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# Microplastics, Macro-Problems: Abundance of Man-Made Materials in the Waters and Sediments of Florida State Parks

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# Microplastics, Macro-Problems: Abundance of Man-Made Materials in the Waters and Sediments of Florida State Parks

## Cover Page Footnote

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# Microplastics, Macro-Problems: Abundance of Man-Made Materials in the Waters and Sediments of Florida State Parks

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**ABSTRACT:** Man-made materials (MMM) are pollutants introduced to the environment by human activity. Microplastics (MP) are a type of MMM that threaten living organisms through bioaccumulation. The term MMM also encompasses pollutants produced from natural materials, such as rayon and microfibrillated cellulose, which are used in food packaging. This study aims to determine the extent of MMM pollution within estuaries in two of Florida's state parks, as well as the effectiveness of using restored vegetation on shorelines to reduce MMM pollution. Tomoka State Park and Gamble Rogers State Park were selected at the request of the Florida Department of Environmental Protection. At each park, we compared MMM in sediments of replicate intertidal areas with bare sand (control) vs. sites with restored vegetation (mangroves, marshgrass). Additionally, MMM in estuarine water directly seaward of control and vegetated areas were compared. Restoration occurred two years prior to this study. MMM were extracted from sediments and water samples and then examined by microscopy. A total of 341 MMM were found; 120 were collected from water samples and 221 from sediments. More MMM (58%) of the total were found in Tomoka State Park samples. Fourier-transform infrared spectroscopy (FTIR) revealed 15% of collected samples were plastic polymers (e.g., polysulfone and polystyrene). More MMM (78) were found in Tomoka State Park water samples than in Gamble Rogers State Park water samples (42) (Kruskal-Wallis: $p = 0.05$). MMM abundance within sediments was not different between parks, or between control and restored sites (Kruskal-Wallis, all comparisons: $p > 0.26$). Our research provides the first documentation of MMM pollution, including MP pollution, in these state parks, thereby giving park managers insight on the resources they manage and the impact of human activity on conserved land.

**KEYWORDS:** plastic pollution; human impacts; anthropogenic changes; public lands; Tomoka State Park; Gamble Rogers State Park

## INTRODUCTION

Microplastics (MP) are defined as small pieces of plastic that are less than 5 millimeters in size (EPA, 2021). There are two different types, which are differentiated by how they were originally created. Primary MP are plastics that are intentionally produced at less than 5 millimeters, such as microbeads or nurdles. Secondary MP are created as the result of the fragmentation of larger plastic materials by mechanical or UV light-induced degradation (Primpke, 2018). MP shapes vary, but are categorized as fragments, pellets, microfibers, film, or foam (EPA, 2021). Fibers are primarily produced from synthetic textiles and ropes, and may be larger than 5 millimeters in length as long as they are smaller than 5 millimeters in width (EPA, 2021). Plastics can be modified with the addition of various chemicals, termed additives, that alter or improve the strength and durability of created materials. Molecularly, many of these additives are small in size and loosely bound to the polymer, which allows their chemicals to leach into the marine environment as plastics degrade (Hammer et al., 2012).

While research on MP abundance and diversity and its effects on aquatic and terrestrial ecosystems has been a prominent topic in the scientific community since the early 2000s (Thompson et al., 2004), scientists have more recently realized the importance of investigating other man-made and hybrid materials that can also be pollutants in the environment (Dris et al., 2017). Man-made materials (MMM) are made up of natural materials, such as cotton and cellulose, but are frequently altered by humans. Examples include cotton fabric that has been chemically dyed, as well as microfibrillated cellulose, a common packaging material for snacks. Hence, these materials do not occur naturally. Moreover, natural fibers have been found to collect chemical pollutants similarly to synthetic fibers that may enable these pollutants to become bioavailable sooner than synthetic ones as a result of their faster degradation process (Ladewig et al., 2015).

MP and MMM can be found in every aquatic habitat, ranging from polar regions to wetlands, and even estuaries, where coastal freshwater meets oceanic saltwater (Zhang, 2017; Rangel-Buitrago et al., 2022). MP are considered ubiquitous in marine environments since plastic materials make up the majority of marine debris, and plastic is being added to the environment faster than it can be naturally degraded (Piperagkas et al., 2019; Hinata et al., 2017). The presence of MP in the ocean was documented as early as 1972, specifically within the surface waters of the western Sargasso Sea (Carpenter & Smith, 1972). Plastic pieces with sharp ends were observed and determined to have either been recently introduced or the result of fragmentation of larger plastics (Carpenter & Smith, 1972). Shim & Thomposon (2015) revealed that the North Pacific Ocean and its adjacent seas have high levels of MP contamination compared to the global average, particularly on the western and southern coasts of Korea. These plastics may have originated from sewage discharge and aquaculture, and wind direction and currents may have influenced distribution patterns (Shim & Thomposon, 2015).

The physical processes and dynamics of estuaries contribute to the abundance of MP within them, making them "microplastic hotspots" (DeGennaro et al., 2020). A study conducted in the Mobile Bay estuary in the Gulf of Mexico found that although MP were widespread throughout the bay, estuarine areas contained significantly more MP (Wessel et al., 2016). Estuaries are also subject to inputs from diverse sources such as river and storm discharge (Zhang, 2017; Zhao et al., 2015). A recent study showed that increased urban footprint adjacent to estuaries, across a gradient from low to high land development, led to increased MP abundance (Hitchcock & Mitrovic, 2019). In the Changjiang estuary and the east China Sea, it was found that areas with the greatest amount of MP were where people often fished (Xu et al., 2018).

In Florida, researchers have documented very high loads of MP in estuaries around the state. Research conducted in 2019 revealed that Tampa Bay contained nearly 4 billion MP particles (McEachern et al., 2019). These authors recorded an average of 0.94 MP particles $L^{-1}$ of water and 280 particles/kg of surface sediment (McEachern et al., 2019). Similarly, Walters et al. (2022) estimated that the Indian River Lagoon contained 1.4 trillion MP particles, with 1.5 MP particles/L. In Manatee Bay, scientists recorded 76,000 particles $L^{-1}$ at a site during one sampling period in a 20 month-long study, which was the highest single density of polystyrene particles ever recorded (Badylak et al., 2021). This was attributed to weather conditions because May is the start of the rainy season, and thus increased freshwater influences from the land (Badylak et al., 2021).

Various types, colors, and lengths of MP and MMM are found in differing abundances in aquatic environments. In a review of 132 studies on MP in marine biota (sea birds, turtles, marine mammals, fish), fibers were the most common type of MP in 62.3% of studies, followed by fragments (25.7%), and pellets and films each at 3.5% (Ugwu et al., 2021). Other scientists have found similar patterns of MP type abundance, including studies conducted in the Indian River Lagoon that found fibers as the most common type of MP in water, followed by fragments (Walters et al., 2022; Waite et al., 2018). A significant type of MMM of interest in MMM research are fibers. Fibers are threads composed of materials used to make clothes, fishing lines, construction, and protective equipment, among other items (Iliff et al. 2020). Iliff et al. (2020) reported that benthic jellyfish can act as bioindicators of MP pollution in coastal marine ecosystems in the Florida Keys. The study found that 80% of sampled jellyfish had MP in their tissues, and μFTIR, which is a specific type of FTIR that provides information on a specific location in a particular sample, detected the presence of both synthetic and natural fibers that could be connected to human pollution (Iliff et al., 2020). Recent studies have found that fibers could be disruptive to natural processes in aquatic ecosystems, causing negative impacts such as tissue damage, reduced growth, and mortality in organisms lower on the food chain (Rebelein et al., 2021). MP fibers have also been found in multiple other benthic invertebrates, including gastropods, bivalves, crustaceans, and other cnidarians (Iliff et al., 2020). Clear and blue are commonly cited as among the most abundant colors of plastic pollutants in the ocean (Martí et al., 2020). Walters et al. (2022) found that the most abundant MP color in the Indian River Lagoon was black and the average MP length (±CI) to be 2.79 ± 0.10 mm.

MP and MMM can also be found inside vertebrates. In Central Florida, Carlin et al. (2020) studied the abundance of plastics found within the gastrointestinal (GI) tracts of birds of prey. They found that all the examined birds had MP in their GI tracts, with a mean of 11.9 MP per bird and a mean of 0.3 MP per gram of GI tract tissue (Carlin et al., 2020). In the Indian River Lagoon, Walters et al. (2022) sampled oyster reefs to examine MP abundance in *Crassostrea virginica* (Eastern oyster) tissues. They found a mean of 2.26 MP/oyster, with 70% of sampled oysters containing MP (Walters et al., 2022). However, there are many areas in Florida that are largely understudied when it comes to MP and MMM abundance and diversity. It is especially important to focus our research on public lands where large numbers of people congregate to harvest wild resources as well as appreciate nature.

On these public lands, especially the shorelines of estuaries, restoration is frequently utilized to minimize the impact of anthropogenic influences such as sea-level rise and recreational boating (Donnelly et al., 2017). One restoration method uses soft-armoring techniques such as living shoreline stabilization (LSS). LSS uses natural elements like native vegetation as an alternative to hard-armoring to increase coastal resilience (Donnelly et al., 2017). Scientists have found living shorelines to be functionally equivalent and comparable to natural vegetated shorelines (Isdell et al., 2021). Wu et al. (2020) concluded that MP were present at a higher number in the naturally vegetated areas (in surface sediments during neap tide) as opposed to the mudflat areas of the Yangtze estuary in China. They reasoned that the vegetation slows the flow of water, thereby promoting settlement out of the water column, and also by trapping particles on plant stems (Wu et al., 2020). Another study suggested that the density of planted vegetation would increase the number of MP found in sediments (Deng et al., 2020).

The objective of our research was to document MMM and MP abundance in two of Florida's estuarine state parks: Tomoka State Park and Gamble Rogers State Park. Both parks are located in northeast Florida, and are open to the public for fishing, picnicking, and walking, and thus are subject to anthropogenic influences. These parks are important nurseries for juveniles of many species (e.g., red drum, black drum, sheepshead, spotted sea trout, common snook, tarpon) that are commercially and recreationally important. To address our objective, we assessed the differences in MMM and MP in surface waters and sediments at both parks. This project also investigated the impact of shoreline stabilization (restoration) on MP accumulation. Our first hypothesis was that restored shorelines with added vegetation would accumulate more MP than eroding, sandy shorelines without vegetation. This could result from the accretion of sediment occurring with successful restoration, as well as the presence of vegetation trapping MP that may be present in the environment.

Our second hypothesis was that fibers would be the most abundant type of MMM found throughout both parks. This is because fibers are the most common MP in urban areas, which can be attributed to pollution from washing machines and the textile industry entering waterways (Singh et al., 2020). Our final hypothesis was that the waters and sediments of Tomoka State Park would contain more MMM/MP than those of Gamble Rogers State Park because Tomoka State park is closer to urban areas than Gamble Rogers, and annual visitor attendance at Tomoka is higher.

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**Vol. 15.1:** 63-75

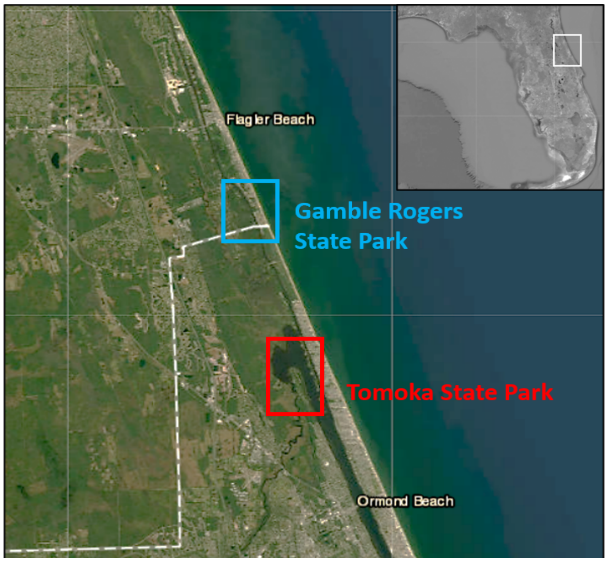
## METHODS

*Study Sites*

This study was conducted in January and February of 2022 on the shorelines of two state parks in northeast Florida: Tomoka State Park and Gamble Rogers State Park (Figure 1). Tomoka State Park (Lat, Long: 29° 19' 55" N, 81° 4' 52" W) is located in the city of Ormond Beach (2020 U.S. Census Population: 43,080) at the intersection of the Tomoka and Halifax Rivers. The park is currently on the U.S. National Register of Historic Places and is designated as an area worthy of protection and preservation, as it is the historical home of the Timucuan Native American tribe of northeast Florida. It is also part of the Indian River Lagoon watershed, which has been described as "one of the most biologically diverse estuaries in North America" (Taylor, 2011). Gamble Rogers State Park (Lat, Long: 29° 26' 13" N, 81° 6' 40" W) is located in the city of Flagler Beach (2020 U.S. Census Population: 5,160) between the Atlantic Ocean and the Intracoastal Waterway, 10.93 kilometers northeast of Tomoka State Park. Recent reports showed higher annual visitor attendance at Tomoka State Park, (166,486 individuals during the 2019-2020 fiscal year), than at Gamble Rogers State Park, (136,902 individuals in the same year) (Cutshaw, 2020). DEP Florida State Park Biologist Alice Bard requested that the University of Central Florida (UCF) quantify the abundance and diversity of MMM in these two areas. This is the first such study to occur in either of these parks.

Tomoka State Park and Gamble Rogers State Park each contained a minimum of 152 meters of shoreline restored by UCF biologists. These living shorelines included three species of mangroves (*Rhizophora mangle, Laguncularia racemosa, Avicennia germinans*), one species of marshgrass (*Sporobolus alterniflorus*), and oyster shell breakwaters to protect the vegetation. The breakwaters were made of Naltex plastic mesh and filled with 5 gallons of recycled oyster shells. Every 7.6 meters of vegetation was followed by 1.5 meters of bare shoreline referred to as "manatee gaps," which are required by the Department of Environmental Protection and U.S. Army Corps of Engineers to enable manatees to have access to shoreline vegetation. These restoration efforts were started in May of 2020. Thus, the vegetation had survived 20 months and was mature by the time of data collection for this study in January and February 2022.

**Figure 1.**
State Park locations.



*Sediment Collections*

At each park, six sites were tested for MMM abundance. Three were restored sites and three were control sites. To start at each site, a transect tape was laid across the shoreline parallel to the water. Once the length of the site was known, three locations along the transect were randomly chosen using random.org. From these three points, transect lines were laid perpendicular to the shore from the outer edge of the shell bags (Figure 2) to the ecotone where the shoreline transitioned to terrestrial flora. On each vertical transect line, seven 0.5 m x 0.5 m PVC quadrats were placed at one meter increments. Hand shovels and rulers were used to collect sediment from quadrats to a depth of 10 cm. Sediment was placed in triple-rinsed buckets (Figure 2).

**Figure 2.**
Sediment collection setup including quadrats and buckets placed along vertical transect lines.

Five liters of water from the site were added to each bucket, stirred, and then allowed to sit until the sediment settled. This allowed MMM/MP to float to the surface of the water. The water was then poured through 63-micron sieves, and forceps were used to remove any suspected MMM. MMM were then transferred to separate, labeled, triple-rinsed containers. Since both parks were considered culturally-sensitive areas, we were not allowed to remove sediment from the sites.

*Water Collection Methods*
At each of the six sites in each park, five replicate water samples were collected in triple-rinsed, one-liter screw-cap bottles. Prior to collection, each bottle was triple-rinsed with 0.45 µm filtered DI water to limit MP contamination. For all sites, the collection location was immediately seaward of the oyster shell restoration bags and was at least 0.25 m deep. Surface water was collected in all cases.

*MP Laboratory Analysis of Water*
In the laboratory, water samples were filtered with a vacuum pump through 0.45 µm gridded filter paper. Each filter paper was then placed in a petri dish for analysis under a dissecting microscope at 20 - 40X magnification. The filter paper was visually scanned and potential MMM were inspected using the Shaw Institute Microplastic Inspection Protocol (2021). Uniform color, uniform shape, clear margins, and resistance to breakage by forceps were used as common MMM characteristics. Information on MMM from water samples was recorded on data sheets, including size (mm), color, and type. Types of MMM included fragments, beads (also referred to as pellets or nurdles), fibers, film, and foam. The time (minutes) taken to analyze each sample was recorded.

*Sediment MP Laboratory Analysis*
One hundred milliliters of 0.45 µm filtered DI water was added to containers with potential MMM, and shaken. This water was poured into a vacuum pump and filtered through 0.45 µm gridded filter paper to separate MMM from containers. Analysis of particles was the same as described above.

*Contamination*
In laboratory analysis of MMM, aerial contamination could end up in samples and alter the results (Miller et al., 2021). During the microscopic analysis of our samples, five blank control filter papers were wetted with 0.45 µm filtered DI water in petri dishes and placed around the base of each microscope. After each field sample was inspected, blanks were also examined under a dissecting microscope at 20 - 40X magnification to document aerial contamination from the surrounding environment. Mean contamination rate associated with blank filters was calculated by finding the mean number of contaminants across each set of blanks and multiplying this by the exposure time in minutes per sample. This provided the contamination rate per minute for each individual sample, which was averaged across all samples to find the overall mean contamination rate per minute. This overall rate was multiplied by the amount of time each sample was exposed during microscope analysis in the laboratory, and the resulting value was then subtracted from the number of MP in each individual sample to yield a corrected MP per sample value (Craig et al., 2021).

*FTIR Analysis*
FTIR analysis, via the JASCO FT/IR-4000 Series machine with an Attenuated Total Reflectance (ATR) attachment, was performed on 25 randomly selected samples - seven from Gamble Rogers State Park and eighteen from Tomoka State Park. Samples were selected using random.org. Sample constraints for FTIR required MMM be 1 mm or larger in order to have success with transference to the machine. FTIR analysis allowed for the identification of MP polymers vs. MMM (Corami et al., 2019).

*Statistical Analysis*
Given that the data did not fit a normal distribution pattern, Kruskal-Wallis non-parametric tests were used to analyze results. In this study, four comparisons were undertaken using Kruskal-Wallis tests: 1) control vs. restored sites at Tomoka State Park, 2) control vs. restored sites at Gamble Rogers State Park, 3) water at Tomoka State Park vs. Gamble Rogers State Park, and 4) sediment at Tomoka State Park vs. Gamble Rogers State Park. We used an alpha level of 0.05 for all statistical tests.

## RESULTS

*MMM from Tomoka State Park*
Of the 181 fibers MMM found at Tomoka State Park, 60% were from sediments and 40% were from water samples (Figure 4). The types of MMM encountered included: nine fragments, with one coming from water samples, four foams, including three from sediments and one from water samples, four films, with one coming from sediments and three from water samples, and three

beads, all in water samples. The mean lengths (± SE) of MMM in Tomoka State Park water samples were 1.4 ± 0.2 mm and 1.5 ± 0.2 mm at control and restored sites, respectively. The mean lengths of MMM in sediments were 1.3 ± 0.1 mm at control sites, and 1.0 ± 0.1 mm at restored sites.

### *MMM from Gamble Rogers State Park*

A total of 131 fibers were found at Gamble Rogers State Park, with 68% from sediments and 32% from water samples. Six fragments, two foams, and three films were also found in sediments at this park. Fibers were the only type of MMM found in the water samples. The mean lengths of fiber MMM from water samples at Gamble Rogers State Park were 1.8 ± 0.3 mm at control sites and 1.7 ± 0.2 mm at restored sites. In sediments, the mean lengths of MMM were 1.3 ± 0.1 mm from control sites and 1.0 ± 0.1 mm from restored sites.

### *FTIR Analysis*

In total, 341 MMM were found (MMM Tomoka: n = 199, MMM Gamble: Rogers n = 142). Of the seven MMM samples from Gamble Rogers examined with FTIR, one was determined to be nitrile rubber, and was from the restored site sediments. Of the eighteen samples from Tomoka, two were found to be plastic. These included polysulfone and nitrile rubber (synthetic rubber derived from acrylonitrile (ACN) and butadiene). Remaining samples were other non-plastic MMM (e.g., cotton, cellulose fibers). Five fibers from blanks were tested, with one producing a plastic signal. Polystyrene was found in control blank samples, but not in field samples.

### *Contamination*

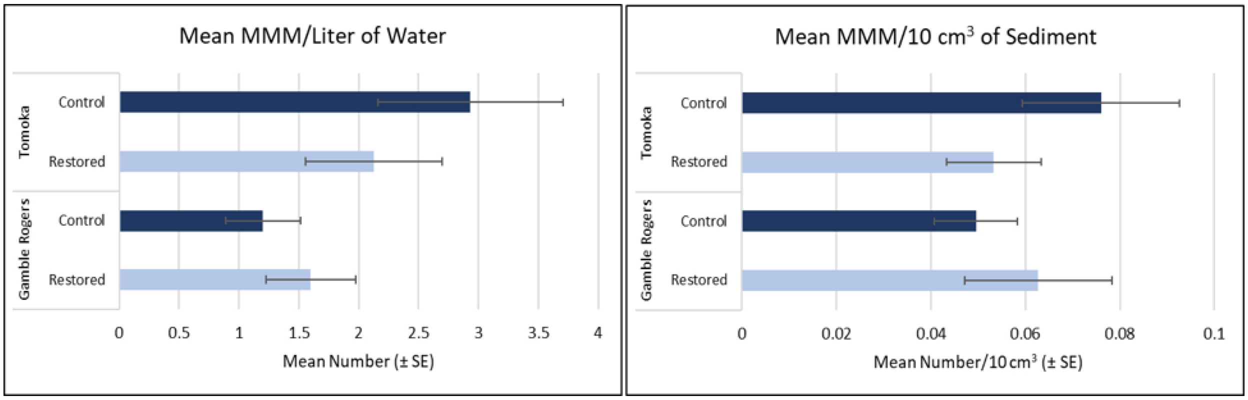
A total of 691 blank dishes were analyzed for aerial contamination. The mean contamination rate, which was used to calculate corrected MMM per sample values, was 0.038 MMM per sample. This means that one out of every 26 field samples contained a contaminant from the laboratory. For this reason, Kruskal-Wallis tests described below were run with values corrected for contamination rather than raw counts per sediment or water sample.

### *Comparisons Between Parks*

Black, clear, and blue MMM were the most common colors found at both parks (Figure 5). Our first hypothesis stated that restored sites at both parks would have more MMM than control sites. No significant difference was found between these groups in the samples from Tomoka State Park (p-value: 0.51). The second test compared MMM per sample values at Gamble Rogers State Park. There was no significant difference between these groups (p-value: 0.83).

Our second hypothesis stated that fibers would be the most abundant type of MMM found in both Tomoka State Park and Gamble Rogers State Park. Our study found 181 fibers in Tomoka State Park and 131 fibers in Gamble Rogers State Park (312 total fibers between both state parks). This means that 94.24% of all MMM found in Tomoka State Park and 92.26% of all MMM found in Gamble Rogers State Park were fibers.

**Figure 3.**
Mean MMM abundances in water and sediment at both parks.



Our third hypothesis stated that Tomoka State Park waters and sediments would contain more MMM than waters and sediments in Gamble Rogers State Park. There was no significant difference between MMM per sample values in sediment sites at Tomoka State Park to MMM per sample values at Gamble Rogers State Park, inclusive of restored and control sites (p-value: 0.26). There was a significant difference between Tomoka State Park and Gamble Rogers State Park in the MMM per sample in water samples (p-value: 0.05). At Tomoka State Park, there were 2.93 ± 0.57 MMM particles $L^{-1}$ of water at control sites, and 2.13 ± 0.77 MMM particles $L^{-1}$ of water at restored sites. At Gamble Rogers State Park, there were 1.20 ± 0.31 MMM particles $L^{-1}$ of water at control sites, and 1.60 ± 0.37 MMM particles $L^{-1}$ of water at restored sites.

## DISCUSSION

Contrary to our original expectation, MMM abundance was not greater in areas with added vegetation. As expected, fibers dominated MMM, and comprised 91.25% of all MMM across sites. Tomoka State Park had a higher total abundance of MMM in both sediment and waters than those of Gamble Rogers State Park, which suggests that our third hypothesis was correct, and that the park was influenced by a larger community that produced more MMM.

### *Control vs. Restored Sites*

We hypothesized that the restored areas would have a higher abundance of MP due to the presence of vegetation (Wu et al., 2020). However, we found similar abundances of MMM for the control and restored sites. This may be attributed to high wind speeds (~20 mph) during collection that could have homogenized the sites by redistributing any potential MP. Also, sites were located only meters apart on the same restored shorelines, which could also limit differences. Both treatments are presumably impacted on by the same external factors, such as boat wakes and human traffic. Further research must be conducted in order to fully understand the effect vegetation has on MP retention. Some studies have found that vegetated areas are sinks for MP (e.g., Wu et al., 2020), while other studies found the lowest amount of MP

**Figure 4.**
MMM abundance by type, separated into Tomoka State Park and Gamble Rogers State Park.

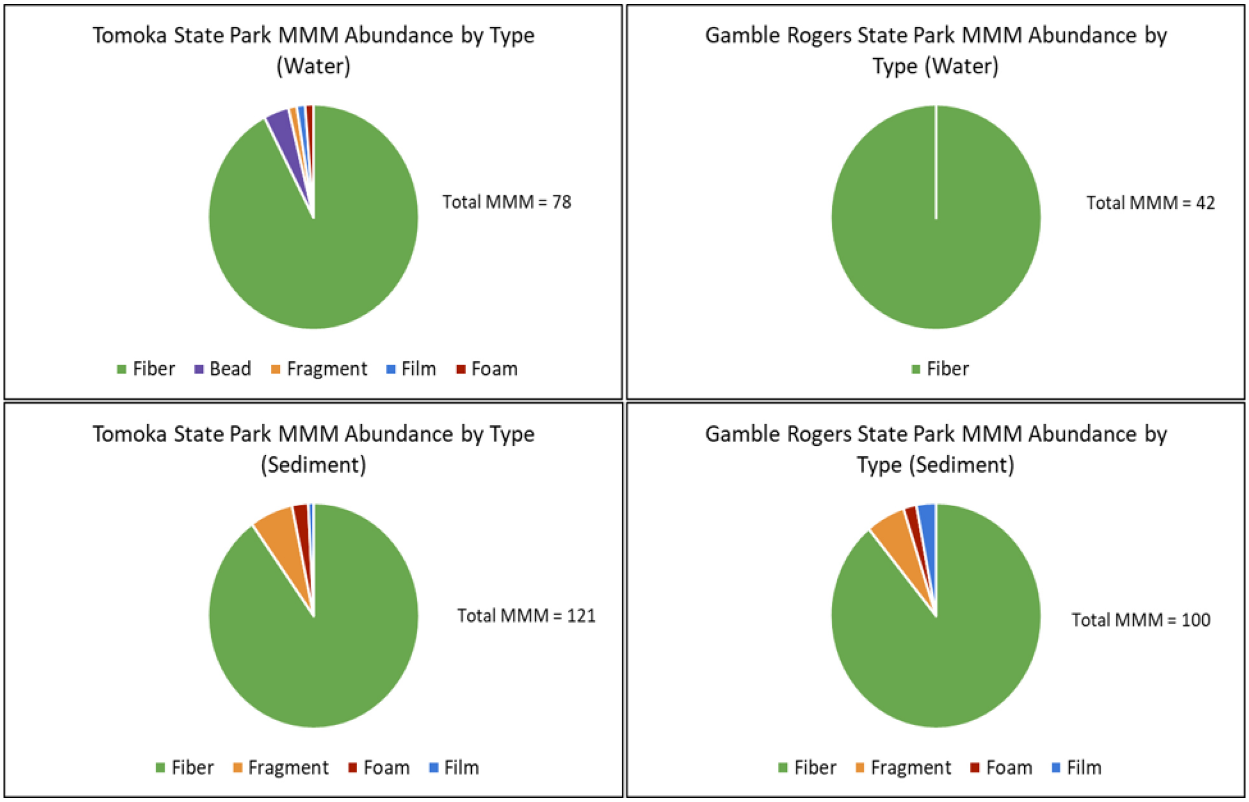
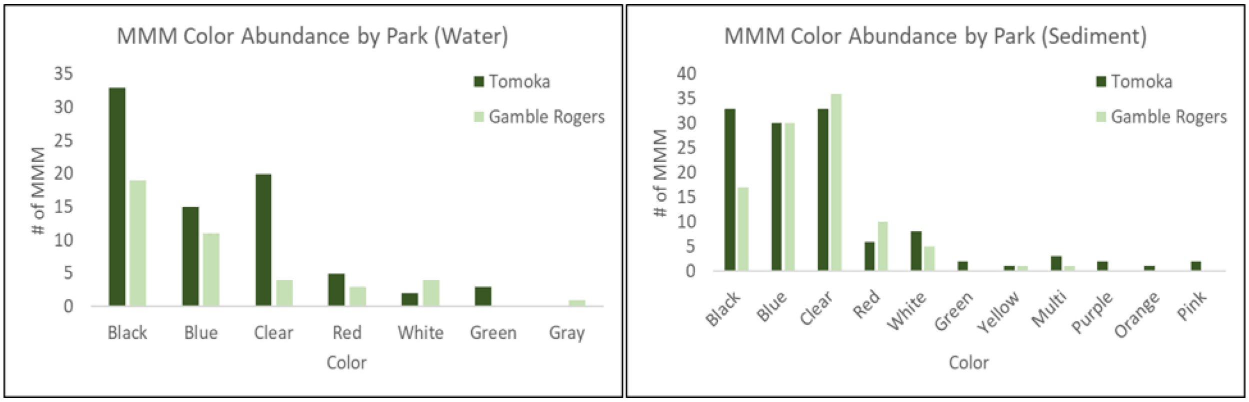


**Figure 5.**
Abundance of MMM colors at both state parks by treatment.



in a densely vegetated area compared to mudflats, channel edges, and drift lines while surveying a tidal freshwater marsh located near Washington D.C. for MP (Helcoski et al., 2020).

Two polymers were found at Tomoka State Park and Gamble Rogers State Park during our study – nitrile rubber and polysulfone. Nitrile rubber is commonly used to make seals, O-rings, hoses, and gaskets because of its ability to resist hydrocarbon fluids, such as gasoline (Mackey & Jorgensen, 2000). It is the most common material used to make fuel hoses on recreational boats (Lydecker, 1986), which could be a potential source for the samples of this material found in sediments at both parks. Nitrile rubber is also associated with medical gloves and masks, which is relevant because our data was collected during the COVID-19 pandemic. The use of personal protective equipment possibly contributed MMM pollutants to these parks. Another potential source of nitrile rubber includes car tires, entering the estuary through runoff from roads. Polysulfone has multiple industrial uses related to its high chemical and physical stability, including use in medical processes such as the controlled release of drugs and dialysis (Serbanescu et al., 2020). It also commonly makes up membranes used to treat wastewater for reuse (Richards et al., 2012). Wastewater treatment plants and septic systems have been identified as a potential source of MP in the Indian River Lagoon (Walters et al., 2022), and could be a potential source of MMM in Tomoka State Park, where the polysulfone sample was found.

### *Tomoka vs. Gamble Rogers*

Tomoka State Park had 40.14% more MMM than Gamble Rogers State Park, but the only significant difference was in the surface waters of the state parks and not within the sediments. The channel adjacent to our study sites in Tomoka State Park was 5.8 times wider than at Gamble Rogers, potentially supporting increased boating and recreational activity. According to the Volusia County Boating Activity Study Update within the County's Manatee Protection Plan, the Tomoka River and its basin were found to be the third most popular boating area in the Intracoastal Waterway (Volusia County, 2005). MP have also been found to accumulate near the inlets of wetlands (Chen et al., 2021). Gamble Rogers State Park is 1.5 km closer to its nearest inlet than Tomoka State Park, making this an unlikely determining factor for differences in MMM abundance, given that Ponce de León Inlet was 33.3 km south of Tomoka State Park, while Matanzas Inlet was 31.8 km north of Gamble Rogers State Park.

The greater amount of MMM found in Tomoka State Park could also be correlated to greater foot traffic. The Florida Department of Environmental Protection reported that the park attendance for the 2019-2020 fiscal year was 29,584 attendees higher at Tomoka State Park than at Gamble Rogers State Park, equating to a 19.5 percent difference in attendance between the parks (Cutshaw, 2020). This data supports higher pollution potential due to higher human impacts, as there is a clear connection between Tomoka State Park having a higher foot traffic and higher amounts of MMM. Fishing is known to be a large contributor to the global MP problem, as the sport and industry becomes increasingly dependent on plastic compared to natural materials (Dowarah & Devipriya, 2019). With the use of netting, fishing line, and floating bobbers, it is likely that these activities have contributed MMM to our waters. Both Tomoka State Park and Gamble Rogers State Park are

popular for recreational fishing (pers. obs.), which is a potential source for the MMM found in both parks.
One limitation of this study was that it was conducted during the winter, when state park attendance may be lower than it would have been during other parts of the year. Seasonality could have impacted the results of our study as lower attendance could equate to fewer pollutants found at our sites in January and February. On our dates of collection, daily low temperatures were from 2 and 12 °C at Tomoka State Park and Gamble Rogers State Park, respectively.

*Modified Natural Pollutants*
Modified, natural pollutants made up 85% of MMM found in our study. According to the Preferred Materials Market Report (2021), natural fibers made up 38% of global fiber production in 2020. Cotton is the second most popular fiber behind polyester, with 26 million tons produced in 2020 (Preferred Materials Market Report, 2021). Six and a half million tons of man-made cellulosic fibers were produced in 2020, making up 6.5% of global fiber production (Preferred Materials Market Report, 2021). Clothing and other textiles can shed such fibers into the environment any time they are worn or washed (Browne et al., 2011). Considering the large scale of natural fiber production, clothes made out of this material could be a major source of natural fiber pollutants in Tomoka State Park and Gamble Rogers State Park.

The dominance of fibers at our sampled water and sediment sites is consistent with findings in previous estuarine studies, including in the nearby Indian River Lagoon, located 44.7 km south of Gamble Rogers State Park and 33.3 km south of Tomoka State Park. Walters et al. (2022) found that fibers constituted 95.6% of the MP found in the Indian River Lagoon. Further research conducted by Geyer et al. (2017) revealed that synthetic fibers account for 14.5% of global plastic production by mass. The popularity of "fast-fashion" polymer-based clothing, coupled with the breakdown of polymer-based materials, has resulted in the mass quantity of plastic fibers found within natural systems globally (Suaria et al., 2020). Additionally, many of these plastic and natural fibrous materials contain colored dyes, which can be toxic to animals if released into the water (Halstead et al., 2017).

Twelve different colors of MMM were found, potentially implying that these materials come from different pollution sources, including wastewater treatment, stormwater runoff, and industrial drainage (Xu et al., 2021; Carlin et al., 2020). The most common MMM colors found in both state parks were black, clear, and blue. A study by Gray et al. (2018) that focused on two South Carolina estuaries identified the same three dominant MP colors. Polymers found in our study included nitrile rubber, polysulfone, and polystyrene. One possible source for black MMM is the degradation of tires creating tire fragments (Gray et al., 2018).

*Limitations and Future Directions*
We were required to leave all sediment at the state parks due to their status as protected areas, which prevented laboratory analysis of the sediment. This could have influenced the results of the statistical tests used to answer our hypotheses, as we only collected samples large enough to be visible to the naked eye. We were able to take water samples out of the parks for laboratory analysis, which could have provided more counts of MMM from our study sites than the sediments did.

Future research should look into the difference in sources between MMM and MP specifically, as well as if they have similar effects on biotic communities. It could also be useful to determine if there is a difference between MMM abundance in state parks at different times of year, since our samples were only collected during the winter in January and February. MMM abundances could be higher during the spring and summer seasons, since the parks have higher foot traffic during these times compared to the rest of the year, possibly leading to an increase in pollution. Additionally, runoff during the rainy season could flush more material from the land and impervious surfaces into these estuaries.

## CONCLUSION

Our original objectives were to document MP abundance along popular estuarine shorelines in two state parks in northeast Florida, and understand if shoreline vegetation acted as a trap for MMM. We found that 1) shoreline vegetation did not act as a trap for MMM in our study, 2) fibers were by far the most common type of MMM in these parks, and 3) more MMM were found in the waters of Tomoka State Park than Gamble Rogers State Park. Although only 15% of our samples were MP, the presence of other man-made materials still points toward the effect of human activities and pollutants on studied areas.

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## REFERENCES

Badylak, S., Phlips, E., Batich, C., Jackson, M., & Wachnicka, A. (2021). Polystyrene microplastic contamination versus microplankton abundances in two lagoons of the Florida Keys. *Scientific Reports*, *11*(1), 6029. https://doi.org/10.1038/s41598-021-85388-y

Bailey, K., Sipps, K., Saba, G. K., Arbuckle-Keil, G., Chant, R. J., & Fahrenfeld, N. L. (2021). Quantification and composition of microplastics in the Raritan Hudson Estuary: Comparison to pathways of entry and implications for fate. *Chemosphere*, *272,* 129886. https://doi.org/10.1016/j.chemosphere.2021.129886

Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of microplastic on shorelines worldwide: Sources and sinks. *Environmental Science & Technology*, *45*(21), 9175-9179. https://doi.org/10.1021/es201811s

Carpenter, E. J., & Smith, K. L. (1972). Plastics on the Sargasso Sea Surface. *Science*, *175*(4027), 1240-1241. https://doi.org/10.1126/science.175.4027.1240

Carlin, J., Craig, C., Little, S., Donnelly, M., Fox, D., Zhai, L., & Walters, L. (2020). Microplastic accumulation in the gastrointestinal tracts in birds of prey in Central Florida, USA. *Environmental Pollution, 264,* 114633. https://doi.org/10.1016/j.envpol.2020.114633

Chen, Y., Li, T., Hu, H., Ao, H., Xiong, X., Shi, H., & Wu, C. (2021). Transport and fate of microplastics in constructed wetlands: A microcosm study. *Journal of Hazardous Materials*, *415*, 125615. https://doi.org/10.1016/j.jhazmat.2021.125615

Corami, F., Rosso, B., Bravo, B., Gambaro, A., & Barbante, C. (2019). A novel method for purification, quantitative analysis and characterization of microplastic fibers using Micro-FTIR. *Chemosphere*, *238*, 124564. https://doi.org/10.1016/j.chemosphere.2019.124564

Craig, C., Fox, D.W., Zhai, L., & Walters, L.J. (2021). In-situ microplastic egestion efficiency of the eastern oyster *Crassostrea virginica*. *Marine Pollution Bulletin*, *178*, 113653.
https://doi.org/10.1016/j.marpolbul.2022.113653

Cutshaw, S. A. (2020). Economic Impact Assessment: Florida State Park System. Florida Department of Environmental Protection. https://floridadep.gov/sites/default/files/2019-2020%20EIA%20Report%20FINAL%20and%20COVER%20MEMO.pdf

DeGennaro, G., & Klos, P.Z. (2020). Identifying microplastic accumulation hotspots in sediment associated with stream outflows into lakes and estuaries. *AGU Fall Meeting Abstracts*. https://ui.adsabs.harvard.edu/abs/2020AGUFMH182...01D/abstract

Deng, J., Guo, P., Zhang, X., Su, H., Zhang, Y., Wu, Y., & Li, Y. (2020). Microplastics and accumulated heavy metals in restored mangrove wetland surface sediments at Jinjiang Estuary (Fujian, China). *Marine Pollution Bulletin, 159*, 111482. https://doi.org/10.1016/j.marpolbul.2020.111482

Donnelly, M., Shaffer, M., Connor, S., Sacks, P., & Walters, L. (2017). Using mangroves to stabilize coastal historic sites: Deployment success versus natural recruitment. *Hydrobiologia*, *803*, 389-401. https://doi.org/10.1007/s10750-017-3155

Dowarah, K. & Devipriya, S. P. (2019). Microplastic prevalence in the beaches of Puducherry, India and its correlation with fishing and tourism/recreational activities. *Marine Pollution Bulletin*, *148*, 123-133. https://doi.org/10.1016/j.marpolbul.2019.07.066

Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., & Tassin, B. (2017). A first overview of textile fibers, including microplastics, in indoor and outdoor environments. *Environmental Pollution*, *221*, 453-458. https://doi.org/10.1016/j.envpol.2016.12.013

Environmental Protection Agency. (2021). EPA's Microplastic Beach Protocol. *EPA.gov*. https://www.epa.gov/trash-free-waters/epas-microplastic-beach-protocol

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, *3*(7), 1700782. https://doi.org/10.1126/sciadv.1700782

Gray, A. D., Wertz, H., Leads, R. R., & Weinstein, J. E. (2018). Microplastic in two South Carolina estuaries: Occurrence, distribution, and composition. *Marine Pollution Bulletin*, *128*, 223-233. https://doi.org/10.1016/j.marpolbul.2018.01.030

Halstead, J., Smith, J.A., Carter, E.A., Lay, P.A., & Johnston, E.L. (2017). Assessment tools for microplastics and natural fibres ingested by fish in an urbanised estuary. *Environmental Pollution, 234*, 552-561. https://doi.org/10.1016/j.envpol.2017.11.085

Hammer, J., Kraak, M. H. S., & Parsons, J. R. (2012). Plastics in the marine environment: The dark side of a modern gift. *Reviews of Environmental Contamination and Toxicology*, *220*, 1-44. https://doi.org/10.1007/978-1-4614-3414-6_1

Helcoski, R., Yonkos, L. T., Sanchez, A., & Baldwin, A. H. (2019). Wetland soil microplastics are negatively related to vegetation cover and stem density. *Science Direct*, *256*, 113391.
https://doi.org/10.1016/j.envpol.2019.113391

Hinata, H., Mori, K., Ohno, K., Miyao, Y., & Tomoya, K. (2017). An estimation of the average residence times and onshore-offshore diffusivities of beached microplastics based on the population decay of tagged meso- and macrolitter. *Marine Pollution Bulletin*, *122*(1-2), 17-26. https://doi.org/10.1016/j.marpolbul.2017.05.012

Hitchcock, J. N., & Mitrovic, S. M. (2019). Microplastic pollution in estuaries across a gradient of human impact. *Environmental Pollution*, *247*, 457-466. https://doi.org/10.1016/j.envpol.2019.01.069

Isdell, R. E., Bilkovic, D. M., Guthrie, A. G., Mitchell, M. M., Chambers, R. M., Leu, M., & Hershner, C. (2021). Living shorelines achieve functional equivalence to natural fringe marshes across multiple ecological metrics. *PeerJ*, *9*, 11815. https://doi.org/10.7717/peerj.11815

Iliff, S.M., Wilczek, E.R., Harris, R.J., Bouldin, R., & Stoner, E.W. (2020). Evidence of microplastics from benthic jellyfish (Cassiopea xamachana) in Florida estuaries. *Marine Pollution Bulletin*, *159*, 111521. https://doi.org/10.1016/j.marpolbul.2020.111521

Kleinschmidt, J. M., & Janosik, A. M. (2021). Microplastics in Florida, United States: A case study of quantification and characterization with intertidal snails. *Frontiers in Ecology and Evolution*, *9*, 645727. https://doi.org/10.3389/fevo.2021.645727

Ladewig, S. M., Shaowu, B., & Chow, A. T. (2015). Natural fibers: A missing link to chemical pollution dispersion in aquatic environments. *Environmental Science & Technology*, *49* (21), 12609-12610. https://doi.org/10.1021/acs.est.5b04754

Leslie, H. A., van Velzen, M. J. M., Brandsma, S. H., Vethaak, A. D., Garcia-Vallejo, J. J., & Lamoree, M. H. (2022). Discovery and quantification of plastic particle pollution in human blood. *Environment International*, *163*, 107199. https://doi.org/10.1016/j.envint.2022.107199

Lydecker, R. (1986). Reducing fuel costs: A guide for recreational boating. https://repository.library.noaa.gov/view/noaa/38803

Mackey, D. & Jorgensen, A. H. (2000). Nitrile rubber. *Kirk-Othmer Encyclopedia of Chemical Technology*, (Ed.). https://doi.org/10.1002/0471238961.1409201813010311.a01

McEachern, K., Alegria, H., Kalagher, A. L., Hansen, C., Morrison, S., & Hastings, D. (2019). Microplastics in Tampa Bay, Florida: Abundance and variability in estuarine waters and sediments. *Marine Pollution Bulletin*, *148*, 97-106. https://doi.org/10.1016/j.marpolbul.2019.07.068

Miller, E., Sedlak, M., Lin, D., Box, C., Holleman, C., Rochman, C., & Sutton, R. (2021). Recommended best practices for collecting, analyzing, and reporting microplastics in environmental media: Lessons learned from comprehensive monitoring of San Francisco Bay. *Journal of Hazardous Materials*, *409*, 124770. https://doi.org/10.1016/j.jhazmat.2020.124770

Piperagkas, O., Papageorgiou, N., & Karakassis, I. (2019). Qualitative and quantitative assessment of microplastics in three sandy Mediterranean beaches, including different methodological approaches. *Estuarine, Coastal and Shelf Science*, *219*, 169-175. https://doi.org/10.1016/j.ecss.2019.02.016

Primpke, S., Wirth, M., Lorenz, C., & Gerdts, G. (2018). Reference database design for the automated analysis of microplastic samples based on Fourier transform infrared (FTIR) spectroscopy. *Analytical and Bioanalytical Chemistry 410*(21), 5131-5141. https://doi.org/10.1007/s00216-018-1156-x

Pruter, A. T. (1987). Sources, quantities and distribution of persistent plastics in the marine environment. *Marine Pollution Bulletin*, *18*(6), 305-310. https://doi.org/10.1016/S0025-326X(87)80016-4

Rangel-Buitrago, N., Williams, A.T., Neal, W.J., Gracia, C.A., & Micallef, A. (2022). Litter in coastal and marine environments. *Marine Pollution Bulletin*. *177*, 113546. https://doi.org/10.1016/j.marpolbul.2022.113546

Rebelein, A., Int-Veen, I., Kammann, U., & Scharsack, J.P. (2021). Microplastic fibers — Underestimated threat to aquatic organisms? *Science of The Total Environment*. *777*, 146045. https://doi.org/10.1016/j.scitotenv.2021.146045

Richards, H., Baker, P., & Iwuoha, E. (2012). Metal nanoparticle modified polysulfone membranes for use in wastewater treatment: A critical review. *Journal of Surface Engineered Materials and Advanced Technology*, *2*(3A), 183-193. https://doi.org/10.4236/jsemat.2012.223029

Shim, W. J. & Thomposon, R. C. (2015). Microplastics in the ocean. *Archives of Environmental Contamination and Toxicology*, *69*(3), 265-268. https://doi.org/10.1007/s00244-015-0216-x\

Singh, R. P., Mishra, S., & Das, A. P. (2020). Synthetic microfibers: Pollution toxicity and remediation. *Chemosphere*, *257*, 127199. https://doi.org/10.1016/j.chemosphere.2020.127199

Serbanescu, O. S., Voicu, S. I., & Thakur, V. K. (2020). Polysulfone functionalized membranes: Properties and challenges. *Materials Today Chemistry*, *17*, 100302. https://doi.org/10.1016/j.mtchem.2020.100302

Suaria, G., Achtypi, A., Perold, V., Lee, J. R., Pierucci, A., Bornman, T. G., Aliani, S., & Ryan, P. G. (2020). Microfibers in oceanic surface waters: A global characterization. *Science Advances*, *6*(23), eaay8493. https://doi.org/10.1126/sciadv.aay8493

Taylor, D. S. (2011). Removing the sands (sins?) of our past: Dredge spoil removal and saltmarsh restoration along the Indian River Lagoon, Florida (USA). *Wetlands Ecology and Management*, *20*(3), 213-218. https://doi.org/10.1007/s11273-011-9236-0

Textile Exchange. (2021). *Preferred Materials Market Report 2021*. https://textileexchange.org/app/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G, McGonigle, D., & Russell, A.E. (2004). Lost at sea: Where is all the plastic? *Science*, *304*(5672), 838-838. https://doi.org/10.1126/science.1094559

Ugwu, K., Herrera, A., & Gómez, M. (2021). Microplastics in marine biota: A review. *Marine Pollution Bulletin*. *169*, 112540. https://doi.org/10.1016/j.marpolbul.2021.112540

United States Census Bureau. (2020). *QuickFacts: Flagler Beach*. https://www.census.gov/quickfacts/fact/table/flaglerbeachcityflorida,ormondbeachcityflorida/PST045221

United States Census Bureau. (2020). *QuickFacts: Ormond Beach*. https://www.census.gov/quickfacts/fact/table/ormondbeachcityflorida/PST045221

Volusia County. (2005). Phase II Manatee Protection Plan for Volusia County. *Volusia.org*. https://www.volusia.org/core/fileparse.php/6333/urlt/MPPPart4-508.pdf

Walters, L.J., Craig, C., Dark, E., Wayles, J., Encomio, V., Coldren, G., Sailor-Tynes, T., Fox, D.W., & Zhai, L. (2022). Quantifying spatial and temporal trends of microplastic pollution in surface water and in the eastern oyster Crassostrea virginica for a dynamic Florida estuary. *Environments*, *9*, 131. https://doi.org/10.3390/environments9100131

Wessel, C. C., Lockridge, G. R., Battiste, D., & Cebrian, J. (2016). Abundance and characteristics of microplastics in beach sediments: Insights into microplastic accumulation in northern Gulf of Mexico estuaries. *Marine Pollution Bulletin*, *109*(1), 178-183. https://doi.org/10.1016/j.marpolbul.2016.06.002

Wu, F., Pennings, S. C., Tong, C., & Xu, Y. (2020). Variation in microplastics composition at small spatial and temporal scales in a tidal flat of the Yangtze Estuary, China. *Science of The Total Environment*, *699*, 134252. https://doi.org/10.1016/j.scitotenv.2019.134252

Xu, P., Peng, G., Su, L., Gao, Y., Gao, L., & Li, D. (2018). Microplastic risk assessment in surface waters: A case study in the Changjiang estuary, China. *Marine Pollution Bulletin*, *133*, 647-654. https://doi.org/10.1016/j.marpolbul.2018.06.020

Zhang, H. (2017). Transport of microplastics in coastal seas. *Estuarine, Coastal and Shelf Science*, *199*, 74-86. https://doi.org/10.1016/j.ecss.2017.09.032

Zhao, S., Zhu, L., & Li, D. (2015). Microplastic in three urban estuaries, China. *Environmental Pollution*, *206*, 597-604. https://doi.org/10.1016/j.envpol.2015.08.027