

## For Immediate Release

### At what point do floating plastics sink?

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#### Summary:

On February 10th and 11th, 2010 Team Marine conducted a lab study in a classroom aquarium to determine what happens to ten common plastic products/pollutants when they enter the ocean. The results of our study generally supported the results obtained by the Algalita Marine Research Foundation (Eriksen, 2005) in terms of which plastics are supposed to sink and float based on their densities. Furthermore, our study assessed the proportion of a plastic object's dry weight needed to sink that plastic object. This was done in order to (a) find out what mass of colonizing (fouling) organisms and/or sand would be needed to sink different kinds of plastics and, (b) to predict where different kinds of plastics would accumulate in ocean water. Our results below show that density is not always a good indicator of whether plastics float or sink, and that different plastics will need different amounts of weight to sink them, which will affect how far from the shore they travel and whether those plastics will end up on the surface, in the middle, or on the bottom of the ocean.

#### Materials and Methods:

The pre-weighed sinker weights that we added to the plastic objects a small amount at a time appear in Table 1, and a photo of what they look like appears below in Figure 1. The plastic objects that we tested, the materials that they're made out of and their densities appear in Table 2, and a photo of what they look like appears in Figure 2.

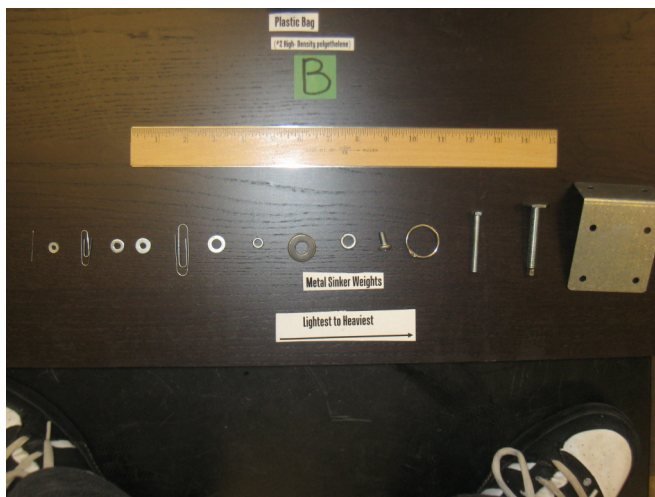
In the back of the classroom, we used the salt-water aquarium to conduct our study. For every plastic object we tested, we performed the following protocol:

1. In the aquarium, we turned off all of the water pumps, so that the plastic objects would not be disturbed by water currents.
2. We put each object under water and shook it for 30 seconds to allow any trapped air bubbles to escape.
3. We observed each plastic item for 30 seconds without adding any weight to see whether it would float or sink.
4. A small amount at a time, we added pre-weighed metal sinkers until we found the minimum weight needed to sink the plastic object. We set up two criteria: (a) the object would sink faster than a rate of

1.83cm/second, in other words, sink to the bottom in less than 30 seconds, and (b) the object would need to stay on the bottom once it landed there.

**Table 1.**

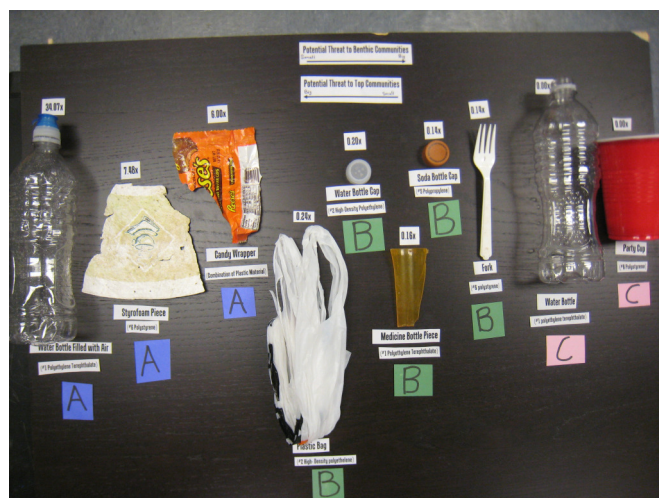
Metal Sinker Weights	Weight (g)
Pins	0.06
Tiny washer	0.37
Small paperclip	0.43
Medium washer	0.94
Medium washer	1
Big paperclip	1.02
Big washer	1.05
Smaller nut	1.84
Brass washer	4.29
Big nut	4.36
Small bolt	4.97
Ring	5.38
Big bolt	11.08
Massive Bolt	35.75
Metal Plates	109.62



**Figure 1.**

**Table 2.**

Plastic Item	Type of Plastic	Densities (g/mL) (from Eriksen, 2005)
Water Bottle Filled w/ Air	Polyethylene Terephthalate (PETE) + Cap = High-Density Polyethylene (HDPE)	Water Bottle = 1.38-1.39 Cap = 0.95-0.97
Styrofoam Piece	Polystyrene (PS)	1.05-1.07
Reese's Peanut Butter Cup Wrapper	Mixed Plastics	N/A
Grocery Bag	High-Density Polyethylene (HDPE)	0.95-0.97
Water Bottle Cap	High-Density Polyethylene (HDPE)	0.95-0.97
Medicine Bottle Piece	Polyethylene Terephthalate (PETE)	1.38-1.39
Soda Bottle Cap	Polypropylene (PP)	0.90-0.91
Fork	Polystyrene (PS)	1.05-1.07
Water Bottle w/o Cap	Polyethylene Terephthalate (PETE)	1.38-1.39
Party Cup	Polystyrene (PS)	1.05-1.07



**Figure 2.**

## Results and Discussion:

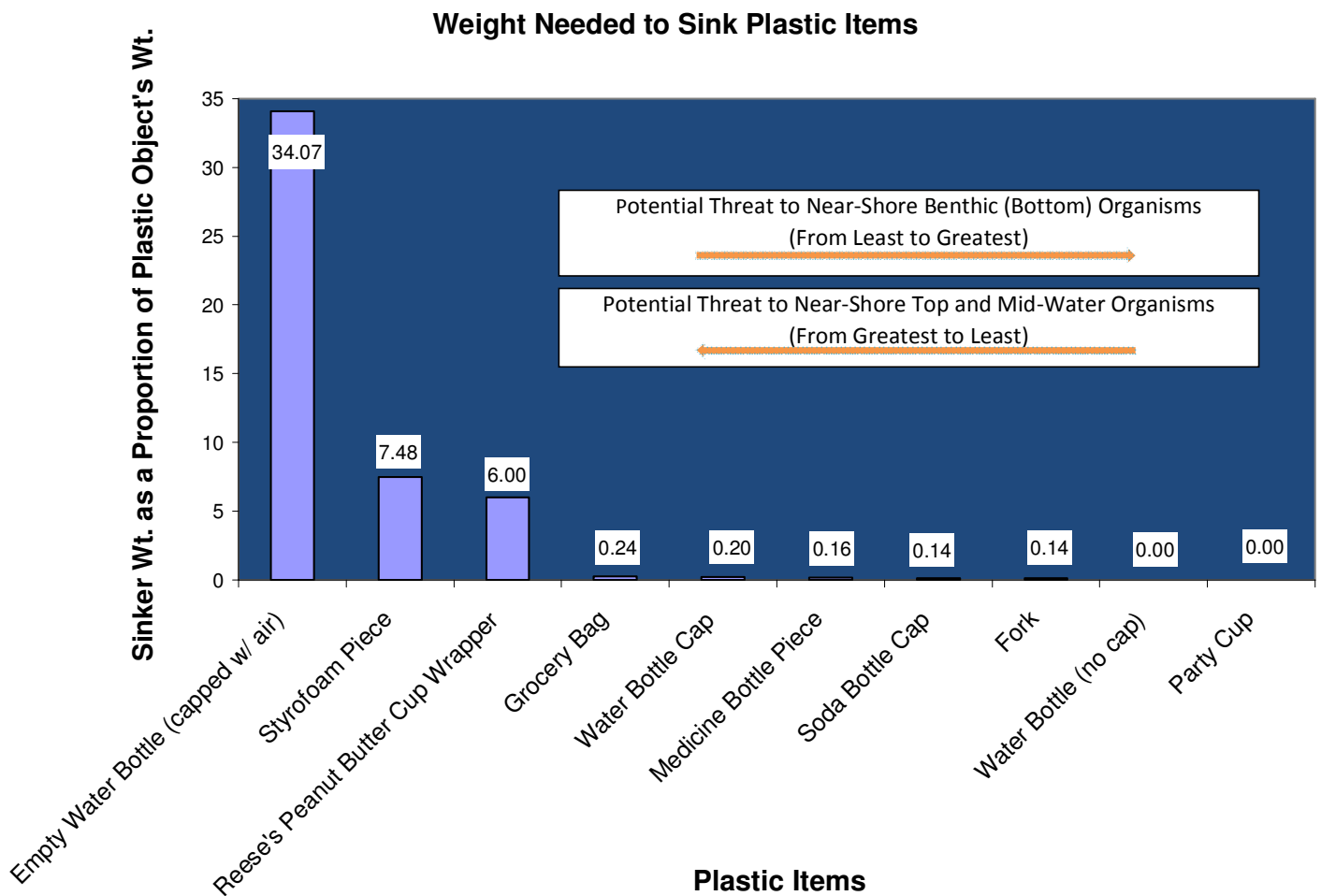
At the end of the study, we were able to separate the ten plastic objects into three distinct categories of plastics based on the amount of weight needed to sink each plastic object. The water bottle filled with air, the Styrofoam cup piece, and the Reese's Peanut Butter Cup wrapper (Figure 2, Category A) made from Polyethylene terephthalate (PETE), polystyrene (PS), and mixed plastics, respectively, were all very buoyant as a result of their known densities (Table 2). According to Eriksen (2005), the density of polystyrene is 1.05 – 1.07g/mL, which means polystyrene should sink to the bottom since ocean water is less dense (1.027g/mL). However, Styrofoam (also made of polystyrene) has air injected into it, therefore making it less dense and allowing it to float. The amount of sinker weight required to sink the capped water bottle filled with air is approximately 34 times the weight of the dry weight of the bottle (Figure 3 below). The amount of sinker weight required to sink the Styrofoam cup piece is 7.5 times the weight of the dry weight of the Styrofoam piece. The sinker weight required to sink the Reese's Peanut Butter Cup wrapper is 6 times the weight of the dry weight of the wrapper. These results suggest that it would be hard for fouling organisms and/or sand to sink these plastic items, so these kinds of plastics are more likely to be found at the surface, make their way into major oceanic gyres, and pose the greatest threat to organisms that live at the surface (see Trajectory 1, Figure 4). Even though fouling organisms are likely to attach to these objects, they are still likely to remain positively buoyant.

Items like grocery store bags, water bottle caps, medicine bottle pieces, plastic soda bottle caps, and plastic forks (Category B, Figure 2) made from high-density polyethylene (HDPE), polyethylene terephthalate (PETE), polypropylene (PP), and polystyrene (PS) respectively (Table 2), required a smaller amount of sinker weight to sink the object. A plastic grocery bag requires 0.24 times the amount of its dry weight to sink as seen below in Figure 3. The amount of sinker weight required to sink a water bottle cap would require 0.2 times the mass of its dry weight to sink. The amount of sinker weight required to sink a medicine bottle piece requires 0.16 times the amount of its dry weight to sink. The amount of sinker weight required to sink a plastic soda bottle cap requires 0.14 times the amount of its dry weight to sink. According to Eriksen (2005), the densities of these plastic materials (see Table 2) are all less than the density of ocean water, which means things like grocery store bags and plastic water bottle caps should float on the top of the ocean. However, their densities may increase when organisms or sand attach to the plastic object (Moore, 2008). We therefore hypothesize that, at first, these plastics will float, and over time, they will eventually sink as denser particles accumulate on them. This suggests that these objects should pose a threat to the top, middle, and bottom communities of the ocean (see Figure 4, Trajectory 2).

Objects like water bottles without caps and plastic party cups (Category C, Figure 2) made from polyethylene terephthalate (PETE) and polystyrene (PS), respectively, both with higher densities than ocean water (Table 2), enable them to sink without the added weight of fouling organisms and/or sand. Therefore we hypothesize that when these plastics are exported from storm drains into the ocean they will immediately sink, accumulate in the near-shore bottom communities, and pose a threat to the life that is there (see Figure 4, Trajectory 3).

In conclusion, Categories A and B will most likely be carried further offshore, while Category C will most likely sink to the near-shore benthic communities. Category A and B plastics which are less dense should accumulate in major oceanic gyres and pose a greater threat to top communities. They also have the potential to transport organisms from one habitat to another, which could become invasive (Moore, 2008). Although Category C plastics are most likely going to be more abundant in the near-shore benthic communities, they may be carried along the ocean floor by water currents, until they get stuck in rocks, kelp, corals, or covered by sand. This study suggests that plastic density does not always accurately predict which plastics will float or sink because some plastics get injected with air, some may trap air, and there may be fouling organisms that may increase the density of that plastic object. It's important to note that when we conducted this lab study, our sample size for each plastic item was one. In order to get more accurate results, we would need to test at least 3 samples of each plastic item. The model that we proposed (see Figure 4) still needs to be tested in the field to see if plastics will accumulate where predicted. Future studies should also investigate some of the unknown variables about our plastic trajectory model. For instance, do the buoyant plastics float forever, or do they eventually get punctured, say, by fish, birds, and/or boats and then sink? How long does it take for different plastic materials to photo-degrade by the sun? Do floating and sinking plastics equally adsorb persistent chemicals, and are top and bottom water organisms equally affected by potential biomagnification of these chemicals that are known to

adsorb onto the plastics (Mato et al., 2001)? Another big question is how much plastic has accumulated on the bottom? A recent study by NOAA studied the deep ocean off the California coast and found that plastics are the most abundant marine debris item on the ocean floor (Watters, 2010).



**Figure 3.**



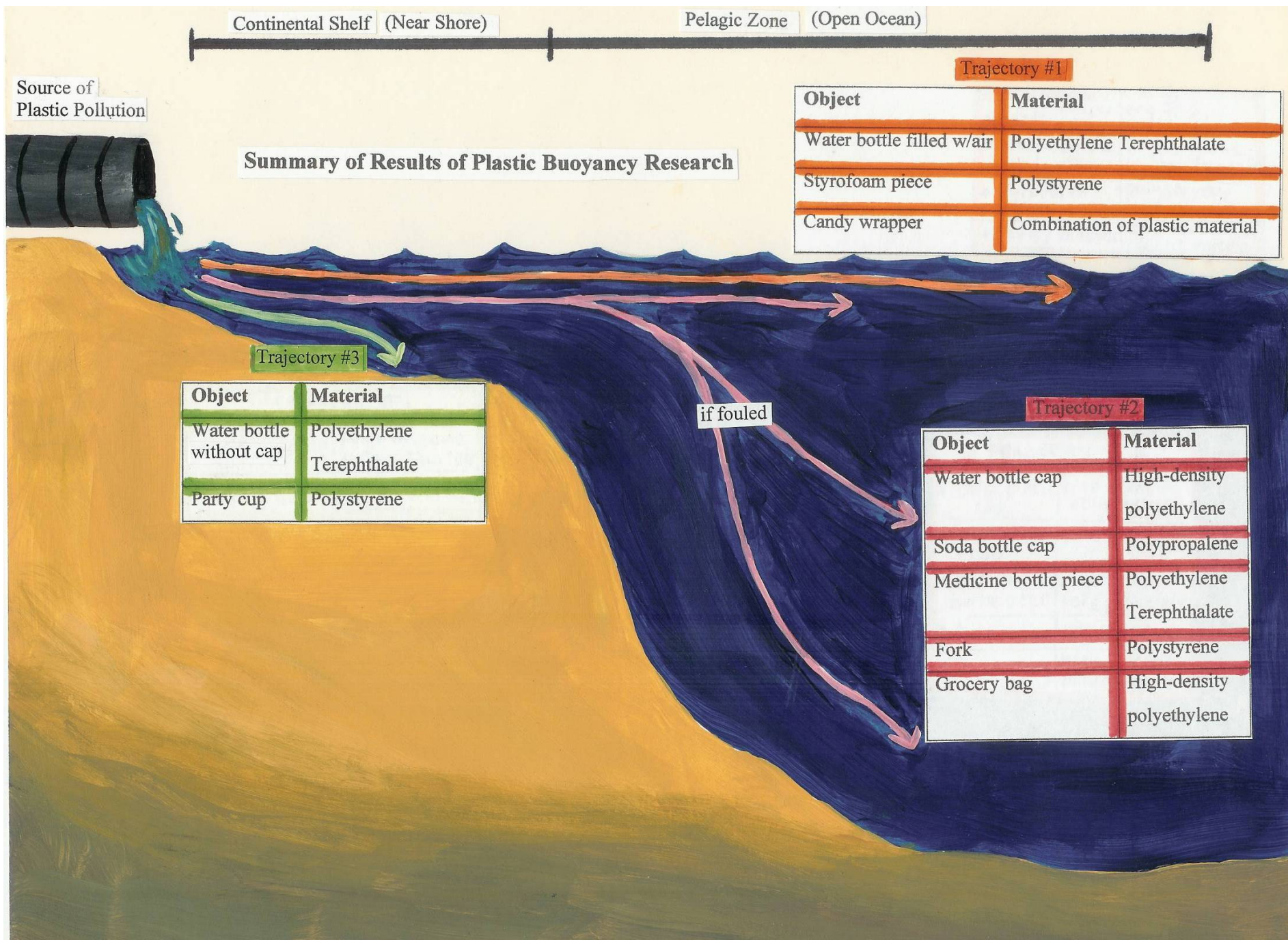


Figure 4

## References:

1. Eriksen, M. (2005). Watershed Wonders: Standard Based Activities and Information About Water and Watersheds for Middle and High School Classrooms. Algalita Marine Research Foundation pgs. 33-40.
2. Moore, C.J. (2008). Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. *Environmental Research* 108 131-139.
3. Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C., and Kaminuma, T. (2001). Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. *Environmental Science Technology* 35, 318-324.
4. Watters, D.L., Yoklavich, M.M., Love, M.S., and Shroeder, D.M. (2010). Assessing marine debris in deep seafloor habitats off California. *Marine Pollution Bulletin* 60 (1), 131-138