The presence of plastic in the marine ecosystem of The Exuma Sound

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Introduction

It is estimated that up to 12.7 million tons of plastic enter the ocean each year (Jambeck et al., 2010). Thus far research has been conducted on the plastic concentrations in the Pacific and North Atlantic oceans as well as on stomach contents of pelagic fish in the South Pacific. However, no concentration data or stomach analysis data has ever been collected in the Exuma Sound, the body of water off of the west coast of Eleuthera. Plastic may enter the ocean as macro plastics (> 5mm), but through oxidation, abrasion, and photodegradation, the plastic breaks down into micro plastics. However, plastic is persistent in the environment and does not decompose. Marine plastics are a problem because they pose ingestion and entanglement risks to marine organisms. Plastic ingestion can cause intestinal blockage, raise toxin levels in fish, and entanglement can cause starvation and inhibit organisms from evading predators, who would then consume the plastic. Wind and ocean currents often create a gyring effect (circular currents), concentrating organic material and plastics in the center of the body of water they are in. The Exuma Sound is on the edge of the North Atlantic Gyre, a large system of currents which flow in a rotational motion and concentrate plastics from the East Cost of the United States and the West Coast of Europe (Law, 2010). The Exuma Sound receives in-flow from the gyre but there is limited out-flow due to eddying ocean currents that create a self-contained circulation within the Exuma Sound (Collins, 1995).

Purpose Statement

This project hypothesizes that the Exuma Sound is a gathering point for plastics from not only The Bahamas, but also the East Coast of the United States and the West Coast of Europe, deposited by the North Atlantic Gyre. Furthermore, it is hypothesized that the pelagic fish of the Exuma Sound are consuming this plastic as part of their diet.

Objectives

- Quantify the number of surface plastics in the Exuma Sound
- Establish which economically important pelagic fish are consuming plastic
- Determine the numerical presence of plastic within pelagic fish

Methods

Trawls

Plastic concentration on the surface of the Exuma Sound was determined by using an AVANI trawl net (Fig. 1a). The location of the individual trawls was randomly selected using a map of the Exuma Sound. Trawls were standardized using ten minute intervals and using either a 1mm of .33mm mesh net. The start and end coordinates were recorded, the distance of each trawl was determined and the area of water trawled was then calcullated. The contents of each trawl were examined (Fig. 1b), and transferred into a beaker (Fig. 1c). Back in the lab, the beaker contents were sieved and the plastics were counted, collected, and saved. The number of plastics counted was used to extrapolate the density of plastic in the Exuma Sound (# plastics/km^2).

Fig. 1a: Trawling in the Exuma Sound

Fig. 1b: Examination of trawl contents

Fig. 1c: Collection of trawl contents

Trawling Photos

Dissections

After a filleted fish carcass was received from local fishermen, fishing tournaments, or by the research team (Fig. 2a), the stomach was removed from the carcass and was sliced open to expose the contents (Fig. 2b). The discernable organisms and macro-plastics were then picked out and rinsed in a beaker. The remaining stomach contents were then rinsed in the same beaker and the contents of that beaker were put through the same sieving process that was used for the trawl samples (Fig. 2c). The potential plastic was placed in salt water; if it was positively buoyant, it was classified as plastic because 99% of plastic ocean plastics float. We recorded fish species, sex,fork length, number of plastics found, prey items, and where the fish was caught.

Fig. 2a: Wahoo carcass before dissection

Fig. 2b: Dissected dolphinfish stomach

Fig. 2c: Examination of sieved stomach contents

Dissection Photos

Results

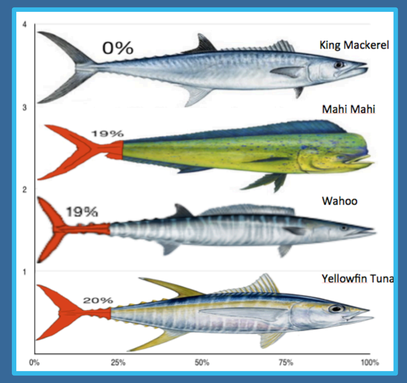

Fig. 3a: **Percentage of Fish with Plastics**. The sample size for this study was 64 fish total. Each fish represents the sample size of stomachs dissected. The red represents the percentage of fish, by species, which contained plastic in their stomach.

Fig. 3b: A plastic bead and piece of a bag found in side a fish stomach

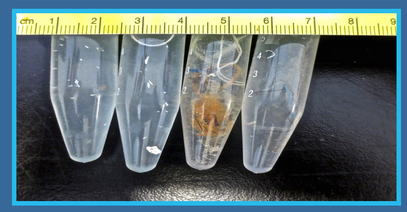

Fig. 3c: Samples of plastic collected in trawls

Species (Common name)	No. Stomachs Examined	Average Length ± SD (cm) [range]	No. Stomachs with debris [% frequency]	Type of Plastic % micro/macro	Average No. Plastics per Fish
Scomberomorus Cavalla (king mackerel)	1	89	0 [0%]	0%	0
Coryphaena hippurus (mahi mahi)	32	90.01 ± 15.3 [74.1 - 105.4]	6/32 [19%]	17% macro 83% micro	0.375
Acanthocybium solanderi (wahoo)	26	122.2 ± 19.2 [103 - 14.4]	5/26 [19%]	100% micro	0.36
Thunnus albacares (yellow fin tuna)	5	63 ± 26.2 [36.8 – 89.2]	1/5 [20%]	17% macro 83% micro	2.4

Table 1

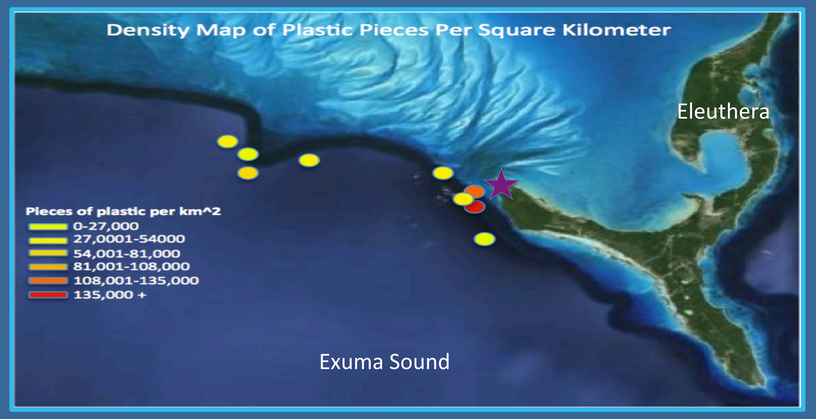

Fig. 4: Density map of plastic concentration in the Exuma Sound

Discussion

Using data gathered from trawls and stomach dissections, this study was able to begin to quantify the amount of plastic floating the in the Exuma Sound and how much plastic economically important pelagic fish are consuming. The trawl data shows a range of 22,500 to 125,000 pieces of floating plastic per square kilometer in different sections of the Exuma Sound, with a single trawl containing 1.95 million pieces per square kilometer. A similar study conducted in the Atlantic found between 0 and 200,000 pieces per square kilometer (Law et al., 2010). This data is able to help confirm the hypothesis that there is a similar density of plastic within the Exuma Sound and Atlantic Ocean.

Over the course of this study thus far, 64 fish stomachs were dissected and analyzed for plastic content. The results showed that 12/64 dissected stomachs contained plastic. The fish found with plastic in their stomachs were mahi mahi (*Coryphanea hippurus*), wahoo (*Acanthocybium solanderi*) and yellow fin tuna (*Thunnus albacares*). Choy and Drazen (2013) conducted a similar study in the South Pacific and found that 2% of the mahi mahi dissected had consumed plastic (Choy et al., 2013). Comparatively, this study has found 19% of the mahi mahi dissected had consumed plastic. These results are significant because it confirms that fish within the Exuma have are consuming plastic as part of their diet.

Fig. 5a: Mahi Dissection

Fig. 5b: Plastic caught while trolling

This study is currently relevant because of the commonality of plastics in consumer goods, and their growing presence in the world's oceans. Once plastic enters the ocean, it takes several years, even decades for it to breakdown into smaller pieces; however it never fully decomposes. Fish often mistake plastic for prey and consume it accidentally. Consumed plastic can have detrimental effects on the fish such as lowered hormone levels, delayed ovulation, and intestinal blockage. Ultimately, this is an important issue because in The Bahamas fishing is the second largest industry, and if there is a concentrated presence of plastic and toxins in fish, consumerism could potentially decrease and the fishing industry could suffer considerably.

This project will continue into the future collecting data on not only pelagic fish, but also smaller bait fish, as well as taking tissues samples of the fish to find the toxin levels in the fish. To ensure plastic does not become a larger issue than it already is, education efforts on the dangers of plastic and plastic pollution so that people know to cut down on on using single use plastics. If consumers demand more sustainable product packaging then large scale manufacturers will cut down their plastic use which in turn will cut down on plastic waste and plastic pollution. Governmental policies against plastic use and littering can also help cut down on plastic pollution.

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