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Debris ingestion by juvenile marine turtles: An underestimated problem

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ABSTRACT

Marine turtles are an iconic group of endangered animals threatened by debris ingestion. However, key aspects related to debris ingestion are still poorly known, including its effects on mortality and the original use of the ingested debris. Therefore, we analysed the impact of debris ingestion in 265 green turtles (*Chelonia mydas*) over a large geographical area and different habitats along the Brazilian coast. We determined the death rate due to debris ingestion and quantified the amount of debris that is sufficient to cause the death of juvenile green turtles. Additionally, we investigated the original use of the ingested debris. We found that a surprisingly small amount of debris was sufficient to block the digestive tract and cause death. We suggested that debris ingestion has a high death potential that may be masked by other causes of death. An expressive part of the ingested debris come from disposable and short-lived products.

1. Introduction

The accumulation of anthropogenic debris, which is primarily plastic, in the marine environment was initially ignored or considered an isolated problem portrayed as an aesthetic concern (Derraik, 2002; Laist, 1987). However, ocean debris has become one of the most ubiquitous and long-lasting changes in natural systems (Barnes et al., 2009). Despite all of its well-recognised impacts on marine wildlife, biodiversity and human health (Gregory, 2009; Rochman et al., 2013; Teuten et al., 2009; Thompson et al., 2009a) the production of plastic and its release into the environment are intensive, continuous and rising (Cózar et al., 2014; Jambeck et al., 2015; PlasticEurope, 2012; Rochman et al., 2013; Thompson et al., 2009b). Recently was estimated that at least 5.25 trillion particles are floating at sea (Eriksen et al., 2014), and 4.8–12.7 million tons entered the ocean in 2010 alone (Jambeck et al., 2015). Currently, anthropogenic debris can be found virtually everywhere in the oceans and coastal ecosystems (Barnes et al., 2009; Ryan and Moloney, 1993; Thompson et al., 2009b), including isolated protected areas (Baztan et al., 2014; Heskett et al., 2012), due to the characteristics of plastic (e.g. durability and lightweight) and its indiscriminate use in disposable and short-lived products (Hopewell et al., 2009).

Anthropogenic debris impacts over 350 marine species (Gall and Thompson, 2015; Laist, 1997), and debris ingestion is a widespread phenomenon both geographically and taxonomically (Anastasopoulou et al., 2013; Bravo Rebolledo et al., 2013; Codina-García et al., 2013; Lusher et al., 2013; Murray and Cowie, 2011; Williams et al., 2011). Debris ingestion can lead directly to death through the blockage of the digestive tract, and it can have sublethal effects, such as a decrease in nutritional gain and exposure to the chemicals leaching from plastic (Ashton et al., 2010; Fisner et al., 2013; Gregory, 2009; Teuten et al., 2009; Yamashita et al., 2011). Marine turtles represent an iconic group of endangered marine animals that are threatened by debris ingestion. Six of the world's seven species have been reported to ingest debris (Schuyler et al., 2014). Although there is a vast body of literature on anthropogenic debris ingestion (Gregory, 2009) and debris ingestion by marine turtles is considered a global research priority (Hamann et al., 2010), the mortality caused by debris ingestion is still poorly known.

The removal of anthropogenic debris from all coastal and oceanic habitats is a nearly impossible task. The first, and more realistic, action to reduce the impact of anthropogenic debris on marine fauna is to avoid the production and entrance of debris into the ocean basins (Gregory, 2009). To do that, we must know the original use of the debris ingested by marine animals. Unfortunately, this key information is lacking in most studies of animal debris ingestion.

Debris ingestion by marine turtles has increased over time (Schuyler et al., 2014). This increase reinforces the need for information about the key aspects related to debris ingestion that are

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still poorly known, including its effects on mortality and the original use of the ingested debris. Therefore, our aims were to (i) quantify the debris ingestion by green turtles (*Chelonia mydas*) over a large geographical area and different habitats; (ii) quantify the deaths caused by debris ingestion and the amount of debris sufficient to cause death; and (iii) determine the original use of the ingested debris.

2. Methods

From 2009 to 2013, 265 dead stranded green turtles were collected along the Brazilian coast (Fig. 1). Detailed information about the study area is shown in Table 1. To evaluate the cause of death, only fresh dead animals were collected. The dead stranded turtles were found during intensive coastal monitoring conducted by TAMAR/ICMBio and CTA – Serviços em Meio Ambiente teams. The necropsies and biometry (weight and curved carapace length – CCL) were performed by trained veterinarians using standard techniques (Wyneken, 2001). To be conservative, we only assigned debris ingestion as the cause of death when the gastrointestinal tract was blocked by debris and there was no evidence of another cause of death. The cause of death was attributed to a fishery when we knew that turtles were caught by fishermen or when we found clear marks of catch equipment interaction (e.g., net wounds). The body conditions of the individuals were evaluated according to Walsh (1999). The body condition was classified as normal, underweight or emaciated by considering the characteristics of the eyes and plastron and the decrease in muscle and fat tissue in the neck and flipper area. We also calculated the body condition index (BCI $\times$ 10^5) using Fulton's index (BCI = weight/CCL^3). All animals were examined for presence of fibropapillomatosis, a debilitating disease that commonly affect green turtles (Herbst, 1994). To avoid bias we excluded all animals that were moderately or heavily affected by this disease from our body condition analysis (Work and Balazs, 1999).

Table 1
Areas and habitats along the Brazilian coast where dead stranded green turtles were collected (N, number of individuals; CCL ± SD, mean curved carapace length ± standard deviation).

	Study area	Habitat	N	CCL ± SD (cm)
1	Sergipe coast (10°53′S, 36°50′W)	Estuarine area	22	42.6 ± 20.4
2	Linhares (19°40′S, 39°70′W)	Estuarine area	21	35.1 ± 3.5
3	Fundão and Aracruz (20°01′S, 40°09′W)	Reef	81	36.5 ± 4.6
4	Vitória (20°18′S, 40°17′W)	Reef (highly urbanised)	103	39.8 ± 7.4
5	Vila Velha (20°25′S, 40°19′W)	Reef	14	37.1 ± 5.3
6	Ubatuba (23°25′S, 45°01′W)	Reef	17	38.1 ± 5.6
7	Florianópolis (27°26′S, 48°19′W)	Reef	7	38.5 ± 3.6

We analysed the entire gastrointestinal system to retrieve debris. The anthropogenic debris found in the green turtles was washed and dried at 60 °C for 48 h. Each piece of debris was categorised according to its material (e.g., hard plastic, soft plastic, rubber, nylon and rope) and investigated to determine the original use (e.g., food related, plastic bag and fishery). All materials and original use categories were quantified by the frequency of occurrence and number of items. We also quantified the materials by their weight (0.01 g) and volume (0.1 ml; via alcohol displacement). To avoid overestimating the amount of debris ingested, only fragments longer than 0.5 cm were considered an item. We considered that debris smaller than 0.5 cm may be generated by fragmentation of larger items inside the turtle. Therefore, these items were

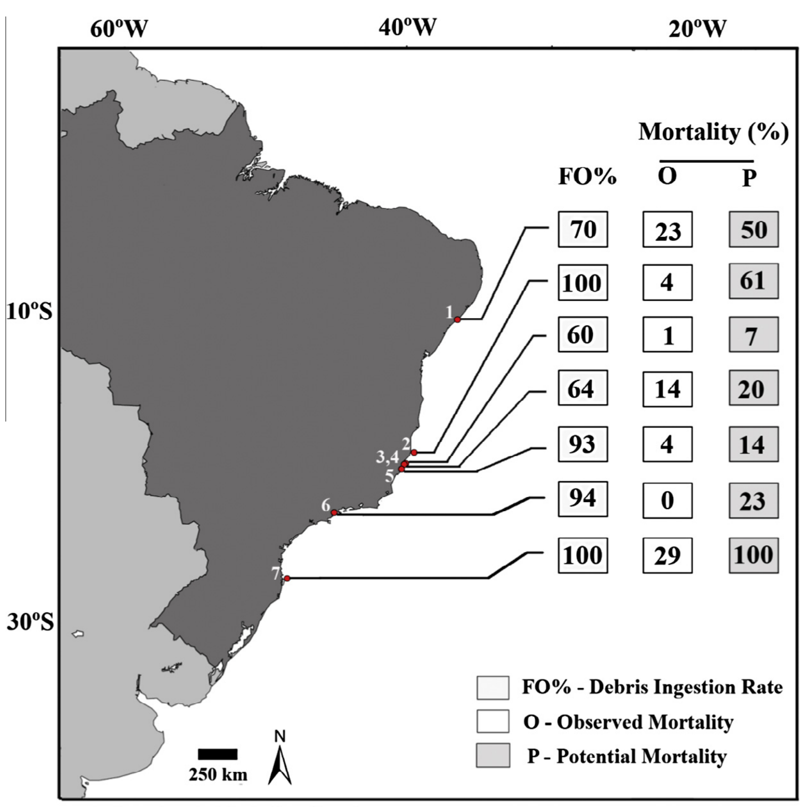

Fig. 1. Study areas along the Brazilian coast where dead stranded green turtles were collected (1 – Sergipe coast; 2 – Linhares; 3 – Fundão and Aracruz; 4 – Vitória; 5 – Vila Velha; 6 – Ubatuba; and 7 – Florianópolis. Detailed information in Table 1). Debris ingestion rate (FO%), the relative number of individuals that died due to debris ingestion (O) and the relative number of individuals that ingested debris above the critical amount (P).

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