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The Effects of Plastic Pollution on Aquatic Wildlife: Current Situations and Future Solutions

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Abstract The majority of consumer products used today are comprised of some form of plastic. Worldwide, almost 280 million t of plastic materials are produced annually, much of which ends up in landfills or the oceans (Shaw and Sahni *Journal of Mechanical and Civil Engineering* 46–48, 2014). While plastics are lightweight, inexpensive, and durable, these same qualities can make them very harmful to wildlife, especially once they become waterborne. Once seaborne, plastics are most likely found circulating in one of five major ocean gyres: two in the Pacific, one in the Indian, and two in the Atlantic. These ocean garbage patches are not solid islands of plastic; instead, they are a turbid mix of plastics (Kostigen 2008; Livingeco 2011). Recent research conducted on the surfaces of the Great Lakes has identified similar problems (Erikson et al. *Marine Pollution Bulletin, 77*(1), 177–182, 2013). A growing concern is that once plastics reach the wild, they may cause entanglement, death from ingestion, and carry invasive species. Several cutting edge technologies have been piloted to monitor or gather the plastics already in our environments and convert them back into oil with hopes to reduce the damage plastics are causing to our ecosystems.

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1 Introduction

Worldwide, about 280 million t of plastic are produced annually (Shaw and Sahni 2014) for the manufacturing of products such as storage containers, packaging material, or even automobiles. In the USA alone, approximately 48 million t of plastic are generated each year (Sarker et al. 2012b). Plastic has become an optimal medium used in vast amounts of consumer products because it is lightweight, durable, inexpensive, and a good insulator. Unfortunately, within the last 30 years, scientists have realized that the useful attributes of plastics are what also make them detrimental to our environment. This is because it is difficult to eliminate plastic waste due to the fact that it does not biodegrade in nature, but only photodegrades into smaller pieces. The chemical bonds between the molecules that comprise plastic not only make them resilient, but also impervious to natural degradation (Shaw and Sahni 2014). The percentage of plastics that make up the total municipal solid waste has risen 12 % over the last four decades (EPA 2014). Almost one third of the plastic produced is used to manufacture single-use plastics (DiGregorio 2012) such as coffee cup lids, stirrers, or straws.

Annually, more than 35 million plastic bottles and 500 billion plastic bags are used by consumers, many of which end up in our oceans and along our beaches

(What a Waste 2010). Bodies of water, particularly the ocean gyres found in the Atlantic, Pacific, and Indian Oceans, are becoming the final destination for many of these non-biodegradable polymers. These gyres are circulating currents caused by the Coriolis effect, or deflection of currents, due to Earth's rotation and surface winds (NOAA 2008). As a result of plastic waste, Earth's ocean and freshwater biodiversity and ecosystems are being negatively affected. To solve problems caused by plastics, new technologies are being piloted which include tracking trash through frequency identification (RFID) tags and cellular transmitters, having citizens track plastic debris using their smartphones, using drones or barriers to collect plastic debris, and turning plastics back into fuel.

2 Issues of Waterborne Plastics in Our Environments

The accumulation of plastics in our environments is a result of improper disposal or shipping spills. Since they are lightweight and durable, plastics are capable of traveling long distances; ending up in terrestrial environments, along shorelines, or floating in the open ocean (Zbyszewski and Corcoran 2011). For example, pill bottles from India along with oil and detergent containers from Russia, Korea, and China have been found on the southern parts of Hawaii (Kostigen 2008). As plastics float in the oceans, they are affecting marine wildlife. Not only do itinerant plastics end up in animals' stomachs or around their necks, but there is also growing concern that plastics are acting as a medium for invasive species. The hard surfaces of plastics are now an alternate material for invasive species such as barnacles, mollusks, and algae to attach, compared to the natural material which previously carried invasive species for centuries (Gregory 2009). With the influx of plastics presently in the oceans, the accumulation of invasive species may escalate at an ever increasing speed.

2.1 Ocean Garbage Patches

The United Nations has estimated that 5–10 million t of plastic are circulating in the North Pacific Ocean between California and Japan, although it is difficult to narrow down an exact amount of debris (Livingeco 2011). Estimated to be twice the size of Texas, the North Pacific Subtropical Gyre is often called "The Great Pacific Ocean Garbage Patch" (NOAA 2013). It is here where colliding currents trap plastics in a circulating pattern. Often misinterpreted as an island of plastic, the Pacific Ocean Gyre is actually a big nebulous clutter of large and small plastic pieces extending 100-ft deep (Kostigen 2008). Scientists have discovered other major garbage patches that encompass just as much plastic with speculation that there may be more: the South Pacific Subtropical Gyre, the North and South Atlantic Subtropical Gyre, and the Indian Ocean Subtropical Gyre (NOAA 2014). After a 20-year study, the North Atlantic Ocean and the Caribbean Sea are estimated to have 200,000 plastic pieces per square kilometer (Gill 2010), thus signifying a problem of similar magnitude to the Pacific Ocean.

Eighty percent of the plastics circulating the oceans are believed to come from shorelines, 10 % from fishing gear, and 10 % from boats and ships (McLendon 2010). Approximately, 10,000 shipping containers plummet off cargo ships into the ocean each year (McLendon 2010). A shipping crate carrying 28,000 plastic ducks was lost at sea between Hong Kong and the USA in the Pacific Ocean over 20 years ago (Nelson 2011). At least 2000 of the ducks are believed to be circulating in the Great Pacific Garbage Patch, while others have been found washed ashore in Hawaii, Alaska, South America, Australia, and the Pacific Northwest (Nelson 2011). The durability of plastics is observed each time any of these ducks emerge on shore still intact.

2.2 Effects of Plastics on Marine Biodiversity

The magnitude of plastic pollution carried to sea has significantly multiplied over the past several decades. Oftentimes, wildlife is injured due to entanglement or ingestion of the plastics found in the environment. For Procellariiformes such as the albatrosses, shearwaters, or petrels, the appearance of eroded plastic pieces are similar to many types of food they consume (Blight and Burger 1997). Microplastics resemble phytoplankton which are eaten by fish and cetaceans (Boerger et al. 2010). Ingested plastic debris has been found to reduce stomach capacity, hinder growth, cause internal injuries, and create intestinal blockage (Plot and Georges 2010). Plastic entanglement with fishing nets or other ring-shaped materials can result in strangulation, reduction of feeding efficiency, and in some cases drowning (Allen, Jarvis, Sayer, and Mills 2012). Due to natural curiosity, pinnipeds often become entangled in marine debris at a young age, which can constrict their body as they grow thus reducing quality of life (Allen et al. 2012). Globally, at least 23 % of marine mammal species, 36 % of seabird species, and 86 % of sea turtle species are known to be affected by plastic debris (Stamper et al. 2009).

2.2.1 Sea Turtles

Numerous autopsies have shown that ingested plastic and tar are the primary culprits of stress and non-natural death for sea turtles. Debris including fishing line, ropes, nets, six pack rings, Styrofoam, and plastic bags have been extracted from turtle digestive tracts. Plastic bags floating in the water strongly resemble the shape of jellyfish, a primary food source for sea turtles, thus resulting in the ingestion of the bags (Mascarenhas et al. 2004).

Due to anthropogenic impact, the population of leatherback sea turtles (*Dermochelys coriacea*) has steadily declined over the last two decades, placing them on the IUCN's critically endangered list (Shillinger et al. 2012). For the last 40 years, of the 371 autopsies conducted on leatherback turtles, 37.2 % of them had plastic in their gastrointestinal tracts (Mrosovsky et al. 2009). Although it is not known if the plastic ingested was the cause of death, 8.7 % of the turtles had a plastic bag presumably blocking the passage of food (Mrosovsky et al. 2009). Plastic has also been found to block the passage of female eggs. In a documented study, researchers removed 14 pieces of plastic from a female cloaca. This enabled the eggs to be laid, but indication of internal damage remained (Plot and Georges 2010).

Green turtles (*Chelonia mydas*) and loggerheads (*Caretta caretta*) have been found in similar predicaments. According to Parker et al. (2005), the National Marine Fisheries service acquired 52 loggerheads through by-catch in the Atlantic Ocean. Of these, 35 % were found to have plastics in their digestive tracts (Parker et al. 2005). In the western Mediterranean, 79.6 % of the 54 loggerheads captured illegally by fishermen contained plastics in their gastrointestinal tracts (Tomas et al. 2002). In Paraiba, Brazil, a turtle taken in for rehabilitation died after excreting 11 pieces of hard plastic and 9 pieces of plastic bag (Mascarenhas et al. 2004). Similarly, a juvenile green sea turtle found minimally responsive, defecated over 74 foreign objects, including an array of different kinds of plastics while being rehabilitated (Stamper et al. 2009). Prior to passing the debris, the turtle was consuming about 8 g of food per day. After all of the debris passed, the food intake was up to 100 g a day (Mascarenhas et al. 2004). Even though some turtles may be capable of passing plastic through their digestive system, it can still cause internal injuries. Those that cannot pass the plastic will eventually starve as plastics accrue in their stomach cavities.

2.2.2 Cetacean

Most cetaceans live far from the shoreline which limits the amount of research on the ingestion of marine debris. If plastic causes unnatural death, cetaceans will most likely sink to the bottom of the ocean (Baird and Hooker 2000). Occasionally, cetaceans will wash ashore allowing for postmortem examinations. Due to cetaceans' echolocation capabilities, mistaken consumption of plastic is not probable (Secchi and Zarzur 1999). Ingestion is most likely because the debris was mixed in with the desired food. Two sperm whales (*Physeter macrocephalus*) were found off the coast of northern California in 2008 with a large amount of fishing gear in their gastrointestinal tracts (Jacobsen et al. 2010). One of the sperm whales had a rupture in the third compartment of the stomach caused by nylon netting; the other had netting, fishing line, and plastic bags completely blocking the stomach from the intestines (Jacobsen et al. 2010). On the coast of Nova Scotia, Canada, a juvenile porpoise (Phocoenidae) was found dead with a balled up piece of black plastic in the esophagus entangled with three spined stickleback fish (Baird and Hooker 2000). In Brazil, the stomach analysis of a Blainville's beaked whale (*Mesoplodon densirostris*) showed the presence of a large bundle of blue plastic thread occupying a substantial part of the stomach chamber (Secchi and Zarzur 1999). Within the last decade, at least seven endangered migrating humpback whales (*Megaptera novaeangliae*) have been spotted towing mass amounts of tangled nylon rope and other debris including a crayfish pot and a buoy with marker pole (Gregory 2009). An endangered North Atlantic right whale (*Eubalaena glacialis*) was found with fishing rope entangled through its mouth. Due to its dangerous behavior, rescuers were only able to successfully remove 250 ft of the commercial fishing line and hoped the rest of the rope would dislodge from the mouth on its own (Foley 2014). Currently, there have not been enough trends found in collected data that prove ingested plastics are the primary cause of death contributing to the decline of cetaceans (Simmonds 2012; de Stephanis et al. 2013; Baulch and Perry 2014). However, these examples show that plastic marine debris can cause direct mortality of cetaceans or even create debilitating scenarios that make the mammals more prone to predation or disease.

2.2.3 Birds

Small plastics such as bottle caps are often mistaken by seabirds (Procellariiformes) for food. In several studies, it was found that diving birds that fed on fish in the water column had less plastic in their stomachs compared to those that were surface eaters (Blight and Burger 1997; Provencher et al. 2010). This could be because birds that maintain a diet of zooplankton may not be able to distinguish between plastics and their primary source of food due to the color or shape of the plastic pieces (Avery-Gomm et al. 2013). Since most adult birds regurgitate what has been ingested as a way to feed their chicks, they pass the bolus containing the plastic pieces onto their young. Birds such as the albatross and shearwater had more plastic in the first region of their stomachs and gizzards, indicating that when these plastics were regurgitated, they would be passed to their young during feeding (Moser and Lee 1992). Juvenile albatross and shearwaters were found to ingest more plastics than adults (Avery-Gomm et al. 2013; van Franeker et al. 2011). Similar to other marine life, swallowed plastic can obstruct and damage a bird's digestive system, reducing its foraging capabilities. Ryan (1988) concluded that ingested plastics could reduce the fitness, growth rate, and food consumption of seabirds, based on the results from a study using domestic chickens (*Gallus domesticus*).

The amount of plastic ingested by different species of birds may be an indicator of the accumulation of plastics in an area. A study carried out by Moser and Lee (1992) found that North Atlantic shearwaters showed an increase in consumption of plastics from 1974 to 1978 compared to 1976–1984. This correlates with the increase of plastic available in the oceans. In 1995, a study completed by Auman et al. (1997) found that of the 251 Laysan Albatross (*Phoebastria immutabilis*) autopsied from Midway Atoll in the North Pacific, only 6 did not contain any ingested plastic. Another study conducted in the eastern North Pacific found that of the 353 ingested items recovered from 11 species of seabirds, 29.2 % were industrial pellets and 70.5 % were broken pieces of everyday use plastics (Blight and Burger 1997). The stomach contents of 67 fulmars washed up on the beaches along the eastern North Pacific from 2009 to 2010 contained on average 36.8 pieces of plastics (Avery-Gomm et al. 2013). Considering this accounted for 92.5 % of the fulmars, Avery-Gomm et al. (2013) speculated that this signified an increase in the ingestion of plastics.

2.2.4 Fish

There have not been any found published studies about the effects of plastics on fish; nonetheless, there is plenty of evidence supporting that fish are consuming plastics. Of the 7 different species studied in the North Sea, only 2.6 % of the 1203 collected fish contained plastic pieces in the digestive tracts (Foekema et al. 2013). When the gastrointestinal tracts of 504 fish were studied in the English Channel, 36.5 % contained plastics (Lusher et al. 2013). Inconsistent results found among studies could possibly indicate important variables such as location, accumulation of plastics, and fish species. A study conducted in the North Pacific Central Gyre found that 35 % of the 670 fish tested had a combined total of 1375 plastic pieces in their stomachs. This equates to about 2.5 pieces per fish. Most of the plastic pieces were blue, white, or clear which are the same colors as plankton, the primary food source of fish (Boerger et al. 2010). In a similar study done in the North Pacific Subtropical Gyre, 9.2 % of 141 fish examined had plastics in their stomachs (Davison and Asch 2011). Based on these results, Davison and Asch (2011) speculate that between 12,000 and 24,000 t of plastic are consumed by fish each year. Understanding the effects of plastics when consumed by fish is of concern because the small fragments of plastic may facilitate the transport of absorbed pollutants to predators within the food chain (Dau 2012; Teuten et al. 2009).

2.3 Plastic Pollution in the Great Lakes

There have been many studies conducted to determine the dispersal, environmental impact, and quantity of plastic pollution in marine ecosystems, but little is known about freshwater plastic pollution. Scientists are now realizing that the same problems observed in the ocean gyres and along coastlines are arising in our bodies of fresh water (Blackwell 2012). The Great Lakes of North America are the largest freshwater systems in the world. Lake Huron, Lake Ontario, Lake Michigan, Lake Erie, and Lake Superior represent the five bodies of freshwater in the Laurentian Great Lakes. In the last few years, these glacial made lakes have been a focus of study for the effects of freshwater plastic pollution.

The shores of Lake Huron in Canada constitute one of the first locations where researchers studied the abundance, type, and distribution of plastic pollution along the Great Lakes (Zbyszewski and Corcoran 2011). According to the authors, the industrial side of the lake contained the most plastics; the majority of which were small pellets used for the production of manufactured goods. It was speculated that many of the pellets were lost during production or carried by the movement of the cyclonic surface current caused by wind and changes in water temperature (Sheng and Rao 2006; Zbyszewski and Corcoran 2011). It is also possible that capsized cargo could have contributed to the accumulation of plastic on the shores of Lake Huron since this waterway is part of a major shipping route (Zbyszewski and Corcoran 2011).

In the summer of 2012, 5 Gyres Institute sailed through Lake Erie, Lake Superior, and Lake Ontario to conduct the first open-water survey of the lakes (Eriksen et al. 2013). While trawling the lakes for plastics, Erikson et al. discovered that Lake Erie consistently had the most concentrated levels of microplastics compared to Lake Huron and Lake Superior. Two explanations for this phenomenon could be that Lake Erie has the most populated shorelines, or it could be receiving the microplastics from the other lakes due to the southward flowing current (Dau 2012; Eriksen et al. 2013). Samples taken from Lake Erie also revealed that the quantity of plastics was three times greater than the amount found in any samples taken from the oceans. Most of these samples were comprised of microplastics which are less than 5-mm wide (Dau 2012). This magnitude of microplastics was unexpected. Dau believed that the lakes would contain larger plastics that eroded into smaller pieces as they made their way through lakes and rivers to the oceans, a process that should take hundreds of years (Blackwell 2012). Eriksen et al. (2013) suspected many of the microplastics collected to be polyethylene and polypropylene microbeads from facial cleansers and other personal care products. When consumers release these microplastics down the drain, it is possible many make their way through wastewater treatment plants and into the freshwater lakes, especially if they are less than .5-mm wide (Eriksen et al. 2013).

Whether on the shores or on the surface, both studies indicate that the Laurentian Great Lakes are teaming with microplastics and plastic pellets. The diminutive size of these plastics makes them easily available for ingestion, thus increasing the bioaccumulation of the chemical ingredients from in the plastic or from the absorption of chemicals onto the plastics (Rochman et al. 2014; Teuten et al. 2009). When consumed, microplastics containing plasticizers such as bisphenol A (BPA) and phthalates have been found to affect hatching success and the development and reproduction of offspring in amphibians, crustaceans, and even insects (Oehlmann et al. 2009). Another problem with microplastics is that they attract harmful pollutants such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT) (Zbyszewski and Corcoran 2011). PCBs have been shown to cause cancers in marine animals or to have negative effects on the immune system, nervous system, endocrine system, and reproductive system (EPA 2013). There is speculation that these minute plastics can make their way up the food chain, causing similar health threats to humans (Dau 2012). Further studies are needed to analyze the infiltration of microplastics into the Great Lakes and the consequential impacts they have on the biodiversity ingesting them (Teuten et al. 2009).

3 Managing the Effects of Plastics

The movement of plastics in our ocean environments and the effects on wildlife has been researched for over 30 years. Knowledge about ocean currents gained from satellite-tracked Lagrangian drifters have been used to predict the trajectories of floating marine debris (Maximenko et al. 2012; Martinez et al. 2009). Lagrangian drifters are instruments that have been used in oceans, lakes, and rivers to measure water currents and to collect other environmental data such as temperature and salinity. Scientists are not the only people tracking trash. The Marine Debris Tracker is a citizen science project that allows community members to log marine debris found along coastlines and waterways using their smartphones, which is then recorded using GPS (Want to Track 2014). Locating and tracking plastic debris is critical to better understand which environments are most vulnerable.

Despite the ability to track waste movement, a solution to ridding our Earth's waters of plastic waste to minimize its effects on marine wildlife remains a challenge. Even though the USA implemented the Clean Water Act and the USA and Canada continue to amend The Great Lakes Water Quality Agreement to reduce the pollution in areas of concern, more plastics continue to accumulate in the Great Lakes each year (EPA 2012). These plastics inevitably make their way to the sea through networks of rivers and streams and then into the ocean gyres. Since the gyres are found in international waters, no country is taking responsibility for cleaning up the oceans. Instead, several private organizations are working to solve the problem. Innovative technologies have been piloted by private companies to help identify, minimize, and eliminate plastics in our ecosystems including tracking trash through radiofrequency identification (RFID) tags and cellular transmitters, using drones or barriers to collect plastic debris, and turning plastics back into oil.

3.1 Tracking Garbage

Recycling is one of the most identified practices available to reduce the impact of waste in our landfills and in our environment through the reuse of materials. Regardless of whether or not a person recycles, there is little evidence that waste is ending up in its intended destination. It is because of this lack of data that Massachusetts Institute of Technology is using RFID tags and cellular transmitters to track garbage and recycling in Seattle and New York (Greengard 2010). According to Greengard, "Trash Track" allows researchers to follow where the trash has been, how long it has been moving before being deposited, and where the trash finally accumulates. Through this study, researchers hope to find more information about the US waste management system, and then use the information to influence people's behavior and recycling efforts. As the trash is tracked, further studies can also be designed to identify where most of the plastics are accumulating and what can be done to prevent further injuries to wildlife in those locations. Currently, researchers have tagged more than 3000 pieces of trash with sensors that will turn off or on when they detect changes in position and location to help preserve the six-month battery (Greengard 2010). Although there are no known studies to date that track plastics into and through our waterways, it is possible this same technology can one day be applied to tracking plastics that make their way into the Great Lakes or oceans.

3.2 Gathering Plastics in the Great Ocean Garbage Patches

Derived from the design of a fish trawler and plankton tow, manta trawlers have been utilized for the collection of pollutants from the ocean for data analysis (Ryan et al. 2009). The manta trawl is placed behind the boat where it skims the surface of the water collecting buoyant plastic debris. Although this technology collects floating plastic debris for study, it still does not pose a solution for the greater challenge of removing the plastics from the oceans. Plastics account for 60–80 % of our marine litter (Moore 2008), which is why it is necessary to find a solution to this problem.

An innovative prototype of a "plastic-eating drone" has been proposed as a possible solution for cleaning up our ocean's garbage patches. While some may believe the idea of removing plastics in the gyres is derisory, Elie Ahovi, an industrial design student, deems differently. Ahovi has proposed using an autonomous device that would tow a trapping net which would siphon the plastic garbage from our ocean waters (Boyle 2012). Sonic transmitters would be used as a deterrent for marine life getting caught in the net. According to Boyle, the drone is designed to travel the oceans for two weeks, but should it gather too much waste or the batteries run low, it would return to an ocean base where crews would empty it of the plastic for recycling. If Ahovi has designed a tool that is powerful enough to gather the plastic in the Great Pacific Garbage patch, similar technologies could be applicable to freshwater systems found on Earth. Should the prototype be implemented, further studies will be necessary to identify if the waste removal is reducing the ingestion of plastics.

The Ocean Clean-up Array is another groundbreaking solution for cleaning up plastics circulating in the ocean gyres. Designed by Boyan Slat and executed with the help of a team of scientists, the Ocean Clean-up Array uses the ocean currents for collecting plastics (The Ocean Clean-up 2014). Solid floating booms are attached to platforms that are anchored to the ocean floor. The Array was designed so that neutrally buoyant marine life will float beneath the booms preventing any wildlife entanglement, while allowing floating plastic carried by the currents of the ocean gyres to collect along the booms on the surface of the water (The Ocean Clean-up 2014). It is estimated that 7.25 million t of plastic waste could be removed from the ocean; most of which is expected to be suitable to be turned into oil (Singh 2013; The Ocean Clean-up 2014). As the Ocean Clean-up Array moves into the pilot phase, this design may not only remove plastic currently floating in gyres that is injuring wildlife, but also may be used in waterways to prevent the plastic from ever reaching the ocean.

3.3 A New Way to Recycle Plastics

While many people recycle household plastic items with the assumption they can all be fully recycled, only about 10 % of plastics are being recycled back into plastics. The majority of plastics are disposed in landfills or incinerated (Sarker et al. 2012b). Several methods for chemical recycling involving gasification or smelting are currently employed (Sarker et al. 2012a). Thermal degradation may be the new solution to recycling and repurposing plastics such as high-density and low-density polyethylene, polypropylene, and polystyrene, without causing further environmental degradation (Livingeco 2011). During thermal degradation, petroleum-based plastic are heated to 25 to 430 °C and then converted into liquid hydrocarbon fuel (Sarker et al. 2012c). The thermal degradation is carried out in an oxygen-free stainless steel reactor. Since incineration or combustion does not occur, smoke is not a by-product (Sarker et al. 2012c). This process results in minimum waste. Waste products from this process include carbon dioxide equivalent to two people breathing out for 24 h, water vapor, and one cup of biodegradable char (carbon) which is disposed of monthly (Livingeco 2011). The Evolucient System designed by researchers from the Clean Ocean's Project can convert 2700 lb of plastic into fuel through thermal degradation over a 24-h period; every 8 lb accounts for 1 gal of fuel (Livingeco 2011).

According to Sarker et al. (2012b), if the amount of waste circulating in the ocean gyres can be gathered using collection vessels, the waste can then be converted into hydrocarbon fuel on the vessel or in off-shore facilities. The Clean Ocean's Project hopes to install an Evolucient System on a wind-powered catamaran that will move around the Great Pacific Garbage Patch collecting the fog of plastic particles (Livingeco 2011). Any fuel that is needed can be extracted from the Evolucient System. This technology is not only applicable to oceans, but can be utilized in the Great Lakes to collect and dispose of the microplastics accumulating in the freshwater.

4 Conclusion

Due to ingestion or entanglement in plastic debris, over 270 species, including turtles, fish, seabirds, and mammals, have experienced impaired movement, starvation, or death (Laist 1997; Wabnitz and Nichols 2010). Researchers have gathered a plethora of information about the number of species affected by plastics in the oceans, but the freshwater wildlife affected in much smaller bodies of water, such as the Great Lakes, still needs to be seriously considered. It is possible that the plastic-collecting drone could be used to collect the majority of plastics in the oceans and Great Lakes or that the Evolucient System will be the new way to recycle through thermal degradation. Recycling is the current solution to the overuse of plastics, but the final destination of a considerable amount of recyclable material is still being assessed. Solutions to ensure materials are recycled or disposed of properly need to be developed. Even with research, recycling, and new technologies, alternate packaging material should be utilized to reduce the dependence on plastic goods. Plastics do not disappear and will remain in our environments indefinitely affecting wildlife, until the pollution is reduced. “Water is something every living organism on this planet cannot live without. If this resource is so precious that life cannot exist without it, we shouldn't be contaminating it” (Sherri Mason as cited in Blackwell 2012 para. 19).

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