Taste the Waste: Quantifying Plastic Pollution in Our Oceans

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Introduction

By 2050 the fish in our oceans will be outweighed by plastic debris, largely due to the fact that one third of all plastic produced ends up mismanaged. Currently, 4.8-12.7 million metric tons of waste enters our oceans annually, and five million metric tons of this is plastic. These plastics eventually break down in to smaller micro plastics via photo-degradation, which are then ingested by marine species including fish. In addition to intestinal blockages or perforation of organs, plastics also cause a false sense of fullness, often leading to starvation.

Plastic often contains Persistent Organic Pollutants (POPs) including common household products such as DDT (dichlorodiphenyltrichloroethane), flame-retardants or polychlorinated biphenyls, whose origins can be sourced to industrial chemicals. Due to their nature of repelling water (hydrophobic), absorption of these chemicals by plastic is common. POP's are lipophilic making them easily absorbed by fats, therefore once consumed by fish, noxious chemicals assimilate into the body tissue. Furthermore, POPs are commonly known as carcinogens and can disrupt hormones, increase diseases, and cause mutations on the genetic level.

Figure 1: Plastics found inside a fish stomach

The accumulation of POPs up the food chain is exacerbated by predator prey interactions through a process known as bio accumulation; therefore large game fish consumed by humans have the potential to contain POPs, which have also been demonstrated to have negative impacts on human health.

Objectives

- Analyze the quantity of plastics consumed by different game fish species.
- Quantify the density of plastics in the epipelagic layer of the water column surrounding Cape Eleuthera.
- Categorize the plastics from the surface and dissected stomachs by size, type and color.

Methods

Target species are caught using rod and reel as well as carcass collection from marinas and fishing tournaments. Stomachs are excised and dissected before contents are passed through a sieve stack to trap any plastic. Trawls are standardised to 15 minutes whereby a mesh net and cod-end gather plastics from the surface water. Locations are stratified by proximity to the continental shelf. All plastics are counted, sorted and recorded. As well as qualitative approaches, analytical methodologies included using ANOVA, T-Tests and Kruskal-Wallis to draw statistical comparisons among these data.

Figure 2: **A)** Capture of pelagic game fish by sport fishing; **B)** Dissection of fish stomachs rinsing all the content into the sieves, **C)** Avani high speed neuston trawl used to collect plastic, and **D)** Selection of plastic from stomachs (top) and trawls (bottom). Red bar indicates 1 cm.

Results

Fish Data

Between January 2015 and May 2016, 203 fish from 11 species have been sampled. Of these, 32 individuals (15.8%) contained plastic in their stomachs. In those fish whose stomachs contained plastics the highest density recorded in an individual fish was 6 pieces (Mahi mahi; *Coryphaena hippurus*) and the mean (± SE) was 3 ± 0.2 pieces. Four of the 11 species sampled (36%) were shown to contain plastic within their stomachs with frequency of ingestion ranging between 11.4 % (Wahoo; *Acanthocybium solandri*) to 50% (Atlantic flying fish; *Cheilopogon melanurus*) (Figure 3). The analysis of variance suggested that ingestion among species was not significantly different (p-value > 0.05).

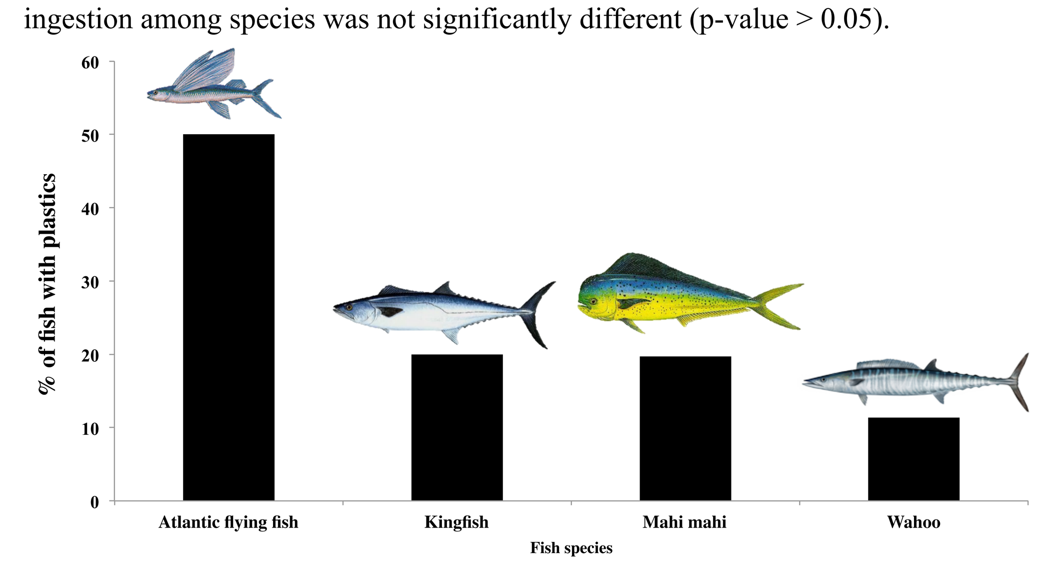

Figure 3: Percentage of fish individuals (categorized by species) which had plastic in the stomachs.

Trawl Data

One hundred percent of trawls conducted collected plastic debris. In a single trawl, the number of plastic pieces ranged from 2 to 35 and the mean (± SE) was 15 ± 3.4 pieces (Figure 4). Among all trawls, the mean plastic density (± SE) was 74,522 ± 17,725.5 pieces/km² and ranged from 9,434 to 178, 771 pieces/km². The highest density of plastics was found directly off the wall around Cape Eleuthera where the density ranged from 82,007 to 178,771 pieces/km² (Fig 5). A Kruskal – Wallis test ran on the trawl density on and off the wall confirmed a significantly greater density (p < 0.05) of plastics on, compared to off the wall.

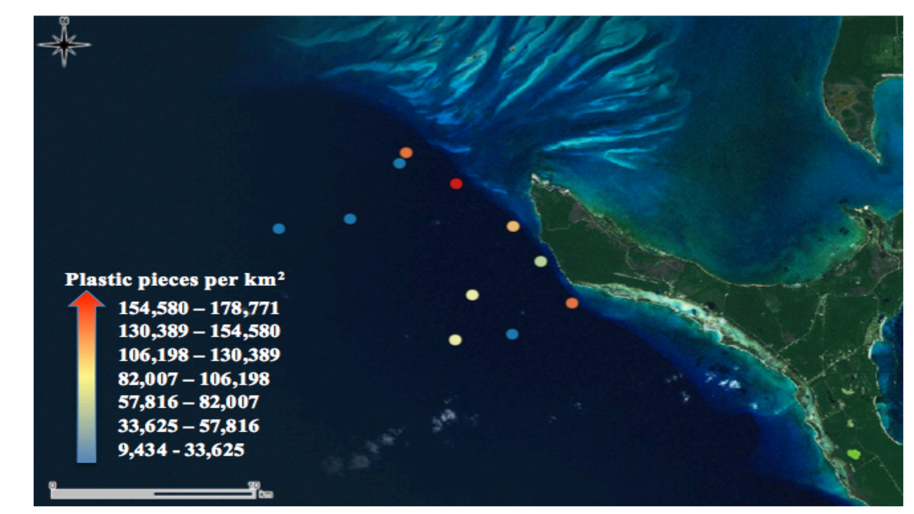

Figure 4: Density of plastic on the epipelagic layer of the ocean surrounding Cape Eleuthera.

Fish and Trawl comparisons

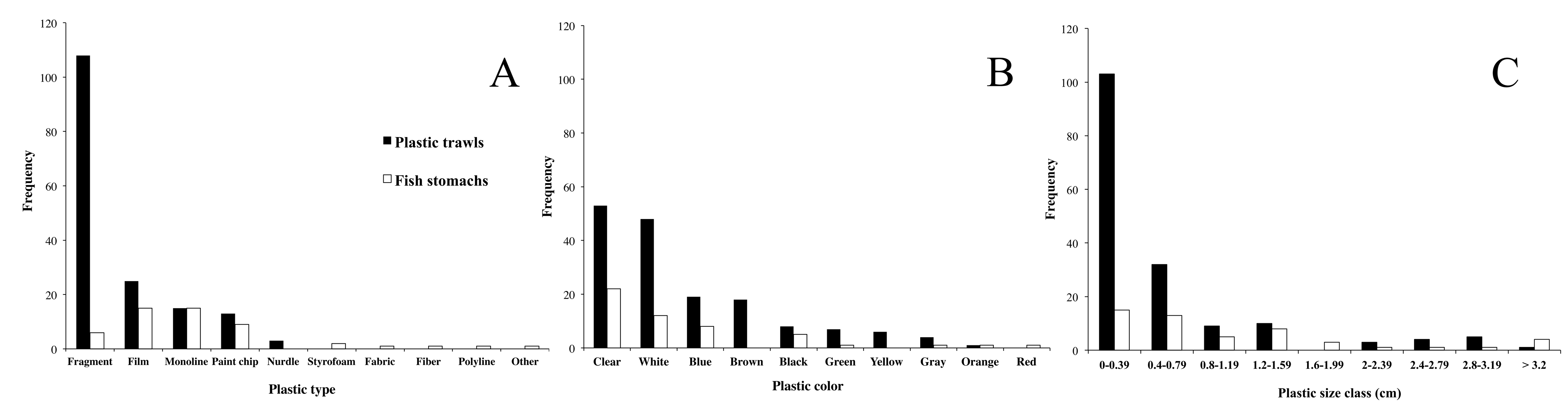

Figure 5: Frequency of plastic type **(A)**, color **(B)** and size **(C)** found in fish stomachs and trawls.

Plastic found in fish stomachs in order of occurrence included: film, mono line, paint chip, fragment, styrofoam, fabric, fiber, and poly line (Fig 5A). Testing for relative abundance among plastic types using ANOVA proved significant (p < 0.01) with film being the most abundant.

The type of plastic most commonly recorded in the trawls was fragments of larger plastic; over 100 of these pieces were collected. ANOVA indicated that the presence of fragments in trawls were statistically significant (p < 0.01). Film, mono line, paint chips and nurdles were also collected, but were less abundant (Fig 5A).

Of the pieces of plastics collected in trawls, clear and white plastics were the colors most commonly present (Figure 5B), both having a frequency of about 50. An ANOVA test run on this color data (p < 0.05), suggested a significant difference between the colors, supporting that clear was significantly different and that orange and red were significantly lower.

The colors of plastics found in stomachs, in order of frequency included: clear, white, blue, black, green, gray, orange and red (Fig 5B). ANOVA suggested a significant difference in the amount of different colors of plastic found, with clear plastic as statistically most abundant, followed by white (p < 0.01).

The size of plastics found in stomachs in order of frequency, included 0-0.39, 0.4-0.79, 1.2-1.59, 0.8-1.19, > 3.2, 1.6-1.99, 2.8-3.19, 2.4-2.79, and 2-2.39 cm (Fig 5C). Again, ANOVA suggested a significant difference in the amount of different sizes of plastic found in stomachs. It provided that 0-3.9 cm was statistically most abundant, followed by 0.4-0.79 cm as next most abundant (p < 0.01).

The size of plastics collected in the trawls, in order of frequency is shown in Figure 5C. ANOVA suggested a significant difference (p < 0.05) in different sizes of plastics within trawls, with 0-0.39 cm as significantly most abundant.

T-tests were used to statistically compare data from fish dissections and trawls. Specifically, type, colour and size were all tested to assess trends from both sampling methods:

- The type of plastic found in fish stomachs vs. trawls was non-significant (p > 0.05).
- The color of plastic collected in fish vs. trawls was significant (p < 0.05).
- The size of plastic found in fish vs. trawls was non-significant (p = 0.05).

Discussion

This study clearly demonstrates that plastic is found in relatively high densities in economically important fish as well as in the epipelagic layer of the water column. Based on our results it is likely that plastic found in game fish is a result of bio accumulation, demonstrated by plastic ingestion in Atlantic flying fish – a common prey for pelagic game fish. Of the entire sample size, 15.7% of fish had plastic in their stomachs. Previous studies conducted had similar percentages of plastic ingestion including 19% and 14%. Approximately 15 out of 100 fish that are caught have plastic in their stomachs, which suggests a large amount of fish that people consume could contain POPs.

There was a higher density of surface plastic pollutants closer to the wall than in the deeper ocean off of the wall. The dynamic nature of the physical ocean is likely mediating these predictable accumulations of plastics in convergence zones. This was demonstrated by an increases in plastics recovered from trawls on the edge of the continental shelf, when compared to offshore trawls.

Fragment plastic was the most abundant type found on the surface of the water, however this plastic was not the most abundant among fish stomach contents. Based on the data, it appeared that fish were targeting plastic pieces that were clear or white of 0-0.39 cm. The data showed that the most abundant colors found in both the trawls and fish stomachs were translucent and white. It can be concluded that because there is more white and clear plastics among the ambient pieces, the fish may be encountering these colors more often and possibly targeting them more than other colors. This finding correlates to previous findings that found that plastic colors translucent and white were found most abundant in small planktivorous within the North Pacific Subtropical Gyre.

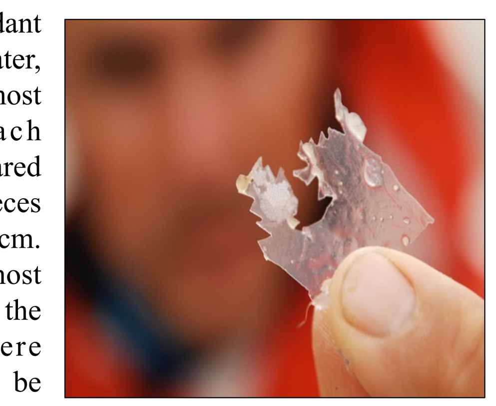

Figure 6: Example of a white translucent plastic pollutant that could be found on the surface or in the stomach of a fish.

Conclusions

- Plastics clearly pervasive in our marine environment.
- Fish affected via bio-accumulation.
- Species and site specific differences, suggest further research is critical.

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