The Density and Consumption of Plastic in the Northern Exuma Sound

By Melanie Carr, Coleman Gould, Anneke Sherry, Jack Stroud, Max Thébaud, & Hannah Van Alstine
Advisor: Zach Zuckerman

INTRODUCTION

Currently, an estimated 5 to 12 million metric tons of mismanaged waste is entering the ocean each year (Jambeck *et al*. 2015). 100 to 250 million tons of plastic are expected to enter the ocean in the next ten years alone (Jambeck *et al*. 2015). Plastics have intentionally been produced to be persistent so once these plastics have entered the ocean, they will break down but never disappear. Persistent organic pollutants, toxins made from mostly chemical byproduct, attach to plastic. When fish eat plastic, the POP's attach to the fat cells because they are lypophilic. When a fish is consumed with plastic in its stomach, those plastics and their toxins travel through the trophic levels, thus demonstrating biomagnification.

Economically and environmentally, the consumption of plastics by pelagic fish, especially sport fish, poses many problems. The POPs that are on these plastics attach to the fishes' fat cells due to being lypophilic. When a fish is consumed, dioxin and plastic levels can travel through the trophic levels, thus demonstrating biomagnification. People that consume fish on a regular basis have been proven to have higher dioxin levels than people that do not (Engler *et al*. 2012). Dioxins are capable of altering hormones, increasing the risk of disease, and causing reproductive disorders. (Engler *et al*. 2012). Annually in the United States, approximately 70 billion dollars goes towards recreational fishing, significantly more money than what goes towards commercial fishing. Recreational fishing also provides more jobs than commercial fishing in the U.S., thus further emphasizing its economic importance in the U.S. When people realize the increased dioxin levels, there will likely be a decrease in demand for both the catching and consuming of fish. The threats posed by plastics in the ocean and its consumption by fish and potentially humans could lead to extreme economic and health concerns, making this a significant issue now and in the years to come.

OBJECTIVES

- Determine the density and spatial distribution of plastics in the Northern Exuma Sound
- Deduce if pelagic fish of economic and ecological importance, specifically sport fish, are consuming plastics
- Observe the changes in plastic densities in the Northern Exuma Sound pre and post hurricane Joaquin

METHODS

Fig. 1 Pelagic sports fish are dissected for any stomach contents (a). A trawl is used to collect any plastic in the top 1/4m of water (b). Any stomach or trawl contents are sieved (c). Plastics are categorized by size, shape, color, type, and weight such as these found in fish (d).

RESULTS

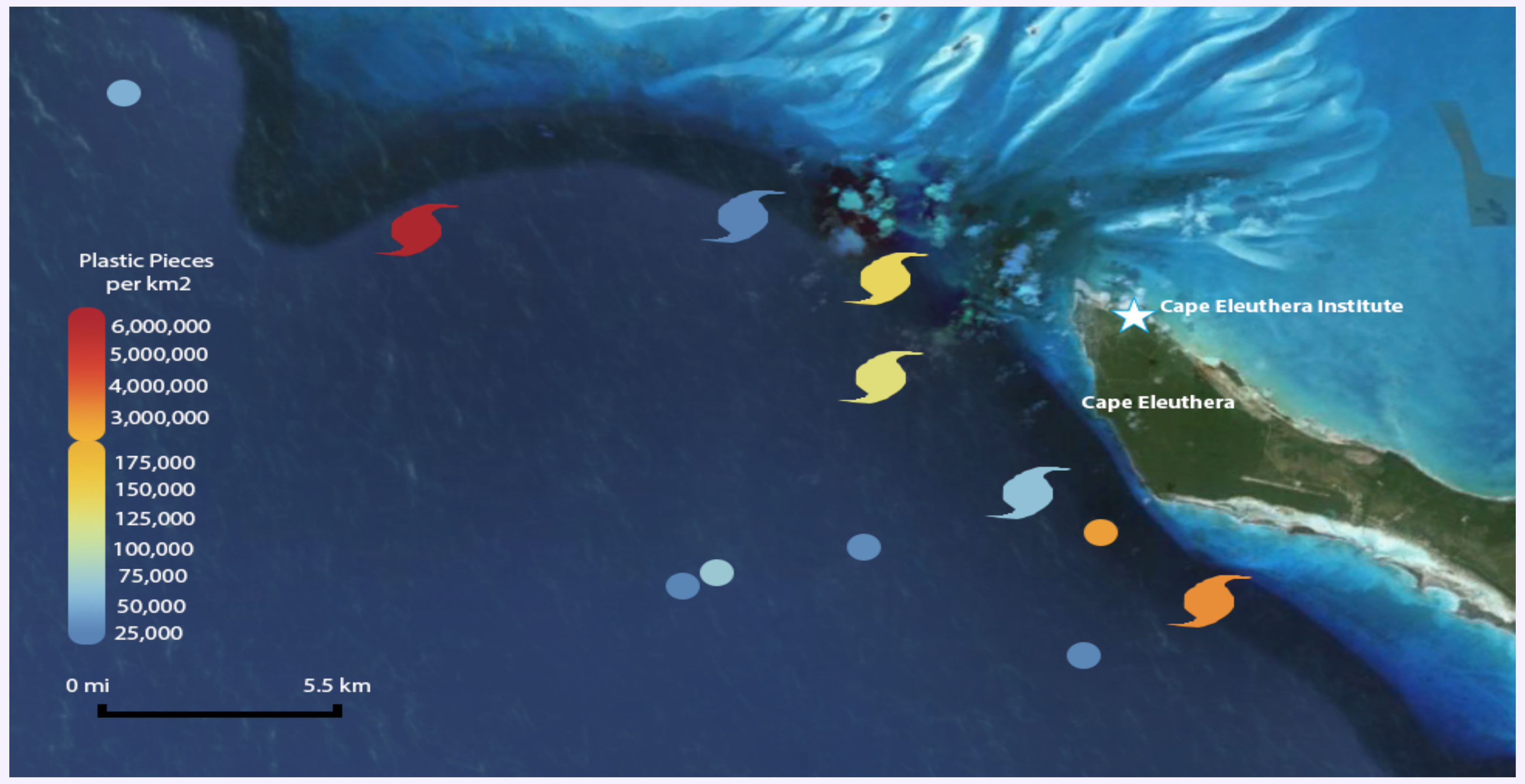

Fig 2. Density and Spatial Distribution of Trawl Collection Data in North Exuma Sound. Circles are pre Hurricane Joaquin, and cyclones are post.

T-Test	Change in macro plastic quantity after the hurricane	Change in micro plastic quantity after the hurricane	Change in plastic density after the hurricane	Change in length plastic after hurricane
P-value	0.1825	0.1825	0.099	0.065

Table 1. T-tests run on trawl data and results

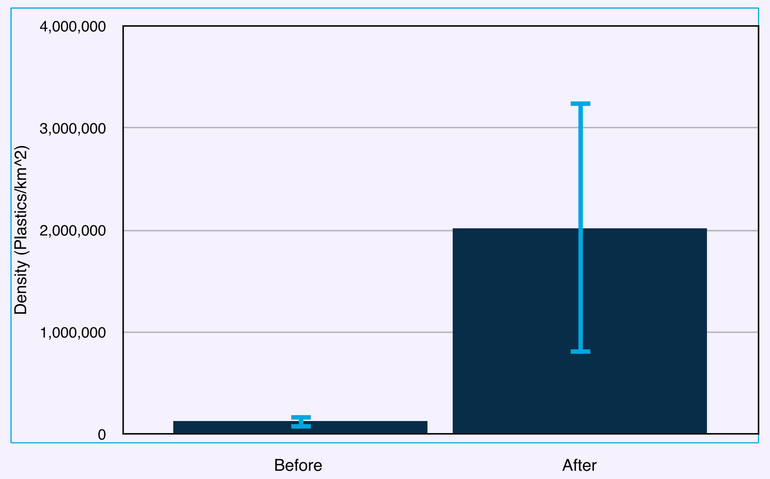

Fig 3. Average density before and after the hurricane

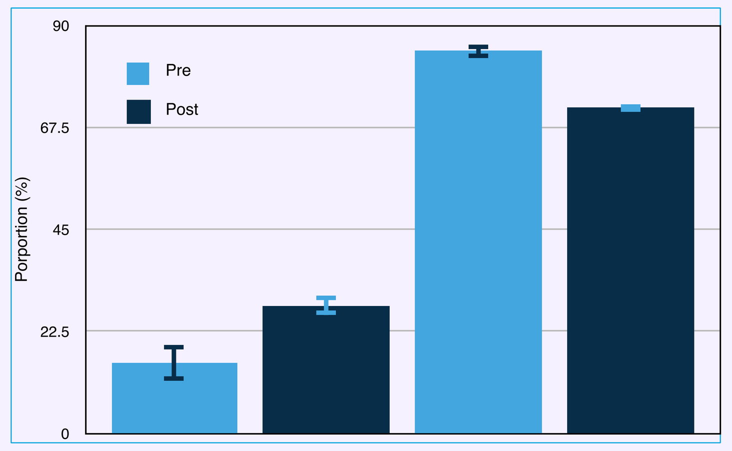

Fig 4. Proportion of plastics before and after the hurricane in trawls

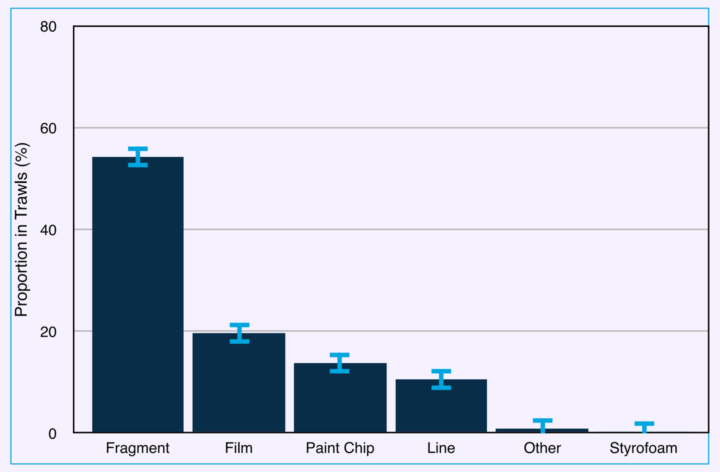

Fig 5. Average frequency of plastic type in trawls

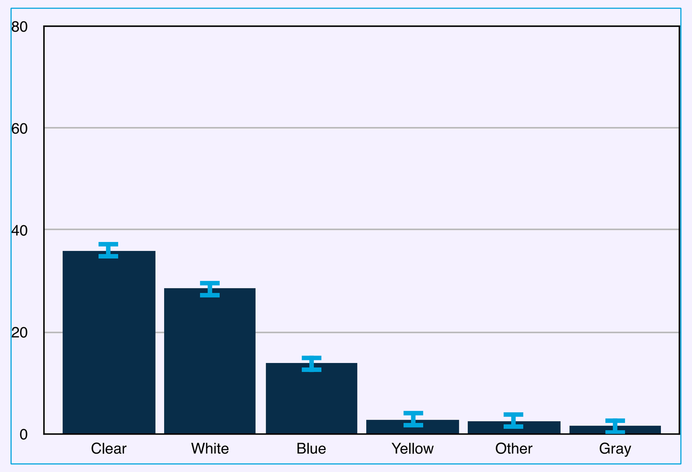

Fig 6. Average frequency of plastic color in trawls

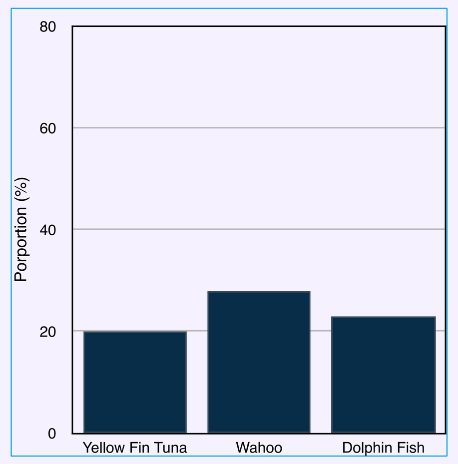

Fig 7. Average frequency of consumption of plastics found in species

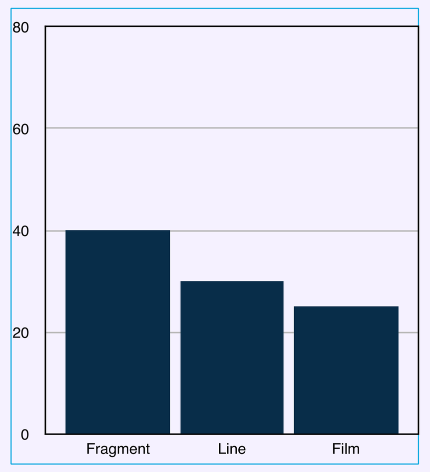

Fig 8. Percent plastic type found in dissected fish

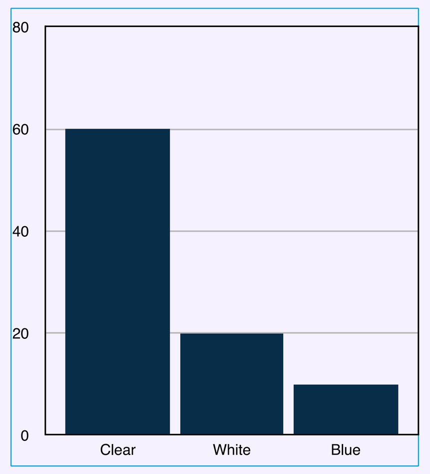

Fig 9. Percent plastic color found in dissected fish

Fig 10. Microplastics found in fish dissections

Fig 11. Macroplastics collected from sargassum patch in Exuma Sound

DISCUSSION

There was an expectation in this study for higher plastic densities and consumption by fish since the Exuma Sound is a potential gyre (Colin, 1995). The Exuma Sound is a semi-closed body of water with two small connections to the Atlantic, drawing in water but having little outflow. There was a variety of plastic types and colors collected in the trawls, which can be explained by the different ways and locations that plastics are entering the ocean, including oil spills and a recent sunken barge.

In all of conducted trawls, micro plastics greatly outnumbered macro plastics, suggesting a high decay rate. The average quantity of macro plastics increased after hurricane Joaquin, suggesting that the hurricane blew in bigger plastics that had not yet had the time to degrade. The slight decrease in micro plastics post hurricane has the potential to be linked to a more widespread distribution due to the currents resulting from the storm. Despite the t-test results that found no significant change, there was still an average of 17x the density of plastic, 1,705,187 pieces/km^2, after hurricane Joaquin, putting into perspective the amount of plastic that the oceans contain. If more trawls had been conducted post Joaquin, these results may have been more accurate and the t-tests may have shown significance.

Despite the fairly small sample size, the results still make clear the entrance of plastics into the food chain. The percentages of plastics found in the stomachs of fish during dissection were higher than those presented in previous studies by a wide margin (Choy & Drazen, 2013). This means that the ingestion of plastics by fish and the possibility of this issue reaching humans could occur much faster than previously estimated.

The prominent presence of plastics poses a great threat to fish species because of the health problems from dioxins on plastics, which could potentially decrease population sizes (Engler, 2013). If humans are consuming pelagic fish such as these, realistically there is a chance humans are ingesting dioxins from POP's as well. This quick impact could also greatly harm the economy; the $70 billion dollar fishing industry is at risk for the U.S. Based on the results found in this study based in the Exuma Sound, it opens the question of potential risk elsewhere. The next step for researchers is to quantify plastic densities in other gyres as well as to determine the connection between plastic consumption by fish to plastic consumption and dioxin intake by humans. Without this knowledge, humans could soon be battling a variety of diseases and disorders that are currently unknown.

ACKNOWLEDGMENTS

Special thanks to:
CEI interns: Connor Gallagher & Toniann Keiling
Island School Gap Year Students: Phoebe Colvin-Oehmig & William Lee
We appreciate the support from the Anderson-Cabot family & 5 Gyres

LITERATURE CITED

Boerger, M.B., Lattin, G.L., Moore, S.L., Moore, C.J. (2010) Plastic ingestion by planktivorous fishes in the north pacific central gyre. *Marine Pollution Bulletin* 60:2275-2278
Choy, C. A., Drazen, J.C. (2013) Plastic for dinner? Observations of frequent debris ingestion by pelagic predatory fishes from the central north pacific. *Marine Ecology* 485:155-163
Colin, P. L., (1995) Surface currents in Exuma Sound, Bahamas and adjacent areas with reference to potential larval transport. *Bulletin of Marine Science* 56:48-57
Derraik, J.G.B.(2002) The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin* 44:842-852
Engler, R. E. (2012) The complex interation between marine debris and toxic chemicals in the ocean. *Environmental Science & Technology* 46:12302-12315
Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Lavendar Law, K. (2015) Plastic waste inputs from land into the ocean. *Science* 347:768-770
Lavender Law, K., More-Ferguson, S., Maximenko, N. A., Proskurowski, G. Peacock, E. E., Hefner, J., Reddy, C. M. (2012) Plastic accumulation in the North Atlantic Subtropical Gyre. *Science* 329:1185-1188
Southwick, A. (2013) Summary of comparing NOAA's recreational and commercial fishing economic data