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The Influence of Weathering on the Sinking Behavior of Microplastic

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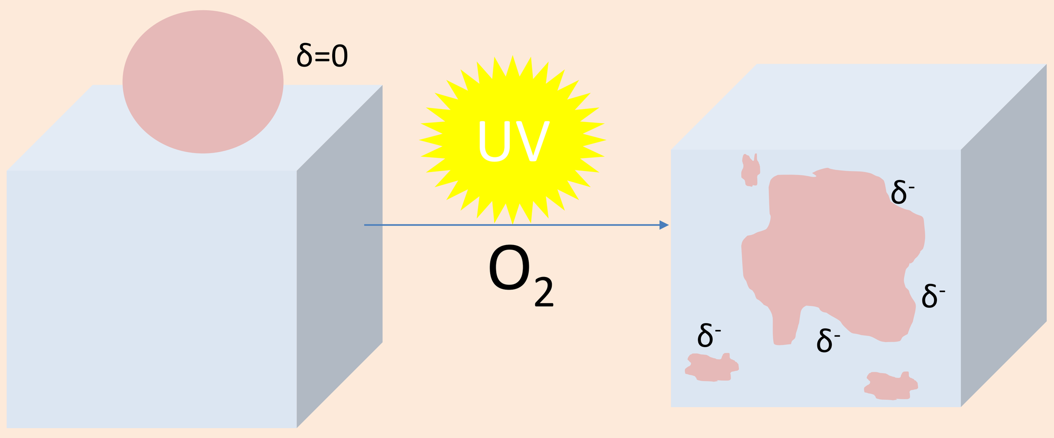
Introduction

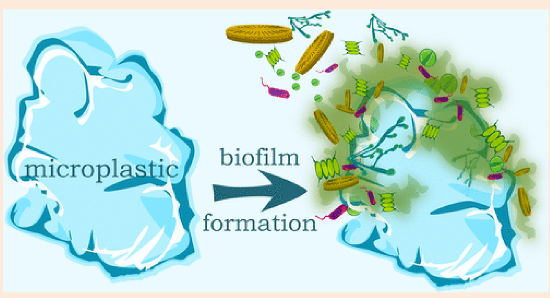
Current estimates project there are 150 million tons of plastic in the ocean, of which only 40 – 250 thousand tons can be found on the surface (Cozar *et al.* 2014, Eriksen *et al.* 2014), or less than 0.2%. Where is the remaining 149.8 million tons? Much of this plastic is below the surface of the ocean, either having sunk to the bottom and reaching the sediments (e.g. Pham et al. 2014, Buhl-Mortensen and Buhl-Mortensen, 2017), or suspended in the water column (Gorokhova, 2017). To understand this better, it is necessary to understand the sinking behavior of plastic and microplastic, as well as how weathering can influence their sinking behavior.

Mechanisms

Oxidation along with mechanical stress changes the surface of microplastic, increases the surface area, hydrophilicity, and leads to fragmentation.



Biofilm growth increases the size and density of microplastic



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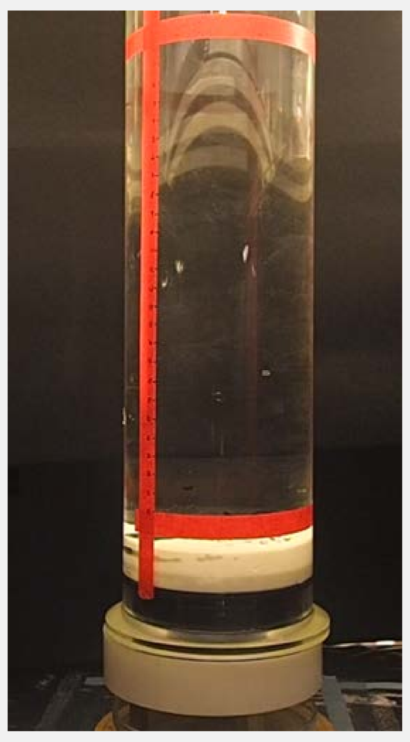
Aggregation with biofilm (marine snow) or incorporation in organisms/feces

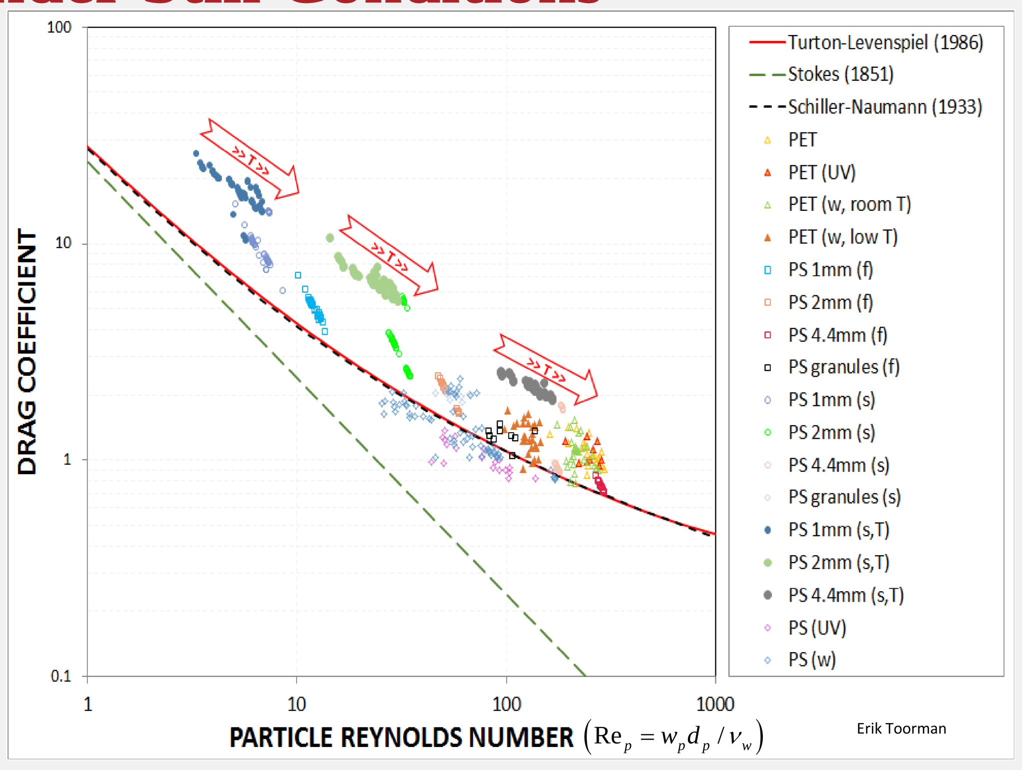
Measurement

Generation of Real-World Weathered Microplastic

Column experiments to measure sinking rates for pristine vs weathered particles at different temperatures and salt concentrations.



Observations and Models of Sinking under Still Conditions



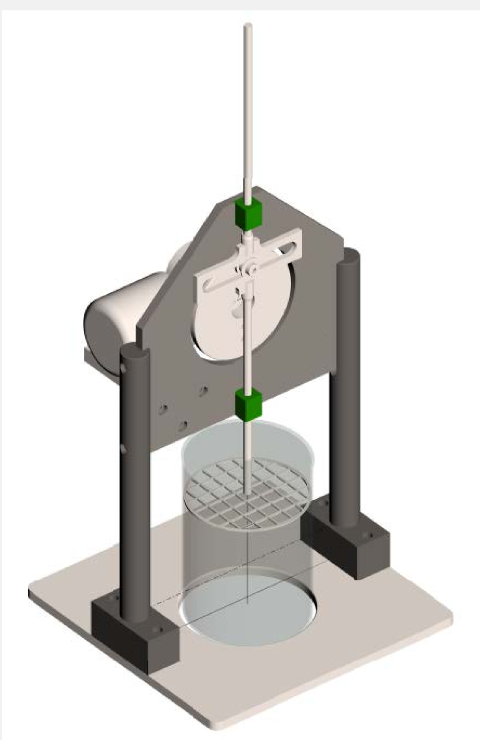
Sinking rates of different types and sizes of plastics in different sea water conditions can be plotted as a function of **drag coefficient vs particle Reynolds number**, and compared with theoretical expectations.

1. Drag coefficient of weathered particles reasonably estimated by drag law for spheres as function of the Reynolds number
2. Amongst other factors, the Reynolds number will increase with microplastic size and density (e.g. from biofilm formation), decrease with fragmentation, or increasing viscosity in seawater (e.g. with depth)
3. «Pristine» microplastic from manufacturer deviated more from theory (higher drag coefficient = slower sinking) than weathered microplastic. The deviation was most extreme in cold, salt water. An effect of surface hydrophilicity?
4. This model can be used to generalize the effect of different seawater and microplastic particle changes with weathering on sinking under still conditions

Influence of Turbulence

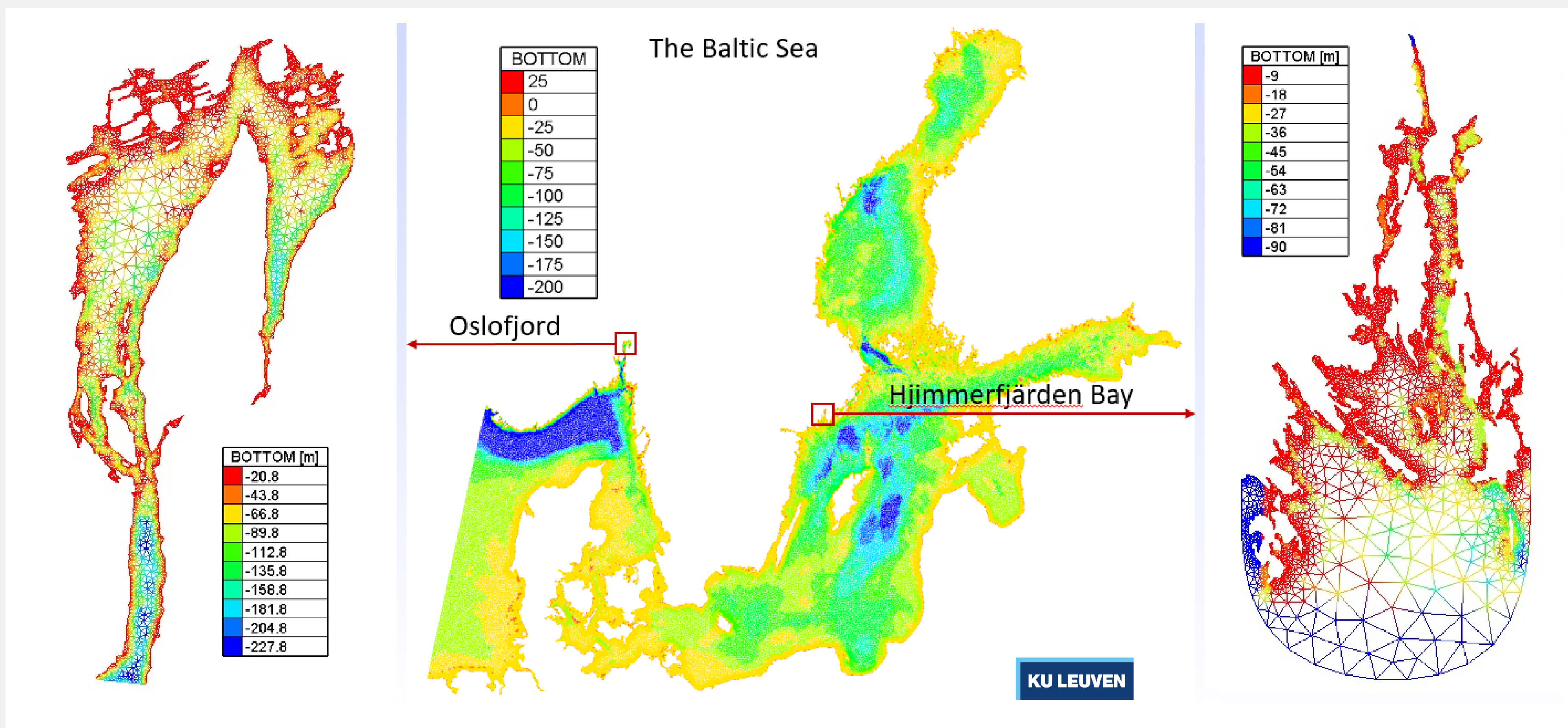
Turbulence can both prevent particles from sinking or accelerate the sinking.

$$\langle F_D \rangle = \langle c_D(\mathrm{Re}_p)\rho_w u_{\mathrm{rel}}^2 A_p \rangle = \rho_w A_p \langle D(\mathrm{Re}_p) u_{\mathrm{rel}}^2 \rangle$$



An oscillating grid was used to observe that PET microplastic <300 µm and fibers (density 1.3 – 1.4 kg/L) remained suspended in the water column under gentle-moderate turbulence.

3-Dimensional Real-World Model



3D nested models are set-up in openTELEMAC.org software for Oslo Fjord (NO) and Hjimmerfjärden Bay (SE), with boundary data generated with a 2D depth-averaged extended Baltic Sea model. The models consider hydrodynamics (tide and wind driven currents and waves) and particle transport (including weathering, flocculation and drift).

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For more info and links to publications see http://www.jpi-oceans.eu/weather-mic/about

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