

# The Linear Production of Plastic and the Unintended Consequences it Poses to the Flow of Nature in Tampa Bay

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**Abstract:** *Plastic consumption continues to increase exponentially, yet there is a finite number of resources on Earth. The model of plastic production is unsustainable as plastic continues to be discarded, invading the entire world. The insufficient management of plastic waste causes plastics to storm marine systems. Marine ecosystems are immensely impacted by the pollution of plastic. Marine species directly interact with plastic debris negatively affecting their vitality. Additionally, as plastic flows through water, microplastic particles are formed. Microplastic particles carry potentially harmful organic chemicals that pose a threat to not only marine species but also humans. An increase in government involvement regarding waste reduction is needed to hold companies accountable for their own waste by shifting to a circular economy. A circular economy on a federal level would significantly reduce the stress marine environments are facing and would diminish the effects of overconsumption.*

**Keywords:** Plastic, pollution, circular economy, marine environments, microplastics

Every January in the city of Tampa, people celebrate with pirate-themed parades and festivals along the Bay for weeks. The Gasparilla Pirate Festival is a popular event that both the residents of Tampa and tourists highly anticipate. During the parades and festivals, countless boats throw pirate parade beads into the Bay, revealing a substantial lack of environmental consciousness in the city's residents. In response to this problem, Mayor Jane Castor implemented the Bead Free Bay initiative asking people to stop throwing beads into Tampa

Bay. (Patterson) Castor hopes this initiative will keep the Bay clean and encourage the residents to be more eco-friendly. Castor also hopes that this initiative will help Tampa's residents be more mindful of plastic pollution's implications on Tampa's ecosystem. Castor acknowledges, "Our Bay really defines us as a community, our river, and our Bay and it is up to us to maintain the pristine character of it for all of the marine life" (as cited in Patterson, 2019). However, when Castor was asked about the ban of single-use plastics she states, "You have to consider the ramifications of [a single-use plastic ban]. The business implications. The economics implications. So, it would be something that I would have to look into what those ramifications are... you know, the unintended consequences" (as cited in Frago, 2020). Castor's contradictory statements avoid the impending problem of plastic pollution and fails to acknowledge how urgently this problem needs to be addressed. If Castor genuinely cares about the community, she should advocate for a more sustainable city, yet she fails to take any legislative action. The initiation of the Bead Free Bay program is not enough to prevent the pollution of plastic in Tampa Bay. Castor should support the reduction of plastic in Tampa if she wants to create a better environment for her city's residents and the bay. Since the mayor of Tampa believes that it is important for the city to keep its marine life safe and its Bay clean, she should also believe that it is equally important to reduce the marine litter entering the Tampa Bay.

Tampa's residents need to take further initiative to prevent the pollution of plastics in the Bay. The Bay is filled with drifting plastic debris and plastic sediment. The introduction of this plastic debris into marine systems starts on land when it is produced in factories by corporations who distribute it to the public. Tampa's residents use the plastic distributed on land and throw away the waste later. The waste that is consumed is often discarded after only one use. After the plastic is discarded, it is frequently mismanaged on land from human activities and

consequently, ends up in the ocean. If this problem continues to be ignored, Tampa's coastal communities will continue to degrade. Castor explains that in order to protect the Bay's "pristine character" the management of plastic waste in the city of Tampa needs to change (Castor, 2019, as cited in Patterson).

The problem of plastic pollution is bigger than just Tampa Bay. It continues to be a growing problem that invades the entire world. Plastic pollution starts with the production of plastic on land eventually making its way into the marine environment through anthropogenic activities. Plastics that make their way through marine ecosystems can interact with the species that reside within them, often causing detrimental impacts on the species' vitality. Pieces of plastic get broken down into smaller particles called microplastics. These particles carry potentially harmful organic chemicals which can end up in marine organisms and even humans. The chemicals ingested through microplastics residing within the body have potentially toxic effects. Unfortunately, the current system of recycling does not prevent the further pollution of plastic. Since most plastics are not recycled, a new system needs to come into place. A waste management system centered around a circular economy would immensely reduce plastic pollution and help prevent further degradation of the ocean's ecosystems. The unproductive model of waste management needs to end locally and globally.

### **The Current Model**

The current approach to waste management is unsustainable, and the deeper problems of plastic waste disposal remain unrecognized. The present model has detrimental impacts on the environment, society, and the economy. The ongoing waste management system follows a linear structure. Companies create products intended for one-time use and are discarded immediately after. The plastic that is discarded ends up in incinerators, landfills, or the environment. This linear model produces an exhaustive amount of waste that reduces finite resources on

Earth. Not only does the current production of plastics waste finite resources, but it also produces toxic waste harmful to humans. Many plastic products contain various chemicals which can persist in the environment after being discarded. These chemicals are Persistent Organic Pollutants (POPs) which are resistant to degradation and can be harmful to humans through bioaccumulation (Andrady 1601). Bioaccumulation occurs when chemicals like POPs gradually gather in an organism's tissues through ingestion (Andrady 1601). Without proper management of plastic waste, these threats will only grow with time as the current system of plastic production continues.

### **How Plastic Enters a Marine Environment**

The threat of plastic pollution to waterways is escalating as more plastic is produced. Plastics are extremely pervasive in the ocean invading marine systems through land-based sources. These sources are "insufficient treat capacity, accidental inputs, littering, illegal dumping, and coastal human activities" (Wang et al. 8). Without proper waste management practices, plastic in the ocean will exponentially increase. When plastic is discarded and placed into an uncontrolled landfill, it is not properly treated. This allows plastic debris to leak into marine systems. Microplastic concentration increases especially when precipitation occurs. The increase of microplastics during rainfall attests to the fact that plastics from the surface enter the water when it rains (McEachern et al. 104). Additionally, coastal populations significantly contribute to marine plastic waste via littering. As one recent study notes, "Despite having robust waste management systems, the large coastal populations and very high per capita waste generation rates in these high-income countries together resulted in large amounts of mismanaged waste due only to litter (estimated 2% of waste generation) that is available to enter the ocean" (Law et al. 1). Littering from coastal populations has an immense impact on the prevention of plastic entering the marine system. Another

land-based source of plastic in the marine environment is illegal dumping. Any waste that is disposed of in an area that is not permitted to hold waste is known as illegal dumping. Items such as “ household trash, furniture, appliances, yard waste, construction and demolition waste, and automobile parts, including tires” were found at illegal dumping sites (Law et al. 5). It was estimated that the amount of known plastic waste in the marine environment caused by illegal dumping in the United States in 2016 was around 2.33% to 2.99% (Law et al. 2 ). The contribution of the illegal dumping of plastic waste is still unknown in various areas throughout the globe, making it hard to accurately estimate the rate plastic enters a marine system in this way. These land-based sources accumulate and are adding to the number of plastics found in the marine environment. Mismanaged plastic waste can enter marine systems from “inland waterways, wastewater outflows, and transport by wind or tides” (Jambeck et al. 768). Plastics are ubiquitous in the marine environment and make up the greatest percentage of marine litter. Approximately 60%- 80% of marine waste consists of plastics and is only increasing (Wang et al. 9). A total of 275 million metric tons of plastic waste was calculated to be produced by 192 coastal countries in 2010, and 4.8-12.7 million tons entered the ocean (Jambeck et al. 770). It is also estimated that plastic enters the ocean at a rate of one garbage truck per minute (Danson 7). The amount of plastic entering the ocean cannot continue at this rate while simultaneously maintaining a healthy ecosystem.

### **Plastics’ Effect on Marine Organisms**

Once plastic enters the marine environment, it poses several threats to marine organisms. Animals frequently get caught in plastic debris, harming them in numerous ways, “Entanglement of species by marine debris can cause starvation, suffocation, laceration, infection, reduce reproductive success, and mortality” (Xanthos and Walker 18). As Wang, et al., prove that

many organisms ingest plastic litter, scientists are finding the debris in various organisms' digestive systems. Over 180 species have been found to ingest plastic litter. Animals like "fish, turtles, marine birds and mammals" have all been found to ingest plastic debris (Wang et. al. 12). There is an "uneven distribution of harm" between animals and humans (Alaimo 488). Unlike animals, humans can choose to avoid excessive plastic consumption. Yet, humans continue to destroy ecosystems by refraining from more sustainable options.

Organisms end up using plastic debris found in the environment, without knowing the risk they are putting themselves under. Moreover, the environmental problem of marine plastic pollution is the only way to visually represent how much damage humans cause to the marine system. Being able to visually identify organisms being harmed by plastic debris is an important way for humans to realize they are poisoning the Earth. The rate of plastic production increases and the negative effects of pollution on marine organisms only grow.

### **Microplastics**

Recently, scientists have become interested in a different form of plastic pollution. Larger pieces of plastics are not the only threat to marine organisms. Marine organisms on the bottom of the marine trophic system ingest plastic particles called microplastics. As larger pieces of plastic continue to be dumped into waterways, they are simultaneously broken down into smaller pieces. Plastic waste is broken down until exceedingly small particles are left; these particles are called microplastics. Microplastics are ingested by various marine organisms such as: "amphipods (detritivores), lugworms (deposit feeders), barnacles (filter feeders), mussels (suspension feeders), sea cucumbers (Echinodermata), *Nephrops norvegicus* (crustacean)" (Wang et. al. 12). Consequently, since these marine organisms are on the bottom of the marine food chain, scientists believe that microplastics are transported up the food chain. This is an

urgent threat because microplastics can make their way through the entire marine trophic system. Therefore, microplastics are potentially toxic to organisms, and scientists are worried about the effects microplastics can have on marine ecosystems and even humans.

Microplastics pose a threat to the marine environment as they are potentially harmful to marine organisms. One study conducted by researchers from the University of Exeter investigates the effects microplastics have on the “feeding, function and fecundity” of marine copepods (Cole et al. 1130). Copepods are small invertebrate zooplankton that occupy the bottom of the food chain and are found ubiquitously in the marine environment. Copepods are at the bottom of the marine trophic system and can ingest microplastics. The researchers exposed the copepods to microplastic polystyrene beads. This zooplankton is an excellent way to measure what effect microplastics may have on the marine environment because the microplastics they ingest are shown to transfer up the food chain. From their analysis, the researchers found that the marine copepods exposed to microplastics ingested less food than the copepods that were not exposed to the microplastics. Some copepods exposed to the microplastics on days eight and nine of the experiment died. This is due to the lack of energy the organisms were experiencing from the reduced ingestion rate. The researchers concluded that microplastics may not only impact the survival of the copepods but also may cause harm to predators of the copepods because of their reliance on the “high lipid content” of this zooplankton for their viability (Cole et al. 1135). Since microplastics reduce the survival and the energy of the copepods, this negatively affects the marine food chain, leading to a reduced survival rate in the organisms higher up on the food chain. The predators of species that ingest microplastics, such as fish, are commercially important to humans. Fish are in high demand, feeding billions of people throughout the world. The Food and Agriculture Organization of the United Nations, an

organization that aims to improve the levels of global food security and increase the productivity of agriculture, tracks the number of fish consumed globally. The Food and Agriculture Organization emphasizes how fish consumption has been increasing in recent years, “Between 1961 and 2016, the average annual increase in global food fish consumption (3.2 percent) outpaced population growth (1.6 percent) (Figure 2) and exceeded that of meat from all terrestrial animals combined (2.8 percent)” (FAO 2). Massive rates of fishing provide a high sale value for fisheries. In 2018, 152 billion USD was earned from capture fishery production (FAO 2). Given that global fish consumption has increased significantly in the past few years, fish are an extremely important food source for humans. The introduction of microplastics into commercially valuable fish species can become a significant problem as microplastics make their way up the trophic system. The possibility that microplastics will be a detriment to marine ecosystems due to the circulation of plastics emphasizes the need to change the progressive line of its production. Plastic continues to be dumped into marine systems, impacting the natural cycle of ecosystems.

Microplastics are equally detrimental to the marine environment as larger pieces of plastics are. Just like larger plastic waste, microplastics are ubiquitous throughout waterways and are even found in the food and water we drink daily (Danson 7). The same plastic we dispose of into the ocean is making its way back into our very own bodies. Unfortunately, microplastics are very tough and it is unlikely that they can be removed from the ocean (McEachern et al. 104). It is too difficult to remove microplastic particles from the ocean, thus the concentration of microplastics in the ocean will only increase over time, making them a threat to the marine environment.

Microplastics have become an increasing interest to scientists because of their ability to absorb pollutants. Some plastics are contaminated by “persistent organic pollutants (POPs)” which absorb onto microplastics (Andrady 1601). Scientists are

worried that the pollutants absorbed by microplastics will be transferred to the organisms that ingest the microplastics. Researchers are conflicted on whether POPs are transferred by the microplastics in the organism's tissues through bioaccumulation. Studies like Batel et. al. and Avio et. al. show that microplastics absorb organic compounds, and transfer through a trophic system having negative effects on different marine organisms like adult fish and molluscs (Rodrigues et al. 257). Some studies have conflicting data, concluding that microplastics do not act as POP vectors contaminating organisms (Rodrigues et al. 258). Even though researchers had varying findings, they recognize that it is important that the transfer of POPs by microplastics is studied more extensively. Microplastics are still a source of POPs in the marine environment which raises the concern that the effects they will have on marine organisms, as well as humans, are unknown. Microplastic concentration in the oceans is only increasing. Without knowing the exact impacts microplastics will have on marine ecosystems, it is important to take preliminary steps to reduce greater amounts of microplastics entering the marine systems.

Tampa Bay is just as affected by microplastics as other cities along the water. A study conducted in 2019 measured the concentration of microplastics in Tampa Bay. The research found that the Bay contains around four billion microplastic particles (McEachern et al. 104). Tampa Bay's microplastic concentration is considerably higher than most waterways that have been previously sampled. The negative effects microplastics can pose to humans and the marine ecosystem is a substantial problem for Tampa. Tampa Bay has the largest estuary in the state of Florida, providing a habitat for numerous species. The addition of plastic waste into Tampa's waterways affects the numerous species that reside in Tampa's estuaries. The additional effect microplastics will have on the species within the bay is another reason why plastic pollution needs to be reduced to help mitigate these increasing issues. POPs are the result of a cumula-

tive linear problem that is increasingly impacting the natural environmental flow. Humans are out of step with nature, continuously producing waste that is toxic to the environment. Changing the way humans think about waste management is key; waste should be managed in a circular way rather than a linear one.

### **Recycling Is Linear, the Irony of Recycling**

Unfortunately, recycling does not help to change plastics' course in the environment. Even with recycling programs, plastics are still being produced in a linear way designed to be used once and discarded. Corporate lobbyists stress that most plastic can be recycled and argue that plastic pollution is not an urgent problem. In 2019, the United States House of Representatives held a hearing to discuss the urgent and growing environmental issue of plastic pollution. They discussed what action should be taken to reduce the detriments plastic pollution poses on the American people, and what implications would emerge from the reduction of plastic. They believe that the time is now to prevent further pollution of the ocean before the damage becomes irreversible. The recycling of plastic products is shown to be ineffective. At the hearing, Ted Danson, a Hollywood Star, and the Vice-Chair of Oceana's Board of Directors discusses why recycling does not solve the problem of plastic pollution: "Of all the plastic waste ever generated, only 9 percent has been recycled. That means the vast majority was sent to a landfill, incinerated, or ended up polluting our natural environment, including our oceans. Recycling is like trying to mop up water from an overflowing bathtub, while the faucet is still running. We need to turn off the faucet and reduce the production of plastic" (Danson 7). Danson argues that recycling will not solve the problem of plastic pollution. Most recycled plastic never ends up being reused, indicating that recycling is not a sustainable option. A fact sheet from the Environmental Protection Agency shows that only 2.96 of the 35.37 billion tons of plastic generated were recycled in 2017 (United States Environmental Protection Agency, 2). Packaging is designed to only be used

once and then immediately be discarded. This linear production of waste by companies needs to end, as it is detrimental to the flow of the marine environment. At the end of the hearing, advocates for a more sustainable waste management system proposed that a “circular economy” would solve this problem. A circular economy is designed to eliminate waste and pollution by creating more sustainable products. The key to switching to a circular economy starts with the immense mobilization of legislative action by the government. The systemic change in waste management would decrease the risk plastic pollution poses to the marine environment: “A circular economy strives to create favorable conditions for economically viable recycling, rather than developing lowest cost products that are not recycled and require expensive recycling technologies to be recovered. Instead of trying to develop end-of-the-pipe solutions, businesses must invest in creating truly circular products with the angle of preventing waste in the first place” (Pitre 61). A circular economy on a federal level would put less stress on the marine environment and would reduce the effects of overconsumption. Restructuring the economy so companies are responsible for their own waste would significantly reduce the number of plastics entering the ocean. Recycling is not an effective way to prevent the pollution of plastic. Although plastic can be recycled, most is thrown away, incinerated, or ends up in the marine environment. To prevent the further pollution of plastic in our oceans, the distribution of wasteful plastics needs to stop.

### **Circular Economy/Legislative Action**

More cleanups and recycling efforts will not solve the problem of plastic pollution. Once plastic enters a marine system, it constantly moves, passing through multiple environments and jurisdictions. This makes the legislative solutions more difficult than just mitigating a fixed source of land-based plastic production. It is expected that the amount of plastic entering the ocean will be increased exponentially by 2025 if the government does not change its current “waste management infrastructure”

(Jambeck et. al.). Companies need to design out the waste, keep materials in use, and work to protect and restore the environment. Continuing the current linear waste system will only further the pollution of materials poisoning the oceans.

In response to this rapidly increasing threat, an economy structured circularly can reduce the negative effects plastic pollution poses to humans. Through this new system, organizations change their products to become more systemically sustainable. Manufacturers would need to redesign products so they are "... sustainably designed with proven non-toxic chemicals and marketed with business models that enable cycles of: i) repair so that the user can keep the product for extended periods without it irreparably breaking down, ii) reuse such as second hand items, iii) remanufacture, using the parts to make new products, iv) recycling of the materials" (Leslie et al. 233). The benefit from mandating this change in manufacturing is immense. Packaging is redesigned so it is reusable, recyclable, and compostable making it not only environmentally sustainable but also reducing the cost of its production. Companies benefit from switching to a circular economy: "On top of toxic plastic additives, the feedstock materials needed for plastic are becoming increasingly environmentally damaging to extract from the earth and carry high external costs to society. As costs of materials for production rise relative to labour costs, the imperative for companies to explore the circular economy and associated innovative business models grows" (Leslie et al. 234). However, even with the economic incentive for companies to switch to more sustainable systems, more action is needed to drive this change. The mobilization of legislative action would be the driving factor influencing companies to convert their products into more sustainable alternatives. Not only is this switch economically beneficial to the organizations, but it would also prevent further damage to the marine environment by plastic waste.

The politicians responsible for their community need to step up and lay the foundations needed to reform the current waste management system. They need to publicly advocate for sustainable change and follow up on their promises with legislative actions. The leaders of the communities should sign bills that would push legislation toward waste reduction, and switch companies' infrastructure into a circular model. This legislation would shift the flow of plastic waste back into the industries forming them. The shift from a linear waste management model to a circular one would reduce resource depletion and waste generation for these industries. Politicians like Jane Castor need to change the way our government deals with local waste management. Establishing local land-based action against plastic waste would stop it at its sources. Regulating the amount of plastic waste before it can enter the environmental cycle of nature will reduce the circulation of toxic chemicals disrupting marine ecosystems. Changing the course of plastic debris will prevent further pollution of waterways running through jurisdictions worldwide. If plastics on the surface were regulated by the City of Tampa, less plastic would enter the waterways and the number of microplastics entering the Gulf of Mexico would decrease. As it is very unlikely for microplastics to be removed from the water, the only solution is to reduce the number of plastics entering the waterways (McEachern et al. 104). Castor's apprehensiveness to enact change is detrimental to Tampa's community. By ignoring this critical problem, Castor is subjecting her community to the unintended consequences of plastic pollution. It is time politicians start advocating for a more sustainable waste management system to help stop the threat plastic poses to the world. By helping to stop this growing issue, Tampa can reduce the threats plastics pose to its own marine environment.

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