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Are we eating plastic-ingesting fish?

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ABSTRACT

Yes, we are eating plastic-ingesting fish. A baseline assessment of plastic pellet ingestion by two species of important edible fish caught along the eastern coast of Brazil is described. The rate of plastic ingestion by king mackerel (*Scomberomorus cavalla*) was quite high (62.5%), followed by the Brazilian sharpnose shark (*Rhizoprionodon lalandii*, 33%). From 2 to 6 plastic resin pellets were encountered in the stomachs of each fish, with sizes of from 1 to 5 mm, and with colors ranging from clear to white and yellowish. Ecological and health-related implications are discussed and the potential for transferring these materials through the food-chain are addressed. Further research will be needed of other species harvested for human consumption.

Marine debris is a growing threat to marine wildlife (Moore et al., 2001). Plastic pollution is found in all coastal and marine environments, from beaches, reefs, mangroves and estuaries, to the open ocean, and takes on many different shapes and forms (pellets, debris, and objects) (Ivar do Sul et al., 2009; Carvalho-Souza and Tinôco, 2011; Costa et al., 2009; Mordecai et al., 2011; Vieira et al., 2011).

Several papers have explored issues related to the accumulation and distribution of plastics in marine habitats and the resulting impacts on aquatic species and various ecological processes (e.g., behavior, bio-invasion, food resources, chemical pollutants) (Laist, 1997; Barnes et al., 2009; Gregory, 2009; Browne et al., 2011; Rochman et al., 2014; Carvalho-Souza, 2015). The ingestion of marine debris by marine wildlife, ranging from zooplankton to marine megafauna (fish, seabirds, sea turtles, and marine mammals) has been widely documented (Laist, 1997; Tourinho et al., 2010; Schuyler et al., 2013; Di Beneditto and Awabdi, 2014).

The first reports of marine debris ingestion by fish was published by Carpenter et al. (1972) and described the presence of plastic particles in larvae and adult fish. Many other species of fish, rays, and sharks have been documented ingesting plastic debris in recent decades, with the number of records still growing steadily (Hoss and Settle, 1990; Laist, 1997; Jackson et al., 2000; Cliff et al., 2002; Boerger et al., 2010; Possatto et al., 2011; Dantas et al., 2012; Choy and Drazen, 2013; Jantz et al., 2013; Foekema et al., 2013; Lusher et al., 2013; Di Beneditto and Awabdi, 2014; Ramos et al., 2012; Romeo et al., 2015).

Plastic can cause direct damage to marine wildlife through entanglement, malnutrition (gut blockage and pseudo-satiation), suffocation and decreased mobility – often resulting in their death (Laist, 1997). Indirect effects have also been documented relating to the accumulation of heavy metals and chemical pollutants such as polychlorinated biphenyls (PCBs), polybrominated diphenyls (PBDEs), and polycyclic aromatic hydrocarbons (PAHs) (Teuten et al., 2009; Frias et al., 2010).

Other harmful effects of discarded plastics include the transport of alien/invasive species (so-called 'hitch-hiking') and the inhibition of gas-exchange and the resulting smothering of seabeds (Gregory, 2009). Rochman and Browne (2013) proposed classifying plastics (synthetic polymers) as hazardous wastes, and the risks of plastic ingestion are now focusing on its transfer between trophic levels, health impacts across food-chains, and possible effects on humans. New research is needed in this key area.

Laboratory studies have confirmed plastic transfer between mussels and crabs (Farrel and Nelson, 2013); a more recent investigation reported the ingestion of plastic microspheres by several zooplankton groups and plastic micro-particle transfer (via planktonic organisms) between trophic levels (mesozooplankton-macrozooplankton) (Setälä et al., 2014). Likewise, medaka fish exposed to a complex mixture of plastic (and their associated chemical pollutants) via ingestion showed disturbances of endocrine system functioning (Rochman et al., 2013, 2014). Matsson et al. (2015) – demonstrating that nanoparticle uptake occurs throughout the algae-zooplankton-fish food chain with resulting genetic, morphological, and behavioral alterations.

In light of these disturbing impacts, it will be important to identify fish species showing plastic residues in their stomachs. We report here a baseline assessment of the ingestion of plastic pellets by two

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commercially valuable fish species caught by artisanal fishermen on the eastern coast of Brazil.

The study area was located along the coast of the city of Salvador, Bahia State, in northeastern Brazil (Fig. 1).

Salvador is the capital of Bahia State and the third largest city in Brazil, with an estimated population of nearly 3 million (IBGE, 2014). The city has two public ports, seven private marine terminals, one oil refinery, and the largest integrated industrial-petrochemical complex in Latin America (since the late 1970s).

The plastic production chains in these industries are composed of three basic steps: 1) monomer generation (cracking, e.g., ethene, propene, butene, benzene); 2) polymerization (e.g., the formation of polyethylene, polypropylene, polystyrene, PVC, EVA, and others); and 3) transformation (manufacturing finished products for consumer markets) (ABIPLAST, 2013).

Occasional unintentionally resin pellet losses into rivers and other watercourses can occur during these steps or during logistic stages (e.g., terrestrial/aquatic transport), and these plastics will eventually migrate to coastal and marine environments (Ogata et al., 2009).

Metal and solid waste contamination has been documented in the Todos os Santos Bay in the metropolitan region of Salvador, impacting beaches, rocky shores, estuaries, and mangrove swamps (Hatje et al., 2010; Carvalho-Souza and Tinoco, 2011; Eça et al., 2013). These sites are known to be nurseries for many aquatic species and are used by artisanal fishermen. Coastal fisheries are an important economic activity in many areas in northeastern Brazil (Diegues, 2008).

Sampling was undertaken from April to May/2011 at two fishing ports in the city of Salvador: Pituba (Z1-APEPI) and Itapuã (Z6-COOPI) (Fig. 1). These are traditional fishing communities (e.g., COOPI was established more than two centuries ago) with artisanal fleets of small wooden boats. The fishermen generally use hook and line fishing techniques to capture high-value specimens (Dominguez et al., 2013).

Fish were collected randomly at the landing points from among recently captured specimens. Biometric measurements (furcal length – cm, weight – g) and taxonomic identifications (based on the scientific literature – Carvalho-Filho, 1999; Froese and Pauly, 2014) were performed at the landing points. The stomachs were removed from the fish and subsequently examined in the laboratory using a binocular dissecting microscope (40×).

The stomach contents were analyzed and separated into natural foods (prey and organic material) and plastic items. The plastic debris was further separated, quantified, and then classified according to its shapes and colors. The fish species were sorted according their habitats (pelagic or demersal) and trophic categories (Carvalho-Filho, 1999; Ferreira et al., 2004; Bornatowski et al., 2012; Froese and Pauly, 2014), noting, for each individual, where it was captured, the presence of plastics debris, and the numbers of plastic items and their frequencies.

The stomach contents of 32 fish specimens belonging 11 species and 9 families (2 elasmobranches and 9 teleosts) were examined (Table 1). Resin pellets were the only type of plastic observed in their stomachs. Plastic pellets were found in the stomachs of 7 individuals (22%) of two species: the king mackerel, *Scomberomorus cavalla* (Cuvier, 1829) (Scombridae) and the Brazilian sharpnose shark, *Rhizoprionodon lalandii* (Müller & Henle, 1839) (Carcharhinidae) (Fig. 2a-b). The highest frequency of plastic occurrence was recorded for *S. cavalla*, with 5 specimens containing pellets (62.5% of the individuals of the species), followed by 2 individuals of *R. lalandii* (33%). From 2 to 6 plastic pellets were encountered in *S. cavalla*, with sizes ranging from 2 to 5 mm in their longest dimension. From 1 to 3 small pellets were encountered in individuals of *R. lalandii* with sizes varying from 1 to 3

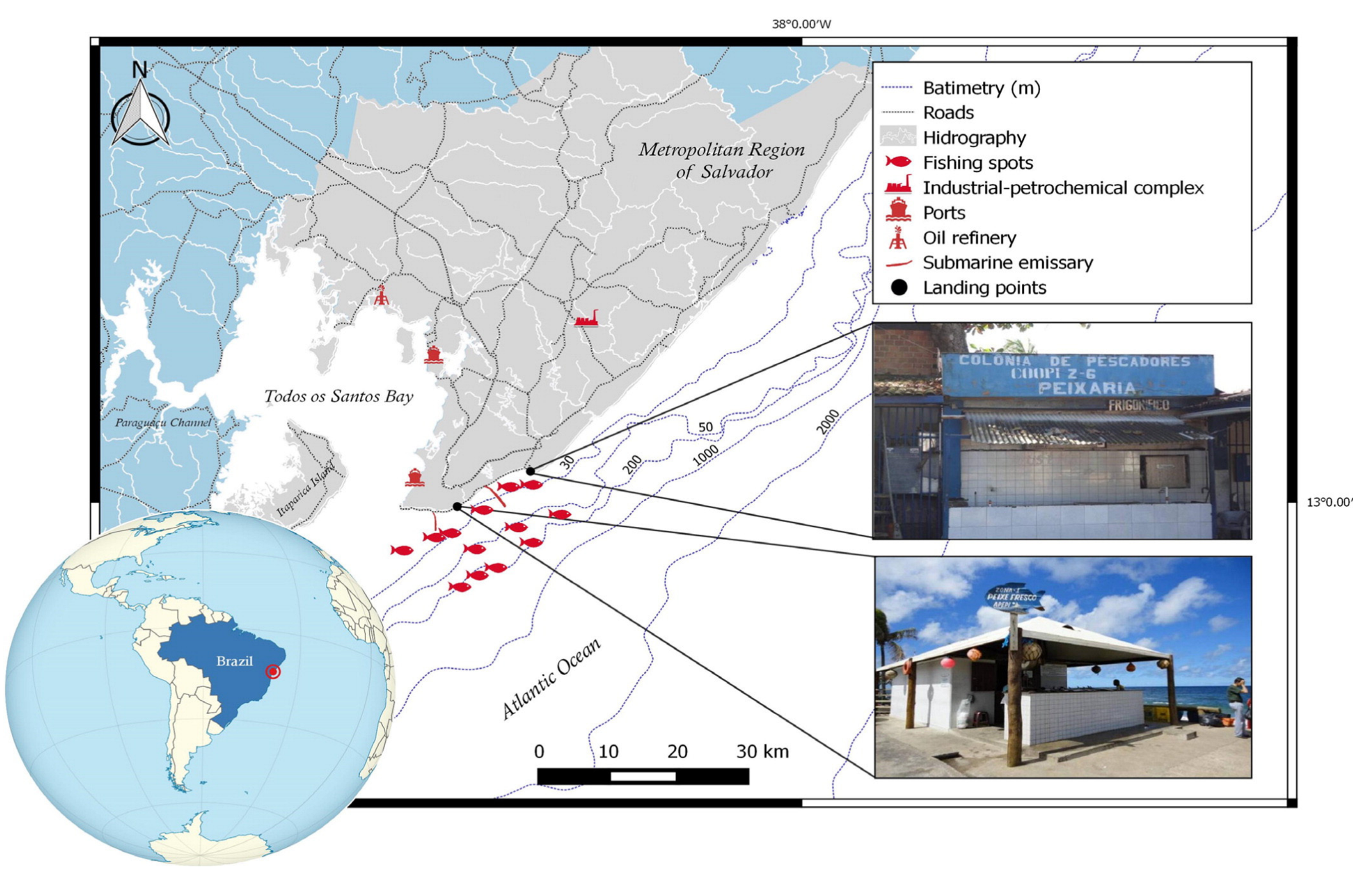

Fig. 1. Map of the metropolitan region of Salvador indicating two fishing ports, Bahia State, Brazil.