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## The Effects of Anthropogenic Plastic in the Ocean

There are many ways our oceans are being affected by anthropogenic change. Humans cause destruction to the ocean biome directly and indirectly. Although climate change is moving at a very rapid increase and the population needs to make lifestyle changes in order to stop it, an even more pressing issue is trash harming the organisms within the ecosystems. Direct harm to the environment from people, is pollution in the oceans. The subject matter is going to focus on the harmful ramifications of pollution in the oceans and how trash affects ecosystems. Specifically, this project is going to look at the cycle of plastics in the water and how it is a critical risk to marine life. Through research, numbers and statistics were identified to show how pressing this issue is regarding wildlife. An important issue that ecologists and humanity should be concerned about is the growing plastic contamination from anthropogenic debris since it directly harms the ocean biome that sustains many unique organisms and other ecosystems that surround it.

The plastic industry, to settle the concerns of consumers decades ago, would say that the only harm to the environment that plastic caused was tainting the scenery of nature. This statement could have been true when the production of plastics wasn't at a record high in history. Now, ecologists are recognizing the increasing issue plastics have had to many ecosystems, including the ocean. The industry has increased worldwide, especially in China. Production of plastic has risen since 1950 when it was 2 metric tons annually, and quickly increased to 380 metric tons produced annually from a recent study in 2015 (1). This data shows numbers have grown exponentially which can cause more problems as it increases.

In relation to the production numbers of plastics, it is important for consumers and companies to know the amount of plastic going into the ocean. According to this source there are 5.25 trillion plastic particles weighing 268,940 tons currently at sea. To better understand this, a minimum of 233,400 tons of larger plastic items contrasted to 35,540 tons of micro-plastics are found in the ocean (4). Since micro-plastics are the main contributor to the harm against marine life, this is a critical research fact.

Organisms are affected by micro-plastics that come from human wastes. Anthropogenic pollution can come from a variety of sources and end up in the ocean. Important contributors to the abandoned plastic nets, lines, and traps at sea are from the fishing vessels. Meanwhile, plastic debris from land is from littering or garbage from a landfill that blows away. As a result of plastic in the ocean from anthropogenic pollution, a range of organisms are affected. From certain plants that were studied, to an overwhelming amount of species of marine creatures, and indirectly humans, micro-plastics affect a range of multiple ecosystems. To begin, in one of the articles it provides a scope to this argument. In the article, the authors do a study of different encounters of marine life with marine debris. In the results section of the article, they said 340 publications were identified to have reported on these encounters. Out of 340 publications, 292 studies report an incident of either ingestion or entanglement (3). These statistics give us insight to what can happen to organisms that come into contact with macro-plastics. Entanglement isn't the main focus of the overall project research, since the project is about the cycle of problems to the ecosystems surrounding oceans. It is still critical to include how plastic can endanger marine life since they

deserve to live just as much as a human life. When it comes to decisions about saving specific species from endangerment, ecologists and government officials have to make complicated decisions. The verdict can come down to whether the organism up for debate can contribute to ecosystem services. That way of thinking can be very selfish to other species living on our planet. All organisms have a life and if humans have the resources and means to help and provide for them, it's imperative to do so. A huge contribution to the preservation of other organisms could be limiting the amount of plastic waste in the ocean.

Studies show that marine plants are affected by micro-plastics as well. During research, an article that came up was: "Physical Adsorption of Charged Plastic Nanoparticles Affects Algal Photosynthesis" which talks about two algae species *Chlorella* and *Scenedesmus*, that bonded with electrostatic plastic nano-sized beads which hindered the algae's photosynthetic functions (8). Photosynthesis is the process by which plants receive energy. Algae is unique in the fact that it isn't a tall plant and it resides at the bottom of an ocean or lake and receives sunlight through small rays of sunlight and light. In this way, the plant is at a disadvantage since the nanoparticles block the plants ways to receive light and air.

Algal species are one of the fundamental producers for marine food chains. There could be a serious interruption of the ecosystem food chain if algae are unable to photosynthesize as a result of blockage by micro-plastics which wouldn't allow for light or oxygen to come in. This could be detrimental to the greater ecosystem and organisms around it if the reproduction of algae decreased and eventually other food groups would be eaten and not have enough for other predators. Micro-plastics that disrupt the ability for algae to live could have an impact on the greater ecosystem around.

Many species of marine life are affected by macro and micro-plastics in the ocean biome and surrounding ecosystems. Species can be affected physiologically and behaviorally by pollution in their environment. During research, an article was found that discusses the effects of anthropogenic plastic in the water on specifically the Zebrafish. This source, "Uptake, Tissue Distribution, and Toxicity of Polystyrene Nanoparticles in Developing Zebrafish (*Danio rerio*)" looks at the effects of nano-plastics in the ocean and how it is relatively new research compared to the data on micro-plastics in the ocean. According to the author's research, larvae exposure to the nano-plastics caused hyperactivity (7). A change in behavioral traits or organisms in the first stages of life could lead to issues in later stages of the reproductive cycle.

Another specific species affected by anthropogenic plastics in the ocean is the brown booby or *Sula Leucogaster*. This species is important to note in the overall project since it comes from a surrounding ecosystem, proving that encompassing organisms are in range of issues from plastic pollution as well. This academic journal article relates to my topic about pollution in oceans affecting ecosystems because it proves that chemicals such as the micro-plastics are creating problems. The bird, the brown booby, takes debris for nesting material and the scientists evaluated what kinds so they can monitor the type of pollutants in the water. The researchers found marine debris in 61% of the brown booby nests on both islands (5). Transportation of the micro-plastics could lead to problems for the brown booby, one of the species of sea bird that uses the plastic for nesting, and other organisms that come into contact. The impact of this debris in nests could reduce the quality of nesting habits since a form pollution is exposed at the very beginning of the organism's life. The brown booby is another organism effected by anthropogenic pollution in the ocean. This land animal stands as a stage in the cycle of impact of the marine debris since the bird's main area of habitation isn't the ocean.

Though there are many ways that micro-plastics cause harm to species directly and indirectly, a variety of fish species are directly at risk from multiple sources of pollution in the ocean biome. A study looked for plastic in 24 different species of marine fish in the South Pacific Islands, a place that relies heavily on sea life for food source (10). According to the article, “Gastrointestinal tracts of 126 fish were visually examined and plastic was found in 7.9% of individual fish and 25% of species.” This is crucial information to the project since it is focused around plastics in the ocean and affecting marine life. Although this article doesn’t go into depth about how specifically these fish are affected by having plastic in the digestive tract, a scientific idea that comes from this article is that the micro-plastics could cause blockage or potential punctures in fish’ body functions. This is also a significant study since the project is going to be centered around a cycle of plastics from the human hand to eventually the human body and why it needs to be interrupted.

Multiple articles from research led to similar conclusions and further questions to be studied. A scientific idea presented from the research found in the various articles is if the micro-plastics that are consumed through the fish and other organisms for food sources, are a transferrable way for chemicals to be brought into diets of the fish that mistakenly eat the plastics, and then cycled through to humans who ingest the fish. This is an important piece of research to be developed further and looked into since the project that will be created is going to be centered around the cycle of deposited plastic waste that moves from human, to ocean, to fish, to dinner plate. This idea of having toxic chemicals move through marine animals and the human population is concerning, and an idea that should be further researched.

As a fine artist, rather than an industrial designer, I am limited to a call for change rather than designing an invention specifically as a reaction to prevent plastics in the water. However, I believe there is an advantage to creating a piece that would inform an audience and creating it to hopefully inspire change and make a difference. I believe the best way to go about a change in human behavior to be recognized and enact change is by providing a lot of research to back what I am showing in a visual concept. I would want to create it as a model for ideally not only the marine biome, I would want to connect it to the ecosystem service it provides to us. This is mainly through a food source, but I could also create a 3D model indirectly showing the scenery deterioration of how pollution collects around the environment, with trash everywhere. That specific design detail could have an emotional effect on the viewer. The 3D model would be constructed with the Autodesk software, Maya, centered around a type of flow chart or obvious visual cycle. Scale would be a major part of my digital art composition, and I would use it to show the consequences of anthropogenic causation of plastic pollution and poor disposal. I could create it with a unique composition going from a human figure depositing a plastic straw or fork item into a trash can (to show trash and not recycling) and eventually leading through from the larger aspect of the fork of smaller broken shards of a fork or straw floating on the surface of the ocean and then being digested by a smaller fish, and eventually working its way through the food chain onto the human’s dinner plate with an X-ray representing the small plastic and within more toxic chemicals, representing the cycle eventually back to a human diet. This can work with scientific idea number two since it involves a food chain and compositions and the basic concepts of the two works would be similar. I would create the environment with an ocean background composite and different textures and colors to differentiate objects and the flow of chemicals, micro-plastics, or energy. The audience I imagine who would be viewing this artwork would be other faculty members of Pratt and other students to inform of the dangers of not recycling and the effects it can have on a variety of organisms.

Scientific Ideas	How it is incorporated into Project
<p>#1) Chemicals being transferred to organisms through anthropogenic micro-plastics that find their way into the ocean.</p>	<p>In the 3D model I would show a flow chart from the chemicals moving through each physical object/organism in the model. I would use scale as an aspect in my composition, as well to show the so-called consequences of anthropogenic causation of plastic pollution and disposal. The flow chart would show a person with a fork or straw and he will deposit it into a trash can and I will start from that until it gets all the way through to his dinner plate with an X-ray of the physical chemicals.</p>
<p>#2) Similar to number 1 above, another scientific idea presented in the article that talked about algae: is the decrease in sustainability of the overall ecosystem food chain if certain algae have issues using photosynthetic functions as a result of plastic exposure.</p>	<p>Again, using a 3D model since I think it would present a unique approach and perspective to this project, I would create a dimensional food energy web starting with a micro-plastic (obviously not being life-size) but still taking into account the scale and how important that is to the point I am making. The web would be in a linear order that cleanly shows the flow of energy and disruption that a ocean biome food web would possibly have if the algae was diminished.</p>
<p>#3) A scientific idea mentioned in the article, "Pollutants in Plastics within the North Pacific Subtropical Gyre," is that micro-plastics could be a major component of organism's diet since according to data there is more plastic than biomass (180 times on average).</p>	<p>This could be shown as a visual composition to show many fish swarming around a trash particle on the surface of the water. I could show a composition that of above water and below water with the surface having a piece of rope and a fish on the surface and some dying below the surface to represent the toxicity.</p>

## Annotated Bibliography

Geyer, Roland, et al. "Production, Use, and Fate of All Plastics Ever Made." *Science Advances*, American Association for the Advancement of Science, 1 July 2017, [advances.sciencemag.org/content/3/7/e1700782.full](https://advances.sciencemag.org/content/3/7/e1700782.full).

1. This article talks about a study involving the production of plastic, such as the materials of what goes into it, and how much it has increased in the 21<sup>st</sup> century. Then the article talks about what other countries do with the recycling plastic and how its effective. A fact from "Production, Use, and Fate of All Plastics Ever Made," is that industry production has "increased from 2 metric tons in 1950 to 380 metric tons in 2015, a compound annual growth rate of 8.4%." A scientific idea that comes from this source is the percentage of plastic accumulation in the future and how that could affect marine species (if humanity doesn't find the means to recycle).

Moore, C. J. (2008). Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. *Environmental Research*, 108(2), 131–139.  
<https://doi.org/10.1016/j.envres.2008.07.025>

2. The source "Synthetic polymers in the marine environment: A rapidly increasing, long-term threat" is a secondary source article that talks about micro-plastics affecting the oceans. One fact that was interesting to me was a quote saying that thirty years ago the plastic industry was insisting that plastics weren't a harm to the environment besides being ugly to look at. Additionally, "In all, 267 species of marine organisms worldwide are known to have been affected by plastic debris, a number that will increase as smaller organisms are assessed. A scientific idea that comes from this article is the effects of plastics continually building up on the sea floor and blocking light for smaller sea plants like algae.

Gall, S. C, and R. C Thompson. "The Impact of Debris on Marine Life." *NeuroImage*, Academic Press, 10 Feb. 2015,  
[www.sciencedirect.com/science/article/pii/S0025326X14008571](http://www.sciencedirect.com/science/article/pii/S0025326X14008571).

3. The article called "The impact of debris on marine life" by S. C. gall and R. C. Thompson talks about the results of a unique study about the encounters of marine life and marine debris. In the results section of the article, they said 340 publications were identified to have reported on these encounters, which is a fact. More facts from this article include a total of 292 publications out of the 340 report an incident of either ingestion or entanglement. A scientific idea identified in this article that is based on the statistical research, is a passageway for chemicals to be transferred from different organisms through micro-plastics in the marine debris.

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., ... Reisser, J. (2014). Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. *PLoS ONE*, 9(12), 1–15.  
<https://doi.org/10.1371/journal.pone.0111913>

4. In the article “Plastic Pollution in the World’s Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea,” the researchers talk about their study unpacking expeditions to the South Pacific, South Atlantic, Indian Ocean, and oceans around Australia. Then, using an oceanographic model of floating debris to calculate how many tons of floating debris is in the ocean. Facts in this article are the results they discovered which is an estimated 5.25 trillion plastic particles weighing 268,940 tons currently at sea. To better understand this, a minimum of 233,400 tons of larger plastic items contrasted to 35,540 tons of micro-plastics.

Tavares, D. C., da Costa, L. L., Rangel, D. F., de Moura, J. F., Zalmon, I. R., & Siciliano, S. (2016). Nests of the brown booby (*Sula leucogaster*) as a potential indicator of tropical ocean pollution by marine debris. *Ecological Indicators*, 70, 10–14.  
<https://doi.org/10.1016/j.ecolind.2016.06.005>

5. This academic journal article relates to my topic about pollution in oceans affecting ecosystems because it proves that chemicals such as the micro-plastics are creating problems. The bird, the brown booby, takes debris for nesting material and the scientists evaluated what kinds so they can monitor the type of pollutants in the water. A fact in “Nests of the brown booby (*Sula leucogaster*) As a Potential Indicator of Tropical Ocean Pollution by Marine Debris,” is that the researchers found marine debris in 61% of the brown booby nests on both islands. An idea of this article is that the impact of this debris in nests could reduce the quality of nesting habits since a form pollution is exposed at the very beginning of the organism’s life.

Tibbetts, J. H. (2015). Managing Marine Plastic Pollution. *Environmental Health Perspectives*, 123(4), A90–A93. <https://doi.org/10.1289/ehp.123-A90>

6. The source, “Managing Marine Plastic Pollution,” relates to my topic because it talks about waste management to hopefully reduce marine pollution. This article includes the main causes of pollution and the main countries responsible for ocean pollution and the degradation of sea life. A fact in this article is that the top waste producing countries are developing countries with growing populations and undeveloped waste management such as China, Indonesia, and the Philippines. An idea in this article is talking about various ways to reduce pollution in the oceans and it brings up a model by the Trash Free Seas Alliance that talks about ways to solve the plastic debris problem while factoring in the economic restraint that some of the developing countries experience.

Pitt, J. A., Kozal, J. S., Jayasundara, N., Massarsky, A., Trevisan, R., Geitner, N., ... Di Giulio, R. T. (2018). Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish (*Danio rerio*). *Aquatic Toxicology*, 194, 185–194.  
<https://doi.org/10.1016/j.aquatox.2017.11.017>

7. This source, “Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish (*Danio rerio*” . This author talks about the effects of nano-plastics in the ocean and how it is relatively new research compared to the data on micro-plastics in the ocean. A fact that is stated here is that according to the author’s research, exposure to nano-plastics altered larvae “behavior as evidenced by swimming hypoactivity in exposed larvae.” An idea that comes from this source is that in all, the author believes his data suggests that nanoplastics are able to get through the membrane of developing zebrafish larvae and concentrate in the tissues which affects physiology and behavior. This in turn might affect the organismal fitness (which is the word to describe how a particular genotype is at leaving offspring. I learned this from: [https://evolution.berkeley.edu/evolibrary/article/evo\\_27](https://evolution.berkeley.edu/evolibrary/article/evo_27) ) in its ecosystem.

#### Physical Adsorption of Charged Plastic Nanoparticles Affects Algal Photosynthesis

Priyanka Bhattacharya, Sijie Lin, James P. Turner, and Pu Chun Ke

*The Journal of Physical Chemistry C* 2010 114 (39), 16556-16561

DOI: 10.1021/jp1054759

8. This article talks about a study done on nano-plastic on two living species of algae, *Chlorella* and *Scenedesmus*. The study was also done onto a model of cellulose film. A scientific fact that comes from this article is the researchers used a CO<sub>2</sub> depletion assay to show that the absorption of the plastics rendered the algae unable to photosynthesize. A scientific idea from this article that shows up a lot in the body of the essay is that the responses of exposure to plastic could cause interruptions to the aquatic food chain.

Chen, Q., Reissner, J., Cunsolo, S., Kwadijk, C., Kotterman, M., Proietti, M., ... Koelmans, A. A. (2018). Pollutants in Plastics within the North Pacific Subtropical Gyre. *Environmental Science & Technology*, 52(2), 446–456. <https://doi.org/10.1021/acs.est.7b04682>

9. A report in “Pollutants in Plastics within the North Pacific Subtropical Gyre,” gives statistics about the chemical concentrations of floating plastic of different sizes and types and the potential risks for the marine life in the North Pacific. A fact found from this article is that “plastics may pose a chemical risk to organisms as 84% of the samples had at least one chemical.” A scientific idea that comes from this source is that plastics may play a role in transferring chemicals to marine organisms.

Forrest, A. K., & Hindell, M. (2018). Ingestion of plastic by fish destined for human consumption in remote South Pacific Islands. *Australian Journal of Maritime & Ocean Affairs*, 10(2), 81–97. <https://doi.org/10.1080/18366503.2018.1460945>

10. In “Ingestion of Plastic by Fish Destined for Human Consumption in Remote South Pacific Islands,” it talks about a study documenting plastic eaten by 24 species of fish caught and sold specifically for food in the South Pacific Islands. A fact that I found from this study is that the Gastrointestinal tracts of 126 fish were visually examined and plastic was found in 7.9% of individual fish and 25% of species.” This will be helpful for my project since it shows a cycle of pollution and back into human digestive tracts when these fish are eaten.

This is considered a scientific idea that a transfer of pollutants from these micro-plastics in the consumed fish are transferred to humans and other predators.