Understanding the fragmentation pattern of microplastics from the North Atlantic Gyre

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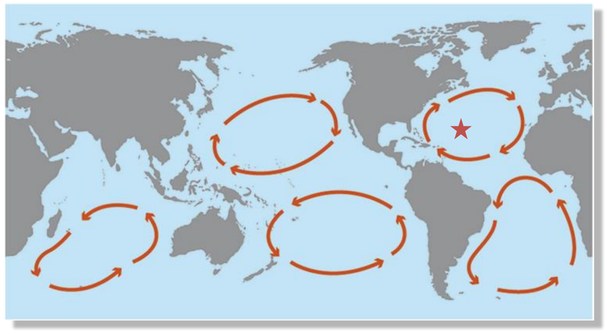
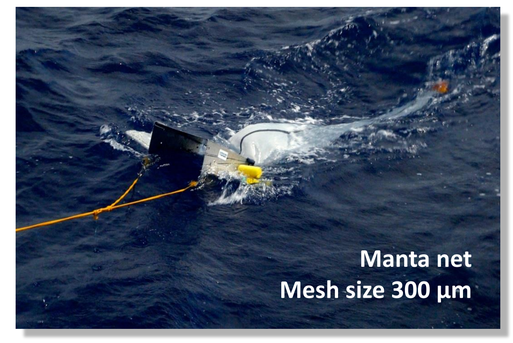
Expedition in the North Atlantic May 2014



Accumulation areas in oceans (sub-tropical gyres)

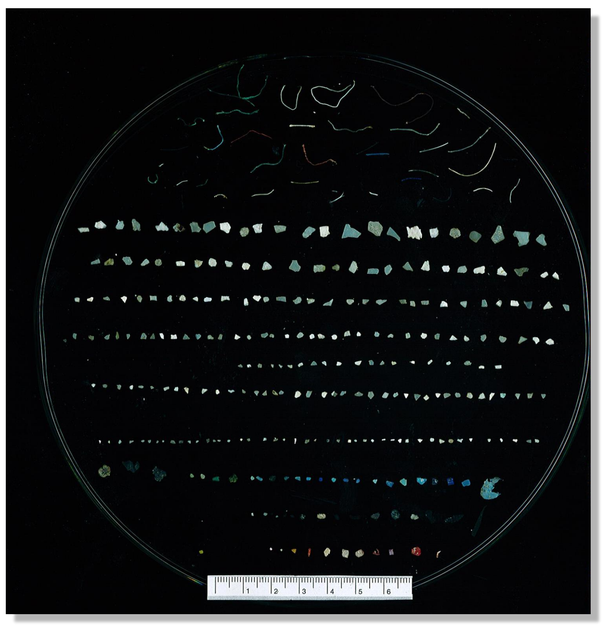
The French expedition 7th Continent 2014 included 9 crue members. The team included the head of the mission Patrick Deixonne, 3 sailors, 4 scientists and 1 cameraman.

Sea campaign in Mai 2014 in North Atlantic



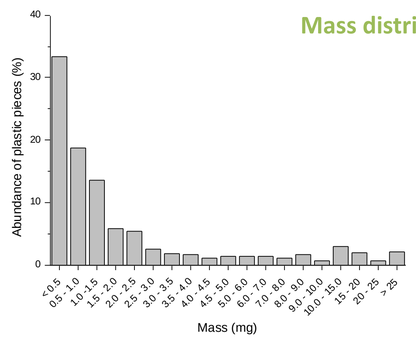
Counting measuring weighting ……

Microplastics collected the 21th of May 2014 (N25° W58°) with a manta mesh size of 300 µm

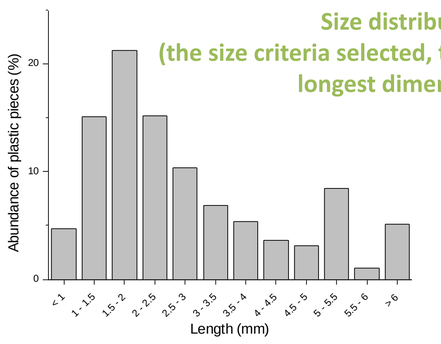


During that experience we collected 274 pieces of plastic debris with a corresponding weight of 821 mg. The microplastic surface concentration in this area was 310 g/km². The majority of the debris collected were between 1,5 et 2,5 mm.

Mass distribution in abundance

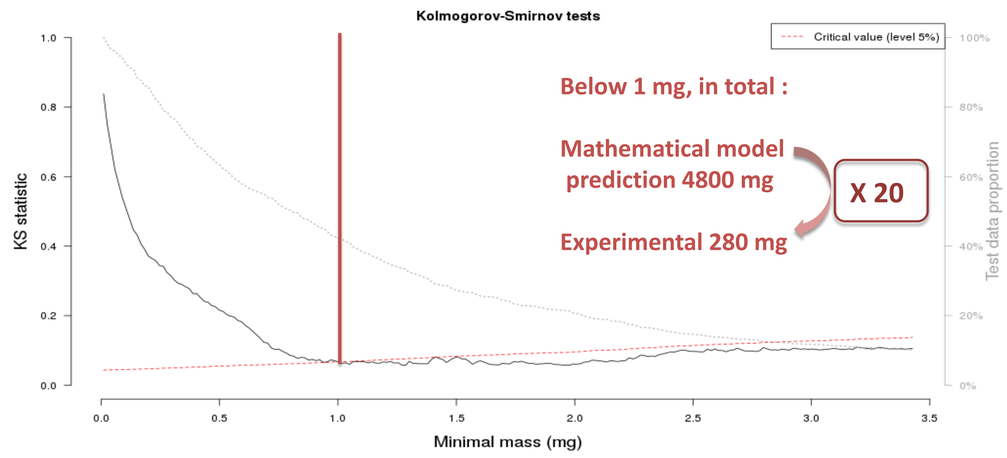


Size distribution in abundance (the size criteria selected, the length, was the longest dimension of the debris)



The abundance by size or mass categories have been obtained with a pool of 1100 plastic pieces.

Kolmogorov-Smirnov statistic according to the minimal mass m_{min} and the critical value of the associated test at 5% level (red doted line). For each value of the minimal mass m_{min}, the plain line is the value of the KS statistic and the dashed line is the critical value below which the test accepts the uniform fragmentation.

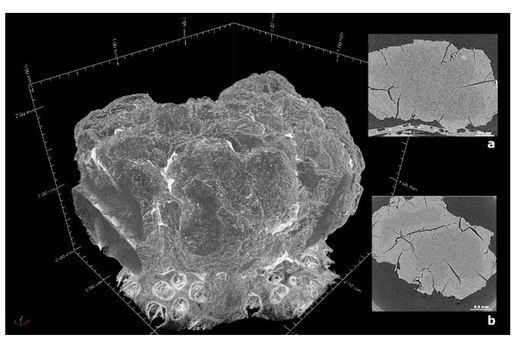


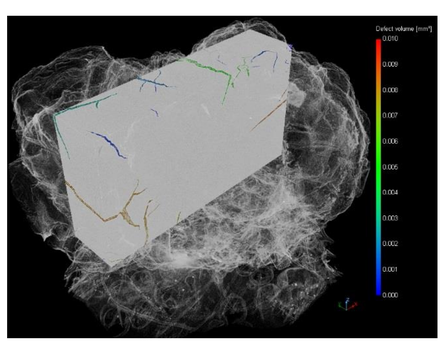
below 1 mg there are less particles than predicted

Microscopic observations

Experimentally, at 1 mg we also observe a transition

X- ray tomography images of a microplastic

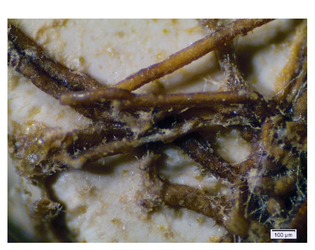


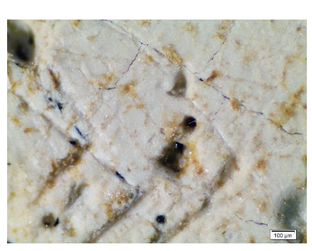


On the left : a volume reconstructed by image stack. The inserts represent 2 sections showing cracks running towards the center of the material.

On the right : In the region of interest, the porous volume was estimated and was smaller than 3%. Long cracks are visible running from the outside of the debris towards the center.

> 1 mg mostly parallelepipeds

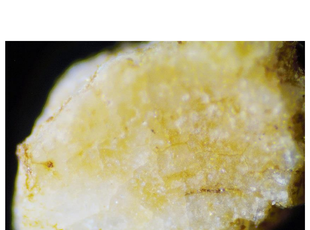




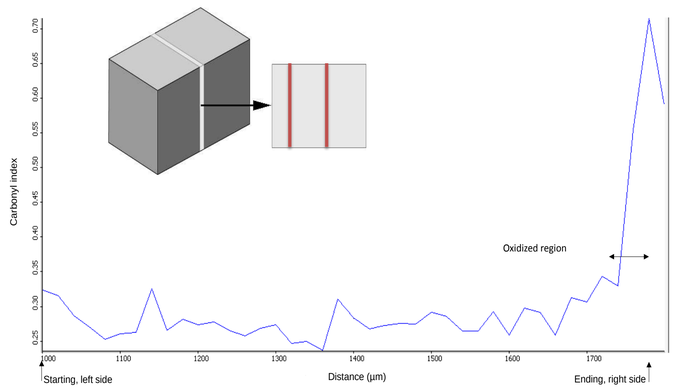
Most of the microplastics show two distinct faces.
One face was much more colonized.
The other face seemed more weathered

< 1 mg mostly cubes

The cubes seemed much less colonized.
All faces seemed equal.

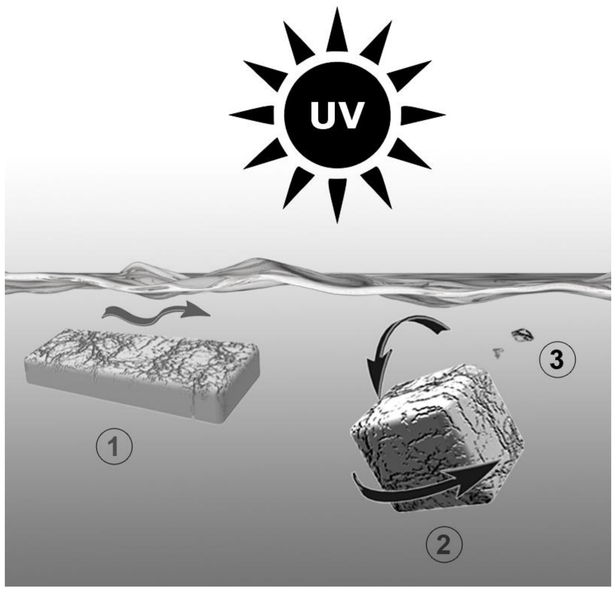


Infrared spectroscopy



Oxidation profile of a parallelepiped plastic debris (2 µm thick slices). The scheme in insert shows how the cross section is obtained. In red is schematized the path analyzed by the FTIR-microscope. The sample presented here has a thickness of 1700 µm. The carbonyl index is plotted as a function of the distance from the edge. There is no oxidation at the left edge of the sample. The carbonyl index on the right edge is significantly higher for about 70 µm.
This oxidation profile is representative of the data gathered.

Hypothesis



We propose two distinct behaviors for microplastics at sea:

The bigger parallelepipeds float flat at the surface of the water (when the sea is calm), with one face preferentially exposed to the sun. The shear or tensile stresses together with a loss of mechanical properties due to photodegradation induce fragmentation (1).

The smaller cubic pieces are certainly formed when the length and width of the parallelepipeds approach the thickness of the piece. The cubic pieces tend to roll at the surface of the water. The motion of the cube (2,3) seemed to prevent the development of a biofilm. Erosion of the edges seems more likely.