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A world current of plastic waste in the marine environment and solutions to the problem

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Photo: Ron Prendergast, Melbourne Zoo.

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Abstract

Pollution is one of the major issues concerning the state of the oceans and has been recognized as a major problem for decades. This project examines the problem of plastic litter in the oceans in terms of its environmental and human health effects. It identifies actions countries such as Ireland, Kenya, China, and others have taken to remedy the problem and it explores plausible alternatives to the current plastic addiction.

Glossary

AMRF	Algalita Marine Research Foundation
CEE	Center for Environmental Education
COPC	California Ocean Protection Council
CSUMB	California State University, Monterey Bay
DDT	Dichloro-Diphenyl-Trichloroethane (pesticide)
EPA (USEPA)	U.S. Environmental Protection Agency
GENI	Global Energy Network Institute
INGO	International Nongovernmental Organization
IMO	International Maritime Organization
MARPOL	International Convention for the Prevention of Pollution from Ships
MPRSA	Marine Protection, Research, and Sanctuaries Act
NGO	Nongovernmental Organization
NOAA	National Oceanic and Atmospheric Administration
PCBs	Polychlorinated biphenyls (pesticide extender)
POPs	Persistent Organic Pollutants
UN	United Nations
UNEP	United Nations Environment Program

Historically, pollution has been one of the major issues concerning the state of the oceans, and the topic of plastics in the ocean has been realized as a major problem for decades. Generally referred to as floatable debris, plastics represent a large percentage of the man-made pollution found in any ocean in the world and introduces an enormous hazard to the health of sea life and the marine environment. This project examines why plastic litter in the oceans is such an enormous environmental and human health problem, the actions countries have taken to remedy the problem and the alternatives to humanity's plastic addiction.

Research Methods and Framework

This project reviewed international literature on the subject of plastic wastes in the oceans and the local, governmental, and international responses and actions taken to address this problem. Qualitative research methods were used to research and analyze the background, current status, and the environmental effects of plastic litter in the oceans. The comparative method was used to research and evaluate the relevant environmental policies of different countries, as well as the policies of grassroots, international governmental and non-governmental organizations, such as the United Nations and Greenpeace.

A combination of secondary sources including articles from scientific journals, books, newspaper articles, and interviews on the subject were utilized. The websites of various grassroots, governmental, non-governmental, and international organizations that address, acknowledge, criticize, and/or offer solutions to the plastic problem were explored. These organizations include, the California Ocean Protection Council, Greenpeace, the International Maritime Organization, Mindfully.org, the United Nations

Environment Program, various news organizations and official the government agencies of different countries and their policies. Peer-reviewed journal articles and newspapers from various countries were examined, in order to obtain information on the responses of these countries to the plastic waste problem.

This paper will examine the problem with plastic contaminants from an environmentalist viewpoint. It will analyze the manufacture of plastics, the specific problem of plastics in the marine environment, and possible alternatives to petroleum-based plastics.

Literature Review

So, What is Plastic, Anyway?

The methods used to refine crude oil and turn it into plastics are involved and complicated. Plastic is made by first extracting petroleum from deep in the Earth, then transporting it to a refinery where the crude oil and natural gas are refined into ethane, propane, and hundreds of other petrochemical products (Columbia Encyclopedia 2007).

Using high-temperature furnaces ethane and propane are made into ethylene and propylene. These chemicals are then combined with a catalyst to make a powdered "fluff" that is combined with various additives, and then melted. The melted substance is cooled, fed into an extruder, which cuts it into tiny pellets (called nurdles), which are then shipped to customers that manufacture numerous plastic products from these pellets.

The positive attributes of modern plastics are that they are useful, low cost, and versatile. They are also essential to modern medicine and creature comforts such as laptops, cell phones, cars, and synthetic fibers for clothing (Stevens 2002). However, the problem with these plastic products is that they *never degrade completely*; they just break

into ever-smaller pieces and further embed themselves into the environment with every division.

Problems for Humans and Wildlife

Plankton are the bottom rung of the marine food chain, basic and vital parts of the hydrosphere. They as small or microscopic organisms, including algae and protozoans, which float or drift in great numbers in fresh or salt water, especially at or near the surface (Encyclopedia Britannica 2008). They also serve as food for fish and other larger organisms. Unfortunately, plankton share the surface of the water with plastic particles, fish and seabirds are now consuming plastic in addition to their natural diet of plankton.

Plastics can also act as a sort of toxin sponge in the water. According to the Center for Environmental Education in Washington D.C., this poses a significant problem for humans since plastic debris release chemical additives and plastic stabilizers into the ocean (CEE 1988). One of these toxins, polyvinyl chloride plastic, is commonly referred to as PVC. It is an environmental and public health hazard because it contains dioxin and other persistent organic pollutants (POPs) that can leach into the surrounding environment over time (CEE 1988). Like the majority of plastics, it does not biodegrade, and this represents an extensive health problem for both human and marine life.

In addition to emitting POPs *into* the environment, plastic also absorbs hydrophobic pollutants, which are not easily mixed with water, as well as pesticides such as PCBs (Polychlorinated biphenyls) and DDT (Dichloro-Diphenyl-Trichloroethane) *from* the surroundings. These pollutants, when eaten by fish, accumulate in their fatty tissues and they accumulate exponentially as fish eat their way up the food chain, which is known as biomagnification (Burton & Eriksson 2003). Fish towards the top of the food

chain eventually find their way to our dinner plates, loaded with the toxins that have been consumed up through the food chain.

Furthermore, plastics pose an enormous danger to wildlife through entanglement, as well as ingestion. Ingestion occurs when an animal swallows any type of floatable debris, which generally is plastic that resembles that animal's natural prey. This problem has an effect on the natural feeding habits of marine birds, mammals and sea turtles; since larger pieces of plastic resemble jellyfish or squid and tiny plastic "nurdles" can be easily confused for small fish eggs (Moore 2003).

Ingestion of debris can lead to starvation or malnutrition if the ingested items obstruct or become permanently stuck in the digestive tract. This makes digestion difficult, leaving the animal feeling "full" and lessening its desire to feed. Also, ingestion of sharp objects can harm the animal's mouth, digestive tract, or stomach lining and cause infection or pain. Ingested items also can block air passages and prevent breathing, causing death. Worldwide, it is estimated that over one million seabirds and 100,000 mammals and sea turtles are killed each year as a result of plastic ingestion (Moore 2003). While ingestion of plastic debris by birds, fish and sea mammals is a concern, they are more often entangled by marine debris (AMRF 2007).

Entanglement results when an animal becomes surrounded or ensnared by debris floating in the water column. This can occur accidentally or when they are attracted to the debris as part of its normal behavior. For example, an animal might try to use a piece of floatable debris for shelter, or as a source of food, especially if other plants and animals are already trapped in the debris or if the debris resembles prey that is part of the animal's normal diet (NOAA 2008). Entanglement is harmful to wildlife for several reasons. It can

cause wounds that lead to infections or loss of limbs and can also cause strangulation or asphyxiation. In addition, entanglement can impair the ability of birds and sea mammals to swim or move through the water column, find food, escape from predators, or cause death by drowning.

Of the various types of marine mammals, seals and sea lions are the most affected, particularly by entanglement, because of their natural curiosity and tendency to investigate unusual objects in the environment. Some studies have linked the decline of the northern fur seal of Alaska and the endangered Hawaiian monk seal to entanglement in debris (NOAA 2007). Whales, including the endangered humpback whale, right whale, and gray whale, have been found entangled in fishing nets and line. Manatees, another endangered species, have become entangled in crab-pot lines, and dolphins and porpoises are frequently caught in fishing nets (USEPA 2007).

Where Does All the Plastic Come From?

Worldwide, the total volume of plastic produced is greater than that of steel production; two hundred billion pounds of plastic product are manufactured annually (Stevens 2002). Of that two hundred billion pounds, over eighty billion pounds is produced by the United States alone, which amounts to around forty pounds of plastic used per person, per year (Stevens 2002).

The two main sources of floatable debris are litter that enters the oceans from land and illegal dumping of waste at sea. Land-based litter debris can blow or wash into bodies of water from a number of sources including landfills, industrial facilities, and the areas along the coasts. Discarded plastic shopping bags blown out to sea from land are among the major culprits of land-based marine litter. Sea-based litter debris is generally

illegally disposed of by merchant ships, cruise liners, fishing vessels, military fleets, and offshore oil and gas platforms (UNEP 2005).

According to a survey conducted by the United Nations Environment Programme (UNEP 2005), 89 percent of the litter observed floating on the ocean surface in the North Pacific was plastic. Researchers from the California-based Algalita Marine Research Foundation have recently found six pounds of plastic for every pound of plankton in the Northern Pacific Ocean (AMRF 2007). Plastic debris is found in *every* ocean in the world, often washing up on remote shores possibly hundreds or thousands of miles from its original source (Goettlich 2005).

International Response

Over seventy percent of our planet is covered by water, totaling over 139 million square miles, and divided into several major oceans and smaller seas (NOAA 2008). One of the characteristics of the ocean is that it does not stay within the confines of the labels humans have put on it. For instance, the waters that circulate within the Pacific Ocean do not stay in the Pacific Ocean; they follow the currents south, around South America, and into the Atlantic. From the Atlantic they either travel north towards Greenland or south around the Cape of Good Hope and into the oceans of the South Pacific, which will eventually lead them back to where they started in the Pacific Ocean. Figure 1 below provides a visual representation of ocean currents.

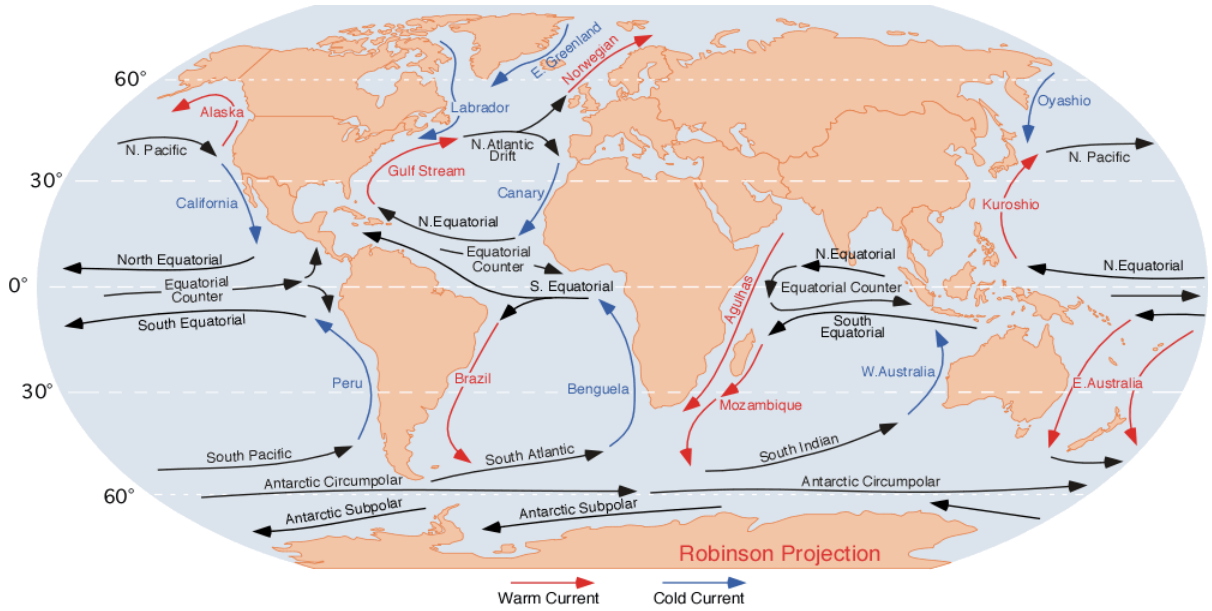

Figure 1. Ocean Currents Map, courtesy of the Global Energy Network Institute

The point is that the waters of the world's oceans are not stagnant; they are constantly moving, circulating around the planet, and returning to where they started, only to complete this cycle over and over again. What is thought of as many individual oceans and seas are really one massive flow of circulating water, collectively called the World Ocean (AMRF 2007).

This is particularly a problem when one thinks about exactly who is responsible for maintaining the cleanliness of all this water. When one piece of plastic, or any piece of rubbish, enters the ocean, it can be carried away by the current and end up absolutely anywhere on the planet. Taking into consideration that plastic never degrades entirely, all that plastic riding the ocean currents will likely stay there for an extremely long time. It is for these reasons that it is the obligation of everyone to take responsibility for the health of the World Ocean.

The first major steps taken to actively fight pollution and dumping on a global scale came in the early 1970s. In 1972, the United States Congress enacted the Marine

Protection, Research, and Sanctuaries Act (MPRSA), also known as the Ocean Dumping Act, to prohibit the dumping of material into the ocean that "would unreasonably degrade or endanger human health or the marine environment" (EPA 2008). The International Convention for the Prevention of Pollution from Ships (MARPOL) is another UN convention concerning the health of the ocean.

The International Maritime Organization (IMO), a division of the United Nations, implemented MARPOL on November 2, 1973 (IMO 2002). As of December 2005, 136 countries, including the United States, had signed on to the convention. The MARPOL convention addresses accidental or purposeful pollution by oil, chemicals, plastics and garbage (IMO 2002). It was designed to minimize ocean pollution, including dumping of solid waste, dredged materials, oil and exhaust pollution. According to the IMO, MARPOL's objective is "to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances" (2002). MARPOL has largely been a success, with many countries agreeing to the terms of the convention. However, worldwide enforcement is less than ideal, as it is based on the honor system and is up to individual countries to monitor ocean dumping.

The United Nations Environment Program (UNEP) is the voice for the environment in the United Nations system. UNEP was established in 1972 and headquartered in Nairobi, Kenya; only one of two UN branches to be headquartered in the developing world. It is an advocate, educator, catalyst and facilitator, promoting the wise use of the planet's natural assets for sustainable development (UNEP 2005a).

UNEP's mission is "to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations" (UNEP 2005a). They do this by promoting international cooperation in the field of the environment and recommending appropriate policies, monitoring the status of the global environment and gathering environmental information. UNEP facilitates the coordination of UN activities on matters concerned with the environment, by developing regional programs for environmental sustainability, providing country-level environmental capacity building and technology support. They also help develop international environmental law and offer expert advice on the development and use of environmental concepts and instruments (UNEP 2005a).

Important UNEP organizations emphasizing global action and sustainability concerning the marine environment are the International Coral Reef Action Network, the Global Marine Assessment, the Global International Waters Assessment, the Global Environment Outlook Process, the World Conservation Monitoring Center, The Global Program of Action for the Protection of the Marine Environment from Land-Based Activities, and the Convention on Biological Diversity (UNEP 2005).

Operational on the global activist level, the Greenpeace ship Esperanza is currently on an environmental research mission, cruising the world's largest trash vortex in the middle of the Pacific Ocean. Sometimes referred to as the “North Pacific Garbage Patch”, this vortex is the epicenter of a system of currents and winds covering most of the North Pacific (Greenpeace 2007). This trash vortex is one of the most studied areas of plastic accumulation in our oceans. Made up of everything from tiny pieces of plastic

debris to large ghost nets lost by the fishing industry, this swirling mass is growing and has reached a surface area equivalent to that of the state of Texas (AMRF 2007).

Waging War on Plastic

The governments of individual nations, in addition to international organizations such as the United Nations and Greenpeace, are taking action to reduce the amount of floatable debris that ends up in the oceans each year. Much of this plastic debris comes from discarded plastic shopping bags and countries are taking steps to limit the amount and sources of plastic bags introduced into the environment.

An example of the most successful ban on plastic shopping bags comes from Ireland. Prior to the ban, it was estimated that some 1.2 billion plastic shopping bags had been provided annually at no cost to consumers as an excessive and largely unnecessary expense. In 2002, the Irish government introduced a 15 cent-per-bag tax (around 19 cents U.S.) on all plastic bags provided to consumers. This levy has been extremely successful, resulting in a 90 percent drop in plastic bag use in the first year alone. It has encouraged consumers to bring their own bags when shopping (UNEP 2003).

Another exceptional example of a country seriously confronting this problem is Kenya. With the help of the UNEP, Kenya has implemented a seven-point plan for confronting plastic bag use in the country (UNEP 2005b). Included in this plan are limits on the thickness of plastic bags, consumer anti-littering campaigns, funding for proper recycling of old bags, and taxes assessed on new bags handed out by retailers. Portions of the levy will go to fund campaigns to find alternatives to plastic bags, including environmentally friendly cotton bags that also help to support Kenya's cotton industry (UNEP 2005b).

Following in the footsteps of Ireland and Kenya are countries such as Uganda, South Africa, Taiwan, Bangladesh and India that have imposed bans or taxes on the use of plastic bags in retail and grocery outlets. China is the newest addition to this list, with a nation-wide ban on plastic bags in January of 2008 (Zaleski 2008).

Cities within the United States that have banned or are planning to ban the use of plastic bags are Santa Cruz, Brooklyn, New York City, and San Francisco. A major step forward in the fight against plastics was taken by the City of San Francisco in March 2007 when it announced that plastic bags were to be banned from grocery stores and pharmacies within the city (Velinov 2007). It is evident that organizations from every level work to reduce the amount of plastic waste generated on land so that it will not end up in the ocean. This is especially important since the members of our global community are so dependent upon the oceans for their sustenance and livelihoods.

An excellent example of local involvement producing tangible results comes from the California Ocean Protection Council (COPC). Recently the COPC has adopted a resolution calling for several new policies and programs aimed at reducing and recycling plastic waste and other marine debris in California. Among the proposals are restrictions on disposable takeout food packaging and waste discharge restrictions for facilities manufacturing plastic products (COPC 2007).

Alternatives to Plastic

Almost all mainstream plastics manufacturers currently use crude oil (petroleum), natural gas, and/or coal as the base for their plastics (Stevens 2002), which means that world oil prices and plastic production are often related. In a world where oil prices are setting new price-per-barrel records, one must consider how these ever-rising prices will

affect the world economy. At the current rate of world consumption, there is estimated to be only enough petroleum to sustain users for another fifty years or so (Stevens 2002). Development of alternatives to petroleum-based plastic would reduce the amount of crude oil a country would need to import for production. The current dependency on and irresponsible disposal of plastics used in every day life is definitely taking its toll on both the terrestrial and marine environment.

Alternatives to petroleum-based plastics have been in development for years. In fact, automobile pioneer Henry Ford had researched how to manufacture plastic car parts from inexpensive soybeans prior to World War II (Stevens 2002). Ford's attempt marks the first large-scale effort to move away from petroleum-based plastics and into the realm of bioplastics.

Bioplastics are the next generation of plastics designed to be environmentally friendly, naturally biodegradable, and derived from renewable plant resources (Stevens 2002). There are currently many bioplastics manufacturers developing alternative, more environmentally friendly ways to produce this material. One of the major American bioplastics manufacturers, Cereplast, Inc., states that it "designs and manufactures proprietary starch-based, renewable plastics created from starches from tapioca, corn, wheat and potatoes" (Cereplast 2006).

By using these biological additives in the manufacture of bioplastics, Cereplast is able to replace the industry-standard petroleum base with natural and renewable elements. In addition to being made with renewable resources, these bioplastics are 100% biodegradable and compostable. They will generally compost completely in 60 to 180 days and leave no toxic residue once composted (Cereplast 2006). Furthermore, the

grains used by Cereplast are primarily purchased from growers in the American Midwest (Cereplast 2006); which not only assists the American economy, but also lessens America's dependence on foreign oil.

Like Cereplast, the European-based company called Trellis Earth manufactures bioplastics as well. It uses corn from America, Japan, and China as the main ingredient in their products (Trellis Earth 2007). They manufacture bioplastic cutlery, plates, bowls, and take-out containers to replace current Styrofoam and plastic items (Trellis Earth 2007). Corn-based bioplastic shopping, produce, and garbage bags are Trellis Earth's most relevant product when the prevalence of traditional plastic bags is considered. Their bags are 100% biodegradable and toxin free (Trellis Earth 2007).

Not only are these products completely biodegradable, they are generally less expensive than their traditional petroleum-based counterparts. However, the success of bioplastics relies largely on the development of new and better production technologies, commercialization, and the acceptance and commitment of society to actually utilize these bioplastics (Stevens 2002).

Conclusion

With all the actions being taken on local, national and international levels, one could reason that the problem of floatable debris in the oceans is at its end. That assumption, however, would be incorrect. Although many grassroots organizations, NGOs, international organizations and the governments of many countries around the world recognize that action needs to be taken, the problem of plastic debris in the marine environment is much larger than anyone could have ever imagined. If there is *already* six pounds of plastic in the ocean for every one pound of naturally occurring plankton, how

will the oceans perform in 10, 20, or 50 years? How much pollution will our World Ocean bear before it stops functioning?

In order to tackle this problem head on, organizations, individuals, and government entities from all levels of the activist scale need to work together to enforce the MARPOL regulations and educate the public about the environmental effects of plastic in the marine environment. Many countries, cities, and individual organizations have taken steps in the right direction, by passing pieces of legislation, conducting local beach clean-ups, and fostering community education and awareness of the problem, but much more needs to be done. As American cultural anthropologist Margaret Mead once said, "Never doubt that a small group of thoughtful committed people can change the world: Indeed it's the only thing that ever has!"

Development of alternatives to bioplastic technology will lead to less reliance on crude oil for the manufacture of plastics, and is a necessary step in the right direction. With current technological advances, bioplastics can actually be manufactured for about the same amount as conventional, petroleum-based plastics. Not only does this open the door to environmentally cleaner bioplastics, but also helps the Global Community to kick its oil habit. It will take all communities working together to stop floatable debris dumping, come up with and *use* alternatives to plastics, clean up the oceans, and reverse the damage already done by the tons of debris currently circulating in the oceans.

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