Quantifying Plastics and its Biological Impacts in the Northern Exuma Sound, The Bahamas

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Introduction

The rise in large-scale industrial use of plastics has led to more marine debris in our world's oceans than ever before. In 1988, it was calculated that 30 million metric tons of plastic were produced by the United States alone (Derraik 2002), with 4.8 to 12.7 million metric tons of plastic discarded annually (Jambeck et al. 2015). Three main contributors of plastics to our world's oceans include: discarded fishing gear (135,400 tons), synthetic packaging material (23,000 tons), and plastic containers (639,000 tons) (Derraik 2002). Despite this, limited research has been conducted to quantify the global-scale impact of plastic pollution in our oceans.

Figure 1: Marine plastic accumulated on beach

Other than numerous physical effects marine debris has on marine wildlife such as entanglement, suffocation, and intestinal blockage and tearing, plastics have been found to have many chemical effects such as decreasing growth and hatch rates, as well as suppressing alarm cues of species when faced with predators. Given their low density, plastics tend to float in sea water allowing them to disperse over long distances and break down into smaller pieces, but not fully biodegrade (Derraik 2002).

Objectives

1) To assess the types and colors of plastics in the Northern Exuma Sound
2) To assess the biological impact of plastics in the marine environment by catching pelagic fish and dissecting their stomachs
3) To investigate where plastics enter the marine food web and how they bio-accumulate and bio-magnify.

Methods

Trawling Nets:

To quantify the amount of plastics in the Exuma Sound a high speed neuston trawl (frame: 10 cm x 56 cm; net: 3 m x 333µm) was used. The net was attached to a boom (660 cm) that was inserted into a crane arm attached to the boat. The crane arm allowed the boom to swing out over the water at a distance far enough to not be dragging in the wake of the boat to avoid surface disturbance. Once deployed the net was towed across the surface of the water for 15 minutes at a speed of approximately 5 knots, before being collected. Once the net was on board the cod end of the net was removed and washed with distilled water to ensure all plastics were transferred from net to sieve.

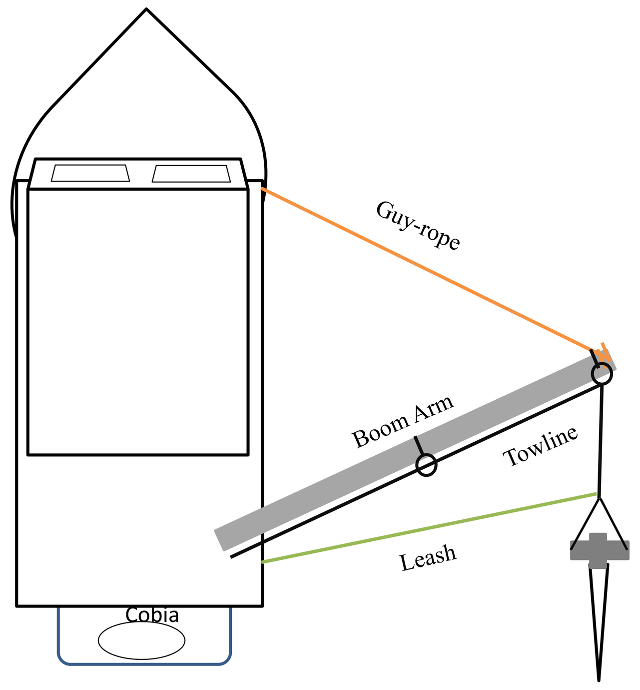


Figure 2: Schematic of plastics trawl

Troll Fishing:

Using fishing poles, lures were attached and lines were cast off the back of the boat. Three poles were used and were trolled in the Northern, Exuma Sound. Once bitten, lures were reeled in and the caught fish were put into a cooler on the boat, which was then brought back to the lab for further observation and dissection. These stomachs were added to a larger data set of previously caught fish as well as the stomachs of tournament-caught fish. Plastics were sorted and data was collected on types and amounts of plastic found.

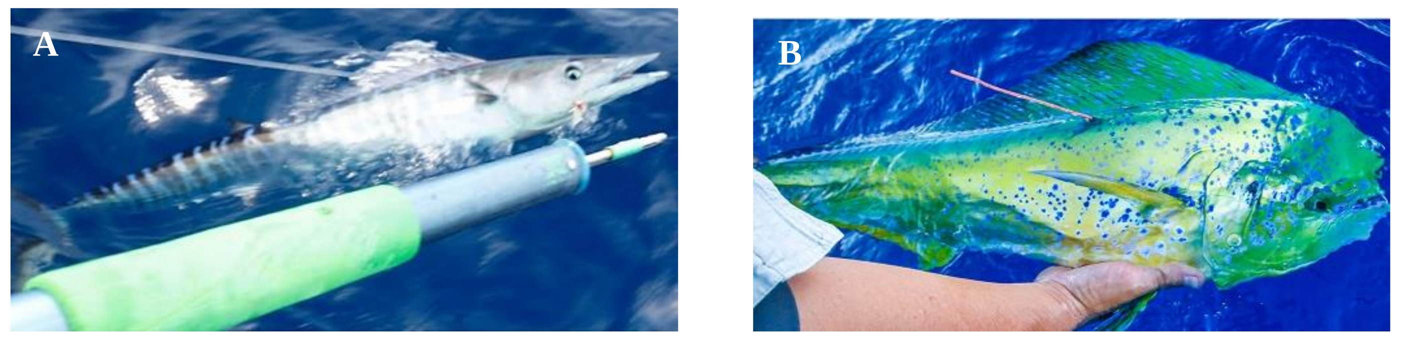


Figure 3: Sample of a Wahoo (A) and Mahi Mahi (B) at the side of the boat.

Methods Continued

Fish Aggregation Device:

A fish aggregation device (FAD) is a platform that is used to attract fish. This provided shelter for predatory species of pelagic fish and allowed large quantities of fish to collect under the FAD. We fished in and around the device to collect specimens for dissection.

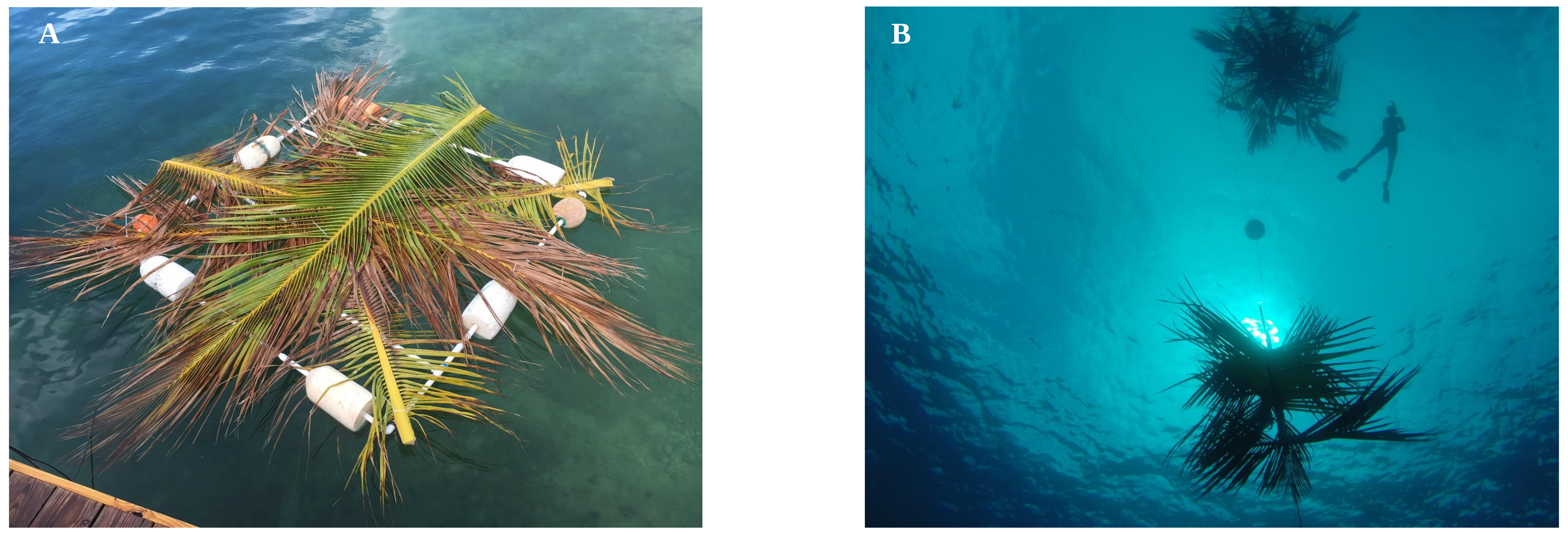


Figure 4: Surface view (A) and underwater view (B) of fish aggregation device.

Analyzing Plastics:

Once in the lab, collected contents (trawl surveys and stomach contents) were poured into a sea water solution with salinity of 35 ppt. Plastics were quantified using two criteria: (1) if debris was positively buoyant, and (2) by visual observation under a microscope. Once identified as plastics, length, color, and type of plastics were recorded.

Figure 5: Sorting plastics from collected trawls (A) and dissection of pelagic fish stomachs (B).

Results

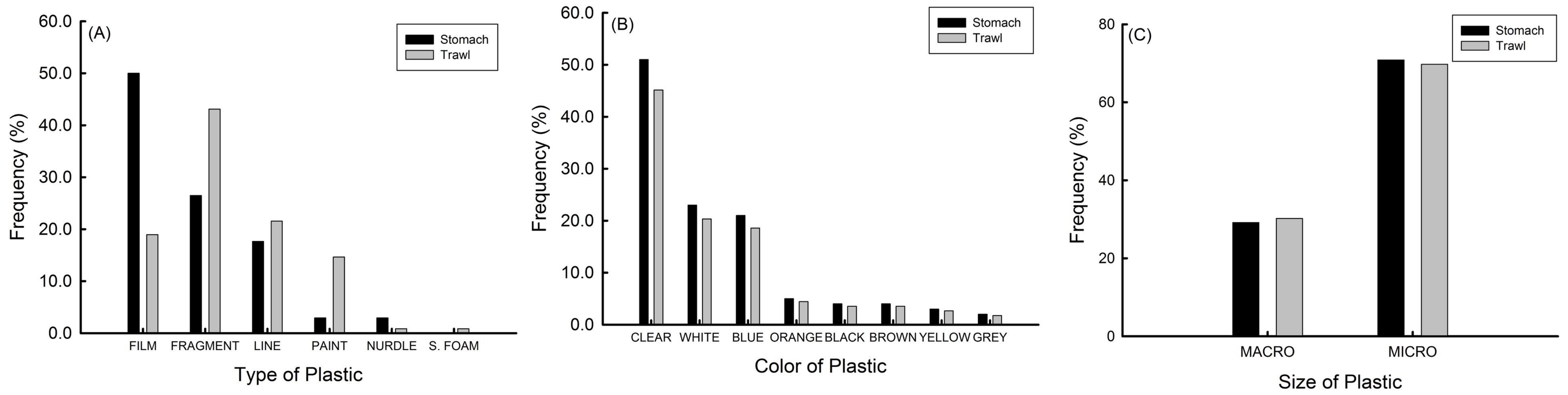


Figure 6A. The percent frequency of different types of plastic collected through trawling and dissection of pelagic fish. Note: difference between amount of film in the environment and in fish stomachs.

Figure 6B. The percent frequency of different colors of collected plastics through trawling and dissection of pelagic fish. Note: clear plastic was the most commonly found in both stomachs and the trawls.

Figure 6C. The percent frequency of micro-plastics versus macro-plastics in the environment and in fish stomachs. Note: close relation between micro and macro plastics for both the trawl and stomach. (Macro plastics $\geq$ 5.0mm, Micro plastics < 5.0mm)

In this study, we found that there is a large amount of plastic in the Exuma Sound. Of these plastics, fragments were the most prevalent in our trawls (43.1%), with Styrofoam being the least (0.9%; Figure 6A). In addition, the majority of our collected plastics were clear in color (45.1%). In stomachs, we found that 50.0% of the plastic collected was film, and the majority were clear in color (51.0%; Figure 6B). Interestingly, we found a disconnect between the amount of film that was found in fish stomachs than in the environment. However, we found similar amounts of line between the environment and fish stomachs (Figure 6A).

From this study, we also found that the majority of the plastic found in the Exuma Sound can be classified as micro (< 5mm; Figure 6C). In addition, a unique similarity was found between the amounts of micro and macro plastics found in both our trawl contents and those of pelagic fish stomachs with no species specificity (Figure 7).

Results Continued

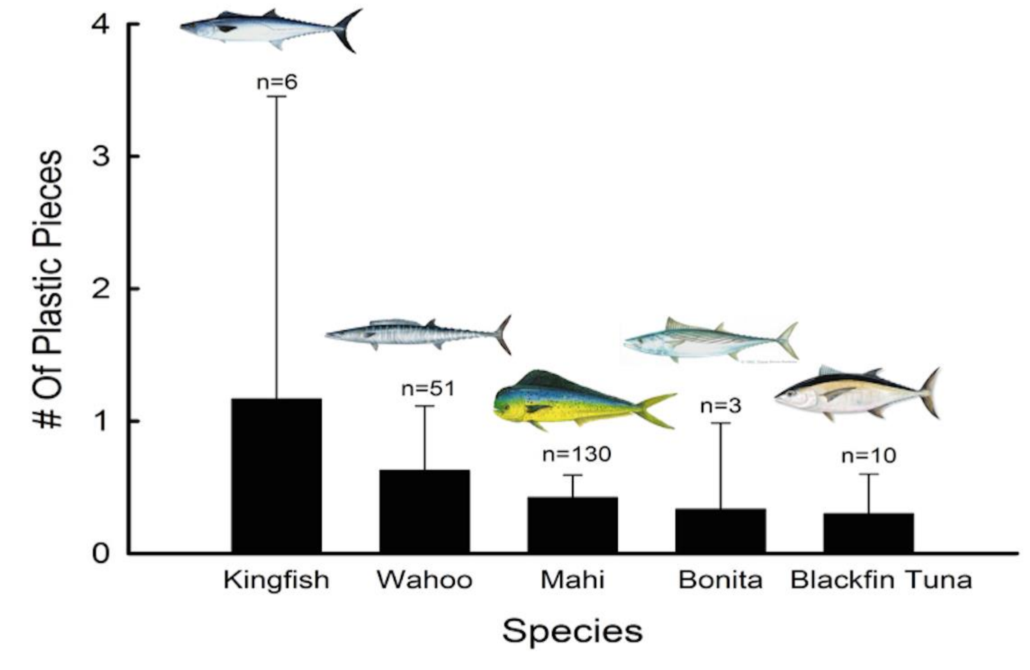


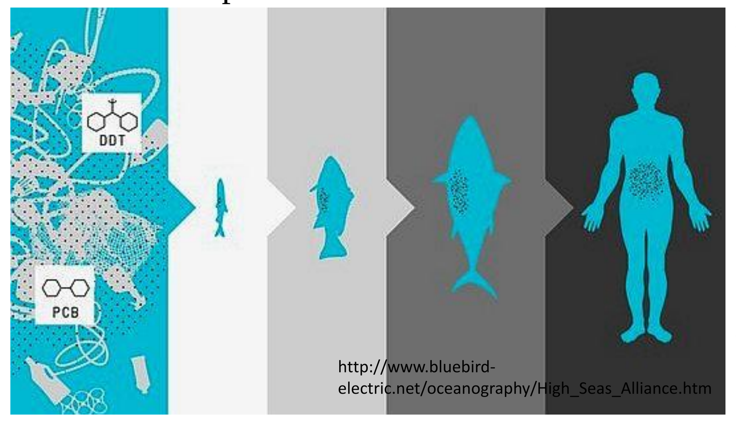
Figure 10. The relationship between the average plastic consumption in different pelagic species. (Error bars represent 95% confidence interval)

In this study, commercially valuable pelagic species were caught and dissected for stomach content analysis. From this, we found that there is no significant difference in the amount of plastic between pelagic species tested ($F_{6,132}$= 1.11, p= 0.37; Figure 10).

Discussion

Our study suggests that the Northern Exuma Sound is a potential "sink" for plastics including a large amount of micro plastics with specific types and colors of marine debris. The prevalence of micro plastic could be due to the photo-degradation of macro plastic. We hypothesize that the abundance of clear, film and fragments found, are likely a result of prey misidentification by smaller prey fish. Because pelagic fish eat smaller bait fish that are normally planktivorous and can therefore mistake these plastics as prey, it is likely how plastics are entering the food web. This accounts for the larger percentage of clear film within pelagic fish stomachs found.

One potential source of error in our experiment could be the misidentification of plastics for biological material such as fish scales. Because there was no significant difference between the plastics consumed by several pelagic species, we can infer that these species are likely consuming similar prey and not purposefully consuming plastic. Another potential source of error could be the limited sample size.



As a whole, our study leads us to further believe that plastic pollution is a relevant problem in the marine environment and, specifically in the Northern Exuma Sound, The Bahamas. Not using plastic bags, avoiding cosmetics that contain microbeads, and being aware of your waste disposal can help keep plastics out of the water. Future studies should focus on the specific behavioral and physiological effects of plastic ingestion, as well as the effects that plastics have on organisms of different trophic levels, including coastal fish and deep sea. Lastly, future studies should assess the chemical components of plastics, and their specific biological effects. We will use this study to spread awareness of this issue and prevent the plastic pollution in the marine environment.

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