

Spatial and Temporal Distribution of Plastic Pollution in the North Atlantic Subtropical Gyre

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Introduction:

This study presents data gathered from 35 surface net tows conducted during 2 expedition legs through the North Atlantic Subtropical Gyre in the winter of 2010. 6 months later, 6 sites were revisited to study seasonal variation.



In January 2010 the vessel "Sea Dragon" traveled over 4,850 kilometers from St. Thomas, Virgin Islands to Bermuda, and onward to Horta, Portugal. The Sea Dragon is a 50-ton, 72ft sloop-rigged sailboat, with long spinnaker poles easily rigged for towing neuston nets for sea surface sampling.

Previous studies of plastic marine debris in the Sargasso Sea span nearly 4 decades, yet have focused on the western region primarily. This study shows evidence of spatial distribution of plastic marine debris further than previously known, and a temporal change showing a summer increase plastic particle abundance over winter samples in the same area.

Methodology:

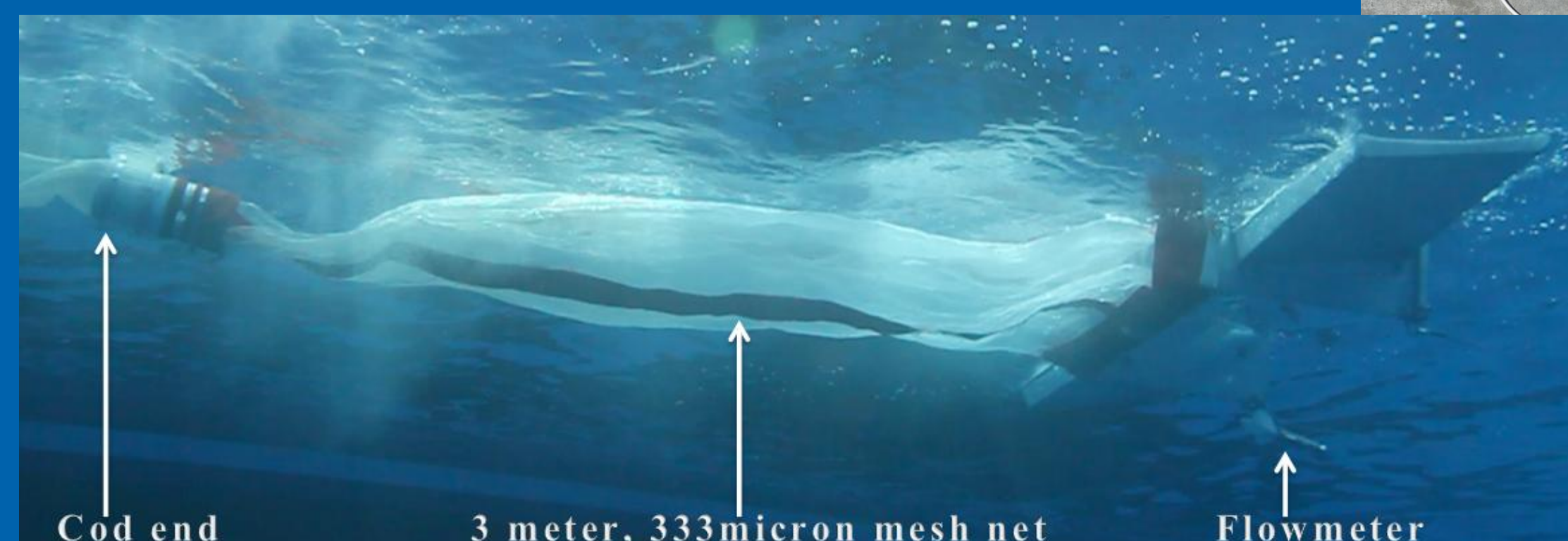
Sea surface samples were collected using a manta trawl with a 60cm x 25cm net aperture, a 333- μ m mesh net, and towed at the air-sea interface. The net is towed off the starboard side using a spinnaker pole extended perpendicular to the boat, which extends the towline 5 meters from the ship's hull, thus avoiding the ship's wake. Tows were typically 3 hours long and traveled 6-8 nautical miles at 1.5-1.75 knots. To measure the area and volume sampled, we used a flowmeter, and recorded GPS coordinates of the start and stop locations. Samples were preserved in 10% buffered formalin for transport to the lab.

Trawl#	TIME start	Lat(N) start	Long(W) start	Flowmeter	Boat Speed	Barometric	Notes
				Bag			
				End			
				Total			
Date	TIME end	Lat(N) end	Long(W) end	Distance	Water Temp.	Microsediment	

Data sheet format



Manta trawl



Manta trawl towed

Plastic particle weight and count density was computed by multiplying the width and height of the net aperture by the length of water traversed according to flowmeter data, then this volume was divided into the total weight in grams, and also the total number of particles. Plastic particle count abundance was computed similarly, but with only net width, not height. GPS coordinates are used to validate flowmeter data.

Individual particles of plastic were then sorted into type categories (pellet, fragment, foam, film, and filament) and size categories (0.355-0.499mm, 0.500-0.709mm, 0.710-0.999mm, 1.0-2.79mm, 2.8-4.749mm, and greater than 4.75mm.)

Results and Discussion:

The first leg of the expedition began in St. Thomas, Virgin Islands and landed in Bermuda, representing the western region between longitudes (64.56W – 62.43W). The average plastic weight density is .0125 g/m³, and the average particle count density is .4488 particles/m³. The average plastic particle abundance was 68,446 /km².

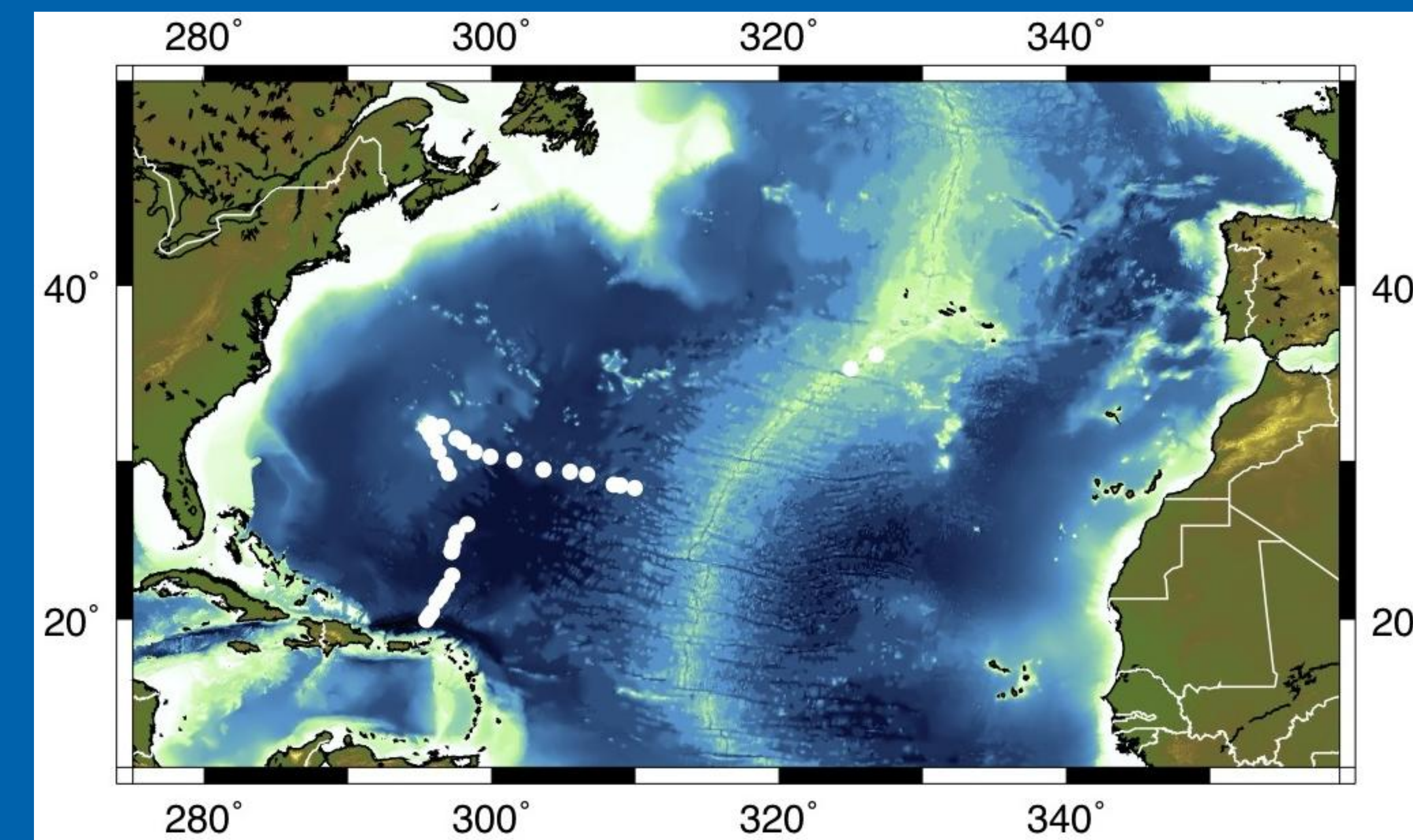
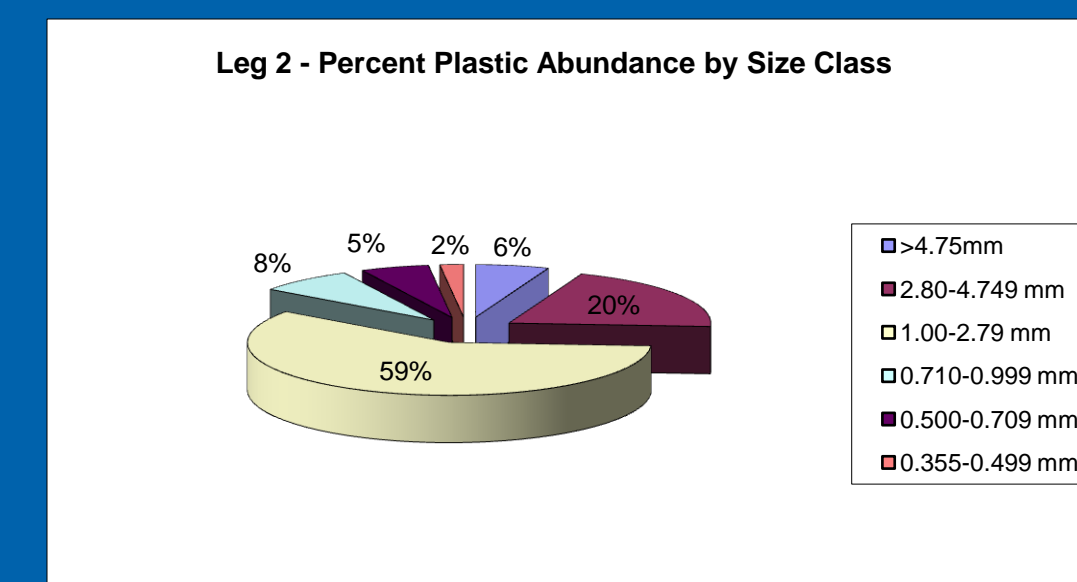
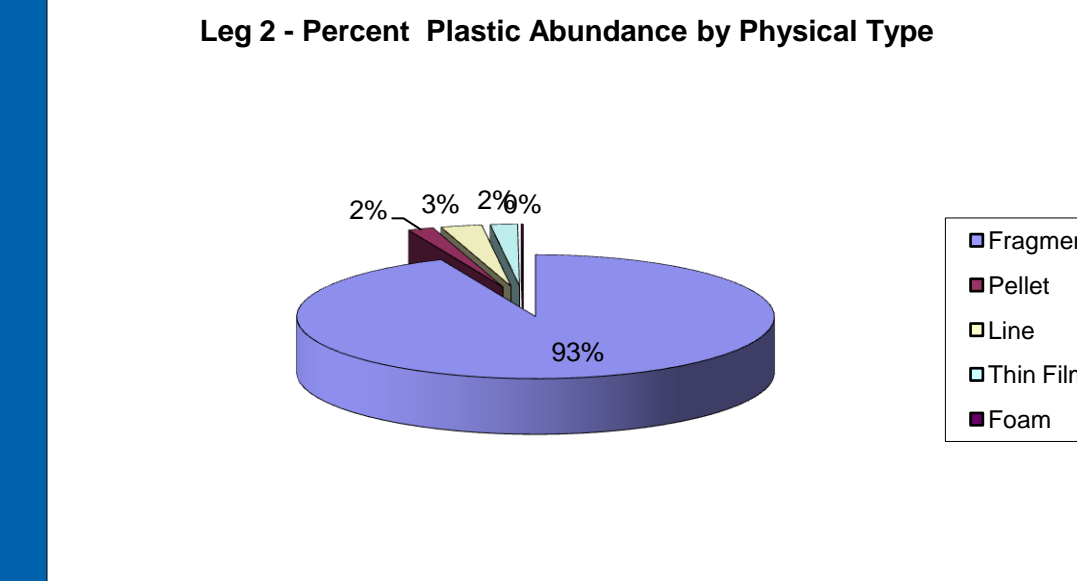
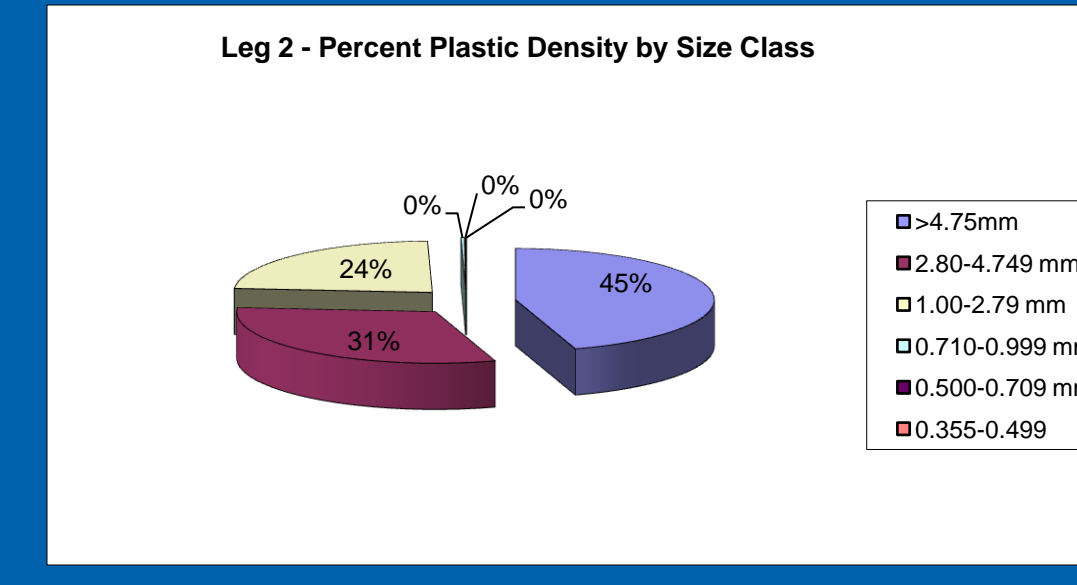
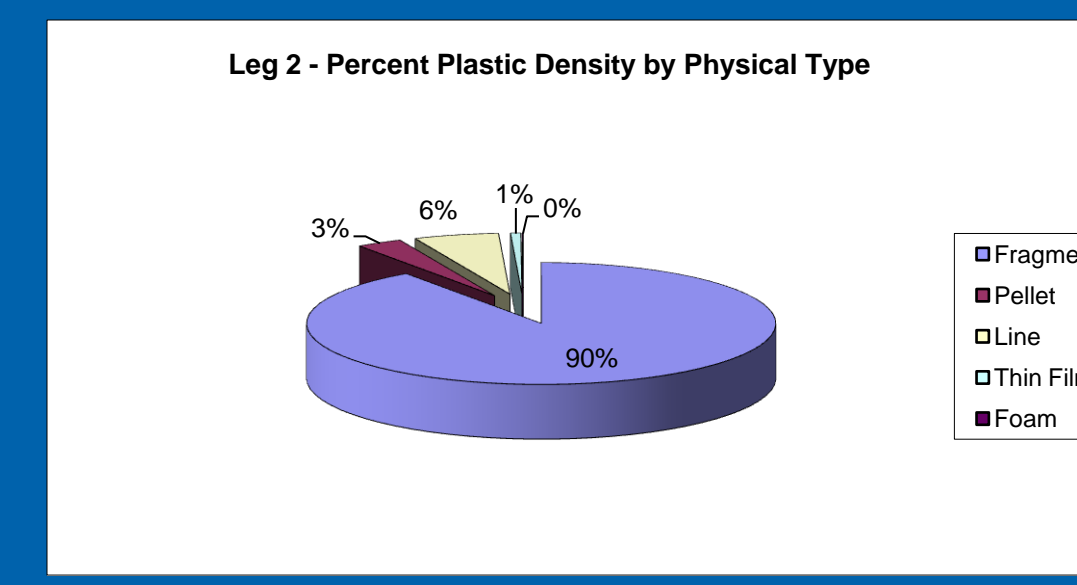
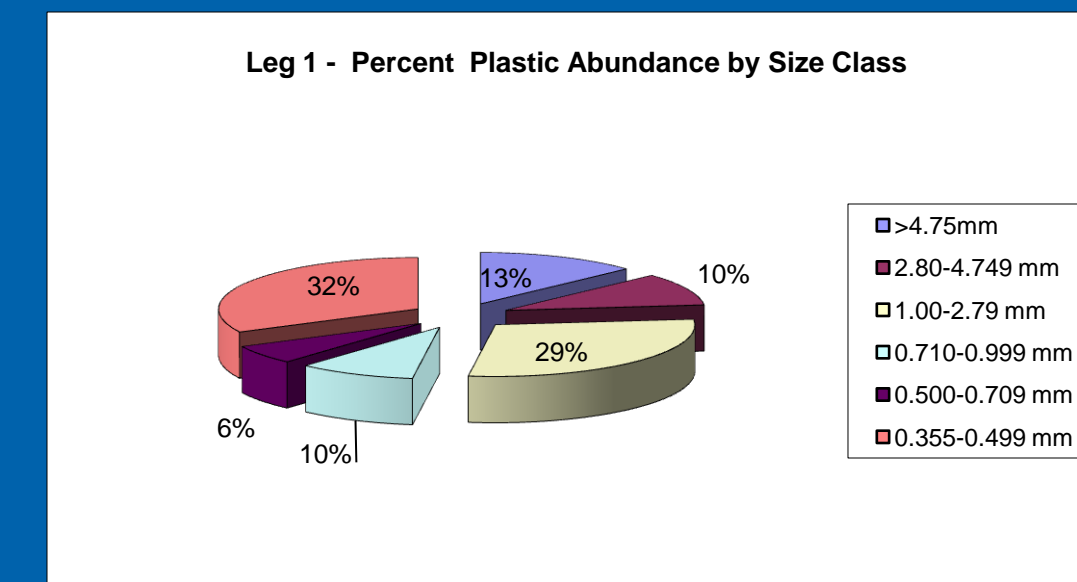
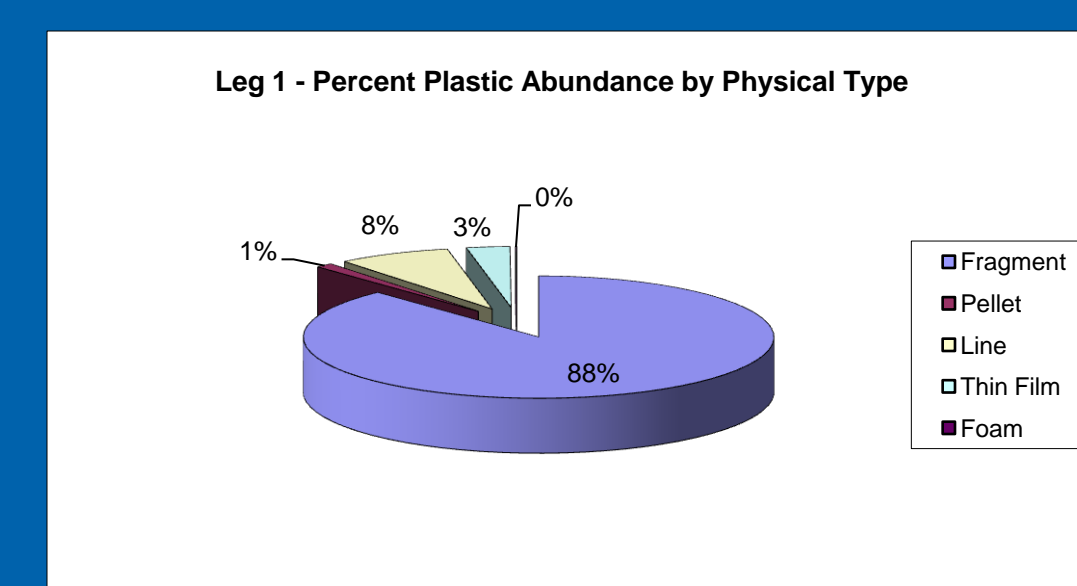
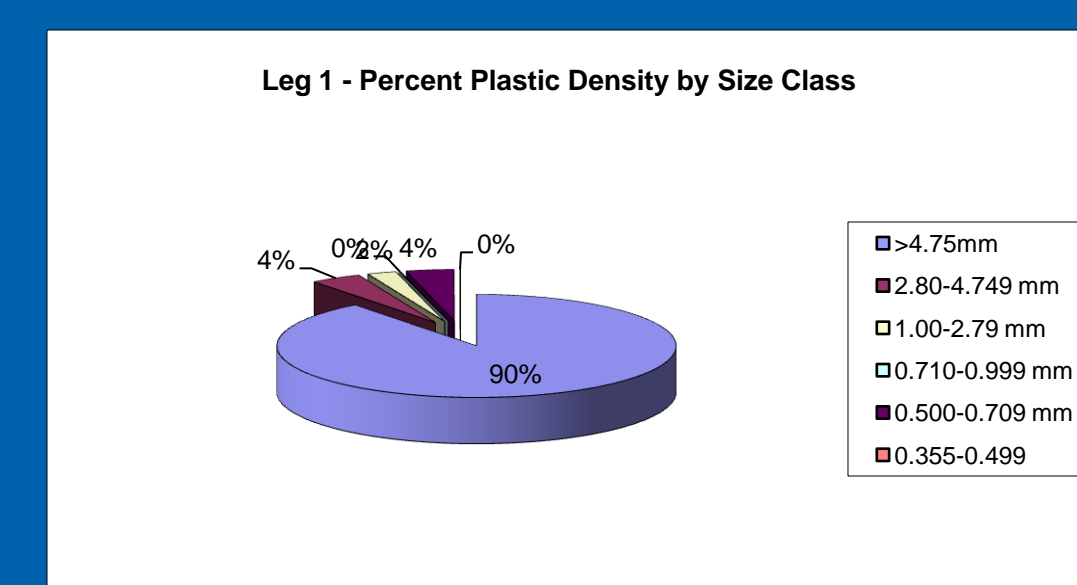
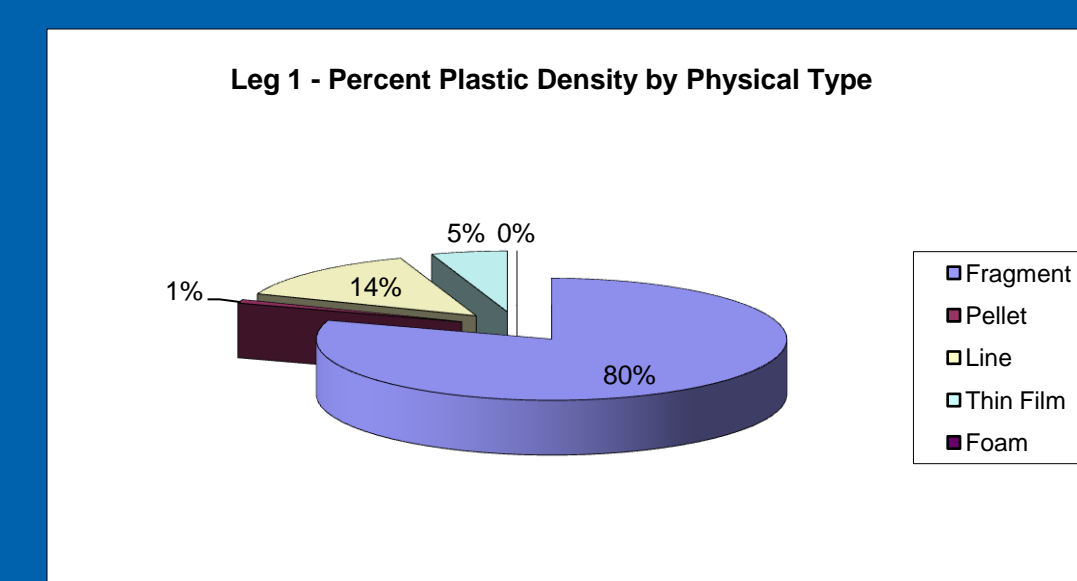
Sample ID	Date	Latitude	Longitude	Count Density (number/m ³)	Weight Density (g/m ³)	Surface Abundance (number/km ²)
1	1/6/2010	19.9432	64.5649	0.515	0.0002	81,899
2	1/6/2010	20.2173	64.3828	0.077	0.0005	11,738
3	1/6/2010	20.4521	64.1968	0.186	0.0283	28,986
4	1/10/2010	21.1293	63.8333	0.089	0.0001	13,619
5	1/10/2010	21.4730	63.5899	0.064	0.0002	9,817
6	1/10/2010	21.7367	63.4227	0.814	0.0138	124,190
7	1/11/2010	22.1500	63.1474	0.147	0.0000	22,347
8	1/11/2010	22.8418	62.7992	0.139	0.0003	21,210
9	1/10/2010	24.3076	62.8109	0.112	0.0002	17,661
10	1/13/2010	24.3576	62.8109	0.215	0.0001	2,215
11	1/13/2010	24.7687	62.7221	0.016	0.0001	2,391
12	1/13/2010	25.3751	62.4785	0.042	0.0000	6,402
13	1/13/2010	25.5607	62.4387	4.483	0.1745	680,524
14	1/14/2010	26.0914	61.7168	0.016	0.0001	2,403
15	1/18/2010	29.2490	62.9857	0.139	0.0013	21,227
16	1/18/2010	29.7453	63.2167	0.277	0.0051	42,290
17	1/18/2010	30.5477	63.7064	1.273	0.0091	194,129
18	1/17/2010	31.1613	64.0147	0.086	0.0010	13,126
19	1/17/2010	31.5350	64.2677	0.287	0.0013	43,709
20	1/18/2010	31.9644	64.5448	0.199	0.0203	30,373
Mean				0.449	0.0125	68,446

The second leg of the expedition began in Bermuda and traveled east toward to Horta, Portugal, with 15 samples collected between longitudes (64.25W – 33.23W). Plastic weight density was .0025 g/m³ and particle count density was .3042 particles/m³. Average plastic particle abundance was 46,393 particles/km².

Sample ID	Date	Latitude	Longitude	Count Density (number/m ³)	Weight Density (g/m ³)	Surface Abundance (number/km ²)
21	1/28/2010	32.3200	64.4322	0.325	0.0039	49,589
22	1/28/2010	32.0790	64.6336	0.365	0.0041	55,632
23	1/29/2010	31.5866	62.7797	0.218	0.0017	33,255
24	1/29/2010	32.7127	62.2048	0.106	0.0019	16,229
25	1/30/2010	33.8735	61.3126	0.046	0.0071	68,461
26	1/31/2010	30.0790	58.7081	0.324	0.0025	49,335
27	1/31/2010	30.0790	58.7081	0.039	0.0003	3,099
28	2/1/2010	29.6835	56.6993	0.036	0.0008	5,545
29	2/2/2010	29.5392	54.9628	0.460	0.0026	70,222
30	2/2/2010	29.2797	53.6117	0.455	0.0024	69,440
31	2/3/2010	28.9070	51.8931	0.209	0.0012	31,890
32	2/3/2010	28.9729	51.8777	0.068	0.0002	10,610
33	2/6/2010	34.5521	50.1006	0.197	0.0016	20,060
34	2/9/2010	35.6229	35.0237	0.075	0.0004	11,393
35	2/9/2010	36.2937	33.3888	0.158	0.0024	24,344
Mean				0.304	0.0025	46,393

On both legs, fragments far outweighed and outnumbered the other 4 types of plastic, by 80% or greater. The smallest size category number of particles. On Leg 1, the distribution of (0.335-0.499mm) accounted for one third of the particles by size favored the smallest size class, 0.335 – 0.499mm, by 32%, with nearly half of the particles, 48%, less than 1mm. On Leg 2, the percent distribution of particles less than 1mm was 15%, with 59% of the number of particles in the 1 – 2.79mm size class.

During Leg 2, the expedition crew experienced a tropical storm with wind gusts exceeding 60 knots and wave heights over 8 meters. Samples were collected during sea states less than Beaufort Scale 4. What is unknown is the effect of sea state on the vertical distribution of different class sizes of particles, as well as the vertical suspension rate of microplastics after storms. This may explain the significant reduction in observed smaller class sizes between the two expedition legs.



Distribution of Plastic Pollution by Size Across the North Atlantic Subtropical Gyre

Net tows 18, 19, 21-24 were repeated 6 months later in summer. The average weight density was .005g/m³. This is a significant increase compared to the average weight density of .0022g/m³ for the winter samples.

Sample ID	Date	Latitude (N)	Longitude (W)	Surface Abundance (number/km ²)
1 (repeats winter 18)	7/15/2010	31.29.860	64.00.914	13,000
2 (repeats winter 19)	7/15/2010	31.30.289	64.29.996	106,000
3 (repeats winter 21)	7/13/2010	32.09.336	64.26.899	44,700
4 (repeats winter 22)	7/17/2010	32.09.191	63.40.124	480,000
5 (repeats winter 23)	7/16/2010	31.30.167	62.28.720	225,000
6 (repeats winter 24)	7/16/2010	31.45.992	62.54.030	62,400
Mean				155,183

Conclusions:

This study aimed to investigate the spatial and temporal distribution of plastic pollution in the North Atlantic Subtropical Gyre. Although only two samples were collected in the eastern region, these samples show evidence of plastic pollution further east than previously known. The data here suggests a decreasing trend eastward across the Sargasso Sea.

Further study is needed to examine plastic pollution in the eastern region, as well as the effect of sea state on the vertical mixing of microplastic particles.

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Sample from North Atlantic Subtropical Gyre