al. 2012. The effect of wind mixing on the vertical distribution of buoyant plastic debris. Geophys. Res. Lett. 39 (7), L07601: 1–6.

[53] Barnes, supra note 3.

[54] Morét-Ferguson, S. et al. 2010. The size, mass, and composition of plastic debris in the western North Atlantic Ocean. Mar. Poll. Bull. 60, 1873-1878.

[55] Moore, C. et al. 2011. Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California. Revista da Gestão Costeira Integrada 11 (1), 65-73 at 68.

[56] Id.

accumulate it in the gut and transfer it to the circulatory system.[57] The microscopic plastic persists in the mussels for over 48 days despite transfer to clean water, suggesting implications for predators like birds, crabs, starfish, and even humans.[58] Microscopic plastics are often from synthetic textiles, and a common source is from laundry.[59] This pollution is ubiquitous, found at 18 sites worldwide representing six continents from the poles to the equator, with more material in densely populated areas.[60] They can also come from plastic products such as Styrofoam or packaging that breaks down when plastic products fragment or degrade.[61]

The scope of plastic pollution is massive. There is so much plastic in our oceans that it has become impossible to clean up. Moreover, the problem is ongoing and accelerating. Accordingly, it is important to stem the tide of plastic into our coastal and ocean ecosystems.

c. Plastic Pollution in Marine Waters Harms Wildlife and Degrades Habitat

Plastic pollution directly harms marine animals through ingestion and constriction, attracts harmful chemicals, potentially threatens human health, and has negative economic repercussions. Plastic kills sea turtles, marine mammals, sea birds, and fish. Nearly 300 species have records of ingestion of or entanglements in plastic.[62] Plastic is degrading important foraging and nursery habitats, and it is further imperiling threatened and endangered species. These detrimental impacts means that plastic is a water quality problem that is preventing the beneficial uses of ocean and other waters.

1. Ingestion by and Entanglement of Marine Life

Over 180 species of animals ingest plastic, including birds, fish, turtles and marine mammals.[63] Birds and fish mistake small plastic pieces floating on the ocean surface for food, and turtles eat suspended plastic bags which they may mistake for jellyfish.[64] Plastic

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[57] Browne, M.A. et al. 2008. Ingested microscopic plastic translocates to the circulatory system of the mussel, *Mytilus edulis* (L.). Environ. Sci. Technol. 42, 5026–503.
[58] Id.
[59] Browne, M.A. et al. 2011. Accumulation of microplastic on shorelines worldwide: Sources and sinks. Environmental Sci. & Technology. 45 (21), 9175–9179.
[60] Id.
[61] Morét-Ferguson, S. et al. 2010. The size, mass, and composition of plastic debris in the western North Atlantic Ocean. Mar. Poll. Bull. 60, 1873-1878.
[62] Laist 1997, see supra fn. 5; see also figure 6.
[63] Teuten, E.L. et al. 2009. Transport and release of chemicals from plastics to the environment and to wildlife. PHIL. TRANS. R. SOC. B, 364 (1526), 2027, 37, http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873017&tool=pmcentrez&rendertype=abstract.
[64] Id.

bioaccumulates in animals higher on the food chain when these animals eat prey that have ingested plastic.[65] Ingestion of plastic has many detrimental consequences, including gastrointestinal blockages, ulceration, internal perforation and death.[66] Even those animals whose innards remain intact may suffer from false sensations of satiation, or experience reduced reproductive output.[67]

Figure 3. Inside the remains of dead baby albatrosses on Midway Atoll where nesting chicks are fed lethal quantities of plastic by their parents, who mistake the floating trash for food as they forage over the vast polluted Pacific Ocean. (Credit: Chris Jordan)

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[65] Id.

[66] Id.

[67] Auman, supra note 24 at 240; California Ocean Science Trust. Plastic Debris in the California Marine Ecosystem: A summary of current research, solution strategies and data gaps, C. Stevenson, University of Southern California Sea Grant. Synthetic Report. Oakland, CA. (September 2011) http://calost.org/pdf/science-initiatives/marine%20debris/Plastic%20Report_10-4-11.pdf.

Figure 4. Unaltered stomach contents, including plastic marine debris of a dead albatross chick photographed on Midway Atoll National Wildlife Refuge in the Pacific in September 2009. Credit: Chris Jordan.

In addition to ingestion, marine animals may be entangled in plastics including derelict fishing gear dragged along the ocean floor by currents, which can also smother coral reefs.[68] Entanglement affects the survival of endangered animals like sea turtles, and is a particular problem for marine mammals, such as fur seals, which are curious and playful, and drawn to plastic.[69]

[68] Marine Debris Impacts, EPA, http://water.epa.gov/type/oceb/marinedebris/md_impacts.cfm (last visited October 26, 2011).

[69] Derraik, J.G.B. 2002. The pollution of the marine environment by plastic debris: a review, MARINE POLLUTION BULLETIN, 44 (9), 842, 45, http://www.ncbi.nlm.nih.gov/pubmed/12405208.

Figure 5. Juvenile female elephant seal with a plastic strap wrapped around her neck. Credit: Monica Bond

Entangling debris may cause drowning, lacerations, infection, strangulation, increased energy expenditure, and mortality. Moreover, marine debris can be a "silent" killer, where ingested hooks or plastic may perforate the esophagus or stomach lining leading to catastrophic infections, organ damage, reduced feeding, and starvation, all with no apparent external signs of entanglement.[70] Young fur seals are attracted to floating debris and often poke their heads into the loops and holes of nets and other plastic pollution, but their hair prevents the plastic from slipping off.[71] Many seal pups grow into the plastic collars, which in time tighten to sever the seal's arteries or strangle it.[72] Tragically, once the entangled seal dies and decomposes, the constraining plastic is free to be picked up by another victim.[73]

[70] Raum-Suryan, K.L., et al. 2009. Entanglement of Steller sea lions (Eumetopias jubatus) in marine desris: Identifying causes and finding solutions. Mar. Poll. Bull. 58, 1487-1495.
[71] Id.
[72] Id.
[73] Id.

Table 2.1
Number and Percentage of Marine Species Worldwide with Documented Entanglement and Ingestion Records

Species Group	Total number of species worldwide	Number and percentage of species with entanglement records	Number and percentage of species with ingestion records
Sea Turtles	7	6 (86%)	6 (86%)
Seabirds	312	51 (16%)	111 (36%)
Penguins (Sphenisciformses)	16	6 (38%)	1 (6%)
Grebes (Podicipediformes)	19	2 (10%)	0
Albatrosses, Petrels, and Shearwaters (Procellariiformes)	99	10 (10%)	62 (63%)
Pelicans, Boobies Gannets, Cormorants, Frigatebirds and Tropicbirds (Pelicaniformes)	51	11 (22%)	8 (16%)
Shorebirds, Skuas, Gulls, Terns, Auks (Charadriiformes)	122	22 (18%)	40 (33%)
Other birds	-	5	0
Marine Mammals	115	32 (28%)	26 (23%)
Baleen Whales (Mysticeti)	10	6 (60%)	2 (20%)
Toothed Whales (Odontoceti)	65	5 (8%)	21 (32%)
Fur Seals and Sea Lions (Otariidae)	14	11 (79%)	1 (7%)
True Seals (Phocidae)	19	8 (42%)	1 (5%)
Manatees and Dugongs (Sirenia)	4	1 (25%)	1 (25%)
Sea Otter (Mustelidae)	1	1 (100%)	0
Fish	-	34	33
Crustaceans	-	8	0
Squid	-	0	1
Species Total		136	177

Source: Laist (1997).

Figure 6. Number and percentage of marine species worldwide with documented entanglement and ingestion records. Source: Laist 1997.

2. Effects of Plastic Pollution on Endangered Species

Plastic debris represents a significant threat to threatened and endangered species. EPA and all federal agencies have duties to conserve protected species. An analysis of records from 2001-2005 in northern and central California reported several entanglements of species protected under the ESA, including a sea otter, a leatherback turtle, three Guadalupe fur seals, three Steller

sea lions, a sperm whale, and two humpback whales.[74] Setting water quality criteria for plastic is a step forward in reducing the threat this poses to imperiled species.

Endangered Sea Turtles

Plastic ingestion is a severe problem for the world's threatened and endangered sea turtles. All of the sea turtles that occur in U.S. waters are protected under the Endangered Species Act. Sea turtles face multiple threats in their habitat, ranging from capture in fishing gear to sea level rise at their nesting beaches. Plastic is an important threat to sea turtles, and will need to be addressed to promote their recovery.

Figure 7. Sea turtle entangled in fishing net. Credit: NOAA.

Many sea turtles forage on jellyfish, and plastic bags or balloons floating in water mimic jellyfish. Sea turtles also are attracted to bright colors and eat a wide range of prey, for which they can mistake plastic. For example, in 2002, autopsies performed on juvenile loggerhead sea turtles showed a high occurrence of plastic material in the intestinal tract.[75] Adult loggerhead

[74] Moore, E., Lyday, S., Roletto, J., Litle, K., Parrish, J. K., Nevins, H., Harvey, J., et al. (2009). Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001-2005. *Marine pollution bulletin*, *58*(7), 1045–51. doi:10.1016/j.marpolbul.2009.02.006

[75] Tomas, J., Guitart, R. 2002. Marine debris ingestion in loggerhead sea turtles , Caretta caretta, from the western Mediterranean. Mar. Pollut. Bull. 44 (3), 211-216.

turtles have been found to ingest soft plastic, ropes, Styrofoam, and monofilament lines.[76] Autopsies of leatherback sea turtles found that 34 percent had plastic in their stomach, which can lead to blockage in the gut and even death.[77] The leatherback sea turtle can mistake floating plastic garbage for jellyfish, their main food source.[78] Juvenile green sea turtles can also mistake plastic pieces for food.[79] For example, a study of 38 green sea turtles, 10 loggerhead turtles, and 2 leatherback turtles found that plastic bags were the main debris ingested.[80] Another study found that female green sea turtles had a higher occurrence of ingested debris when compared to males.[81] For sea turtles, even small quantities can be deadly.[82] Estimates of debris ingestion rates vary depending on geography, species, year, and life-stage of the turtles.[83] Recent work from South American populations of marine turtles found that up to 100 percent of stranded turtles contained marine debris in their gastrointestinal systems.[84] In Queensland, 54.5 percent of pelagic-sized sea turtles had ingested marine debris whereas only 25 percent of benthic feeding turtles were found with debris in their gastrointestinal system.[85]In addition to ingestion, observations of entanglement of sea turtles has been reported for all species of sea turtles that inhabit U.S. waters.[86]

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[76] Lazar, B. Gracan, R. 2011. Ingestion of marine debris by loggerhead sea turtles, Caretta caretta, in the Adriatic sea. Mar. Pollut. Bull. 62, 43-47.

[77] Mrosovsky, N., Ryna, G., James, M. 2009. Leatherback turtles: the menace of plastic. Mar. Pollut. Bull. 58, 287-289.

[78] Id.

[79] Stamper, M., Spicer, C., Neiffer, D., Mathews, K., Fleming, G. 2009. Morbidity in juvenile green sea turtles due to ocean-bourne plastic. Journal of Zoo and Wildlife Medicine. 40 (1), 196-198.

[80] Bugoni, L., Krause, L., Petry, M. 2001. Marine debris and human impacts on sea turtles in southern brazil. Mar. Pollut. Bull. 42 (12), 1330-1334.

[81] Bjorndal, K., Bolten, A., Lagueux, C. 1994. Ingestion of marine debris by juvenile sea turtles in coastal florida habitats. Mar. Pollut. Bull. 28 (3), 154-158.

[82] Id.

[83] Schuyler Q, Hardesty BD, Wilcox C, Townsend K. 2012. To Eat or Not to Eat? Debris Selectivity by Marine Turtles. PLoS ONE 7(7): e40884. doi:10.1371/journal.pone.0040884.

[84] Tourinho, P.S. et al. 2010. Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil? Mar. Poll. Bull. 60 (3), 396-401.

[85] Schuyler, Q., et al. 2012. To Eat or Not to Eat? Debris Selectivity by Marine Turtles. PLoSone 7 (7), e40884. doi:10.1371/journal.pone.0040884.

[86] EPA. 2011. Marine Debris in the North Pacific: A summary of existing information and identification of data gaps. EPA-909-R-11-006, *available at* http://www.epa.gov/region9/marine-debris/pdf/MarineDebris-NPacFinalAprvd.pdf (last visited August 20, 2012).

Endangered Marine Mammals

Many of our marine mammals are also protected as threatened or endangered. Marine mammals are especially prone to entanglement in marine debris. They become tangled in derelict fishing gear and their curiosity draws them to investigate deadly packing straps, rubberbands, and plastic rings.

Entanglement has been documented in 58% of all pinniped populations.[87] Entanglement rates of seals vary from 0.1% to 7.9% of populations surveyed. In addition to direct mortality resulting from drowning of injury, fitness costs have been associated with pinniped marine debris entanglement. These costs can manifest as lower reproductive success, represented by reduced pre-weaning pup growth,[88] and by an increased metabolism to compensate for increased drag during swimming caused by entangling debris.[89]

Marine debris is arguably the largest documented anthropogenic impact to the recovery of the endangered Hawaiian monk seal.[90] Breeding colonies of the seal are limited to six small islands and atolls in the Northwestern Hawaiian Island, and because of their proximity to the Great Pacific Garbage Patch, large amounts of marine debris have been found in monk seal habitat. A majority of the marine debris found in Hawaiian monk seal habitat is trawl net webbing from trawl fisheries, followed by gillnet, seine net, and other types of netting. Hawaiian monk seals are critically endangered with a population of about 1,100 individuals and declining on average of 4 percent each year. "Continual accumulation of marine debris in the critical habitat of the Hawaiian monk seal likely contributes to this species' lack of recovery."[91]

Entanglement in marine debris has also led to injury and mortality of endangered Steller sea lions.[92] Steller sea lion populations have declined by 80% over the last 30 years, and entanglement in plastic debris is known to contribute to sea lion mortality. Surveys conducted in

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[87] Boland, R.C., M.J. Donahue. 2003. Marine debris accumulation in the nearshore marine habitat of the endangered Hawaiian monk seal, *Monachus schauislandi* 1999-2001. Mar. Poll. Bull. 46, 1385-1394.

[88] Delong, et al. 1988. Incidence and impact of entanglement in netting debris of northern fur seal pups and adult females, St. Paul Ialand, Alaksa. In Kozloff, P., Kajimura, H. (Eds.), Fun Seal Investigations 1985. US Department of Commerce, NOAA Technical Memo. NOAA-TM-SMFS-F/NWC-146, 58-68.

[89] Feldcamp et al, 1988. Energetic and behavioral effects of net entanglement of juvenile northern fur seals, Callorhinus ursinus, Fish. Bull. 87 (1), 85-94.

[90] Boland, supra note 60.

[91] Id.

[92] Raum-Suryan, K. et al. 2009. Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions. Mar. Poll. Bull. 28 (58), 1487-1495.

Alaska between 2000 and 2007 found 386 Steller sea lions that had either become entangled in marine debris or had ingested fishing gear. Packing bands were the most common entangling material while the most common ingested material was lures.

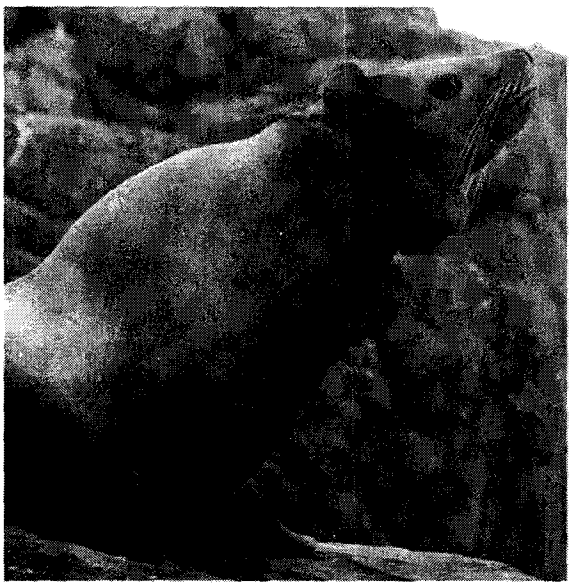

Figure 8. Entangled Steller sea lion. Credit: NOAA

A recent review of impacts of marine debris on cetaceans found that 48 percent of all cetacean species have been impacted by marine debris.[93] Of the 309 debris interactions documented, 20 percent were identified as the cause of mortality.[94] The decadal rate of recorded cases of debris ingestion by cetaceans has risen from the 1960s and peaked in the last decade (2000-2010).[95] For example, in 2008 two endangered sperm whales were found stranded along the California coast had large amounts of fishing net scraps, rope, and other plastic debris in their stomachs.[96] The suspected cause of death was from gastric impaction due to ingesting plastic.[97] A third sperm whale stranded in 2008 showed evidence of entanglement scars.[98]

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[93] Baulch, S. and C. Perry. 2012. A sea of plastic: Evaluating the impacts of marine debris on cetaceans. IWC SC/64/E10, available at http://iwcoffice.org/cache/downloads/anztojxkvwg0wkgk084swkcso/SC-64-E10.pdf (last visited August 20, 2012).

[94] Id.

[95] Id.

[96] Jacobsen, J., Massey, L., Gulland, F. 2010. Fatal ingestion of floating debris by two sperm whales. Mar. Pollut. Bull. 60, 765-767.

[97] Id.

[98] NOAA, U.S. Pacific Marine Mammal Stock Assessments: 2012 (draft), *available at* http://www.nmfs.noaa.gov/pr/sars/draft.htm (last visited August 20, 2012).

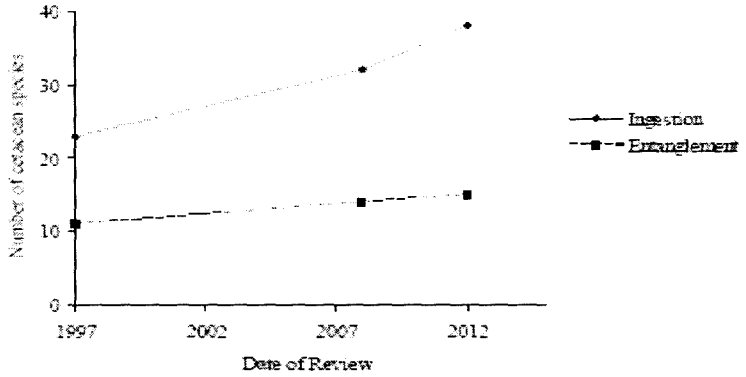
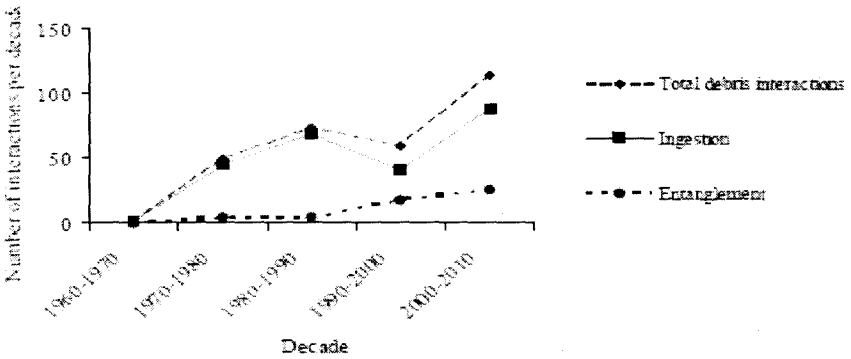


Figure 2: Decadal rates of debris interactions involving cetaceans between 1960 and 2010



Recorded rates of debris ingestion differed between families and sub-orders, with a higher proportion of mysticete species (57%) compared to odontocete species (42%) recorded ingesting debris. Items ingested by cetaceans were most commonly plastic (47%), with fishing gear (e.g. nets, hooks, lines etc) (25%) and miscellaneous items (28%) constituting the remainder (see Figure 3). Debris items ingested range in size from small particles (<5mm) to large plastic sheeting or netting. Exceptional examples included 134 different net types of up to 16m² documented in one Pygmy sperm whale (*Kogia breviceps*) and 378 items recorded in a Cuvier's beaked whale (*Ziphius cavirostris*) with a collective weight of 33kg (Jacobsen *et al.*, 2010; Poncelet *et al.*, 2000).

Figure 9. Number of cetacean species recorded with debris interactions. Source: Baulch & Perry (2012).

Impacts of microplastics on baleen whales, which potentially ingest particles by filter feeding, are largely unknown.[99] A recent study presented the first evidence of the potential impact of plastic additives (phthalates) in baleen whales, and is important for examining both the toxicological impacts of micro-plastics in filter-feeders and the potential use of these animals as

[99] Report of the Scientific Committee, Annex K: Report of the Standing Working Group on Environmental Concerns, IWC (2012), IWC/64/Rep 1, Annex K, at section 11.2, pp. 12-14, available at http://iwcoffice.org/cache/downloads/dytjqysr2o00ksswcg4wk8k0c/Annex-K-E.pdf (last visited August 20, 2012).

sentinels to the presence and impact of microplastics by using phthalates as a tracer of microplastics consumption.[100]

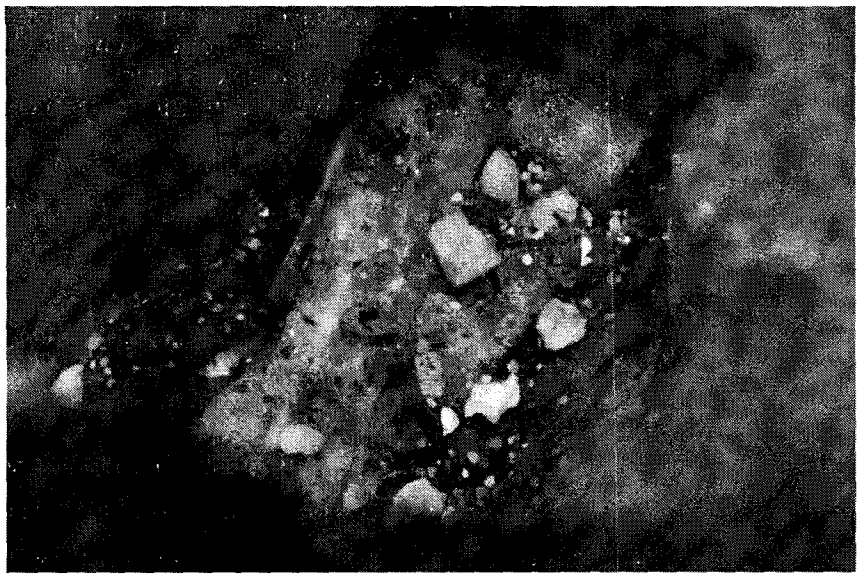


Figure 10. Marine debris sample collected in towing net by NOAA scientists, composed mostly of very small plastic particles. Credit: NOAA Okeanos Explorer Program.

These examples demonstrate that plastic in the marine environment threatens imperiled species, from small sea birds to large whales.

3. Potential Toxicological Hazard of Plastic Pollution

Plastic harms the environment by concentrating toxic chemicals. Studies of polychlorinated biphenyls (PCB) in nurdles found that the concentration of these chemicals in the resin pellets was 100,000 to 1,000,000 times that of the surrounding waters, suggesting that the nurdles serve as a potential source for toxic chemicals in the marine environment.[101]

The manufacture of PCBs has been banned in the United States due to their highly toxic effects and persistence in the environment once released. The EPA has characterized PCBs as

[100] Id. (citing Fossi, M.C., Guerranti, C., Coppola, D., Panti, C., Giannetti, M., Maltese, S., Marsili, L., and Minutoli, R., 2012. Preliminary results on the potential assumption of microplastics by Mediterranean Fin whale: the use of phthalates as a tracer. 6th SETAC World Congress 2012, Berlin, Germany, May 20-24).
[101] Mato, supra note 6.

"mutation-causing, cancer-causing, and teratogenic [meaning they can interfere with normal embryonic development]."[102] The EPA notes:

> PCBs have been shown to cause cancer in animals and have also been shown to cause a number of serious non- cancer health effects...including effects on the immune system, reproductive system, nervous system, endocrine system, and other health effects. Studies in humans provide supportive evidence for potential carcinogenic and non-carcinogenic effects of PCBs.

This has effects on wildlife; PCBs have been implicated in reduced primary productivity in phytoplankton, reduced hatchability of contaminated fish and bird eggs, reproductive failure in seals, reproductive impairment in fish, and reduced fertilization efficiency in sea urchins.[103] Exposure to PCBs may also increase susceptibility of marine species to infection, and result in the exposure of those infections to other species, and humans.[104]

Harmful hydrophobic chemicals, like PCBs, attach to plastic pellets because of their low polarity, and nurdles can become especially concentrated because of their large surface area relative to their size.[105] Other studies have found that plastic pellets concentrate persistent organic pollutants (POP), including PCBs, up to quantities ranging from 27 to 980 nanograms per gram.[106] POPs are synthetic organic compounds that are considered among the most persistent anthropogenic organic compounds introduced into the environment.[107] Some of these are highly toxic and have a wide range of chronic effects, including endocrine disruption, mutagenicity and carcinogenicity.[108] Furthermore, POPs are chemically stable, and therefore not easily degraded in the environment or in organisms.[109] They are lipophilic (that is, they are

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[102] U.S. EPA, Region 5 Superfund, Ecological Toxicity Information, *available at* http://www.epa.gov/reg5sfun/ecology/toxprofiles.htm

[103] Adams, J., Slaughter-Williams, S. 1988. The effects of PCBs on fertilization and morphology in *Arbacia punctulata*. Water Air Soil Pullot. 38, 299-310; Brouwer, A., Reijnders, P. Koeman, J. 1989. Polychlorinated biphenol (PCB)-contaminated fish induces vitamin A and thyroid hormone deficiency in the common seal. Aquatic Toxicology. 15, 99-106.

[104] Rutland & Stamford Mercury, Stamford, United Kingdom, "Warning over swimming with dolphins." August 18, 2011; Report of the Scientific Committee, Annex K: Report of the Standing Working Group on Environmental Concerns, IWC (2012), IWC/64/Rep 1, Annex K, at section 7.1, pp. 1-3, available at http://iwcoffice.org/cache/downloads/dvtjqvsr2o00ksswcg4wk8k0c/Annex-K-E.pdf (last visited August 20, 2012).

[105] Id. and Ashton, supra note 8.

[106] Rios, L.M., Moore, C. & Jones, P.R. 2007. Persistent organic pollutants carried by synthetic polymers in the ocean environment, MARINE POLLUTION BULLETIN, 54(8), 1230, 30. http://www.ncbi.nlm.nih.gov/pubmed/17532349.

[107] Id. at 1231.

[108] Id.

[109] Id.

attracted to nonpolar substances like fats) and accumulate in animals who ingest plastic, and in other animals through the food chain.[110]

Other chemicals that present in plastic pollution may also affect animals.[111] A range of chemicals like phthalate plasticizers are used as additives in the manufacture of plastic, which are potentially harmful and have been associated with carcinogenic and endocrine disrupting effects.[112] Bisphenol A (BPA) was termed an "environmental oestrogen" when it was shown to stimulate the reproductive system by binding to oestrogen receptors in female rats, and exposure to high doses of BPA during pregnancy and/or lactation has adverse developmental effects, including reduced survival, birth weight, growth of offspring early in life and delayed onset of puberty in male and female rodents.[113] Additionally, phthalates can affect production of testosterone and impair male reproduction and development.[114] Furthermore, acidic gastric conditions (e.g., stomach acid) may enhance the leaching of metals bound to plastic.[115] This breakdown may cause a human who has eaten fish with bioaccumulated toxins from plastic ingestion to be exposed to endocrine disruptors or other toxic chemicals.[116] A positive correlation has been observed between the mass of ingested plastic and the PCB concentration in the fat tissue of birds (great shearwaters; *Puffinus gravis*).[117]

Because plastic pollution is known to accumulate toxins such as PCBs in the environment, plastic may transfer contaminants to wildlife and possibly humans.[118]

4. Plastic Pollution Impacts Human Activities

Plastic marine debris can directly interfere with navigation, impede commercial and recreational fishing, threaten health and safety and reduce tourism.[119] Direct impacts to humans include entanglement in nets and lines while swimming or being injured by sharp debris that

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[110] Id.
[111] Barnes, supra note 3.
[112] Id.
[113] Koch, H.M. & Calafat, A.M., 2009. Human Body Burden of Chemicals Used in Plastic Manufacture. PHIL. TRANS. R. SOC. B, 364(2063, 64-65) (2009) http://rstb.royalsocietypublishing.org/content/364/1526/2063.short.
[114] Id.
[115] Teuton, E.L., et al. 2009. Transport and release of chemicals from plastics to the environment and wildlife. Phil. Trans. R. Soc. B, 364, 2027-2045.
[116] Id. at 2042.
[117] Id.
[118] Id.
[119] EPA. Marine Debris in the North Pacific: A summary of existing information and identification of data gaps. (2011). EPA-909-R-11-006, *available at* http://www.epa.gov/region9/marine-debris/pdf/MarineDebris-NPacFinalAprvd.pdf (last visited August 20, 2012).

accumulates on beaches.[120] Plastic pollution degrades aesthetics and recreational uses of ocean waters and beaches. These impacts can have significant economic impacts due to beach closures, loss of tourism, damage to vessels, and hindering fishermen.[121]

Plastic pollution has other economic costs. The National Oceanographic and Atmospheric Administration (NOAA) attempts to locate fishing "ghost nets" in large masses before the North Pacific convergence zone takes them to the Hawaiian Islands, and this cleanup costs millions of dollars.[122] The costs rise when one considers such additional risks as damage to ships and submersible propellers by bulkier debris, and environmental costs like the extinction of the endangered Hawaiian monk seal.[123] Between 1996 and 2006, NOAA recovered a total of 511 metric tons of fishing gear from the reefs of the Hawaiian conservation area.[124] The economic loss of commercial fish caught in ghost nets, the time and expense of rescue operations for entangled or damaged vessels, the environmental loss of endangered species and rare coral, and the cost of cutting nets from reefs by hand can be measured in millions of dollars annually in the U.S. alone.[125]

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While only a few decades since mass production of plastic products began in the 1950s, plastic debris today is a major threat to the health of our oceans. The accumulation of plastic debris in our oceans has the potential to negatively impact marine organisms worldwide. From entanglement, ingestion, and choking, to the accumulation and transport of persistent organic pollutants, plastic debris is causing problems along the entire length of the food chain. The science is clear; wildlife and humans are threatened by plastic pollution. These impacts are interfering with the designated uses of our nation's waters. Thus, EPA should be compelled to update its scientific findings, and incorporate these findings into rulemaking on plastic pollution's effect on water quality. Plastic pollution poses a special threat to the environment, so developing special criteria concerning plastic helps policy makers find tailored solutions to tackle these threats in financially feasible ways.

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[120] Id. at 12.
[121] Id.
[122] Plastic Pollution in the Ocean: Forum Introduction, PBS NEWSHOUR, (Nov. 13 2008) http://www.pbs.org/newshour/forum/science/july-dec08/plastic_11-131.html
[123] Id.
[124] Id.
[125] Pichel, W.G. et al. 2007. Marine debris collects within the North Pacific Subtropical Convergence Zone, MARINE POLLUTION BULLETIN, 54 (8), 1207, 07, http://www.ncbi.nlm.nih.gov/pubmed/17568624.

III. Clean Water Act Background

The objective of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a). According to the Supreme Court, "the Act does not stop at controlling the 'addition of pollutants,' but deals with 'pollution' generally . . . which Congress defined to mean 'the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water.'" S.D. Warren v. Maine Bd. Of Envt'l Protection, 547 U.S. 370, 385 (2006). The national goal of the Clean Water Act is to guarantee "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation." 33 U.S.C. § 1251(a)(2).

Toward these goals of eliminating water pollution and maintaining the water quality of the nation's waters, the Clean Water Act provides a variety of tools to control water pollution from all sources. The Clean Water Act requires that states adopt water quality standards. 33 U.S.C. § 1313. Water quality standards include: designated uses, water quality criteria sufficient to protect the designated uses, and an antidegradation policy. 40 C.F.R. § 131.6. States are required from time to time (and at least every three years) to review and, if necessary, revise water quality standards. 33 U.S.C. § 1313(c).

To guide states in their adoption and periodic review of water quality standards the Clean Water Act requires the EPA to establish national water quality criteria, and publish information on the protection of water quality. 33 U.S.C. § 1314(a)(1),(2). The Clean Water Act requires the EPA to revise "from time to time" both the water quality criteria and protection information that it develops under Section 304. 33 U.S.C. § 1314(a)(1),(2). Water quality criteria and information, and revisions thereof, are required to be issued to the states and published in the Federal Register and otherwise be made available to the public. 33 U.S.C. § 1314(a)(3).

State water quality standards are the foundation of the Clean Water Act and are at the heart of each strategy of pollution control under the Act. For example, section 402 requires polluters to obtain permits and adhere to effluent limitations and technology controls necessary to meet water quality standards. 33 U.S.C. §§ 1342, 1311. Section 303 requires states to identify impaired waters—those failing to meet water quality standards—and establish limits on pollutants causing the impairment. 33 U.S.C. § 1313(d). Moreover, section 401 requires applicants for any federal permit or license to obtain state certification that the permitted activity will comply with state water quality standards. 33 U.S.C. § 1341.

a. National Water Quality Criteria

Under section 304(a)(1) of the Clean Water Act, the EPA is required to develop and publish water quality criteria "accurately reflecting the latest scientific knowledge":

> (A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, including ground water;
>
> (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and
>
> (C) on the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication and rates of organic and inorganic sedimentation for varying types of receiving waters.

33 U.S.C. § 1314(a)(1). These criteria must be issued to the states and be made available to the public. 33 U.S.C. § 1314(a)(3). To date, the EPA has not issued water quality criteria for plastic pollution.

b. Water Quality Protection Information

Section 304(a)(2) of the Clean Water Act requires that the EPA develop and publish information on four topics necessary to protect water quality:

> (A) on the factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters, ground waters, waters of the contiguous zone, and oceans;
>
> (B) on the factors necessary for the protection and propagation of shellfish, fish, and wildlife for classes and categories of receiving waters to allow recreational activities in and on the water; and
>
> (C) on the measurement and classification of water quality; and
>
> (D) for the purpose of section 1313 of this title, on the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

33 U.S.C. § 1314(a)(2). These criteria must be issued to the states and be made available to the public. 33 U.S.C. § 1314(a)(3). The publication of this information is critical because it provides states with the necessary information to evaluate the needs of the waters in their jurisdiction, which may require modification of state water quality standards or pollution control requirements.

c. State Adoption of Water Quality Standards

The national water quality criteria and information required by section 304 are significant because they establish a baseline for nationwide implementation of the Clean Water Act. Guided by the EPA's criteria and information, states must either adopt the national recommended water quality criteria as their part of their water quality standards or provide a science-based explanation for alternate criteria. In establishing criteria, States should:

(1) Establish numerical values based on:
(i) 304(a) Guidance; or
(ii) 304(a) Guidance modified to reflect site-specific conditions; or
(iii) Other scientifically defensible methods;
(2) Establish narrative criteria or criteria based upon biomonitoring methods where numerical criteria cannot be established or to supplement numerical criteria.

40 C.F.R. § 131.11(b). The EPA oversees state water quality standards and must either approve the states' standards or promulgate standards for that state. 33 U.S.C. § 1313(a)-(c); 40 C.F.R. § 131.5.

d. Total Maximum Daily Loads (TMDLs)

Once a water quality standard is enacted, section 303(d) of the Clean Water Act establishes a Total Maximum Daily Load (TMDL) program, a water quality based approach whereby states regulate waters that fail to meet water quality standards despite the use of effluent limitation and other pollution control requirements. 33 U.S.C. § 1313(d). TMDLs help regulators devise the limitations necessary to meet water quality standards by identifying and quantifying the individual sources contributing to a particular water quality problem. A TMDL for plastic pollution would establish limits on the amount of plastic allowed in watersheds around the country. Should EPA could adopt a plastic pollution criterion, a plastic TMDL would be a powerful regulatory tool for watersheds that fail to meet water quality standards.

IV. Requested Rulemaking

a. The Latest Scientific Knowledge Requires Plastic Pollution Criteria

Because the latest scientific knowledge demonstrates that plastic seriously harms water quality, EPA must develop criteria and information to specifically address plastic pollution.

As a threshold point, plastic is subject to controls under the Clean Water Act. Section 304(a)(1) requires the EPA to develop criteria based on information regarding the presence, dispersal, and effects of "pollutants." 33 U.S.C. § 1314(a)(1). Similarly, section 304(a)(2) requires identification of such "pollutants." 33 U.S.C. § 1314(a)(2). Under section 502 of the Clean Water Act, the term "pollutant" is defined to include, inter alia, "solid waste," "garbage," and "industrial [and] municipal waste" in water. 33 U.S.C. § 1362(6). Because plastic pollution originates primarily from industrial and commercial waste, plastic constitutes "pollution" under the Clean Water Act.[126]

Section 304 of the Clean Water Act requires EPA to develop, publish, and from time to time update water quality criteria "reflecting the latest scientific knowledge," and to develop, publish, and update information regarding the protection of water quality, aquatic life, and recreational activity in water. 33 U.S.C. § 1314(a)(1),(2). As described extensively in this petition, see Part II. Plastic Pollution, there is extensive new scientific knowledge about plastic pollution's impacts on marine water quality and designated uses.

The latest scientific information shows that (1) plastic is increasingly polluting our oceans, (2) plastic is injuring and killing wildlife, (3) plastic is interfering with designated uses for aquatic life, fishing, and recreation, and (4) plastic water quality criteria will improve management, clean-up, and prevention of plastic pollution. For these reasons a rulemaking is warranted.

First, the scope of plastic pollution is vast, and it has reached a magnitude that requires decisive action to curb the flow of plastic into our ocean. A 2012 study found that the Pacific Ocean has 100 times more small plastic particles now than it did in the 1970s.[127] In light of the significant increase in plastic production over the past few decades, the increasing occurrence of

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[126] Courts have interpreted "pollution" broadly. See, e.g., N. Plains Res. Council v. Fid. Exploration & Dev. Co., 325 F.3d 1155 (9th Cir. 2003) (finding salty groundwater released into river by methane gas extraction was a pollutant, though the extraction process did not add chemicals to the water).

[127] Goldstein, M.C., M. Rosenberg and L. Cheng. 2012. Increased oceanic microplastic debris enhances oviposition in an endemic pelagic insect. Biology Letters.

plastic as pollution in our oceans is not surprising. Abundant research shows that plastic does not break down well in marine environments, which causes it to persist for extremely long periods of time in our oceans.[128] Thus, the plastic introduced into the marine environment is accelerating and accumulating.

Second, there is a considerable body of scientific evidence documenting the harms to wildlife and the environment from plastic pollution. With nearly 300 species involved in documented entanglements in or ingestions of plastic,[129] and numerous studies of the sublethal and lethal effects of plastics on sea turtles, cetaceans, marine mammals, and sea birds,[130] it is certain that once plastics enter the marine environment they are harmful and deadly. Plastic pollution directly tangles animals, damages corals and kills thousands of animals, which satisfies the scientific requirement of showing the effects of health and welfare of marine animals under section 304(a)(1)(A).

Third, plastic pollution is interfering with the designated uses of waterbodies and frustrating the goals of the Clean Water Act. In sum, the primary goals of the law are to ensure that all waters are fishable and swimmable, indicating the intent to protect aquatic life and human uses of waters. In addition to the clear impacts from entanglement and ingestion, plastic pollution interferes with recreational, fishing, and shellfishing uses of oceans by impinging vessels causing extensive and costly damage. The aesthetic blight of plastic pollution also has an impact on the recreational uses of water bodies and beaches that depend on beautiful and pristine areas for tourism and enjoyment.

Fourth, plastic debris is a problem that crosses local and state lines, so only a large, collaborative effort of cleaning up our nation's waters will have a meaningful impact on plastic pollution. The plastic pollution problem has become so serious that states have nonetheless begun to use the Clean Water Act to address the plastic problem. This provides further evidence of the need for criteria that are specifically designed for plastic. For example, within the rubric of solid waste pollution, states such as Alaska, Hawaii, and California have identified waters within their boundaries as impaired by trash pollution.[131] In the last ten years, the EPA has

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[128] Id.
[129] Laist 1997.
[130] See Part II. c. Plastic Pollution in Marine Waters Harms Wildlife and Degrades Habitat.
[131] Water Quality Assessment and Total Maximum Daily Loads Information, EPA, http://www.epa.gov/waters/ir/index.html (last visited November 12, 2011).

established or approved 46 trash TMDLs for California waters.[132] These TMDLs establish the maximum amounts of trash that may be discharged into impaired waters while still meeting a state's water quality standards. 33 U.S.C. § 1313(d)(1)(C). A rulemaking for plastic water quality criteria would facilitate monitoring and early action to clean-up problem water bodies.

In sum, exacting water quality criteria specifically for plastic pollution sets a clear path forward for monitoring, assessing, and reducing plastic pollution. The best way to protect designated uses of our waters for wildlife is to tackle the problem of plastic directly. Furthermore, identifying plastic pollution independently of trash highlights the importance of regulating plastic *before* it becomes trash. This focus incentivizes efforts to reduce plastic production and promotes reuse and recycling of plastic materials.

b. Plastic Pollution Water Quality Criteria

As a part of its duty under section 304 of the Clean Water Act, EPA must revise water quality criteria in accord with the latest scientific information on the impacts of plastic pollution. 33 U.S.C. § 1314(a). This is consistent with the goals of the Clean Water Act to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a). Accordingly, petitioner urges the EPA to promulgate a rule that will adopt the following water quality criteria targeted at abundance of plastic pollution:

1. Ocean and coastal waters shall be free of all visible plastic waste; and
2. Zero discharge of plastic debris from stormwater or other outfalls; and
3. Less than one item of plastic (>5 mm) per m^2 for ocean sediments, including beaches at or below the high tide line; and
4. Less than one item of plastic (>5 mm) per m^3 in the water column; and
5. Less than one item of microplastic ($\leq$5 mm) per m^2 for sediments or m^3 in the water column and no more than one synthetic fiber per 50 mL sediment for subtidal sediments; and
6. No visible plastic in the intestines or stomachs of marine biota, including marine mammals, sea turtles, and sea birds.

The basis for adopting each of these criteria is explained below. These criteria are scientifically supported and warranted by the available science. Nevertheless, if EPA declines to

[132] California TMDLs, TMDL Pollutant: Trash, EPA, http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.tmdls?p_state=CA&p_pollutant_id=1092&p_report_type=T (last visited November 12, 2011).

adopt these criteria, EPA should explain its rationale and establish alternative plastic pollution criteria.

1. Criterion for visible plastics

EPA should institute qualitative standards that "ocean and coastal waters should be free of all visible plastic waste" to monitor and control visible plastic pollution. This criterion would work to achieve aesthetic and recreational values and help protect wildlife from plastic that is readily accessible. This criterion is applicable both to post-consumer plastics, fragmented plastics, and nurdles. Examples of similar criteria are contained in the EPA's Gold Book for aesthetic qualities and suspended solids.[133] This sort of standard could provide easier monitoring and reach a wide range of marine waters, because it would make unacceptable levels of plastic pollution readily discernible. Adoption of such criteria would encourage watersheds to institute controls including reducing the amount of plastic produced, educating the public on reducing user plastic pollution, and collecting plastic debris before it reaches their waters.

2. Criterion for stormwater and outfall discharges

EPA should institute a "zero plastic" criterion for discharges from stormwater and other outfalls. This is modeled on the trash TMDLs to complement their goals and facilitate implementation. California and the EPA have recently declared the Los Angeles River impaired by trash pollution.[134] To address this problem, California has begun regulating trash that can be caught by a five-millimeter mesh screen.[135] In the Los Angeles River Watershed Trash TMDL, the target goal is to achieve zero trash over ten years.[136] The benefit of a criterion focused on stormwater outfalls is that it can stop ocean pollution at its source. The critical point is that the EPA set a limit on plastic pollution in order to stop the trend of increasing plastic pollution and harm to wildlife. If this number sets a meaningful goal that will significantly reduce plastic pollution when implemented, the EPA will have fulfilled part of its obligation under the Clean Water Act.[137]

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[133] Gold Book, epa.gov (1986)

[134] Gordon, supra note 12.

[135] Moore, C.J. et al. 2011. Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California, JOURNAL OF INTEGRATED COASTAL ZONE MANAGEMENT 11 (1), 65-73, 72, available at http://www.algalita.org/uploads/Urban_River_Debris.pdf

[136] Id. at 20. The Los Angeles TMDL also refers to this criteria as narrative, but because TMDL's are susceptible to measurement by weight or volume for collected plastics, this memo will address TMDLs as a quantitative criterion.

[137] While this petition does not request a specific reduction goal of plastics, it is instructive that Los Angeles chose zero trash discharge as its goal. It indicates a decision by a city that no amount of trash, which includes plastics, is

3. Criterion for beaches

We propose the adoption of a quantitative criterion for beaches and sediments that requires "less than one item of plastic per m^2 for ocean sediments, including beaches at or below the high tide line" for a waterbody to attain plastic standards. Setting a plastic pollution criterion that measures the amount of collected plastic from beach cleanups is a proxy for marine water quality.[138] This measurement criterion would be cost effective, and "provide the best proxy for at-sea abundance of litter."[139] The criteria results from a measurement of the amount of plastic collected at beach surveys, sieving samples of beach sand, as well as samples of ocean sediments. It provides an opportunity for citizen science and monitoring, which facilitates data collection across broad regions and serves to raise awareness about plastics in the community.

4. Criterion for the water column

For plastic items in the water column, we proposed a criterion that waters should have "less than one item of plastic per m^3 in the water column." This comports with plastic pollution monitoring that has already occurred and would further help to harmonize measurements.[140] Because even low wind speeds mix surface plastic into the water column, plastic particles are vertically distributed, thus accurate estimates must take into account mixing.[141] Keeping plastics out of the water column is highly relevant for many marine species that may ingest plastic. For example, one study found 54.5 percent of pelagic-sized sea turtles had ingested marine debris whereas only 25 percent of benthic feeding turtles were found with debris in their gastrointestinal system; most ingested items were plastic and positively buoyant.[142] This suggests that certain species and life-stages of species are particularly vulnerable to plastic in the water column.

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acceptable. The petition, however, leaves room for the EPA to choose feasible goals for plastic reduction, recognizing that EPA has more experience in designating workable criteria for water bodies.

[138] Ryan, P.G., et al. 2009. Monitoring the Abundance of Plastic Debris in the Marine Environment , PHIL. TRANS. R. SOC. B, 364, 1999-2003.

[139] Id.

[140] Avery-Gomm, S., et al. 2012. Northern fulmars as biological monitors of plastic pollution in the Eastern North Pacific. Mar. Poll. Bull. http://dx.doi.org/10.1016/j.marpolbul.2012.04.017; Hidalgo-Ruz, V., et al. 2012. Microplastics in the Marine Environment; A Review of the Methods used for Identification and Quantification. Environ. Sci. Tech. 46, 3060-3075.

[141] Kukulka et al. 2012.

[142] Schuyler, Q., et al. 2012. To Eat or Not to Eat? Debris Selectivity by Marine Turtles. PLoSone 7 (7), e40884. doi:10.1371/journal.pone.0040884.

5. Criteria for microplastic

Due to the unique properties of small plastics, EPA should adopt a water quality criterion particular to microplastic. A criterion of "less than one item of microplastic (≤5mm) per m^2 for sediments or m^3 in the water column and no more than one synthetic fiber per 50 mL sediment for subtidal sediments" is appropriately based upon the measurement standards noted by Hidalgo-Ruz et al. (2012).[143] Fibers and other microplastic warrant different management practices than larger post-consumer plastic products. A unique microplastic criterion is necessary because a combined measure tends to focus only on larger items of trash.[144] Microplastics can absorb persistent bioaccumulative and toxic compounds from seawater, which include persistent organic pollutants and metals.[145] Once ingested, the absorbed pollutants may be transferred to the respective organisms.[146] By separating the criteria, states would be able to prevent plastic pollution at its sources. If certain waters are only listed as impaired for microplastic, for example, then reduction efforts could be tailored to include more stringent manufacturing, shipping, or cleanup regulations specific to these smaller pieces of plastic.

6. Biological criteria for plastics

Because of the profound impact on marine life, EPA should adopt biological criteria for plastics. An appropriate criteria would require "no visible plastic in the intestines or stomachs of marine biota, including marine mammals, sea turtles, and sea birds." Such criteria are useful in gauging the effects of plastic on wildlife. For example, the stomach contents of northern fulmar have proven a cost-effective biomonitor of plastic pollution.[147] Different waters' impairment would depend on the feeding habits and presence of the aquatic life at that location. Such criteria have also proven useful in analogous circumstances for monitoring mercury in waters using mercury in fish as an indicator of pollution. Biological criteria specifically assess the effects of plastic on aquatic life.

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[143] Hidalgo-Ruz at 3070.
[144] Id.
[145] Id. at 3060.
[146] Id.
[147] Avery-Gomm et al. (2012); van Franeker, Jan a, Christine Blaize, Johannis Danielsen, Keith Fairclough, Jane Gollan, Nils Guse, Poul-Lindhard Hansen, et al. 2011. "Monitoring Plastic Ingestion by the Northern Fulmar Fulmarus Glacialis in the North Sea." *Environmental Pollution (Barking, Essex : 1987)* 159 (10) (October): 2609–15. doi:10.1016/j.envpol.2011.06.008. http://www.ncbi.nlm.nih.gov/pubmed/21737191.

This suite of criteria for plastic pollution applies the most recent scientific information about plastic pollution. Establishing these water quality criteria would provide effective and flexible monitoring methods, which can help to address the various ways that plastics enter the ocean environment and also affect wildlife.

c. Publish Information Regarding Plastic Pollution

The EPA is required to publish information about plastic pollution pursuant to section 304(a)(2), which says that the EPA shall publish and revise information from time to time:

> (A) on the factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters, ground waters, waters of the contiguous zone, and oceans;
>
> (B) on the factors necessary for the protection and propagation of shellfish, fish, and wildlife for classes and categories of receiving waters to allow recreational activities in and on the water; and
>
> (C) on the measurement and classification of water quality; and
>
> (D) for the purpose of section 1313 of this title, on the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

33 U.S.C. § 1314(a)(2). States require this information to adequately evaluate section 304(a)(1) criteria and their applicability to the state's waters. In addition, the information may play a critical role in educating states about methods of managing water resources.

The EPA must publish new information under section 304 to guide states in managing plastic pollution and inform the public to the special dangers that plastic pollution poses to the aquatic environment. Specifically, EPA should publish information on (1) the threats of plastic pollution to aquatic life as described above; (2) guidance on monitoring and measuring plastic pollution; (3) best management practices for preventing plastic pollution; and (4) establishing and implementing plastic TMDLs.

1. Threats of plastic pollution

Section 304(a)(2) requires EPA to publish information on how to protect water quality. While some regions have provided leadership in the area of curbing the influx of trash into the

marine environment, there are still many states and regions that have not taken adequate action with regard to stopping plastic pollution. Foremost, to address the problem of plastic states would benefit from understanding the scope of the problem and the threats of plastic to the environment.

2. Guidance on monitoring and measuring plastic pollution

EPA should also develop protocols for collecting data and monitoring plastic pollution. This would provide a blueprint for obtaining the type and quality of environmental data and information needed for evaluating whether waterbodies are impaired by plastic pollution. International coastal cleanups, which are volunteer efforts to clean beaches and inland waters of debris, have collected data for 25 years. Other federal agencies, such as the Fish and Wildlife Service and the National Oceanic and Atmospheric Administration, also collect data on marine debris that may inform the EPA's decision on how best to monitor plastic pollution. This data should be readily used. EPA's advice on how best to interpret this long-term data and to add to these data is essential for monitoring plastic pollution nationwide. States need this information to determine if and when their waters are impaired and how to achieve compliance.

3. Best Management Practices (BMPs)

In addition to establishing monitoring guidance, EPA should publish best management practices for user plastic and pre-production plastic.

For user plastic, outreach to the public and retailers can be effective. Trash receptacles can also be useful for proper disposal of cigarette butts and to prevent litter from spilling into waterways. Programs and ordinances to promote recycling can also reduce the stem of plastic into the ocean. Another BMP could be a law requiring a larger percentage of goods to be recycled. Efforts to provide incentives for recycling can increase the fraction recycled.[148] Structural controls (e.g. physical filtering devices such as mesh screens, centrifugal separation, and trash racks) are an effective, but more expensive, way to control plastic debris. Municipal storm drain systems can by modified and systems that capture all trash less than 5 mm in size can be installed. This could potentially lower the cost of, or even be done in lieu of, monitoring water bodies. These structural devices usually cannot prevent nurdles from entering the environment.[149] Where structural controls are infeasible, regular street sweeping can prevent

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[148] Id.
[149] Stormwater Menu of BMPs, supra note 96.

litter from accumulating before it is washed into nearby water ways. Another affordable mandate could be covering landfills when not in use and building sufficiently high landfill walls to avoid dispersal of pollutants from regular winds.[150] Other possible state regulations include requiring more sustainable packaging, reforming loading requirements for nurdles that diminish the risks of incidental spills or mandate cleanup of spills, putting in more garbage bins, and instituting cleanups or educational campaigns.[151]

The best management practices to control nurdles from entering water bodies necessarily put the onus on plastic manufacturers. There are, however, relatively cheap and easy solutions to curb the release of these dangerous pollutants. EPA has already endorsed several best management practices for plastic pellets and must provide this information to state water quality managers. These practices include education of manufacturers, containment systems, recycling, spill clean-up procedures, puncture-resistant packaging, and periodic inspections of pellet containers.[152]

These kinds of procedural protections against plastic pollution reduce the amount of plastic that is ever added to waters, and may be the most efficient way of reducing our nation's plastic pollution problems. The EPA should highlight and recommend such preventative measures against plastic pollution wherever possible.

4. TMDL development

After EPA adopts water quality criteria targeting plastic pollution, section 303(d) provides for development of TMDLs in watersheds that fail to meet local water quality standards. 33 U.S.C. § 1313(d). States would benefit from existing model TMDLs that aim to reduce trash and plastic pollution. The Los Angeles River Watershed, for example, has a landmark TMDL that requires Southern California cities discharging into the Los Angeles River to reduce their trash contribution by 10% each year for a period of 10 years, with an eventual goal of zero trash.[153] The Los Angeles trash TMDL has been a success in Southern California, with over a

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[150] Barnes, supra note 3.

[151] For a longer list of BMPs, see Gordon, Miriam, Eliminating Land-Based Discharges of Marine Debris in California: A Plan of Action from The Plastic Debris Project, CALIFORNIA COASTAL COMMISSION, (2006) available at http://www.plasticdebris.org/CA_Action_Plan_2006.pdf; and Gordon, M., Zamist, R. MUNICIPAL BEST MANAGEMENT PRACTICES FOR CONTROLLING TRASH AND DEBRIS IN STORMWATER AND URBAN RUNOFF, CALIFORNIA COASTAL COMMISSION, available at http://www.plasticdebris.org/Trash_BMPs_for_Munis.pdf

[152] Id. at 10-11.

[153] See Basin Plan Amendment – Resolution No: 2007-102, In Effect Sept. 23, 2008, Trash TMDL for the Los Angeles River Watershed, documents available at

Pollution Bulletin 60 (12) (December): 2275–8. doi:10.1016/j.marpolbul.2010.08.007. http://www.ncbi.nlm.nih.gov/pubmed/21067782.

Boland, R.C., M.J. Donahue. 2003. Marine debris accumulation in the nearshore marine habitat of the endangered Hawaiian monk seal, *Monachus schauislandi* 1999-2001. Mar. Poll. Bull. 46, 1385-1394.

Bowmer, T. & Kershaw, P. 2010. *Proceedings of the GESAMP International Workshop on Microplastic Particles as a Vector in Transporting Persistent, Bioaccumulating and Toxic Substances in the Ocean.*

Brandão, Martha L. Karina M Braga, and José L Luque. 2011. "Marine Debris Ingestion by Magellanic Penguins , Spheniscus Magellanicus (Aves : Sphenisciformes), from the Brazilian Coastal Zone." *Atlantic* 62: 2246–2249. doi:10.1016/j.marpolbul.2011.07.016.

Brd, Usgs, Wisconsin Cooperative, and Wildlife Ecology. 1998. "Use of Indicator Items to Monitor Marine Debris on a New Jersey Beach from 1991 to 1996." *Science* 36 (I): 887–891.

Brouwer, A., Reijnders, P. Koeman, J. 1989. Polychlorinated biphenol (PCB)-contaminated fish induces vitamin A and thyroid hormone deficiency in the common seal. Aquatic Toxicology. 15, 99-106.

Browne, Mark A. 2008b. "Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, Mytilus Edulis (L.)." *Environmental Science & Technology* 42 (13) (July): 5026–5031. doi:10.1021/es800249a. http://pubs.acs.org/doi/abs/10.1021/es800249a.

Browne, Mark a., Awantha Dissanayake, Tamara S. Galloway, David M. Lowe, and Richard C. Thompson. 2008a. "Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, Mytilus Edulis (L.)." *Environmental Science & Technology* 42 (13) (July): 5026–5031. doi:10.1021/es800249a. http://pubs.acs.org/doi/abs/10.1021/es800249a.

Browne, Mark Anthony, Phillip Crump, Stewart J Niven, Emma Teuten, Andrew Tonkin, Tamara Galloway, and Richard Thompson. 2011. "Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks." *Environmental Science & Technology* 45 (21) (October 4): 9175–9179. doi:10.1021/es201811s. http://www.ncbi.nlm.nih.gov/pubmed/21894925.

Bugoni, L., Krause, L., Petry, M. 2001. Marine debris and human impacts on sea turtles in southern brazil. Mar. Pollut. Bull. 42 (12), 1330-1334.

California Regional Water Quality Control Board, Los Angeles Region, Trash Total Maximum Daily Loads for the Los Angeles River Watershed, 1, 18 (2007), http://www.epa.gov/waters/tmdldocs/34863-RevisedStaffReport2v2.pdf (last visited October 26, 2011)

Carpenter, E J, and K L Smith. 1972. "Plastics on the Sargasso Sea Surface." *Science (New York, N.Y.)* 175 (27) (March 17): 1240–1. http://www.ncbi.nlm.nih.gov/pubmed/5061243.

Casey, B.S. & Segal, G. 2007. Our oceans are turning into plastic ... are we?, Best Life Magazine, 1, 1 http://www.enviroplumbing.com/pdf/Plastic_Oceans_.pdf.

Colabuono, Fernanda Imperatrice, Satie Taniguchi, and Rosalinda Carmela Montone. 2010. "Polychlorinated Biphenyls and Organochlorine Pesticides in Plastics Ingested by Seabirds." *Marine Pollution Bulletin* 60 (4) (April): 630–4. doi:10.1016/j.marpolbul.2010.01.018. http://www.ncbi.nlm.nih.gov/pubmed/20189196.

Colton, JB, and FD Knapp. 1974. "Plastic Particles in Surface Waters of the Northwestern Atlantic." *Science* 185 (4150) (August 9): 491–7. doi:10.1126/science.185.4150.491. http://www.ncbi.nlm.nih.gov/pubmed/17830390.

Connors, P, and K Smith. 1982. "Oceanic Plastic Particle Pollution: Suspected Effect on Fat Deposition in Red Phalaropes." *Marine Pollution Bulletin* 13 (1) (January): 18–20. doi:10.1016/0025-326X(82)90490-8. http://linkinghub.elsevier.com/retrieve/pii/0025326X82904908.

Cooper, David A, and Patricia L Corcoran. 2010. "Effects of Mechanical and Chemical Processes on the Degradation of Plastic Beach Debris on the Island of Kauai , Hawaii." *Marine Pollution Bulletin* 60 (5): 650–654. doi:10.1016/j.marpolbul.2009.12.026. http://dx.doi.org/10.1016/j.marpolbul.2009.12.026.

Copello, S. and F. Quintana. 2003. Marine debris ingestion by Southern Giant Petrels and its potential relationships with fisheries in the Southern Atlantic Ocean. Marine Pollution Bulletin, Vol. 46, pp. 1504-1515

Council, California Ocean Protection. 2008. "An Implementation Strategy for the California Ocean Protection Council Resolution to Reduce and Prevent Ocean Litter." http://www.opc.ca.gov/2010/04/preventing-ocean-litter-3/.

Dameron, Oliver J, Michael Parke, Mark a Albins, and Russell Brainard. 2007. "Marine Debris Accumulation in the Northwestern Hawaiian Islands: An Examination of Rates and Processes." *Marine Pollution Bulletin* 54 (4) (April): 423–33. doi:10.1016/j.marpolbul.2006.11.019. http://www.ncbi.nlm.nih.gov/pubmed/17217968.

Dau, Brynie Kaplan, Kirsten V K Gilardi, Frances M Gulland, Ali Higgins, Jay B Holcomb, Judy St Leger, and Michael H Ziccardi. 2009. "FISHING GEAR – RELATED INJURY IN CALIFORNIA MARINE WILDLIFE" 45 (2): 355–362.

Davison, P, and Rg Asch. 2011. "Plastic Ingestion by Mesopelagic Fishes in the North Pacific Subtropical Gyre." *Marine Ecology Progress Series* 432: 173–180. doi:10.3354/meps09142. http://www.int-res.com/prepress/m09142.html.

Day, RH, DG Shaw, and SE Ingell. 1990. "The Quantitative Distribution and Characteristics of Neuston Plastic in the North Pacific Ocean, 1985-88." *NOAA Technical Memorandum* NOAA-TM-NM: 247 – 266. http://www.vliz.be/imisdocs/publications/135814.pdf.

Delong, et al. 1988. Incidence and impact of entanglement in netting debris of northern fur seal pups and adult females, St. Paul Ialand, Alaksa. In Kozloff, P., Kajimura, H. (Eds.), Fun Seal Investigations 1985. US Department of Commerce, NOAA Technical Memo. NOAA-TM-SMFS-F/NWC-146, 58-68.

Derraik, J.G.B. 2002. The pollution of the marine environment by plastic debris: a review, MARINE POLLUTION BULLETIN, 44 (9), 842, 45, http://www.ncbi.nlm.nih.gov/pubmed/12405208.

Donohue, M J, R C Boland, C M Sramek, and G a Antonelis. 2001. "Derelict Fishing Gear in the Northwestern Hawaiian Islands: Diving Surveys and Debris Removal in 1999 Confirm Threat to Coral Reef Ecosystems." *Marine Pollution Bulletin* 42 (12) (December): 1301–12. http://www.ncbi.nlm.nih.gov/pubmed/11827117.

Ebbesmeyer, Curtis C, W J Ingraham, Jason A Jones, and Mary J Donohue. 2012. "Marine Debris from the Oregon Dungeness Crab Fishery Recovered in the Northwestern Hawaiian

Islands : Identification and Oceanic Drift Paths." *Marine Pollution Bulletin* 65 (1-3): 69–75. doi:10.1016/j.marpolbul.2011.09.037. http://dx.doi.org/10.1016/j.marpolbul.2011.09.037.

EPA, California TMDLs, TMDL Pollutant: Trash http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.tmdls?p_state=CA&p_pollutant_id=1092&p_report_type=T (last visited November 12, 2011).

EPA, Marine Debris Impacts, http://water.epa.gov/type/oceb/marinedebris/md_impacts.cfm (last visited October 26, 2011).

EPA, Plastics, http://www.epa.gov/wastes/conserve/materials/plastics.htm (last visited October 26, 2011)

EPA, Region 5 Superfund, Ecological Toxicity Information, *available at* http://www.epa.gov/reg5sfun/ecology/toxprofiles.htm

EPA, Water Quality Assessment and Total Maximum Daily Loads Information, http://www.epa.gov/waters/ir/index.html (last visited November 12, 2011).

EPA. 1993. Plastic Pellets in the Aquatic Environment: Sources and Recommendations, http://water.epa.gov/type/oceb/marinedebris/upload/2009_11_23_oceans_debris_plasticpellets_plastic_pellets_summary.pdf.

EPA. 2011. Marine Debris in the North Pacific: A summary of existing information and identification of data gaps. EPA-909-R-11-006, *available at* http://www.epa.gov/region9/marine-debris/pdf/MarineDebris-NPacFinalAprvd.pdf (last visited August 20, 2012).

Eriksson, Cecilia, and Harry Burton. 2003. "Origins and Biological Accumulation of Small Plastic Particles in Fur Seals from Macquarie Island." *Ambio* 32 (6): 380–384. http://www.ncbi.nlm.nih.gov/pubmed/14627365.

Feldcamp et al, 1988. Energetic and behavioral effects of net entanglement of juvenile northern fur seals, Callorhinus ursinus, Fish. Bull. 87 (1), 85-94.

Goldstein, M.C., M. Rosenberg and L. Cheng. 2012. Increased oceanic microplastic debris enhances oviposition in an endemic pelagic insect. Biology Letters.

Gordon, M., Zamist, R. Municipal Best Management Practices For Controlling Trash And Debris In Stormwater And Urban Runoff, CALIFORNIA COASTAL COMMISSION, available at http://www.plasticdebris.org/Trash_BMPs_for_Munis.pdf

Gordon, Miriam. 2006. Eliminating Land-Based Discharges of Marine Debris in California: A Plan of Action from The Plastic Debris Project, CALIFORNIA COASTAL COMMISSION, 1, 3 (2006) available at http://www.plasticdebris.org/CA_Action_Plan_2006.pdf

Gregory, Murray R. 2009. "Environmental Implications of Plastic Debris in Marine Settings--entanglement, Ingestion, Smothering, Hangers-on, Hitch-hiking and Alien Invasions." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 364 (1526) (July 27): 2013–25. doi:10.1098/rstb.2008.0265. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873013&tool=pmcentrez&rendertype=abstract.

Henderson, John R. 2001. "A Pre- and Post-MARPOL Annex V Summary of Hawaiian Monk Seal Entanglements and Marine Debris Accumulation in the Northwestern Hawaiian Islands , 1982 ± 1998." *Marine Pollution Bulletin* 42 (7): 1–6.

Heskett, Marvin, Hideshige Takada, Rei Yamashita, Masaki Yuyama, Maki Ito, Yeo Bee Geok, Yuko Ogata, et al. 2012. "Measurement of Persistent Organic Pollutants (POPs) in Plastic Resin Pellets from Remote Islands: Toward Establishment of Background Concentrations for International Pellet Watch." *Marine Pollution Bulletin* 64 (2) (February): 445–8. doi:10.1016/j.marpolbul.2011.11.004. http://www.ncbi.nlm.nih.gov/pubmed/22137935.

Hidalgo-Ruz, Valeria, Lars Gutow, Richard C Thompson, and Martin Thiel. 2012. "Microplastics in the Marine Environment: a Review of the Methods Used for Identification and Quantification." *Environmental Science & Technology* 46 (6) (March 20): 3060–75. doi:10.1021/es2031505. http://www.ncbi.nlm.nih.gov/pubmed/22321064.

Hirai, Hisashi, Hideshige Takada, Yuko Ogata, Rei Yamashita, Kaoruko Mizukawa, Mahua Saha, Charita Kwan, et al. 2011. "Organic Micropollutants in Marine Plastics Debris from the Open Ocean and Remote and Urban Beaches." *Marine Pollution Bulletin* (June 28). doi:10.1016/j.marpolbul.2011.06.004. http://www.ncbi.nlm.nih.gov/pubmed/21719036.

Hoss, DE, and LR Settle. 1990. "Ingestion of Plastics by Teleost Fishes." *NOAA Technical Memorandum* NOAA-TM-NM: 639–709.

http://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-154_P693.PDF.

Howell, Evan A EA, SJ Steven J Bograd, Carey Morishige, Michael P Seki, and Jeffrey J Polovina. 2012. "On North Pacific Circulation and Associated Marine Debris Concentration." *Marine Pollution Bulletin* 65 (1-3): 16–22. doi:10.1016/j.marpolbul.2011.04.034. http://www.ncbi.nlm.nih.gov/pubmed/21592531.

IWC, Report of the Scientific Committee, Annex K: Report of the Standing Working Group on Environmental Concerns, (2012), IWC/64/Rep 1, Annex K, at section 11.2, pp. 12-14, available at http://iwcoffice.org/cache/downloads/dvtjqvsr2o00ksswcg4wk8k0c/Annex-K-E.pdf (last visited August 20, 2012).

IWC. 2011. "Warning over swimming with dolphins." August 18, 2011; Report of the Scientific Committee, Annex K: Report of the Standing Working Group on Environmental Concerns, IWC (2012), IWC/64/Rep 1, Annex K, at section 7.1, pp. 1-3, available at http://iwcoffice.org/cache/downloads/dvtjqvsr2o00ksswcg4wk8k0c/Annex-K-E.pdf (last visited August 20, 2012).

Jacobsen, J., Massey, L., Gulland, F. 2010. Fatal ingestion of floating debris by two sperm whales. Mar. Pollut. Bull. 60, 765-767.

Jacobsen, Jeff K, Liam Massey, and Frances Gulland. 2010. "Fatal Ingestion of Floating Net Debris by Two Sperm Whales (Physeter Macrocephalus)." *Marine Pollution Bulletin* 60 (5) (May): 765–7. doi:10.1016/j.marpolbul.2010.03.008. http://www.ncbi.nlm.nih.gov/pubmed/20381092.

Karapanagioti, H K, S Endo, Y Ogata, and H Takada. 2011. "Diffuse Pollution by Persistent Organic Pollutants as Measured in Plastic Pellets Sampled from Various Beaches in Greece." *Marine Pollution Bulletin* 62 (2) (February): 312–7. doi:10.1016/j.marpolbul.2010.10.009. http://www.ncbi.nlm.nih.gov/pubmed/21092999.

Keller, Aimee A, Erica L Fruh, Melanie M Johnson, Victor Simon, and Catherine Mcgourty. 2010. "Distribution and Abundance of Anthropogenic Marine Debris Along the Shelf and Slope of the US West Coast." *Marine Pollution Bulletin* 60 (5): 692–700. doi:10.1016/j.marpolbul.2009.12.006. http://dx.doi.org/10.1016/j.marpolbul.2009.12.006.

Kobayashi, Jun, Kyoko Kinoshita, Kaoruko Mizukawa, Takeo Sakurai, Yoshitaka Imaizumi, Hideshige Takada, and Noriyuki Suzuki. 2011. "Dietary Uptake Kinetics of Polychlorinated Biphenyls from Sediment-contaminated Sandworms in a Marine Benthic Fish (Pseudopleuronectes Yokohamae)." *Chemosphere* 82 (5) (January): 745–50. doi:10.1016/j.chemosphere.2010.10.087. http://www.ncbi.nlm.nih.gov/pubmed/21126752.

Koch, H.M. & Calafat, A.M., 2009. Human Body Burden of Chemicals Used in Plastic Manufacture, PHIL. TRANS. R. SOC. B, 364(2063, 64-65) (2009) http://rstb.royalsocietypublishing.org/content/364/1526/2063.short.

Kukulka, T. et al. 2012. The effect of wind mixing on the vertical distribution of buoyant plastic debris. Geophys. Res. Lett. 39 (7), L07601: 1–6.

Laist, D. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. SPRINGER SERIES ON ENVIRONMENTAL MANAGEMENT.

Law, K. et al. 2010. Plastic Accumulation in the Atlantic Subtropical Gyre. Science. 329, 1185-1188.

Lazar, B, Gracan, R. 2011. Ingestion of marine debris by loggerhead sea turtles, Caretta caretta, in the Adriatic sea. Mar. Pollut. Bull. 62, 43-47.

Mace, Thomas H. 2012. "At-sea Detection of Marine Debris : Overview of Technologies , Processes , Issues , and Options." *Marine Pollution Bulletin* 65 (1-3): 23–27. doi:10.1016/j.marpolbul.2011.08.042. http://dx.doi.org/10.1016/j.marpolbul.2011.08.042.

Mato, Y. et al. 2001. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment, ENVIRONMENTAL SCIENCE TECHNOLOGY, 35 (2), 318-324, http://www.ncbi.nlm.nih.gov/pubmed/11347604.

Mcdermid, Karla J, and Tracy L Mcmullen. 2004. "Quantitative Analysis of Small-plastic Debris on Beaches in the Hawaiian Archipelago." *Marine Pollution Bulletin* 48: 790–794. doi:10.1016/j.marpolbul.2003.10.017.

Meeker, John D, Sheela Sathyanarayana, and Shanna H Swan. 2009. "Phthalates and Other Additives in Plastics: Human Exposure and Associated Health Outcomes." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 364 (1526) (July 27): 2097–113. doi:10.1098/rstb.2008.0268.

http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873014&tool=pmcentrez&rendertype=abstract.

Moore, C J, G L Lattin, and A F Zellers. 1989. "CONTRIBUTIONS OF PLASTIC AND OTHER TRASH TO COASTAL WATERS": 1–9.

Moore, C.J., GL Lattin, and AF Zellers. 2011. Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California. *Journal of Integrated Coastal Zone Management*, 11 (1), 65-73.

Moore, Charles James. 2008. "Synthetic Polymers in the Marine Environment: A Rapidly Increasing, Long-term Threat." *Environmental Research* 108 (2) (October): 131–139. doi:10.1016/j.envres.2008.07.025. http://linkinghub.elsevier.com/retrieve/pii/S001393510800159X.

Moore, CJ, SL Moore, and MK Leecaster. 2001. "A Comparison of Plastic and Plankton in the North Pacific Central Gyre." *Marine Pollution Bulletin* 42 (12): 1297–1300. http://www.sciencedirect.com/science/article/pii/S0025326X0100114X.

Moore, CJ. 2007. "A Brief Analysis of Organic Pollutants Sorbed to Pre and Post- Production Plastic Particles from the Los Angeles and San Gabriel River Watersheds." http://5gyres.org/media/Brief_Analysis_of_Organic_Pollutants.pdf.

Moore, E., Lyday, S., Roletto, J., Litle, K., Parrish, J. K., Nevins, H., Harvey, J., et al. 2009. Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001-2005. *Marine pollution bulletin*, *58*(7), 1045–51. doi:10.1016/j.marpolbul.2009.02.006

Moore, Emma, Shannon Lyday, Jan Roletto, Kate Litle, Julia K Parrish, Hannah Nevins, Jim Harvey, et al. 2009. "Entanglements of Marine Mammals and Seabirds in Central California and the North-west Coast of the United States 2001-2005." *Marine Pollution Bulletin* 58 (7) (July): 1045–51. doi:10.1016/j.marpolbul.2009.02.006. http://www.ncbi.nlm.nih.gov/pubmed/19344921.

Moore, S L, D Gregorioà, M Carreon, S B Weisberg, and M K Leecaster. 2001. "Composition and Distribution of Beach Debris in Orange County , California." *Marine Pollution Bulletin* 42 (3): 1–5.

Moore. Shelly L, and M James Allen. 2000. "Distribution of Anthropogenic and Natural Debris on the Mainland Shelf of the Southern California Bight." *Marine Pollution Bulletin* 40 (1): 83–88.

Morét-ferguson, Skye, Kara Lavender, Giora Proskurowski, Ellen K Murphy, Emily E Peacock, and Christopher M Reddy. 2010. "The Size , Mass , and Composition of Plastic Debris in the Western North Atlantic Ocean." *Marine Pollution Bulletin* 60: 1873–1878. doi:10.1016/j.marpolbul.2010.07.020.

Morishige, Carey, and Kris Mcelwee. 2012. "At-sea Detection of Derelict Fishing Gear in the North Pacific : An Overview." *Marine Pollution Bulletin* 65 (1-3): 1–6. doi:10.1016/j.marpolbul.2011.05.017. http://dx.doi.org/10.1016/j.marpolbul.2011.05.017.

Morris, Robert. 1980. "Plastic Debris in the Surface Waters of the South Atlantic." *Marine Pollution Bulletin* 11: 164–166. http://5gyres.org/media/Plastic_Debris_the_South_Atlantic_Gyre.pdf.

Mrosovsky, N., Ryna, G., James, M. 2009. Leatherback turtles: the menace of plastic. Mar. Pollut. Bull. 58. 287-289.

National Research Council. 2008. *Tackling Marine Debris in the 21st Century*, National Academes Press: Washington, D.C.

NOAA, U.S. Pacific Marine Mammal Stock Assessments: 2012 (draft), *available at* http://www.nmfs.noaa.gov/pr/sars/draft.htm (last visited August 20, 2012).

Novotny, Thomas E, Kristen Lum, Elizabeth Smith, Vivian Wang, and Richard Barnes. 2009. "Filtered Cigarettes and the Case for an Environmental Policy on Cigarette Waste": 1–15. doi:10.3390/ijerph60x000x.

Ocean Conservancy. 2011. Tracking Trash: 2011 Report.

Oehlmann, Jörg, Ulrike Schulte-Oehlmann, Werner Kloas, Oana Jagnytsch, Ilka Lutz, Kresten O Kusk, Leah Wollenberger, et al. 2009. "A Critical Analysis of the Biological Impacts of Plasticizers on Wildlife." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 364 (1526) (July 27): 2047–62. doi:10.1098/rstb.2008.0242. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873012&tool=pmcentrez&rendertype=abstract.

Ogata, Yuko, Hideshige Takada, Kaoruko Mizukawa, Hisashi Hirai, Satoru Iwasa, Satoshi Endo, Yukie Mato, et al. 2009. "International Pellet Watch: Global Monitoring of Persistent Organic Pollutants (POPs) in Coastal Waters. 1. Initial Phase Data on PCBs, DDTs, and HCHs." *Marine Pollution Bulletin* 58 (10) (October): 1437–46. doi:10.1016/j.marpolbul.2009.06.014. http://www.ncbi.nlm.nih.gov/pubmed/19635625.

Ogi, H., Fukumoto, Y. 2000. A sorting method for small plastic debris floating on the sea surface and stranded on sandy beaches. Bulletin of the Faculty of Fisheries, Hokkaido University 51(2):71-93.

Pichel, W.G. et al. 2007. Marine debris collects within the North Pacific Subtropical Convergence Zone, MARINE POLLUTION BULLETIN, 54 (8), 1207, 07, http://www.ncbi.nlm.nih.gov/pubmed/17568624.

Plastic Pollution Coalition. 2010. Common Misconceptions, (2010), http://plasticpollutioncoalition.org/learn/common-misconceptions/

Possatto, FE, and Mário Barletta. 2011. "Plastic Debris Ingestion by Marine Catfish: An Unexpected Fisheries Impact." *Marine Pollution ...* 62 (5): 1098–1102. doi:10.1016/j.marpolbul.2011.01.036. http://dx.doi.org/10.1016/j.marpolbul.2011.01.036.

Provencher, Jennifer F, Anthony J Gaston, Mark L Mallory, Patrick D O'hara, and H Grant Gilchrist. 2010. "Ingested Plastic in a Diving Seabird, the Thick-billed Murre (Uria Lomvia), in the Eastern Canadian Arctic." *Marine Pollution Bulletin* 60 (9) (September): 1406–11. doi:10.1016/j.marpolbul.2010.05.017. http://www.ncbi.nlm.nih.gov/pubmed/20557901.

Raum-Suryan, K. et al. 2009. Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions. Mar. Poll. Bull. 28 (58), 1487-1495.

Register, K., Cigarette Butts as Litter - Toxic as Well as Ugly?, http://www.cigarettelitter.org/index.asp?pagename=un (last visited November 27, 2011)

Ribic, C.A., et al. 1997. Distribution, type, accumulation, and source of marine debris in the United States, 1989-1993. In *Marine Debris: sources, impact and solutions* (eds J.M. Coe & D. B. Rogers), pp. 35-48. New York, NY: Springer Verlag.

Ribic, Christine A, Seba B Sheavly, David J Rugg, and Eric S Erdmann. 2010. "Trends and Drivers of Marine Debris on the Atlantic Coast of the United States 1997 – 2007." *Marine*

Pollution Bulletin 60 (8): 1231–1242. doi:10.1016/j.marpolbul.2010.03.021. http://dx.doi.org/10.1016/j.marpolbul.2010.03.021.

Ribic. CA.. 2012. "Trends in Marine Debris Along the U . S . Pacific Coast and Hawai ' i 1998 – 2007." *MARINE POLLUTION BULLETIN* 64 (5): 994–1004. doi:10.1016/j.marpolbul.2012.02.008. http://www.ncbi.nlm.nih.gov/pubmed/22385753.

Richardson. Bruce J. Rei Yamashita. Hideshige Takada. Masa-aki Fukuwaka. and Yutaka Watanuki. 2011. "Physical and Chemical Effects of Ingested Plastic Debris on Short-tailed Shearwaters . Puffinus Tenuirostris . in the North Pacific Ocean." *Marine Pollution Bulletin* 62 (12): 2845–2849. doi:10.1016/j.marpolbul.2011.10.008. http://dx.doi.org/10.1016/j.marpolbul.2011.10.008.

Rios, L.M., Moore. C. & Jones, P.R. 2007. Persistent organic pollutants carried by synthetic polymers in the ocean environment. MARINE POLLUTION BULLETIN. 54(8). 1230. 30. http://www.ncbi.nlm.nih.gov/pubmed/17532349.

Rios. Lorena M. Patrick R Jones, Charles Moore. and Urja V Narayan. 2010. "Quantitation of Persistent Organic Pollutants Adsorbed on Plastic Debris from the Northern Pacific Gyre's 'Eastern Garbage Patch'." *Journal of Environmental Monitoring : JEM* 12 (12) (December): 2226–36. doi:10.1039/c0em00239a. http://www.ncbi.nlm.nih.gov/pubmed/21042605.

Ryan. P. a Connell. and B Gardner. 1988. "Plastic Ingestion and PCBs in Seabirds: Is There a Relationship?☆." *Marine Pollution Bulletin* 19 (4) (April): 174–176. doi:10.1016/0025-326X(88)90674-1. http://linkinghub.elsevier.com/retrieve/pii/0025326X88906741.

Ryan, P.G.. et al. 2009. Monitoring the Abundance of Plastic Debris in the Marine Environment . PHIL. TRANS. R. SOC. B. 364. 1999-2003.

Sazima. Ivan. Otto B F Gadig. and Rafael C Namora. 2002. "Plastic Debris Collars on Juvenile Carcharhinid Sharks (Rhizoprionodon Lalandii) in Southwest Atlantic." *Scientific Monthly* 44: 1147–1149.

Schuyler Q. Hardesty BD. Wilcox C, Townsend K. 2012. To Eat or Not to Eat? Debris Selectivity by Marine Turtles. PLoS ONE 7(7): e40884. doi:10.1371/journal.pone.0040884.

Schuyler. Qamar. Britta Denise Hardesty. Chris Wilcox. and Kathy Townsend. 2012. "To Eat or Not to Eat? Debris Selectivity by Marine Turtles." Ed. Graeme Clive Hays. *PLoS ONE* 7 (7)

(July 19): e40884. doi:10.1371/journal.pone.0040884. http://dx.plos.org/10.1371/journal.pone.0040884.

Sileo, Louis, Paul R Sievert, Michael D Samuel, and Stewart I Fefer. 1990. "Prevalence and Characteristics of Plastic Ingested by Hawaiian Seabirds" (200 cc): 2–7.

Stamper, M., Spicer, C., Neiffer, D., Mathews, K., Fleming, G. 2009. Morbidity in juvenile green sea turtles due to ocean-bourne plastic. Journal of Zoo and Wildlife Medicine. 40 (1), 196-198.

Stevens, C. 2011. California Ocean Science Trust. Plastic Debris in the California Marine Ecosystem: A summary of current research, solution strategies and data gaps, C. Stevenson, University of Southern California Sea Grant. Synthetic Report. Oakland, CA. (September 2011) http://calost.org/pdf/science-initiatives/marine%20debris/Plastic%20Report_10-4-11.pdf.

Teuten, Emma L, Jovita M Saquing, Detlef R U Knappe, Morton a Barlaz, Susanne Jonsson, Annika Björn, Steven J Rowland, et al. 2009. "Transport and Release of Chemicals from Plastics to the Environment and to Wildlife." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 364 (1526) (July 27): 2027–45. doi:10.1098/rstb.2008.0284. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873017&tool=pmcentrez&rendertype=abstract.

Teuten, Emma L, Steven J Rowland, Tamara S Galloway, and Richard C Thompson. 2007a. "Potential for Plastics to Transport Hydrophobic Contaminants." *Environmental Science & Technology* 41 (22) (November 15): 7759–64. http://www.ncbi.nlm.nih.gov/pubmed/18075085.

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D. and Russell, A.E. (2004) Lost at sea: Where is all the plastic? *Science*, 304, 838-838. (doi:10.1126/science.1094559).

Thompson, Richard C, Charles J Moore, Frederick S vom Saal, and Shanna H Swan. 2009. "Plastics, the Environment and Human Health: Current Consensus and Future Trends." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 364 (1526) (July 27): 2153–66. doi:10.1098/rstb.2009.0053.

http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2873021&tool=pmcentrez&rendertype=abstract.

Tomas, J., Guitart, R. 2002. Marine debris ingestion in loggerhead sea turtles , Caretta caretta, from the western Mediterranean. Mar. Pollut. Bull. 44 (3), 211-216.

Tourinho, Paula S, Juliana a Ivar do Sul, and Gilberto Fillmann. 2010. "Is Marine Debris Ingestion Still a Problem for the Coastal Marine Biota of Southern Brazil?" *Marine Pollution Bulletin* 60 (3) (March): 396–401. doi:10.1016/j.marpolbul.2009.10.013. http://www.ncbi.nlm.nih.gov/pubmed/19931101.

UNEP. 2011. "Marine Debris as a Global Environmental Problem" (November).

United Nations. Marine Litter: Trash that Kills. 14 Feb 2011. http://www.unep.org/regionalseas/marinelitter/publications/docs/trash_that_kills.pdf, pp. 10; Wallace, N. "Debris Entanglement in the Marine Environment: A Review." Proceedings of the Workshop on the Fate and Impact of Marine Debris. Eds. R.S. Shomura, H.O. Yoshida. U.S. Department of Commerce: NOAA Technical Memorandum. NMFS, NOAA-TM-NMFS-SWFC-5, pp. 259-277; http://www.montereybayaquarium.org/cr/oceanissues/plastics_albatross

van Franeker, Jan a, Christine Blaize, Johannis Danielsen, Keith Fairclough, Jane Gollan, Nils Guse, Poul-Lindhard Hansen, et al. 2011. "Monitoring Plastic Ingestion by the Northern Fulmar Fulmarus Glacialis in the North Sea." *Environmental Pollution (Barking, Essex : 1987)* 159 (10) (October): 2609–15. doi:10.1016/j.envpol.2011.06.008. http://www.ncbi.nlm.nih.gov/pubmed/21737191.

Veenstra, Timothy S, and James H Churnside. 2012. "Airborne Sensors for Detecting Large Marine Debris at Sea." *Marine Pollution Bulletin* 65 (1-3): 63–68. doi:10.1016/j.marpolbul.2010.11.018. http://dx.doi.org/10.1016/j.marpolbul.2010.11.018.

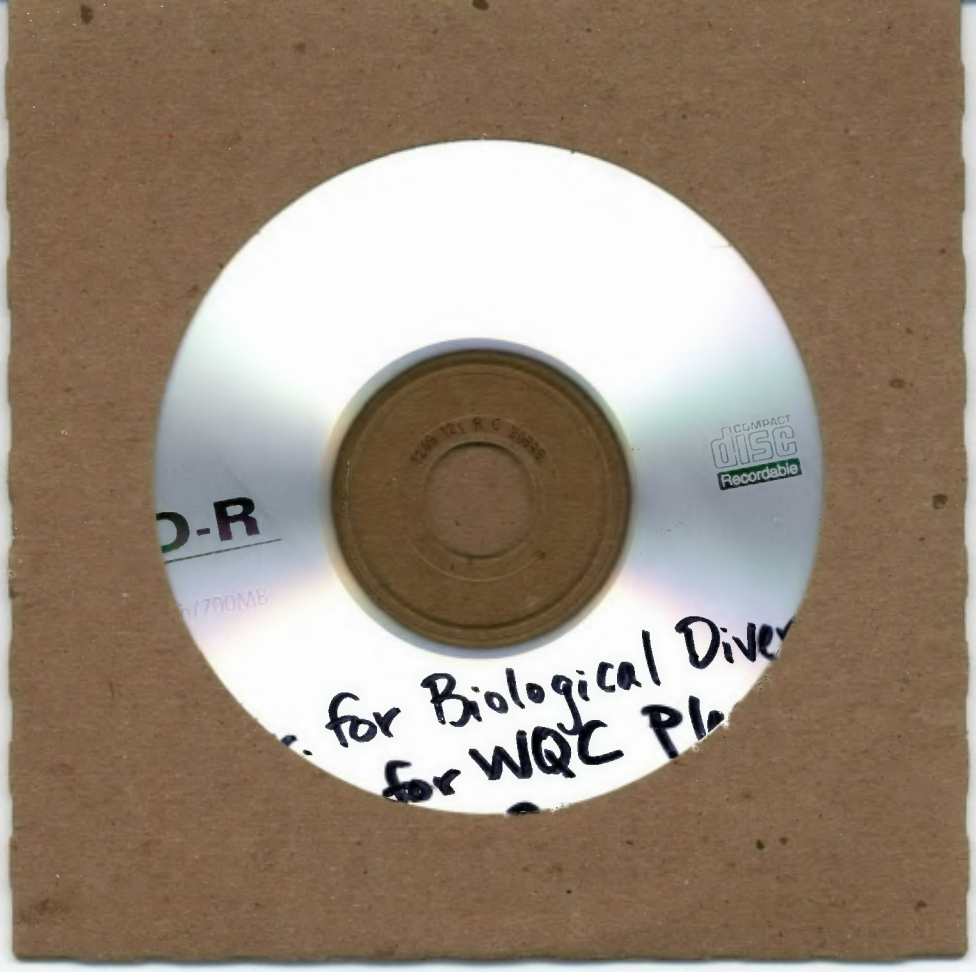
Viehman, Shay, Jenny L Vander, Jennifer Schellinger, and North Carolina. 2011. "Characterization of Marine Debris in North Carolina Salt Marshes." *Marine Pollution Bulletin* 62 (12): 2771–2779. doi:10.1016/j.marpolbul.2011.09.010. http://dx.doi.org/10.1016/j.marpolbul.2011.09.010.

Walker, T R, K Reid, J P Y Arnould, and J P Croxall. 1997. "Marine Debris Surveys at Bird Island , South Georgia 1990-1995." *Packaging (Boston, Mass.)* 34 (1): 61–65.

Williams, Rob, Erin Ashe, and Patrick D O Hara. 2011. "Marine Mammals and Debris in Coastal Waters of British Columbia , Canada." *Marine Pollution Bulletin* 62 (6): 1303–1316. doi:10.1016/j.marpolbul.2011.02.029. http://dx.doi.org/10.1016/j.marpolbul.2011.02.029.

Young, Lindsay C, Cynthia Vanderlip, David C Duffy, Vsevolod Afanasyev, and Scott a Shaffer. 2009. "Bringing Home the Trash: Do Colony-based Differences in Foraging Distribution Lead to Increased Plastic Ingestion in Laysan Albatrosses?" *PloS One* 4 (10) (January): e7623. doi:10.1371/journal.pone.0007623. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2762601&tool=pmcentrez&rendertype=abstract.

Zarfl, C. & Matthies, M. 2010. Are marine plastic particles transport vectors for organic pollutants to the Arctic?, MARINE POLLUTION BULLETIN, 60 (10), 1810, 12, http://www.ncbi.nlm.nih.gov/pubmed/20579675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