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Comparing quantity of marine debris to loggerhead sea turtle (*Caretta caretta*) nesting and non-nesting emergence activity on Jekyll Island, Georgia, USA

Jeannie Miller Martin[a,*], Jenna R. Jambeck[b], Breanna L. Ondich[a], Terry M. Norton[a]

[a] Georgia Sea Turtle Center, 214 Stable Rd, Jekyll Island, GA 31527, USA
[b] University of Georgia College of Engineering, 597 DW Brooks Drive, Athens, GA 30602, USA

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ABSTRACT

Marine debris is defined as any manmade item, commonly plastics, which ends up in the ocean regardless of the source. Debris found along coastlines can cause harm or even death to nesting and hatchling sea turtles through ingestion, entrapment, or entanglement. Jekyll Island is a prominent nesting beach for loggerhead sea turtles with over 1700 emergences from 2012 to 2017. This study uses debris logged through NOAA's Marine Debris Tracker and loggerhead sea turtle nesting activity on Jekyll Island to generate density maps and evaluate possible interactions. These maps provide valuable information on portions of the coast most at risk for debris and sea turtle interactions. Using these maps help the GSTC Marine Debris Initiative focus citizen science efforts in high overlap areas of the beach. With marine debris being a global issue that impacts all sea turtle and beach nesting species, lessons learned can be applied across a wide range of taxa and management strategies.

1. Introduction

Marine debris is now known to have affected 663 species of wildlife, which is a 40% increase from only 247 species reported in 1997 (Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel-GEF, 2012; Laist, 1997). Marine debris can come in many forms such as wood, paper, fabric, glass, metal, and plastic. Some of these items, like paper and wood, can biodegrade over a period of time, but others like glass and plastic do not. Plastic is considered to be one of the leading products likely to become marine debris since it is an inexpensive material and used so widely in packaging and single use items. This likelihood is realized as it is the material most commonly removed from the beach (Derraik, 2002).

Marine debris can be a fatal threat to sea turtles. Sea turtles can mistake marine debris as food, such as a plastic bag resembling a jellyfish (Schuyler et al., 2012). Some marine debris, like derelict fishing gear, can entangle sea turtles as well (Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel-GEF, 2012). Debris found along the coast can be sourced as washback, debris coming in or returning from the ocean, or land-based debris, debris coming from terrestrial sources. In densely populated or highly visited areas, recreationalists are a major contributor to land-based debris. For example, 62% of the debris observed in Halifax Harbor in Canada, an area with high levels of tourism, originated from recreation or some form of land-based source (Derraik, 2002).

Jekyll Island is located along the coast of Georgia, and is one of four barrier islands accessible to the public by vehicle in the state of Georgia. Over 1,000,000 people visit the island each year (Jekyll Island Authority Annual Report, 2015). Loggerhead sea turtles (*Caretta caretta*) are the primary nesting species on Jekyll Island, depositing 637 out of 638 total nests from 2012 to 2015. Green (*Chelonia mydas*) and Leatherback (*Dermochelys coriacea*) sea turtles nest occasionally but have only been responsible for fewer than five nests from 2007 to 2017Jekyll Island Sea Turtle Nest Monitoring Program, 2012–2017). Loggerhead sea turtles are listed as threatened under the Endangered Species Act (Endangered Species Act, 1973) and are currently listed as endangered by the Georgia Department of Natural Resources (Georgia Department of Natural Resource, O.C.G.A. 391-4-10-09). Loggerheads are considered opportunistic carnivores, and a species highest at risk of marine debris consumption, especially if the debris is encrusted with eggs or barnacles (Lutcavage et al., 1997; Frick et al., 2009; Plotkin and Amos, 1990). This has been seen throughout the world. In the Western Mediterranean Sea of the Tuscany and Sardinia coasts, debris in the gastrointestinal tract was observed in 60 of 175 loggerheads (Tomas et al., 2002; Camedda et al., 2014). In the Adriatic Sea, 19 of 54 loggerheads had ingested debris, with 68.4% of these findings consisting of

* Corresponding author.
E-mail address: jeanniem@jekyllisland.com (J.M. Martin).

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plastic (Lazar and Gračan, 2011).

Marine debris impacts can be fatal or non-fatal. Gastrointestinal impaction and entanglements are the most prevalent causes of marine-debris-based fatalities. The most frequent non-fatal impacts include nutritional dilution and low glucose concentrations resulting in lower energy or absorbing toxins (Hoarau et al., 2014). Plastic fragments are another type of debris that can cause serious threats sea turtles by resembling food to all age classes of sea turtles. Plotkin and Amos (1990) found that 60 of 111 turtles necropsied had some form of marine debris in their stomachs or gastrointestinal tract. A majority of debris found in loggerhead stomachs is some form of plastic debris (Lazar and Gračan, 2011; Hoarau et al., 2014; Campani et al., 2013; Tomas et al., 2002) with percentages reaching as high as 99% (Moore et al., 2001), particularly plastic sheeting which could resemble jellyfish, a popular food source for sea turtles (Campani et al., 2013). Bjorndal (1997) suggested that the ingestion of debris could have long term effects on the populations of sea turtles through decreasing growth rates, fertility, and sexual development, which could one day cause the population to be at an even greater risk.

Shoreline debris also poses a threat to not only nesting sea turtles (Zavaleta-Lizàrraga and Morales-Màvil, 2013) but also hatchlings (Triessnig et al., 2012; Burger and Gochfeld, 2014; Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel-GEF, 2012; Laist, 1997; Tomillo et al., 2010). This debris could lead to a non-nesting emergence of a nesting sea turtle, or trap a hatchling crawling to the sea. Debris has been shown to be a major problem hindering hatchlings from reaching the ocean (Triessnig et al., 2012; Tomillo et al., 2010; Burger and Gochfeld, 2014). Triessnig et al. (2012), found that hatchling sea turtles had the most trouble when encountering debris on their way to the water. Most of the hatchlings would not try to avoid the debris but would continue crawling straight becoming trapped, sometimes permanently. When encountering an open container, 84% of the 44 hatchlings became trapped (Triessnig et al., 2012). These trapped hatchlings would continue forward, pushing against the wall of the container never escaping. Styrofoam cups had the same effect trapping 41% of hatchlings. The remaining 59% were able to escape the cup but spent an average of 1.4 min in the cup (Triessnig et al., 2012). This period of time also extends the amount of exposure to predators making them more susceptible to predation, Triessnig et al. (2012). Fishing line clumps and forms a net-like structure that can easily entangle not only hatchling but also nesting sea turtles. During a three year study in the northwestern Gulf of Mexico, 30 of 400 sea turtles that were reported stranded were entangled in some form of fishing gear (Plotkin and Amos, 1990). An indirect impact to sea turtle populations can come from alterations to nest temperatures during egg incubation. Plastic presence inside the egg chamber can alter the incubation environment, and disrupt natural sex ratios (Carson et al., 2011).

Direct debris removal by citizen science volunteers can reduce the impacts of marine debris, while engaging community members in meaningful service to the conservation community. Citizen science programs can be mutually beneficial providing managers with critical data and infrastructure, while also provided volunteers technical training and providing them opportunities to be more engaged in community development (Pollock and Whitelaw, 2005). In this study, the Georgia Sea Turtle Center's (GSTC) Marine Debris Initiative uses citizen science generated data to compare the quantity of shoreline debris on Jekyll Island to the nesting activity of loggerhead sea turtles.

2. Materials and methods

Jekyll Island was separated into 15 one-kilometer zones based along the sandy shoreline. These zones were used as identifiers for both marine debris collection and sea turtle nest monitoring. Data on marine debris were collected with the NOAA Marine Debris Program mobile application, Marine Debris Tracker, a participatory sensing device for collection of scientific and citizen science data (Jambeck and Johnsen, 2015). Citizen Scientists used the app during marine debris clean ups, allowing for data on debris item and location (GPS coordinates of latitude and longitude) to be recorded. Citizen science survey effort was attempted to be distributed evenly, however, volunteers with limited mobility, volunteer group scheduling and beach accessibility due to tides led to zones nine and 15 being monitored slightly more frequently due to their ease of access.

Data collected from December 6, 2012 to December 29, 2015 along the 15.5 km shoreline of Jekyll Island were downloaded from the Marine Debris Tracker database for review. Data not collected on the beach with no potential for interaction with actively nesting sea turtles, defined as within 121 m of the shoreline, were excluded. Logged debris was sorted into eight categories: cloth, fishing gear, glass, metal, paper and lumber, rubber, plastic, and other. Items classified as “other” were materials of undetermined origin. Plastic debris was further separated into the following categories: plastic or foam fragments, cigarettes, fireworks, plastic food wrappers, plastic bottles or container caps, plastic bags, plastic bottles, Styrofoam packaging, tobacco packaging or lighters, straws, foam/plastic cups, plastic toys, balloon/balloon strings.

Sea turtle nesting and non-nesting activity data were collected by the GSTC's research team during sea turtle nesting season (May 1, 2012 to August 31, 2015) (Georgia Sea Turtle Center, unpublished data). For the purpose of this study sea turtle activity was categorized as a nesting emergence, or non-nesting emergence. A nesting emergence was when the sea turtle emerged from the ocean and successfully laid a complete nest. A non-nesting emergence was when the sea turtle emerged from the ocean, but returned to the water prior to successfully laying a nest. The authors then created density heat maps overlaying marine debris and sea turtle nesting activity results were created using Quantum GIS 2.6 (QGIS Developmental Team, 2014).

3. Results

From 2012 to 2017, 12,214 pieces of debris were logged along the shoreline of Jekyll Island with 85% (n = 10,382) plastics, 5% (n = 611) metal, 4% (n = 489) paper and lumber, 3% (n = 366) fishing gear, 1% (n = 122) each of cloth, glass and other (Fig. 1). 85% (n = 10,382) of the pieces logged were plastics. Of the plastic items recorded, 39% (n = 4049) were cigarettes, 20% (n = 2076) were plastic or foam fragments, 10% (n = 1038) were fireworks, 9% (n = 934) were plastic food wrappers, 6% (n = 623) each of plastic bags and plastic bottles, 2% (n = 208) were straws, and 1% (n = 104) each of Styrofoam packaging, tobacco packaging or lighters, plastic cups, plastic toys and balloons and or balloon strings (Fig. 2). Debris was found in all 15 zones of Jekyll Island's beach with the highest debris density being located in Zones eight and nine.

Sea turtle nesting activity was spread throughout 12 of the 15 zones with no nesting found in zones three, four, and five. Nesting activity was distributed widely throughout the remaining zones. Non nesting emergences occurred in all 15 zones with high concentrations occurring in zones six, seven, and 12. When debris and nesting density were compared, there was a higher concentration of both in zone eight. High quantities of debris and a low number of nests were found in Zone nine. The remaining areas with higher concentrations of nests had lower quantities of debris (Fig. 3). The comparison of debris to non-nesting emergences did not show any consistency between debris quantity and non-nesting emergences. The highest areas of non-nesting emergence were in some of the areas with lower quantities of marine debris (Fig. 4).

4. Discussion

The debris found along the coast of Jekyll Island was a mixture of washback debris and debris left behind by visitors. Zones eight and nine were the most visited areas of the island due to the ease of access and

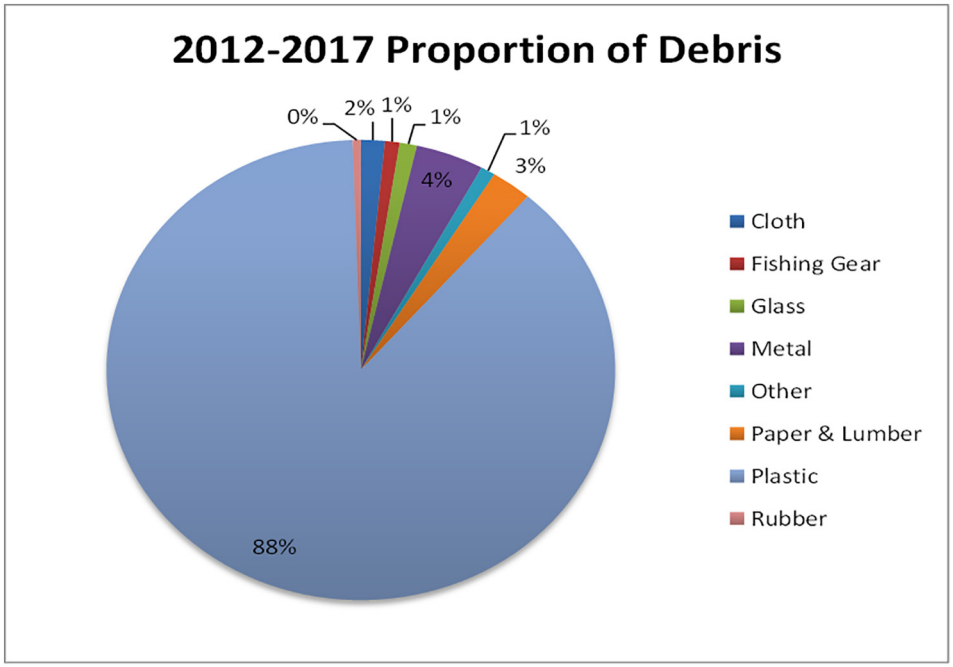

Fig. 1. Analysis of marine debris found on Jekyll Island, Georgia, USA (2012–2017): Of all debris found on Jekyll Island, plastics created the largest percentage at 88%. This was followed by metal, paper and lumber, and cloth.

availability of water fountains and restrooms, which is one possible reason for the high volume of debris in these zones. Sea turtle activity was common in these areas, but it did not appear that debris was causing concerns for sea turtles nesting. Zones three, four, and five, had no nesting activities and few non nesting emergences contains a rock wall. This barrier likely prevents both marine debris accumulation and sea turtle nesting activity.

It is highly likely that hatchlings and nesting sea turtle risk from

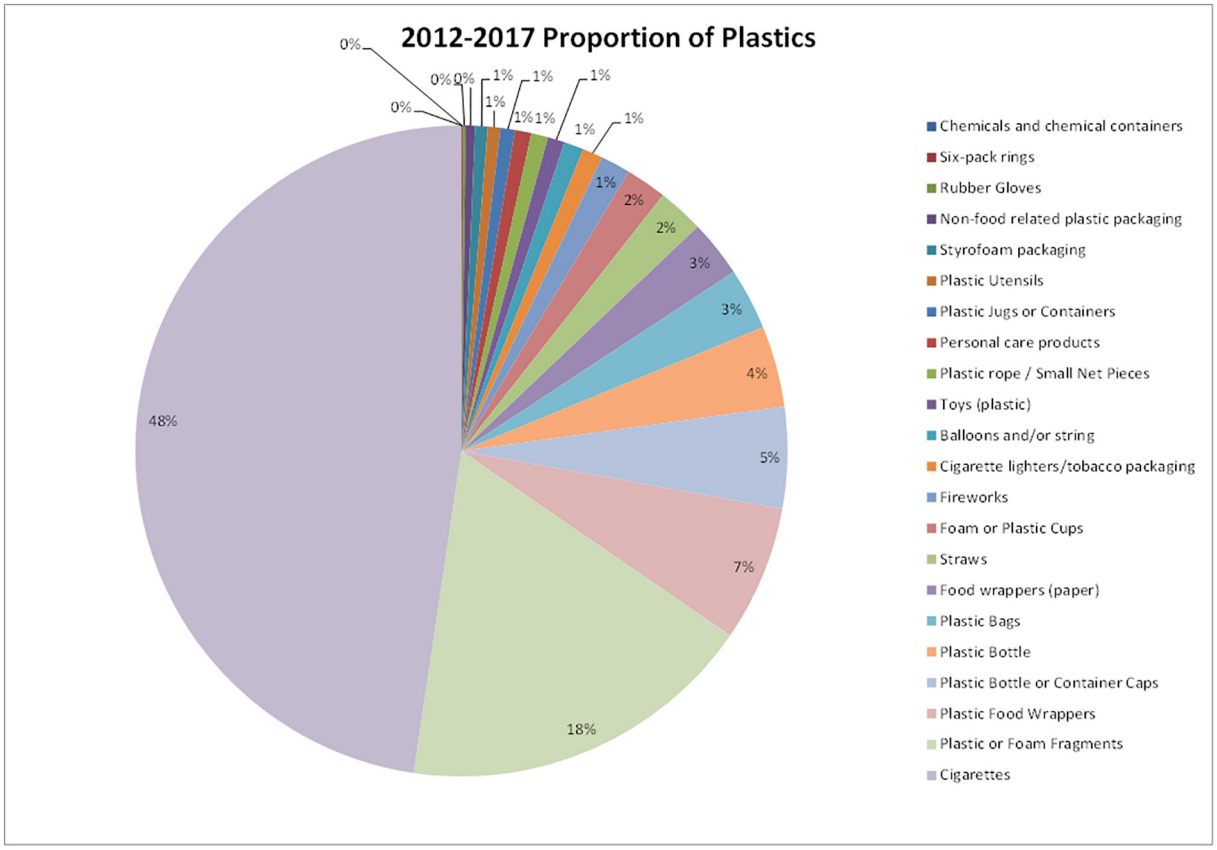

Fig. 2. Analysis of plastics found on Jekyll Island, Georgia, USA (2012–2017): Plastic was the largest contributor to debris found on Jekyll Island. Of that, cigarettes made up the largest portion at 48% and plastic and foam fragments at 18%. The remaining miscellaneous plastics contributed the remainder.

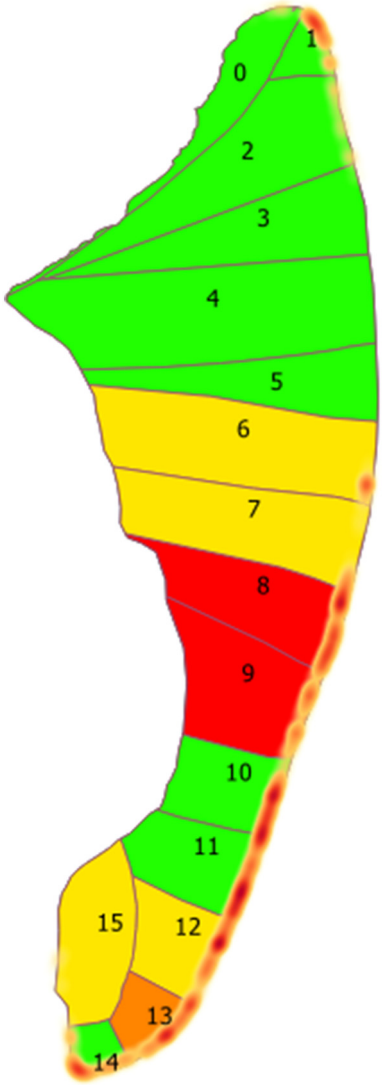

Fig. 3. Marine debris vs. loggerhead sea turtle nesting events on Jekyll Island, GA (2012–2017): Density of debris was compared to sea turtle nesting event density and moderate overlap was determined.

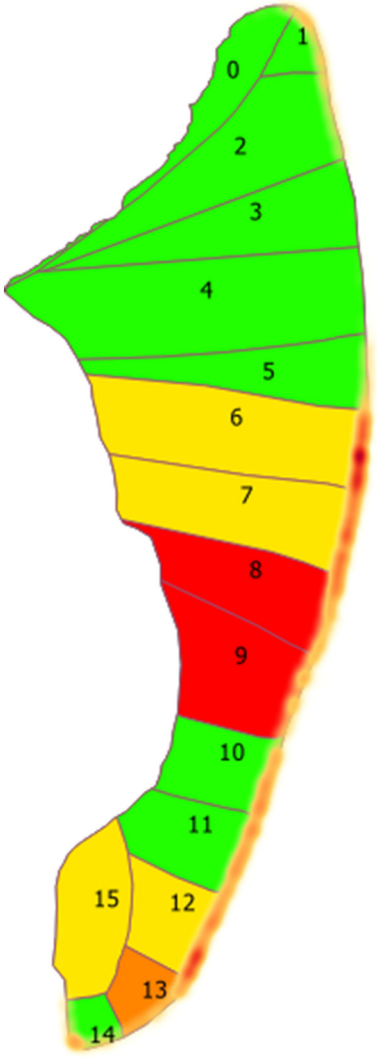

Fig. 4. Marine debris vs. loggerhead sea turtle non-nesting emergences on Jekyll Island, GA (2012–2017): Density of debris was compared to sea turtle non-nesting emergency event density and overlaid on a heat map.

marine debris on Jekyll Island, GA is limited and lower than areas that do not have active removal efforts. This is not to say there is no risk, however. Plastic and foam fragments and cigarette butts were the most significant type of debris found on Jekyll. Since there is a consistent overlap between debris presence and sea turtle activity, caution and further evaluation are warranted. Plastic fragments that become incorporated in the sand pose a threat to the incubation period of loggerheads. The thermal insulation properties of plastic can reduce subsurface temperatures which have been experimentally shown to affect sex-determination in temperature-dependent loggerhead nests. Since the temperature difference between producing all male or female is only 4 °C in loggerheads, more males will be produced than females (Carson et al., 2011). This could potentially skew sex ratios in hatchlings and have future impacts on the population level.

Another risk that exists to Jekyll Island's sea turtle hatchlings is entanglement while in the nest. While line and rope were not the most common debris items found during citizen science efforts, there has been documentation of hatchlings being entangled while in the nest on Jekyll Island (Georgia Sea Turtle Center, unpublished data). Continuing efforts to prevent them from being left behind and removed from the beach is important to continue to minimize impacts to sea turtles.

While not practical to give credit solely to the citizen science project on Jekyll Island, it is clear that it is having a positive impact on the beaches and nesting sea turtle populations when compared to other areas around the world. Further, the awareness that is being created is likely contributing to a reduced amount of debris being deposited on the beach. The ability to have the marine debris data provided through the Marine Debris Tracker App, has helped managers on Jekyll Island better understand where specific threats to sea turtle populations are coming from and which areas need further investigation. Without this tool and volunteer efforts, managers would have a harder time targeting where to invest their resources.

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