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The Pelagic Plastic Problem

Ciera Dye
University of Maine School of Law

THE PELAGIC PLASTIC PROBLEM

Ciera Dye[*]

Plastic's inexpensive and versatile qualities have led to its use in an ever-increasing number of applications and in staggering quantities. As the volume and variety of plastic applications have expanded, there has been a corresponding increase in the supply of plastic waste products. Much of this waste makes its way into the world's oceans as a result of improper disposal. I term this use-disposal-escape cycle the "pelagic plastic problem," and advocate a partial solution.

This Comment undertakes a cost-benefit analysis of single-use plastic bags and argues for policies that would reduce or eliminate their use. The analysis finds that the benefits of using plastic bags are far outweighed by their costs and that continued use of the product is indefensible, especially in light of available alternatives.

I focus on plastic bags for several reasons. First, plastic bags are emblematic of consumerism and its obsession with convenience. It is hoped that an appreciation of the product's environmental consequences may spark a re-evaluation of consumer culture. Second, individuals can easily reduce or eliminate plastic bag use and thereby contribute to a solution to the pelagic plastic problem even if governments do not act. Third, the anti-bag movement is gaining momentum. Governments are increasingly considering or enacting bag reduction policies and are encountering political and legal resistance in the process.

This Comment supports the anti-plastic bag movement by providing justifications for bag reduction policies, anticipating the opposition that such policies may encounter, and identifying policies capable of diffusing the opposition.

I. INTRODUCTION

"*Plastics have transformed the surface of the planet.*"[1]

* J.D. Candidate, University of Maine School of Law, Class of 2014.

The ubiquitous plastic bag can claim the dubious distinction of ranking among the most abundant types of marine debris.[2] In the world's oceans, plastic bags slowly degrade into small pieces, take an unknown amount of time to mineralize, and harm aquatic life at all depths and in all stages of the degradation process.[3] Whales, sharks, and sea turtles regularly ingest whole floating plastic bags, mistaking them for prey,[4] while sea birds and fish indiscriminately feed upon floating plastic particles.[5] Encounters with floating plastic can also result in entanglement, impairing the mobility of aquatic creatures.[6] Plastic bags cause additional environmental harm when they settle on the sea floor, where they are known to smother sedentary flora and fauna,[7] and thought to disrupt important hydrological processes.[8]

Despite the magnitude of the pelagic plastic problem, the continued manufacture and consumption of plastic bags is among the most easily addressed of contemporary environmental problems. This Comment focuses on plastic bags because the environmental harms caused by their mismanagement could be easily prevented. Prohibiting the use of plastic bags would require a relatively painless shift by consumers and have the effect of dramatically reducing environmental degradation. Plastic bags have negligible social benefits and significant environmental costs that are not associated with currently available and easily implemented alternatives. The abundance and reflexive use of plastic bags is thus a feature of contemporary society that can and should be eliminated.

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1. David K.A. Barnes et al., *Accumulation and Fragmentation of Plastic Debris in Global Environments*, 364 PHIL. TRANSACTIONS ROYAL SOC'Y BIOLOGICAL SCI. 1985, 1995 (2009).

2. *See* U.S. EPA, MARINE DEBRIS IN THE NORTH PACIFIC: A SUMMARY OF EXISTING INFORMATION AND IDENTIFICATION OF DATA GAPS 2 (2011).

3. *See* Charles James Moore, *Synthetic Polymers in the Marine Environment: A Rapidly Increasing, Long Term Threat*, 108 ENVTL. RES. 131, 132 (2008).

4. *Id.* at 134; *see also* Colette Wabnitz & Wallace J. Nichols, *Plastic Pollution: An Ocean Emergency*, 129 MARINE TURTLE NEWSL. 1, 1 (2010), *available at* www.seaturtle.org/mtn/PDF/MTN129.pdf.

5. Murray R. Gregory, *Environmental Implications of Plastic Debris in Marine Settings – Entanglement, Ingestion, Smothering, Hangers-On, Hitch-Hiking, and Alien Invasions*, 364 PHIL. TRANSACTIONS ROYAL SOC'Y BIOLOGICAL SCI. 2013, 2016 (2009) [hereinafter Gregory, *Implications*]; *see also* Fernanda E. Possatto et al., *Plastic Debris Ingestion by Marine Catfish: An Unexpected Fisheries Impact*, 62 MARINE POLLUTION BULL. 1098, 1098 (2011).

6. Wabnitz & Nichols, *supra* note 4, at 2.

7. *Marine Debris Impacts*, U.S. ENVTL. PROT. AGENCY, http://water.epa.gov/type/oceb/marinedebris/md_impacts.cfm#CP_JUMP_495983 (last visited Oct. 26, 2013).

8. Gregory, *Implications*, *supra* note 5, at 2017.

To prevent the environmental harms wrought by plastic bags, governments of all sizes are disincentivizing[9] or outright banning the use of plastic bags.[10] This Comment examines the environmental justifications and sources of legal authority for plastic bag bans to bolster the position of governmental units that have already passed or are currently contemplating the passage of plastic bag reducing measures.

Part II lays out an argument in favor of plastic bag reduction. It first considers two of the practical realities that account for plastics' environmental and economic harms—the difficulties associated with its disposal and its longevity. Next, it explains the environmental parameters of the problem, cataloguing plastic pollution's adverse effects on the health and welfare of plants, animals, and humans. It subsequently summarizes the economic harms associated with pelagic plastic. Part III explores three possible categories of policy solutions to the pelagic plastic problem, all of which focus on the role that individual and industrial norms play in perpetuation of the problem. Part IV introduces some of the economic and social forces behind plastic bag use by describing the interests of the plastics industry and the disposable consumer culture that the industry has helped to create. It describes some of the tactics that these groups have used to oppose plastic bag reduction measures, and then touches upon the arguments and strategies that could be used to overcome this opposition.

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9. *See, e.g.*, D.C. MUN. REGS. tit. 21, § 1001.1 (2012) (requiring consumers to pay retailers five cents for each disposable carryout bag provided).

10. Dozens of U.S. municipalities have enacted bag bans. *See, e.g.*, BARRINGTON, R.I., MUNICIPAL CODE § 161-8 (2013); LOS ANGELES COUNTY, CAL., CODE tit. 12, ch. 12.85.020 (2010). All of Hawaii's counties have banned plastic bags, effectively making Hawaii the first state in the nation to ban bags. *See* Miguel Llanos, *Hawaii First State to Ban Plastic Bags at Checkout*, NBC NEWS (May 16, 2012, 11:54 AM), http://usnews.nbcnews.com/_news/2012/05/16/11720480-hawaii-first-state-to-ban-plastic-bags-at-checkout?lite. A number of countries have also banned bags, including China, Mauritania, Rwanda, Ireland, Italy, and Bangladesh. *See China Bans Free Plastic Shopping Bags*, N.Y. TIMES, http://www.nytimes.com/2008/01/09/world/asia/09iht-plastic.1.9097939.html?_r=0 (last visited Oct. 27, 2013) (China); *Mauritania Bans Plastic Bag Use*, BBC NEWS (Jan. 2, 2013, 11:35 AM), http://www.bbc.co.uk/news/world-africa-20891539 (Mauritania and Rwanda); Kate Galbraith, *Should Plastic Bags Be Banned?*, N.Y. TIMES, http://www.nytimes.com/2012/02/09/business/energy-environment/should-plastic-bags-be-banned.html?pagewanted=all (last visited Oct. 27, 2013) (Ireland); Kitt Doucette, *The Plastic Bag Wars*, ROLLING STONE (July 25, 2011, 1:30 PM), http://www.rollingstone.com/politics/news/the-plastic-bag-wars-20110725 (Italy and Bangladesh).

II. AN ARGUMENT IN FAVOR OF PLASTIC BAG REDUCTION

A. Plastic Bags Are Problematic Waste Products

Plastic bags are prone to pollution because of their composition. As components of the municipal waste stream, bags threaten our environment because their structure enables mobility and an inordinately long existence. After a bag's useful life is over—often after only one use or two—it becomes a problematic waste product.

The science of waste management holds that the proper management of plastic bags requires either their destruction or containment.[11] Methods of destruction include incineration for energy recapture[12] and recycling.[13] But most single-use plastics are not destroyed. They are instead deposited in landfills, which have difficulty adequately containing them.[14] Even with adequate containment, disposal of plastics in landfills is problematic. Plastics are slow to degrade in landfills[15] and occupy significant amounts of space[16] in the large proportion of existent landfills that are at or near capacity.[17] Discarding plastics in landfills is also objectionable because it "represents a valuable resource discarded well before the end of its useful lifetime."[18]

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11. Barnes et al., *supra* note 1, at 1987.

12. Incineration of plastic bags is an efficient method of resource reuse because common plastics have high heat content. *See* ANTHONY L. ANDRADY, PLASTICS AND THE ENVIRONMENT 53 (2003); *see also* Thomas Archer & Jon Huls, RESOURCE RECOVERY FROM PLASTIC AND GLASS WASTES, U.S. EPA, EPA-600/S2-81-123, at 4 (1981).

13. Although plastic bags can be recycled, studies have found that only 1% of the plastic bags used in the United States go through a recycling process. Moore, *supra* note 3, at 136; *but see* Doucette, *supra* note 10 (reporting that nearly 10% of plastic bags are recycled).

14. Barnes et al., *supra* note 1, at 1986.

15. Juliet Lapados, *Will My Plastic Bag Still Be Here in 2507?*, SLATE (June 27, 2007, 6:20 PM), http://www.slate.com/articles/news_and_politics/explainer/2007/06/will_my_plastic-_bag_still_be_here_in_2507.html (suggesting that it takes anywhere from 500 to 1,000 years for plastic bags to degrade in landfills).

16. ANDRADY, *supra* note 12, at 140 (noting that the "important measure in a landfill is contribution by volume" and that plastics take up a relatively large amount of space per unit of weight, because of their low density). Paper bags, on the other hand, take up even more space than plastic. *Id.* at 143.

17. *See* U.S. CONGRESS, OFFICE OF TECH. ASSESSMENT, FACING AMERICA'S TRASH: WHAT'S NEXT FOR MUNICIPAL SOLID WASTE 271 (1989) ("MSW landfill capacity in the United States is declining . . . because old landfills are being closed and because siting new facilities is difficult.").

18. ANDRADY, *supra* note 12, at 53.

Adequate containment of light plastics, like bags, requires regular coverage by soil or synthetic materials to prevent capture by the wind.[19] Plastic film products, like plastic bags, are likely the largest contributor to land-based plastic debris accumulation due to the ease with which they escape landfills and enter the environment.[20] Because even a light breeze can easily transport plastic bags from coastal grocery store parking lots and landfills,[21] a significant proportion of improperly managed plastic waste finds its way to the world's oceans. Plastic bags are also transported from inland areas to the ocean through municipal drainage systems, storm water conveyances, and streams and rivers.[22]

B. Pelagic Plastics are Long-Lived, Mobile Pollutants

Once a plastic bag reaches the ocean, it may remain there for thousands of years.[23] Plastic's durability at least partially explains the fact that plastic bags are among the five most common items found during beach and ocean cleanups.[24] Although plastic comprises only 10% of all solid waste, it accumulates unremittingly due to its longevity and thus constitutes roughly 80% of global oceanic debris.[25] Most of the litter in the world's oceans consists of plastic in various phases of the degradation process.[26]

In the ocean, a combination of atmospheric, hydrologic, and solar forces renders thermoplastics,[27] including plastic bags, brittle, causing

19. Barnes et al., *supra* note 1, at 1987.

20. *Id.* at 1986.

21. Moore, *supra* note 3, at 132 (noting that "the ocean is downhill and downstream from virtually everywhere that humans live, and [that] about half of the world's human population lives within 50 miles of the ocean").

22. Jose G.B. Derraik, *The Pollution of the Marine Environment by Plastic Debris: A Review*, 44 MARINE POLLUTION BULL. 842, 843 (2002); *see also* U.S. DEP'T OF COMMERCE, NAT'L OCEANIC AND ATMOSPHERIC COMM'N, MARINE DEBRIS PROGRAM, PLASTIC MARINE DEBRIS: AN IN-DEPTH LOOK 1-3 (Aug. 2011) *available at* http://marinedebris.noaa.gov/info/pdf/plasticdet.pdf.

23. *See* Barnes et al., *supra* note 1, at 1993.

24. MARINE DEBRIS IN THE NORTH PACIFIC, *supra* note 2.

25. Wabnitz & Nichols, *supra* note 4, at 1; *see also* Moore, *supra* note 3, at 135 (suggesting that plastic may comprise up to 95% of all marine debris in some areas).

26. Derraik, *supra* note 22, at 843. In the ocean, whole plastic bags constitute "megalitter," whereas degraded pieces of plastic bags are classified as either "macrolitter" or "mesolitter." *See* Murray R. Gregory, *The Hazards of Persistent Marine Pollution: Drift Plastics and Conservation Islands*, 21:2 J. OF THE ROYAL SOCIETY OF N.Z. 83, 84 (1991) [hereinafter Gregory, *Hazards*].

27. Thermoplastics are plastics whose shape is not permanently set. *See* Archer & Huls, *supra* note 12, at 1. They harden when exposed to cold ocean temperatures. *Id.*

them to break apart into smaller and smaller pieces.[28] In this process of photo-degradation, partially degraded bits of plastic known as "scrubbers"[29] eventually break down into individual molecules, which in turn become bioavailable only after further degradation.[30] Plastic requires more time to degrade in the ocean because cool water inhibits the process,[31] and when it reaches the seafloor it may be even slower to degrade because of low oxygen concentrations and the absence of sunlight at great depths.[32] Scientists have not reached consensus about how much time is required for complete degradation,[33] but some believe that plastic never fully degrades in the marine environment.[34] Those holding this view conclude that "all of the conventional plastic that has ever been introduced into the environment still remains to date unmineralized, either as whole items or as fragments."[35]

Plastic bags are buoyant and like most other plastic debris, initially float near the ocean surface.[36] But as bags break down into small pieces and become fouled, they slowly sink to the seabed[37] and accumulate with other marine debris in the seafloor's coastal canyons.[38] Once plastics settle in sediments, "they may persist for centuries."[39] The persistence of plastic in the marine environment is a function of its "stubborn" molecular structure[40] and chemical resistance to degradation.[41] This

28. Moore, *supra* note 3, at 132.

29. Derraik, *supra* note 22, at 846 (describing plastic pieces smaller than 0.5 mm across as "scrubbers").

30. Moore, *supra* note 3, at 132.

31. Lorena M. Rios et al., *Persistent Organic Pollutants Carried by Synthetic Polymers in the Ocean Environment*, 54 MARINE POLLUTION BULL. 1230, 1231 (2007).

32. Barnes et al., *supra* note 1, at 1993.

33. *See id.* ("Estimates for the longevity of plastics are variable but are believed to be in the range of hundreds or even thousands of years depending on the physical and chemical properties of the polymer.").

34. Courtney Arthur et al., *Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris* 8 (Sept. 9-11, 2008), NOAA TECHNICAL MEMORANDUM (2009).

35. *Id.*

36. MARINE DEBRIS IN THE NORTH PACIFIC, *supra* note 2, at 4.

37. *Id.*; *see also* Barnes et al., *supra* note 1, at 1990 ("Plastics have been found on the seabed of all seas and oceans across the planet.").

38. *Id.* at 1992 (citing a survey of a coastal canyon that found 112 items of debris per kilometer, 70% of which were plastic).

39. Derraik, *supra* note 22, at 842; *but see* Barnes et al., *supra* note 1, at 1990 ("[T]he [aging] of plastics at depth is not well researched.").

40. Rios et al., *supra* note 31, at 1230.

41. Anthony L. Andrady & Mike A. Neal, *Applications and Societal Benefits of Plastics*, 364 PHIL. TRANSACTIONS ROYAL SOC'Y BIOLOGICAL SCI. 1977, 1981 (2009).

persistence and resulting accumulation, coupled with the process of photo-degradation in which plastic is reduced to smaller and smaller pieces, greatly increases the potential for ingestion by marine life.[42]

As they are on land, plastic bags are prone to movement by natural forces at sea. Once plastic bags reach the ocean, offshore winds push them and their degraded parts to ocean transport systems,[43] which then carry the bags from shorelines to convergence zones on the high seas.[44] Also known as "gyres," these zones assume the form of high-pressure systems that collect debris in significant densities.[45] There are five major high-pressure zones in the world's oceans[46] created by the mixing of hot and cold currents.[47] These gyres harbor the world's "garbage patches," the most remarkable of which is the North Pacific Subtropical Gyre.[48] Also known as the "Pacific [T]rash [V]ortex," this gyre harbors a collection of floating debris that is estimated to cover up to nine million square miles.[49] Other lesser-known garbage clusters include the Eastern Garbage Patch (located between Hawaii and California) and the Western Garbage Patch (a Pacific accumulation off the coast of Japan), which together are "estimated to contain approximately 100 million tons of garbage."[50]

In spite of its tendency to accumulate, and perhaps because of its tendency to sink, plastic marine debris is nearly impossible to recover or collect. The ocean, for lack of a better description, is "hard to clean."[51] Because pelagic plastic is so long-lived and difficult to recover, the environmental problems associated with it are going to be with us for a

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42. Wabnitz & Nichols, *supra* note 4, at 1; *see also* Barnes et al., *supra* note 1, at 1994 ("[P]lastic fragments . . . have the potential to be ingested by a much wider range of organisms than larger items of debris.").

43. Moore, *supra* note 3, at 133.

44. Wabnitz & Nichols, *supra* note 4, at 1.

45. *Ocean Gyre,* NAT'L GEOGRAPHIC, http://education.nationalgeographic.com/education/-encyclopedia/ocean-gyre/?ar_a=1 (last visited Apr. 21, 2013).

46. *Currents,* U.S. DEP'T OF COMMERCE, NAT'L OCEANIC AND ATMOSPHERIC COMM'N, http://oceanservice.noaa.gov/education/tutorial_currents/welcome.html (last visited Oct. 27, 2013).

47. *See* Barnes et al., *supra* note 1, at 1989.

48. *See id.*

49. *De-mystifying the "Great Pacific Garbage Patch,"* U.S. DEP'T OF COMMERCE, NAT'L OCEANIC AND ATMOSPHERIC COMM'N, MARINE DEBRIS PROGRAM, http://marinedebris.noaa.gov/info/patch.html (last visited Oct. 27, 2013) ("This [area] is equivalent to approximately three times the area of the continental United States (3 million square miles).").

50. MARINE DEBRIS IN THE NORTH PACIFIC, *supra* note 2, at 3.

51. Gregory, *Implications*, *supra* note 5, at 2020; *see also* ANDRADY, *supra* note 12, at 54 (noting that cleanup efforts "do not work well in the marine environment").

long time. Of those problems, the most visible are the cases of animal ingestion or entanglement. Pelagic plastic's less visible environmental harms are also attributable to the material's longevity and mobility and include the material's function as a geographical disperser and bio-accumulator of contaminants.[52]

C. Environmental Harms Caused by Pelagic Plastic

The increasing accumulation of floating plastic debris in the world's oceans is transforming the natural processes by which marine flora and fauna are transported throughout the environment.[53] Contaminants have been shown to adhere to and concentrate on plastics "at levels far superior to the surrounding marine environment."[54] A 2005 study, for example, found that 40% of the marine debris sampled were colonized by marine fauna.[55] After they attach, contaminants and invasive species are dispersed throughout the marine environment by "hitchhiking" on plastic.[56] This allows the colonizers to reach maturity at unlikely locations, due to plastics' durability and tendency to travel long distances.[57] The movement of plastic debris in the oceans also facilitates the transport of persistent organic pollutants (POPs).[58] Pelagic plastic thus serves as a vector in the dispersal of organisms and substances that potentially endanger endemic biota,[59] and hastens the extinction of

52. *See id.*

53. D.K.A. Barnes & P. Milner, *Drifting Plastic and its Consequences for Sessile Organism Dispersal in the Atlantic Ocean*, 146 MARINE BIOLOGY 815, 815 (2005).

54. Wabnitz & Nichols, *supra* note 4, at 2; *see also* Derraik, *supra* note 22, at 847 ("Plastics floating at sea may acquire a fauna of various encrusting organisms such as bacteria, diatoms, algae, barnacles, hydroids and tunicates."). Larger organisms like iguanas have also been spotted rafting on pelagic plastic. Barnes & Milner, *supra* note 53, at 815. These creatures probably were not rafting on plastic bags.

55. Barnes et al., *supra* note 1, at 1989 (citing another 2005 study showing that more than 60% of the debris sampled carried fouling organisms).

56. Gregory, *Implications*, *supra* note 5, at 2018; *see also* Derraik, *supra* note 22, at 847 ("Drift plastics can . . . increase the range of certain marine organisms or introduce species into an environment where they were previously absent."); Barnes et al., *supra* note 1, at 1985 ("[P]lastic debris . . . may . . . distribute the algae associated with red tides.").

57. *Id.* at 1989.

58. MARINE DEBRIS IN THE NORTH PACIFIC, *supra* note 2, at 8; *see also* Rios et al., *supra* note 31, at 1231 (defining POPs as "persistent organic anthropogenic compounds" that accumulate in the food chain and noting that some POPs are highly toxic).

59. Gregory, *Implications*, *supra* note 5, at 2021.

endangered species by facilitating the introduction of invasive and alien species.[60]

Because of plastic's tendency to absorb pollutants,[61] plastic ingestion at the bottom of the food chain raises the specter of increased toxicity levels across species.[62] Studies have shown that animals are capable of desorbing some of the elements that accumulate on plastics, a process that involves storing these elements in their bodily tissue.[63] Through the process of bioaccumulation, the harmful effects of plastic debris ingestion are likely to become concentrated at the top of the food chain.[64]

Plastic marine debris also causes environmental harms that are far more visible. Exposure to the material itself can directly or indirectly hasten an animal's death, through the infliction of external wounds upon entanglement or internal wounds upon accidental ingestion.[65] Animals are rendered both easier prey and less effective predators as a result of plastic induced wounds or weakness.[66] Entanglement reduces an animal's fitness by increasing the amount of energy required for travel[67] and can cause death by drowning or strangulation.[68]

Accidental ingestion of plastics harms digestive health[69] by interfering with normal physiological processes through blockage of the

60. Barnes & Milner, *supra* note 53, at 816 (suggesting that removing invasive species from the ocean is probably not feasible); *see also* Gregory, *Hazards*, *supra* note 26, at 83.

61. Moore, *supra* note 3, at 131.

62. Rios et al., *supra* note 31, at 1236 ("It is not only the initial organism that ingests . . . plastics that may be affected by . . . POPs, but also the organisms within its food web."); *see also* Wabnitz & Nichols, *supra* note 4, at 2 (noting the potential of plastics to transfer toxic substances up the food chain).

63. Moore, *supra* note 3, at 131.

64. *See* G.W. Bryan et al., *Bioaccumulation of Marine Pollutants*, 286 PHIL. TRANSACTIONS ROYAL SOC'Y BIOLOGICAL SCI. 483, 483 (1979) (discussing bioaccumulation of marine pollutants generally).

65. Wabnitz & Nichols, *supra* note 4, at 2.

66. *See* Derraik, *supra* note 22, at 846; *see also* Possatto et al., *supra* note 5, at 1101.

67. Derraik, *supra* note 22, at 846.

68. Moore, *supra* note 3, at 132.

69. *See* Gregory, *Implications*, *supra* note 5, at 2015-16; *see also* Moore, *supra* note 3, at 132 (plastic ingestion may cause stomach irritation); Derraik, *supra* note 22, at 845 (plastic ingestion blocks gastric enzyme secretion and can cause death by blocking an animal's digestive tract); Moore, *supra* note 3, at 135 (ingestion of plasticizers, estrogenic compounds, and chemical additives via ingestion of plastics may disrupt the endocrine system); Possatto et al., *supra* note 5, at 1101 (plastic ingestion is known to cause tumors).

digestive tract and displacement of food.[70] The accumulation of non-nutritive elements in the digestive tract causes nutrient deficiency by displacing food and diluting the nutrients that are available for absorption.[71] The accumulation of plastic debris in an animal's digestive tract may also induce feelings of satiation, reducing the desire to feed, and ultimately causing starvation.[72]

The population stability and regenerative capacity of affected species may be more at risk from the sub-lethal effects of plastic ingestion than from the lethal ones.[73] Nutrient dilution caused by plastic ingestion can lead to decreased growth rates and longer developmental periods, increasing the time during which animals are "most vulnerable to predation."[74] Plastic ingestion also harms species' reproductive capacity by lowering steroid hormone levels and delaying ovulation.[75]

Much of the feeding that occurs in the ocean is indiscriminate, meaning that animals eat all objects of ingestible size when feeding in any given area.[76] The prevalence of indiscriminate feeding coupled with the increasing accumulation of plastic marine debris has resulted in a worrisome phenomenon in which "[t]he bodies of almost all marine species . . . now contain plastic."[77] Furthermore, the minority of species whose feeding practices are not indiscriminate are nonetheless susceptible to entanglement, strangulation, and death resulting from contact with plastic debris.[78] High trophic-level species like tuna and sea turtles are especially likely to suffer harms associated with plastic

70. Donald C. Baur & Suzanne Iudicello, *Stemming the Tide of Marine Debris Pollution: Putting Domestic and International Control Authorities to Work*, 17 ECOLOGY L.Q. 71, 83 (1990).

71. Wabnitz & Nichols, *supra* note 4, at 2.

72. *Id.*; *see also* Derraik, *supra* note 22, at 845 (describing a study of plastic ingestion by domestic chickens that showed that accumulation of plastics in an animal's intestines reduces the storage volume of the stomach); Possatto et al., *supra* note 5, at 1101.

73. Shannon J. McCauley & Karen A. Bjorndal, *Conservation Implications of Dietary Dilution from Debris Ingestion: Sublethal Effects in Post-Hatchling Loggerhead Sea Turtles*, 13 CONSERVATION BIOLOGY 925, 926 (1999).

74. Wabnitz & Nichols, *supra* note 4, at 2; *see also* McCauley & Bjorndal, *supra* note 73, at 926-27.

75. Derraik, *supra* note 22, at 845.

76. Moore, *supra* note 3, at 134.

77. Wabnitz & Nichols, *supra* note 4, at 1. "In all, 267 species of marine organisms worldwide are known to have been affected by plastic debris." Moore, *supra* note 3, at 131.

78. *Id.*

pollution because of their habit of associating with and feeding off of natural "drifters" in the convergence zones where plastics accumulate.[79]

Sea turtles are seriously threatened by the indiscriminate ingestion of plastic.[80] Young turtles are especially susceptible[81] because they generally feed on surface clusters of drifting seaweed in the ocean's convergence zones, where the process of advection introduces concentrations of plastic.[82] A 1994 study of 50 post-hatchling sea turtles captured off the coast of Florida found that 32% had ingested plastic debris.[83] Sea turtles are thought to mistake floating plastic bags for jellyfish and are known to ingest them whole,[84] causing death by impairing flotation and mobility.[85] Plastic ingestion also harms sea turtles by diluting their dietary nutrient intake.[86] Young turtles have a limited ability to compensate for dilution by increasing food consumption and suffer from "reduced energy and nitrogen intakes."[87] These dietary deficiencies stunt the growth and development of young turtles and damage the regenerative capacity of the species as a whole.[88]

Whales, manatees, and porpoises are also thought to mistake plastic bags and their degraded parts for prey.[89] Other mammals, such as seals and sea lions, have a "deadly curiosity" for buoyant plastic debris.[90] These victims of plastic pollution certainly raise the profile of the problem. While the increasing prevalence of plastic debris in the world's

79. MARINE DEBRIS IN THE NORTH PACIFIC, *supra* note 2, at 7.

80. Gregory, *Implications*, *supra* note 5, at 2017. "[M]arine debris . . . affects . . . 86% of all sea turtle species." Derraik, *supra* note 22, at 844.

81. McCauley & Bjorndal, *supra* note 73, at 926-27.

82. Wabnitz & Nichols, *supra* note 4, at 2.

83. McCauley & Bjorndal, *supra* note 73, at 926-27.

84. Moore, *supra* note 3, at 134.

85. MARCO SOLANO ET AL., INTER-AMERICAN CONVENTION FOR THE PROTECTION AND CONSERVATION OF SEA TURTLES – AN INTRODUCTION 10 (Julio Montes De Oca ed., Lucinda Taft trans., 2004); *see also* Wabnitz & Nichols, *supra* note 4, at 2 ("[e]ven in small quantities, plastics can kill sea turtles due to obstruction of the esophagus").

86. Wabnitz & Nichols, *supra* note 4, at 2.

87. McCauley & Bjorndal, *supra* note 73, at 927.

88. *Id.* at 928.

89. *See* Derraik, *supra* note 22, at 845 (listing incidents of plastic ingestion causing the deaths of pygmy sperm, orca, and Blainville's beaked whales and of endangered Florida and West Indies manatees); *see also* Robin W. Baird & Sascha K. Hooker, *Ingestion of Plastic and Unusual Prey by a Juvenile Harbour Porpoise*, 40 MARINE POLLUTION BULL. 719, 719 (2000).

90. Paul E. Hagen, Comment, *The International Community Confronts Plastics Pollution from Ships: MARPOL Annex V and the Problem That Won't Go Away*, 5 AM. U. J. INT'L L. & POL'Y 425, 437 (1990).

oceans is pushing these and other endangered species closer to extinction, pelagic plastic is also dangerously trimming fish stocks. [91]

Fishermen commonly remark on the ingestion of plastic by fish,[92] and the scientific literature provides examples of both estuarial and pelagic fish ingesting plastics.[93] Like sea turtles, fish that ingest plastic may suffer both lethal and sub-lethal consequences.[94] The buoyancy of plastic may make it hard for mesopelagic fish to get to deep waters, forcing them to alter their feeding habits (an objectively quantifiable consequence), and almost certainly affecting them in less quantifiable ways. [95] One study conducted in the North Pacific Central Gyre in 2010 confirmed that even small fish ingest plastic,[96] and found that approximately 35% of the 670 fish examined had plastic pieces in their digestive systems.[97] The study also found that larger fish were found to have ingested more plastic than smaller ones,[98] lending support to the theory that increased levels of plastic in large fish may be caused by upward transmission and concentration at higher levels of the food chain.[99]

The first recorded incidence of plastic ingestion was by a seabird in the 1960s. [100] Since that time the increased rate of plastic manufacture and consumption has resulted in corresponding growth in the rate of plastic ingestion by birds.[101] As with most other animals, the consequences of plastic ingestion for birds can be both lethal and sub-lethal.[102] Seabirds that carry large amounts of plastic in their digestive tracts are unable to accumulate fat deposits because they eat less due to a false feeling of satiation.[103] Plastic ingestion begins tragically early in the avian lifecycle because the adult seabirds that ingest plastic return to their nests and regurgitate the deadly particles for their young.[104] Today,

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91. *Id.* at 439-40.
92. Possatto et al., *supra* note 5, at 1098.
93. *Id.*
94. Christiana M. Boerger et al., *Plastic Ingestion by Planktivorous Fishes in the North Pacific Central Gyre*, 60 MARINE POLLUTION BULL. 2275, 2277 (2010).
95. *Id.*
96. *Id.* at 2275.
97. *Id.* at 2276.
98. *Id.*
99. *See* Possatto et al., *supra* note 5, at 1101.
100. Barnes et al., *supra* note 1, at 1993.
101. Derraik, *supra* note 22, at 844.
102. *Id.* at 845.
103. *Id.* at 845; *see also* Moore, *supra* note 3, at 132 (noting that fat deposits play a crucial role in seabirds' ability to migrate and reproduce).
104. Hagen, *supra* note 90, at 439.

more than 100 species of seabirds are known to suffer the harms associated with plastic marine debris.[105] This phenomenon is due in part to the fact that birds are indiscriminate feeders and ingest "anything that might resemble their natural food,"[106] but it is also a testament to the scale of global plastic production and the extent to which plastic waste is mismanaged.

Because the seafloor is the "ultimate sink" for marine debris, floating pelagic plastic ultimately harms sedimentary life forms when it sinks to the bottom after becoming denser due to fouling.[107] When they settle, large plastic particles smother the flora and fauna that inhabit the seabed[108] and microplastics are likely to be ingested by sedentary fauna.[109] With evidence suggesting that it effectively blankets the seabed, sunk plastic is also thought to disrupt the hydrological processes that occur in the depths of the world's oceans by inhibiting natural gas exchanges between pore waters and seawaters.[110] These water and gas exchanges have been shown to affect the composition of life in benthic ecosystems[111] and are also thought to play a role in carbon sequestration.[112]

Some plastic particles affect the carbon cycle without ever reaching the sea floor. Buoyant plastics, such as plastic bags, often become weighed down by fouling and sink to a place that cannot be reached by sunlight.[113] Living foulants then die for lack of sunlight and the plastics return to the surface.[114] Moore describes this process as the mixing of plastics with marine "snow," and suggests that it may prevent natural

105. Gregory, *Implications*, *supra* note 5, at 2016; *see also* Moore, *supra* note 3, at 131 (noting that "44% of all seabird species are known to ingest plastic"); Derraik, *supra* note 22, at 844 (citing a North Carolina study of 1033 birds, which showed that over [50%] of the species had ingested plastic).

106. Rios et al., *supra* note 31, at 1231; *see also Marine Debris Impacts, supra* note 7 (suggesting that seabirds often mistake plastic pellets for fish eggs).

107. Gregory, *Implications*, *supra* note 5, at 2017.

108. *Marine Debris Impacts, supra* note 7.

109. Arthur et al., *supra* note 34. Affected species include lugworms, amphipods, barnacles, and mussels. *Id.*

110. Gregory, *Implications*, *supra* note 5, at 2014 (citing Goldberg); *but see* Moore, *supra* note 3, at 135 (calling attention to the need for further research in order to determine the consequences of partial seabed blanketing).

111. Moore, *supra* note 3, at 135.

112. *Id.* at 32.

113. *Id.*

114. *Id.*

detritus from reaching the sea floor where it facilitates carbon sequestration.[115]

D. Other Harms Associated With Pelagic Plastic

The environment is also damaged by the methods of plastic production and distribution.[116] Plastics harm the environment even before they become pelagic. The production process uses raw materials,[117] creates waste, and contributes to emissions through the shipping of intermediate product and transport to the consumer.[118]

In addition to the harms that it inflicts upon individual plants and animals, species, ecosystems, and natural processes, pelagic plastic imposes economic costs upon ship owners engaged in recreational boating and commercial transport.[119] Plastic has been known to "foul [ship] propellers and clog water valve intakes,"[120] leading to delays and causing ship owners to incur considerable expenses for repairs.[121]

Sometimes plastic wastes move from the land to the ocean and then back to the land. Near the coast, plastic debris accumulates along with natural flotsam on high-tide strandlines.[122] The natural accumulation of flotsam, commonly known as "the wrack," provides a seasonal and dynamic environment for seabirds and small mammals.[123] Because the presence of plastics in the environment is not aesthetically pleasing, however, many coastal communities mechanically "clean" their beaches by removing the wrack entirely, crippling the ecosystem that the natural accumulation supports.[124] Cleanup efforts are generally funded by the nearby coastal community despite their considerable financial and

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115. *Id.*

116. ANDRADY, *supra* note 12, at 6 ("[T]he production of plastics use[s] fossil fuel, contribute[s] to emissions, and leaves behind waste materials to be disposed of.").

117. *Id.* at 19 fig. 1.5 (depicting the use of fossil fuel-based raw materials like oil, coal, and natural gas to produce plastic resin).

118. *Id.*

119. Gregory, *Hazards*, *supra* note 26, at 84. When plastics impose costs on commerce, those costs are passed on to the consumers of the products whose shipping is hampered by plastic pollution. *Id.*

120. Baur & Iudicello, *supra* note 70, at 81.

121. Hagen, *supra* note 90, at 442.

122. Gregory, *Implications*, *supra* note 5, at 2017.

123. *Id.*

124. *Id.*; *see also Marine Debris Impacts, supra* note 7 (stating that mechanical beach raking, which "uses a tractor or other mechanical device to remove marine debris from beaches and marine shorelines . . . can adversely impact shoreline habitats").

environmental cost.[125] These efforts persist because clean beaches support an entire industry founded upon the influx of tourism.[126] The economic and environmental costs of beach cleaning are thus incurred to alleviate the reduction in tourism revenues attributable to the accumulation of pelagic plastics near coastlines. Plastic debris degrades the world's beaches both environmentally and economically[127] by damaging coastal ecosystems, depressing property values, imposing cleanup costs, and discouraging tourism.

E. Plastic Bags & Cost-Benefit Considerations

Plastic refuse is accumulating on both land and at sea. It serves as a vector in the dispersion of invasive species and organic pollutants and entangles or is ingested by numerous marine fauna, from endangered sea turtles and whales to fish and seabirds.[128] When plastic settles on the sea floor, it smothers sedentary flora and fauna and disrupts ecologically critical hydrological processes.[129] Ingestion, entanglement, and smothering damage not only directly affected species and individuals, but also the food chains to which those species belong. Plastic debris thus threatens marine biodiversity and the human activities associated with it. Plastic waste also imposes economic costs upon ship owners and coastal communities by damaging ships, depressing property values, and discouraging tourism. Plastics harm the environment even before they become waste.[130]

Given these costs, why do we use plastics?[131] In some applications, the benefits of plastic undoubtedly outweigh the costs. The entire spectrum of consumer benefits provided by plastic bags, however, fails to justify the economic and environmental costs associated with even modest levels of their manufacture and consumption. Unlike many other

125. Baur & Iudicello, *supra* note 70, at 80-81.

126. *Id.* at 81.

127. Moore, *supra* note 3, at 133 (noting that "[c]lean beaches, free from debris, are a thing of the past"). The buoyancy of plastics enables its global dispersion; even beaches far-removed from civilization bear its marks. *Id*.

128. Gregory, *Implications*, *supra* note 5, at 2021; *see also supra* Part I, § C.

129. *Marine Debris Impacts, supra* note 7; Gregory, *Implications, supra* note 5, at 2017.

130. *See supra* Part I, § D (describing the environmental harms associated with plastic production and distribution).

131. Most, if not all, of the costs associated with plastic bag use are not borne by the parties who receive the benefits of plastic bag production and consumption. Full cost internalization could be achieved through a fee or tax, and would likely render plastic bag production and consumption inefficient.

food-packaging products,[132] the use of plastic shopping bags is entirely a matter of convenience—a relatively unimportant form of utility, which must be weighed against the attendant costs.

Plastic bags present a consumer benefit by facilitating the consumption and transportation of consumer goods. Bags generally serve a containment function that enables their carrier to transport multiple products as a single unit.[133] Plastic bags possess several of plastic's most beloved qualities—they have a high strength-to-weight ratio[134] and are light, durable, and cheap.[135] But it is these beloved characteristics—durability and lightweight—that make plastic bags a "persistent and nondegradable presence in the [marine] environment."[136]

These advantages pale further when they are contrasted with the costs associated with the increasing rate at which plastic bags escape into the environment. Perhaps most importantly, for purposes of arriving at a tenable judgment on the basis of a cost-benefit analysis, plastic bags could easily be replaced by "an alternate material that has a lower environmental penalty associated with its use."[137] In light of the significant environmental costs associated with plastic bag use, the containment function should be entrusted to reusable bags.[138]

III. METHODS OF ACHIEVING PLASTIC BAG REDUCTION

A. Reducing Plastic Bag Use through Norm Change

Because the environmental degradation associated with plastic is directly correlated with the rate at which plastic is manufactured and consumed, societies must move toward reduced plastic use in order to

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132. ANDRADY, *supra* note 12, at 142. Other food packaging products, like disposable cups and food wrappers, effectively contain food products and protect them from contamination. *Id.* Liquids and grains, for example, require containment for transportation. *Id.*

133. *Id.*

134. Andrady & Neal, *supra* note 41, at 1981; *see also* Doucette, *supra* note 10 (stating that plastic bags are able to carry 1,000 times their own weight).

135. Derraik, *supra* note 22, at 842. Unlike paper, plastic is also waterproof. *Id.*

136. Baur & Iudicello, *supra* note 70, at 77; *see also* Gregory, *Implications*, *supra* note 5, at 2014; Gregory, *Hazards*, *supra* note 26, at 83; Barnes & Milner, *supra* note 53, at 815 (stating that "[p]lastic became a major marine problem for exactly the same reasons that had made it a commercial success").

137. ANDRADY, *supra* note 12, at 6. Alternate materials include cloth or other reusable products, paper, and biodegradable plastic. *Id.*

138. *But see id.* at 143 (noting that plastic bags may provide more transport utility than paper bags, because plastics do not lose their strength when they become wet).

mitigate the attendant pollution. The results of a cost-benefit analysis, taking into consideration the availability of viable alternatives, clearly indicate that current social practices regarding plastic bag use result in a net negative outcome for society and the natural world. Reduction in the use of plastic bags is therefore a desirable social outcome that could potentially be achieved through minimally interventionist policies that encourage consumer and industrial norm change.[139]

Land-based plastics, packaging materials in particular, comprise a larger share of total marine debris in densely populated urban areas than in regions more removed from cities.[140] Urban areas can therefore loosely be thought of as point sources for plastic pollution.[141] But the pelagic plastic problem is mostly a function of nonpoint source pollution because plastic bags and other single-use plastic packaging items are primarily employed for individual consumption.[142]

"Did you remember your reusable bags today?" "Would you like paper or plastic?" These questions are representative of the seemingly unimportant choice made by millions of individuals every day. Though each individual's choice may have negligible environmental impacts, the summation of these individual choices imposes significant costs upon the environment.[143] An effective solution to the pelagic plastic problem must account for the problem's cumulative nature. The problem consists of inefficient levels of the supply and demand for plastic bags, given the costs and benefits associated with the product and the available alternatives. A solution could target either the supply side or the demand side of the problem. Solutions that seek to change individual norms target the demand side and are likely to face less political and legal opposition than solutions that target the supply side.

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139. In this context, consumer norm change would entail a shift away from plastic bag consumption, while industrial norm change would involve a shift away from plastic bag production.

140. Derraik, *supra* note 22, at 844.

141. *See* Barnes et al., *supra* note 1, at 1988 (citing study showing that an abundance of large plastic debris on beaches correlates strongly with human population).

142. Governments have been regulating many forms of point source pollution for years, but many types of nonpoint source pollution go unregulated. John R. Nolon, *Historical Overview of the American Land Use System: A Diagnostic Approach to Evaluating Governmental Land Use Control*, 23 PACE ENVTL. L. REV. 821, 838 (2006). This regulatory gap arguably exists not for lack of authority, but for lack of political tenability or popularity.

143. *See* Katrina Fischer Kuh, *When Government Intrudes: Regulating Individual Behaviors that Harm the Environment*, 61 DUKE L.J. 1111, 1112 (2012) (terming these and other similar choices "environmentally significant individual behaviors").

The nature of the pelagic plastic problem calls for a movement from the bottom-up—a change in norms that begins with the individual. A government that wants to reduce plastic pollution might, therefore, try to reduce demand for plastic bags by funding research and informational campaigns to raise public awareness of plastic pollution. These "soft" policies would push norm change through efforts to alter the habits of individuals, and they could be used alone or in conjunction with more direct policy tools. Although a comprehensive solution will likely require localized approaches and direct policy tools, a full appreciation of the geographic and temporal dimensions of the pelagic plastic problem will require large-scale, long-term research efforts.[144]

Education that inspires individual norm change may very well prove more effective at reducing plastic pollution than other more direct policy tools because of the difficulty of enforcing regulations that target individual behaviors. Furthermore, informational campaigns that generate public awareness of the harms associated with plastic bag pollution are likely to change both individual and industrial norms.[145] If consumers consistently decline single-use disposable plastic bags, then stores will eventually cease to offer them.[146] Stores might also stop offering bags on their own initiative as a way to make a statement or create a positive brand correlation.[147] And if stores cease to offer plastic bags, then manufacturers will decrease production for lack of demand, turning instead to the production of recycled, degradable, and reusable

144. Barnes et al., *supra* note 1, at 1985-86. Direct regulations should not be put off, however, in anticipation of a certain level of knowledge and understanding resulting from research efforts. *See* ANDRADY, *supra* note 12, at 25 ("[The precautionary] principle holds that when a . . . technology is suspected (but is not proven) of environmental harm, scientific uncertainty about the scope of the harm should not necessarily preclude precautionary action.").

145. Baur & Iudicello, *supra* note 70, at 137 ("Citizen education, which can translate into consumer pressure on manufacturers and retailers, is the key to source reduction."); *see also* ANDRADY, *supra* note 12, at 30 ("The majority of American consumers claim that a company's environmental reputation affects their product choice."); Moore, *supra* note 3, at 136 ("The prevailing attitude among [U.S.] manufacturers is that they are responding to the demands of the market, and that it is the responsibility of individuals and governments to create infrastructure for dealing with the resultant waste.").

146. Because paper is more expensive than plastic, ANDRADY, *supra* note 12, at 143, retailers are not likely to switch from plastic to paper of their own initiative. Environmentally conscious consumer preference must provide the catalyst for change.

147. Whole Foods Market, for instance, does not offer plastic bags. It offers its customers paper and it incentivizes the use of reusable bags by crediting a customer's purchase five cents for every reusable bag used. Legislation could potentially achieve the same result for all retail locations that currently distribute plastic bags free of charge. *See infra* Part III.B.

bags.[148] Individual norm change is thus capable of catalyzing industrial norm change.[149] However, a transformation of this magnitude in the values that motivate consumer behavior has yet to take hold. Further, such a change appears somewhat unlikely to occur in the near future due to the ubiquitous presence of disposable plastics in consumer culture and the powerful influence of industrial practice on individual consumption.[150]

Local and regional public awareness campaigns could utilize beach cleanups to raise the profile of the pelagic plastic problem. Cleanup efforts could also target municipal storm drains and regional catch basins in an effort to prevent debris in these transport systems from ever reaching the ocean. Indirect efforts like these would undoubtedly increase awareness, but they might not significantly reduce the rate at which plastic bags are produced, consumed, and released into the environment.

Other norm changes that would reduce plastic bag pollution include increased rates of reuse and recycling. Using reusable shopping bags would decrease the number of plastic bags requiring proper disposal, and increased rates of plastic bag recycling would ensure proper disposal of more bags. Both changes would thereby decrease the potential for plastic bags to escape into the environment upon mishandling.

Plastics are inherently recyclable,[151] and recycling is a powerful resource conservation strategy because it frees up space in landfills and allows for energy recapture.[152] But plastics are not regularly recycled.[153] At least one commentator believes that the low rate of plastics recycling can be blamed on low rates of citizen participation in recycling programs.[154] Low rates of plastics recycling could also be due to

148. Manufacturers might also seek to increase production of paper bags—a product that poses its own environmental concerns. Although paper bags degrade much faster than plastic, they are heavier and they take up more space, and their transport thus contributes to increased carbon dioxide emissions. ANDRADY, *supra* note 12, at 53.

149. *See, e.g.*, *id.* at 7 (describing the fast food industry's switch from Styrofoam packaging to paper products and its impetus: consumer preference).

150. *But see* Doucette, *supra* note 10 (stating that community mobilization against plastic bags is widespread and that consumers have already soured on the product).

151. Andrady & Neal, *supra* note 41, at 1982; *but see* Doucette, *supra* note 10 (suggesting that thin film plastics are a "nightmare to recycle" because they clog recycling machines).

152. Andrady & Neal, *supra* note 41, at 1982.

153. *See* Moore, *supra* note 3, at 136.

154. Barnes et al., *supra* note 1, at 1987 (suggesting that industrial capacity for plastics recycling could expand to accommodate increased rates of plastics recycling).

inefficiencies in the recycling process[155] or to relatively weak demand for recycled products.[156] Low rates of recycling of plastic bags in particular are likely due to lack of infrastructure capable of processing ultrathin plastics.[157] At present, recycling of plastics often involves the fashioning of plastic "wood"—an item that is not itself widely recycled.[158] Despite these challenges, increased rates of citizen participation in plastic bag recycling could increase recycling capacity and prompt the manufacture of more widely recyclable goods.

"Soft" policy tools like research and education, however, may fail to achieve the desired level of plastic bag reduction. Plastic bag norms may persist in spite of increased awareness of plastic pollution.[159] In that case, norm change could be incentivized through taxes designed to force plastic bag producers and consumers to internalize the externalities associated with plastic bag pollution. Other policy tools that would work upon the problem more directly include regulation of the degradability of single-use plastics, debris-tracking systems, and plastic bag bans. Some scholars suggest that a combination of policy tools would be most likely to solve the pelagic plastic problem in the near to intermediate term.[160]

B. Incentivizing Norm Change

Several policy tools could bring about reduced plastic bag pollution through manipulation of incentives. A government could, for example, charge a deposit for plastic bags to incentivize their recycling.[161] This

155. *See* ANDRADY, *supra* note 12, at 22 (noting that sometimes it is less expensive to use raw materials than it is to reprocess an end product); *see also* Archer & Huls, *supra* note 12, at 3 ("One obstacle [to recycling of plastics] is the . . . price differential between virgin and recycled materials.").

156. ANDRADY, *supra* note 12, at 22.

157. Doucette, *supra* note 10.

158. Moore, *supra* note 3, at 137.

159. *See id.* at 136 (suggesting that raising awareness of the pelagic plastic problem would not reduce the amount of marine debris).

160. *See, e.g.*, Derraik, *supra* note 22, at 848 (suggesting that environmental problems are best addressed by "[a] combination of legislation and enhancement of ecological consciousness through education").

161. Deposit systems have contributed to increased rates of bottle recycling in the states that employ them. W. Kip Viscusi et al., *Discontinuous Behavioral Responses to Recycling Laws and Plastic Water Bottle Deposits* 12 (Nat'l Bureau for Econ. Res., Working Paper No. 15585, Dec., 2010), *available at* http://www.nber.org/papers/w15585 (finding that in states that lack recycling and bottle deposit laws only 4.3 out of every 10 water bottles are recycled, while in states that have both recycling and bottle deposit laws 8.59 out of every 10 water bottles are recycled).

approach would force consumers to internalize at least some of the costs associated with plastic pollution. A government could, alternatively, force plastic bag manufacturers to internalize such costs by imposing a tax upon non-recyclable, non-degradable plastic bags. A government could also use the power of taxes to incentivize production of recyclable, degradable plastics by offering tax breaks for the production of those products.

A number of California municipalities currently use the power of taxes and bans in conjunction to encourage use of reusable bags.[162] For example, San Francisco, San Jose, and Los Angeles County each prohibit retail establishments from providing customers with conventional plastic bags.[163] These municipalities allow stores to provide consumers with recyclable paper, compostable plastic, or reusable bags for a fee.[164] This policy first channels demand for bags away from conventional plastics. It then hits consumers in the wallet, reducing demand for paper and non-conventional plastic bags by providing an incentive for customers to bring their own reusable bags.

C. Forcing Norm Change

Governments that wish to take aggressive steps to reduce plastic bag pollution could consider regulating the degradability of single-use plastic bags, or implementing a system that would impose liability on polluters by tracking plastic bags.

Regulation of the degradability of disposable plastic bags could be modeled after the provisions of the Solid Waste Disposal Act that regulate the degradability of plastic six-pack rings.[165] Those provisions were a response to the entanglement of marine life in the rings,[166] and have forced a change in the composition of the rings[167] such that their initial degradation now occurs much more quickly in the marine

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162. *See infra* note 165.

163. S.F., CAL., ENVIRONMENT CODE, ch. 17, § 3 (2007); *see also* SAN JOSE, CAL., MUNICIPAL CODE ch. 9.10 § 2020 (2011); LOS ANGELES COUNTY, CAL., CODE § 12.85.020 (2010).

164. These governmental units all require retailers to charge customers ten cents for each bag provided. *See* S.F., CAL., ENVIRONMENT CODE, ch. 17, § 3.5 (2012); SAN JOSE, CAL., MUNICIPAL CODE ch. 9.10 § 2020 (2011); LOS ANGELES COUNTY, CAL., CODE § 12.85.040 (2010). In 2014, the price of a recyclable paper bag in San Jose will rise to twenty-five cents. SAN JOSE, CAL., MUNICIPAL CODE ch. 9.10 § 2020 (2011).

165. Moore, *supra* note 3, at 133.

166. *Id.*

167. *See id.*

environment. Although a similar recipe for the composition of plastic bags would probably reduce incidents of entanglement, it would probably not reduce incidents of ingestion.[168] This is because the composition formula used in the six-pack rings makes plastic more brittle, causing it to break apart into "scrubbers" faster,[169] but does not hasten full degradation.[170] Although regulating the degradability of plastic bags might reduce some of the environmental harms associated with plastic pollution, it would not reduce all of them and would not itself decrease the total amount of plastic pollution.

Such regulation may also be scientifically infeasible at present. A recipe for marine-degradable plastic is not currently cost-effective—if it even exists at all. Most plastics are made out of polymers derived from petroleum.[171] Bio-based plastics, on the other hand, are made from renewable carbon sources instead of fossil fuels.[172] Bio-plastics generally degrade much faster than their petro-based counterparts,[173] but do not degrade any faster in the ocean than conventional plastics because they are designed to degrade at high temperatures.[174] There have been attempts to devise a polymer for use in marine-disposable trash bags,[175] but no products have yet hit the market. Furthermore, when marine-degradable polymers actually reach the market, their substitution for conventional polymers will be limited by the fact that bio-plastics currently cost between five and ten times as much as conventional plastics.[176]

A debris tracking system could potentially impose liability on plastic bag polluters by facilitating enforcement of wildlife and fisheries laws that prohibit the killing or injury of marine wildlife.[177] The Migratory Bird Treaty Act, for example, makes it unlawful to kill migratory

168. *Id.*

169. *Id.*; *see also* ANDRADY, *supra* note 12, at 54 (noting that the disintegration of degradable plastics could prevent cases of whole ingestion, but would not prevent ingestion of plastic particles).

170. Moore, *supra* note 3, at 133-34.

171. Rios et al., *supra* note 31, at 1230.

172. MARINE DEBRIS PROGRAM, *supra* note 22, at 1-3. These include corn, wheat, tapioca, sugar, and algae. *Id.*; *see also* Andrady & Neal, *supra* note 41, at 1981. All but the last are arguably objectionable sources of plastic because they may be put to their best, most valued use in a food-related application.

173. Moore, *supra* note 3, at 137.

174. *Id.*

175. Derraik, *supra* note 22, at 848 (noting that the U.S. Navy has designed such a polymer, but its degradability and potential effects on marine life are still being studied).

176. Moore, *supra* note 3, at 137.

177. *See* Baur & Iudicello, *supra* note 70, at 111.

birds.[178] The Act has been construed to impose strict liability, and thus prohibits even unintentional killings.[179] Similar federal legislation protects other marine life, and the argument could be made that animal deaths and injuries caused by plastic bags fall within the purview of these laws. Realistically, however, a debris tracking system would be impracticable due to the economic infeasibility of tracking plastic bags and the scientific challenges associated with tracking an item that disintegrates.

The most direct and certain way to reduce plastic bag use is to ban plastic bags.[180] The United Nations Environmental Project has called for a worldwide bag ban[181] due to a perceived need for a coordinated international response to the challenge facing the global commons. Some commentators, however, suggest that regional bag bans could prove more effective at reducing plastic pollution than an international regime.[182] Municipal governments are also the units most likely to possess the political capital necessary to enact bag bans due to the fact that they perceive the problems associated with solid waste management most directly.[183]

Given the United States' record of participation in international environmental treaties, a federal ban on plastic bags is probably not politically feasible at present. The United States has not ratified the United Nations Convention on the Law of the Sea,[184] one possible source of authority for a federal ban.[185] And this lack of participation is not the

178. 16 U.S.C. § 703(a) (2004).

179. Baur & Iudicello, *supra* note 70, at 111.

180. *See* BUREAU OF PLANNING AND SUSTAINABILITY, CITY OF PORTLAND, OREGON PROMOTING REUSABLE CHECKOUT BAGS IN PORTLAND (Oct. 3, 2012) (reporting a 304% increase in reusable checkout bag use during the first year of the city's plastic bag ban).

181. *Report Brings to the Surface the Growing Global Problem of Marine Litter*, UNITED NATIONS ENV'T PROGRAM, http://www.unep.org/documents.multilingual/default.asp?documentid=589&article-id=6214&l=en (last accessed Oct. 27, 2013).

182. Baur & Iudicello, *supra* note 70, at 122. ("Special regulatory approaches can be more easily crafted when fewer nations are involved."). Regional bodies may also be more motivated to tackle environmental challenges and, therefore, less likely to suffer political paralysis. *Id.* For coastal regions, as opposed to landlocked regions, "the problem [is] closer to home." *Id.*

183. Bruce Weddle & Edward Klein, *A Strategy to Control the Garbage Glut*, 15 EPA J. 30, 30 (1989).

184. *See* Stewart M. Patrick, *(Almost) Everyone Agrees: The U.S. Should Ratify the Law of the Sea Treaty*, THE ATLANTIC (June 10, 2012), http://www.theatlantic.com/international/archive/-2012-/06/-almost-everyone-agrees-the-us-should-ratify-the-law-of-the-sea-treaty/258301/.

185. *See* United Nations Convention on the Law of the Sea, arts. 194(1), 207, 211(5), 213, Dec. 10, 1982, 1833 U.N.T.S. 397.

exception. The United States is also a major national outlier in its lack of support for the international regime of emissions regulation established by the 1997 Kyoto Protocol.[186] One political commentator has argued that President Obama, after handily winning reelection in 2012, was nonetheless rational in concluding that major climate change legislation (itself years in the making by environmental groups and business leaders) had little chance of passing Congress.[187]

Although the United States is unlikely to ban bags at the federal level in the near future, a number of other nations[188] have enacted bag bans. To date, only one state[189] has banned bags, but nearly 10 have considered bans in the last few months alone.[190] Many municipalities[191] have also enacted bag bans, some with mixed success.[192]

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186. Steven Bernstein, *International Institutions and the Framing of Domestic Polices: The Kyoto Protocol and Canada's Response to Climate Change*, 35 POL'Y SCIENCES 203, 203 (2002).

187. Nicholas Lemann, *When the Earth Moved*, THE NEW YORKER, http://www.newyorker.com/arts/critics/atlarge/2013/04/15/130415crat_atlarge_lemann (last accessed Oct. 27, 2013).

188. *See* Doucette, *supra* note 10.

189. Bags have been banned in all of Hawaii's counties, effectively rendering Hawaii the first state in the nation to ban bags. *See id.*

190. *State Plastic and Paper Bag Legislation: Fees, Taxes and Bans; Recycling and Reuse*, NAT'L CONFERENCE OF STATE LEGISLATURES, http://www.ncsl.org/issues-research/env-res/plastic-bag-legislation.aspx (last accessed Oct. 27, 2013) (as of October 2013, California, Louisiana, Maine, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington were all considering banning plastic bags).

191. In California, the cities of Long Beach, Palo Alto, San Francisco, San Jose, and Santa Monica ban bags; Los Angeles and Santa Clara counties do so as well. LONG BEACH, CAL., MUNICIPAL CODE § 8.62.030 (2011); PALO ALTO, CAL., MUNICIPAL CODE § 5.35.020 (2009); S.F., CAL., ENVIRONMENT CODE, ch. 17, § 3 (2007); SAN JOSE, CAL., MUNICIPAL CODE ch. 9.10 § 2020 (2011); SANTA MONICA, CAL., MUNICIPAL CODE ch. 5.45 § 20 (2011); LOS ANGELES COUNTY, CAL., CODE § 12.85.020 (2010); SANTA CLARA COUNTY, CAL., CODE § B11-510 (2011). Municipalities outside of California are adopting bag bans as well; *see also, e.g.*, PORT TOWNSEND, WASH., MUNICIPAL CODE ch. 6.26, § 10 (2012); PORTLAND, ORE., MUNICIPAL CODE ch. 17 § 103 (2011) EUGENE, ORE., CITY CODE § 6.855 (2012).; CORVALLIS, ORE., MUNICIPAL CODE ch. 8.14 § 40 (2012).

192. In Oakland, California, for example, adoption of a bag ban was delayed by a lawsuit brought by the Coalition to Support Plastic Bag Recycling. Christopher Heredia, *Lawsuit Delays Oakland's Plastic Bag Ban*, SAN FRANCISCO CHRONICLE (Jan. 29, 2008, 4:00 AM), http://www.sfgate.com/bayarea/article/Lawsuit-delays-Oakland-s-plastic-bag-ban-3229310.php.

IV. OPPOSITION TO BAG REDUCTION MEASURES

A. The Plastics Industry

An understanding of the pelagic plastic problem cannot be obtained without consideration of the parties invested in its perpetuation. Bag reduction measures face opposition from two major interest groups: the plastics industry and consumers. Because these groups stand to lose the most from reduced bag use, they are also the most likely to use the political process to oppose potential bag reduction measures and to use the legal process to overturn existing bag bans. Successful bag reduction efforts must therefore anticipate these political and legal challenges, and utilize mechanisms to appease or change the interests of the opposition.

The plastics industry's stake in the pelagic plastic problem is fairly straightforward. Bag bans decrease demand for bags, which puts downward pressure on bag prices, which in turn eats into the industry's profit margins. Before briefly turning to the plastic industry's political power, its arsenal of legal claims, and the mechanisms that could potentially neutralize those claims, this Comment addresses the proportions of the industry's interest.

In 2008, worldwide demand for plastics was 245 million tons.[193] Over one-third of that amount—more than 80 million tons—was dedicated to production of packaging, a category that includes plastic bags.[194] This enormous level of production is a relatively new historical phenomenon, dating from the advent of the age of modern plastics in the 1950s.[195] Since the middle of the twentieth century, the mass production of plastics has increased dramatically[196] and the predominance of plastics has spread geographically[197] as "global affluence has encouraged the increased use of disposable plastic packaging products in the developing world."[198] Though the single-use plastic bag was only invented in the

193. Andrady & Neal, *supra* note 41, at 1977.

194. *Id.* at 1980; ANDRADY, *supra* note 12, at 6 ("[A]bout 30% of [] plastics production [is used] in packaging.").

195. Andrady & Neal, *supra* note 41, at 1977; *see also* Barnes et al., *supra* note 1, at 1988.

196. Moore, *supra* note 3, at 131 ("Between 1960 and 2000, the world production of plastic resins increased 25-fold").

197. *Id.* at 135 (noting that plastic production was historically concentrated in North America and Europe, but has accelerated rapidly in all global markets since the 1990s).

198. ANDRADY, *supra* note 12, at 4.

mid-1960s,[199] its presence is now ubiquitous: "[w]ell over a billion single-use plastic bags are given out for free every day."[200]

The plastics industry actively opposes bag reduction measures[201] by obstructing potential bans[202] and threatening existing bans.[203] One industry tactic that hinders potential bans involves the filing of Strategic Litigation Against Public Participation (SLAPP) lawsuits against activists who speak out against plastic bags.[204] The industry has challenged many existing bans by alleging that they violate state versions of the National Environmental Policy Act (NEPA) because they were implemented without preparation of an Environmental Impact Statement (EIS).[205] Reusable bag manufacturers have also faced suits from the plastics industry alleging defamation of plastic bags.[206]

B. Overcoming Opposition

Governmental units can take steps to diffuse some of the potential roadblocks to bag reduction measures that this Comment has identified. State governments can support the passage of plastic bag bans by their municipalities through the enactment of enabling legislation[207] explicitly authorizing bag bans. Through enactment of anti-SLAPP laws,[208] states

199. Doucette, *supra* note 10.

200. Wabnitz & Nichols, *supra* note 4, at 1.

201. Doucette, *supra* note 10 ("[I]n the United States, the plastics industry has launched a concerted campaign to derail and defeat anti-bag measures nationwide. The effort includes well-placed political donations, intensive lobbying at both the state and national levels, and a pervasive PR campaign designed to shift the focus away from plastic bags to the supposed threat of canvas and paper bags.") "Their sole aim is to maintain the status quo and protect their profits" and "[l]eading the charge to protect the plastic bag is the American Chemistry Council (ACC), an industry whose members include petro-chemical giants like ExxonMobil and Dow Chemical." *Id.*

202. *Id.* (noting that the ACC was responsible for defeating statewide bans proposed in Oregon and California).

203. *Id.* (noting that the ACC was responsible for overturning Seattle's bag ban; it both collected the necessary signatures to get Seattle's bag ban on a referendum and turned voter sentiment against the ban).

204. *Id.*

205. *See, e.g.*, *Save the Plastic Bag Coalition v. City of Manhattan Beach*, 254 P.3d 1005, 1008 (Cal. 2011); *see also* Doucette, *supra* note 10.

206. Doucette, *supra* note 10.

207. *See generally* ROBERT C. ELLICKSON & VICKI L. BEEN, LAND USE CONTROLS 24 (Erwin Chemerinksy et al. eds., 3d ed. 2005) (defining enabling legislation).

208. *See* Shannon Hartzler, *Protecting Informed Public Participation: Anti-SLAPP Law and the Media Defendant*, 41 VAL. U. L. REV. 1235, 1242-43 (2007) (identifying

can also protect individuals and organizations seeking to raise awareness of the pelagic plastic problem. Municipalities can weather legal challenges to bag reduction measures by looking to the examples set by other municipalities that have done so. To date, bag reduction measures have survived legal challenges assuming a variety of forms.[209]

Several sources of legal authority have the potential to sustain bag bans passed by states and municipalities if they are challenged in court. Federal and state source-reduction[210] legislation, for example, could possibly provide legal authority for a challenged ban. Bag bans also lie squarely within the state's police powers[211] because plastic bags pose a threat to the public health, safety, and welfare.[212] States and their authorized municipalities thus have the power to ban bags outright or to declare that they constitute a public nuisance.

Some municipalities have justified bag reduction measures by invoking the police powers[213] and citing bags' adverse effects on citizens' health and welfare, while others have proceeded without explicit justification. When crafting a bag reduction ordinance, a municipality would do well to explicitly invoke the source of its legal authority, whether it is the state's enabling legislation, the municipality's police powers, or the need to comply with source-reduction legislation. A carefully crafted ordinance is likely to face fewer legal challenges.

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some common features and challenges involved in the drafting of anti-SLAPP legislation).

209. *See, e.g.*, *Schmeer v. County of Los Angeles*, 213 Cal. 4th 1310 (2013) (holding county's bag ban was not a "tax" that required voter approval); *see also City of Manhattan Beac*h, 254 P.3d at 1018 (holding that city's bag ban did not significantly affect the environment, and that the ban would not be overturned for the city's failure to undertake an environmental impact report prior to the ban's implementation).

210. "Source reduction involves minimizing the volume . . . of products that ultimately require disposal, and making goods more durable so that longer periods of time elapse before they are discarded." Weddle & Klein, *supra* note 183, at 30.

211. A state's police powers are very broad, and "embrace[] regulations designed to promote the public convenience or the general prosperity, as well as regulations designed to promote the public health, the public morals, or the public safety." *Chicago B & Q. Ry. Co. v. People of the State of Illinois*, 200 U.S. 561, 592 (1906).

212. *See* Part II.C (cataloguing the many environmental and economic harms associated with plastic bags).

213. *See, e.g.*, S.F., CAL., ENV'T. CODE, ch. 17, § 9 (2007) ("In undertaking the implementation of [the Plastic Bag Reduction] Ordinance, the City is assuming an undertaking . . . to promote the general welfare."); SANTA CLARA COUNTY, CAL., CODE § B11-508 (2011) (finding that the "use of single-use carryout bags by consumers . . . is detrimental to the . . . public health and welfare").

V. CONCLUSION

The pelagic plastic problem encompasses all forms of plastic marine debris, and although plastic bag pollution constitutes only a part of the problem, it is a part that could easily be redressed. The bags themselves provide negligible benefits in comparison to their environmental costs. Consumers and governments are increasingly recognizing this discrepancy and taking actions to reduce plastic bag use. Consequently, plastic bag reduction is no longer a fringe movement. That said, no state government has yet banned bags, and only a minority of municipalities have adopted bag reduction policies.

Scholarship that raises the profile of the pelagic plastic problem could provide the impetus for further change. Increased awareness of the costs that attend plastic bag use may inspire more governmental units to enact laws that force internalization of those costs. Recognition of the interests at stake may further embolden governments by enabling them to anticipate challenges. And an appreciation of the legal and political forms that such challenges have taken in the past may enable governments to craft durable, defensible plastic bag reduction policies.