Effect of Filtration of Particulate Matter into Coastal Megaripples on Distribution of Microplastics in Sediment

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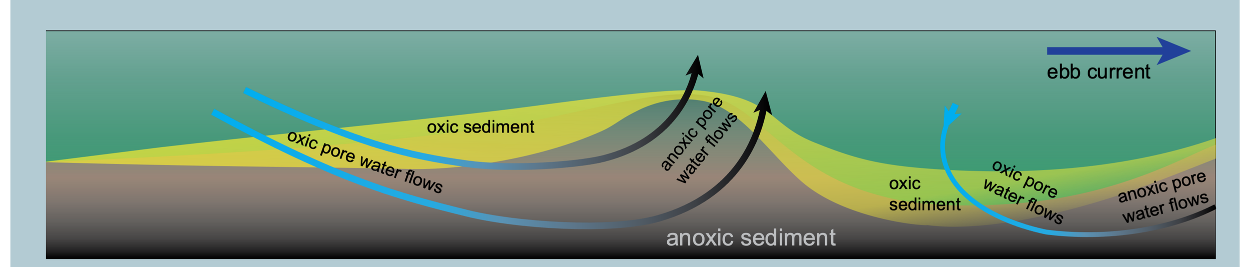
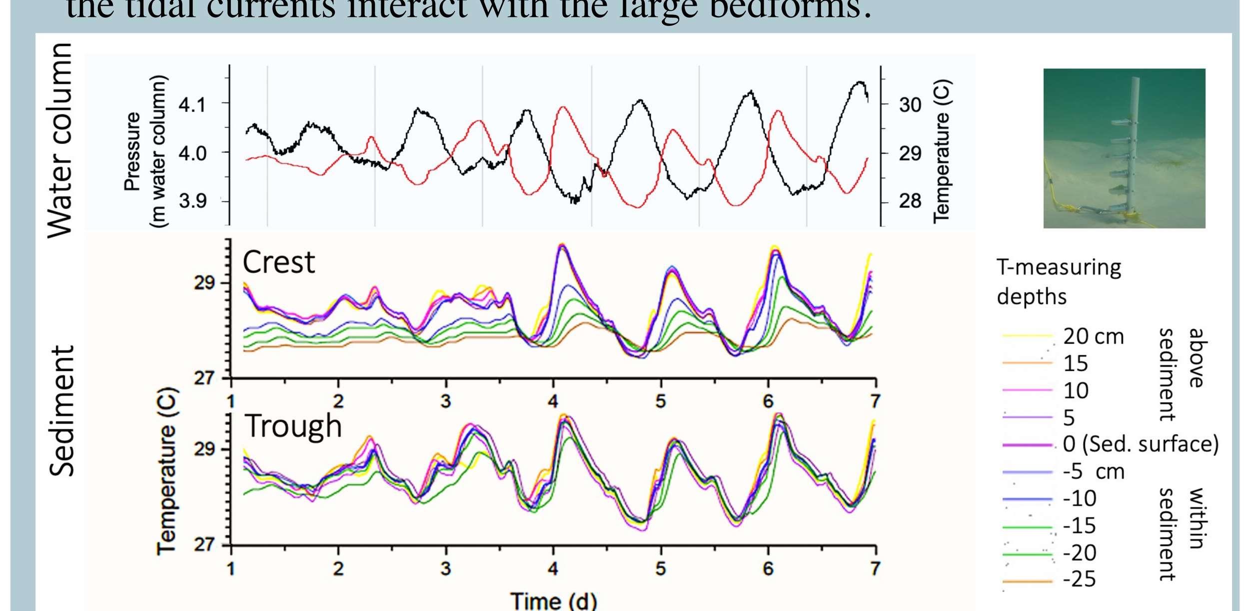
Background

- Large amounts of microplastics are released into rivers and coastal bays. Sand megaripples formed in coastal inlets filter large volumes of water that is pumped through them by the strong tidal currents. The removal of microplastics from the water column through this process can reduce the release of harmful microplastics to the ocean, but data quantifying the effects of this filtration do not exist.
- The purpose of this study was to determine whether microplastics are pumped into permeable sands of coastal megaripples and whether these particles are then separated within the sediment by size.
- **Working Hypothesis**: We test the null-hypothesis that microplastics will not be transported into the sediment and separated.



Pathways of pore water flows through permeable megaripple sediment. The flows are driven by pressure gradients generated when the tidal currents interact with the large bedforms.



Temperature gradients revealing pore water flows through the megaripples. Upper pane, black line: hydrostatic pressure oscillations at the sediment surface caused by the tidal water level change. Red line: temperature oscillations caused by warmer bay water can colder Gulf water. Middle pane: temperature gradients in the sediment oscillating with the tidal flow. The stronger ebb currents draw colder pore water to the surface under the crest. In the trough, no temperature gradients develop because here water penetrates the sediment at relatively high rate.

Methodology

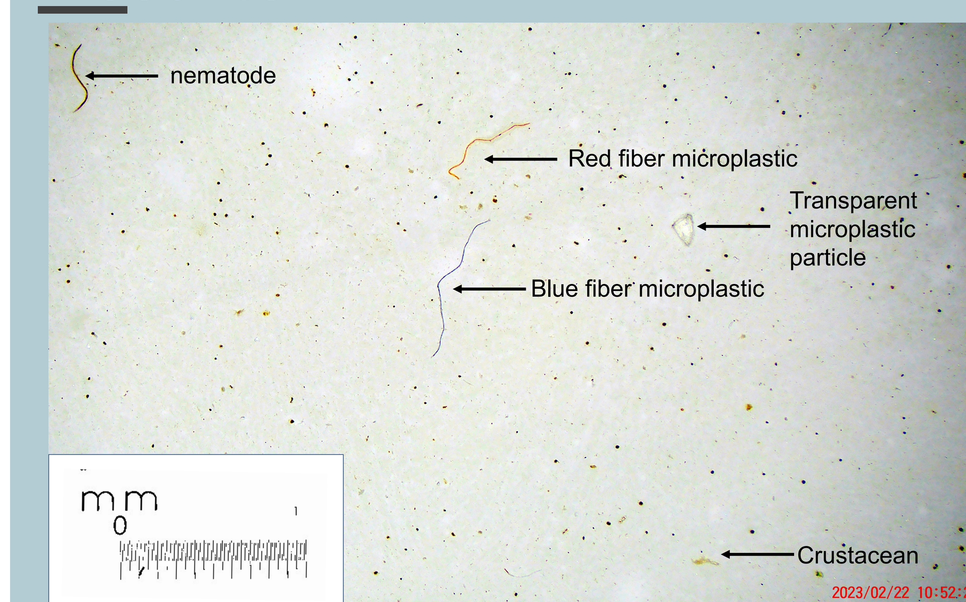
- Sediment cores of approximately 18 cm in length were collected from the crest and trough of megaripples from the Destin Inlet (Images lower right).
- Each sediment core was cut into 0.5 and 1 cm thick slices for particle extraction.
- Each sediment slice was resuspended in water for 30 seconds, after which the supernatant was decanted into a filtration unit and filtered onto a nylon filter with 0.45 µm pore size.
- Fluorescence microscopy and image analysis with the program ImageJ then was used to analyze particles.
- Microplastic counts were plotted against sediment depth using excel.

Sampling Location at Destin, FL

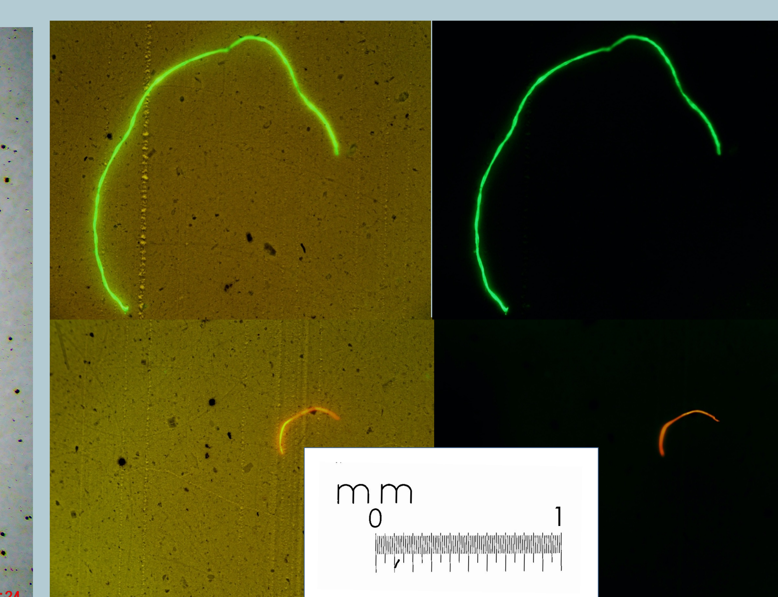
Destin inlet with megaripples next to Crab Island, a source of microplastics

Megaripples in the Destin inlet

Results

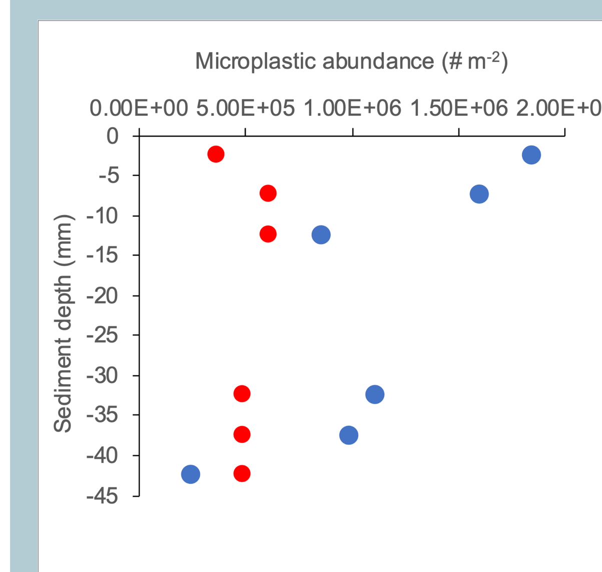


Filter under white light with fibers and organisms



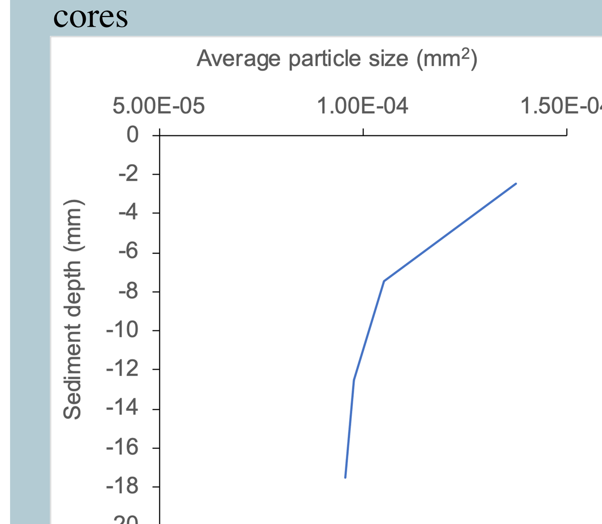
Filter under blue UV illumination with fluorescent fibers

- Megaripples do indeed effectively filter microplastics into the sediment as seen in our filters. Unusual colors revealed plastic particles (e.g. blue, orange) but also fully transparent fragments were found.
- Green and red fluorescence, enhanced through UV-illumination, revealed microplastic fibers on the filters.



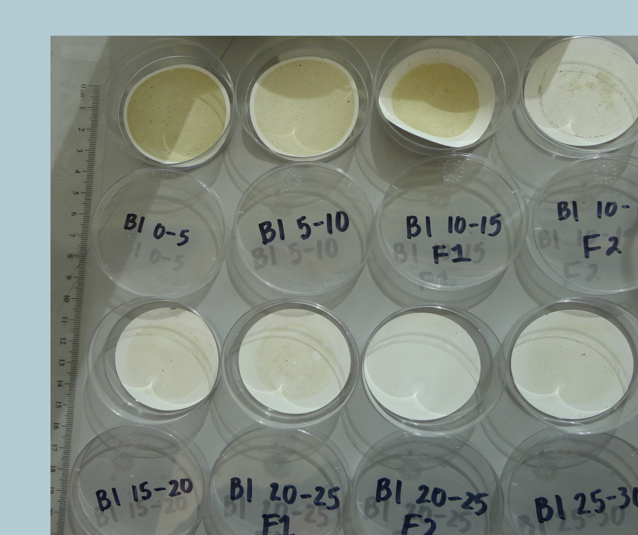
Example microplastic counts from megaripple crest (red) and trough (blue) cores

- Abundance of microplastics were highest in the megaripple trough. This was due to water being forced into the trough, bringing in microplastics with it.
- In contrast, the abundance of microplastics was lower under the ripple crest, where upwelling of pore water reduced overall filtration.
- In the trough, the abundance of microplastics decreased from the surface downward, reflecting the trapping of the particles in the pore space.
- In contrast, abundance of microplastics under the crest was similar in all sediment layers, reflecting the lack of infiltration in this area.
- Storms occasionally resuspend the surface sediment layers, winnowing microplastics from the bed, explaining why microplastics do not accumulate to large abundances in the sand.

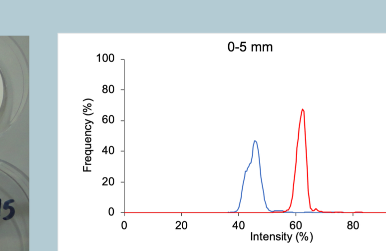


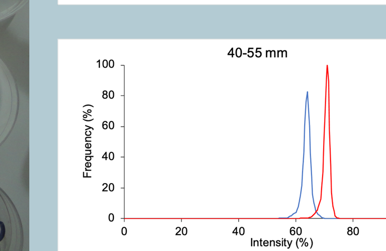
The size of particles filtered into the sediment decreases with sediment depth

Image analysis revealed that the larger particles were trapped near the surface, while smaller particles penetrated deeper into the sediment.



Example for a trough filter set showing high surface layer particle concentration





Blue and red light reflection is lower in the surface

Reflected light of particles trapped in the surface layer contained less blue and red components suggesting that these particles were largely phytoplankton detritus particles.

Discussion

Data shows microplastics not only can be filtered into the sediment, but they are also transported deeper into the sediment with the pore water flows. Whether and how deep microplastics are transported depends on their size and shape. Long plastic fibers (e.g. as resulting from washing clothing made of polyester) get trapped near the surface, while smaller plastic fragments (e.g. as produced through degradation of polystyrene or polypropylene) can be transported deeper into the sediment by the pore water flows. The interaction with the sediment matrix separates the microplastics into size fractions, with the smallest particles penetrating deepest where they are not so easily removed by storm events. Megaripples in inlets thus can remove microplastics from highly plastic-contaminated coastal bay waters before they are released to the ocean. This process is critical because it prevents microplastics from ending up in the water as well as the pelagic food web and eventually in the fish we may consume.

Conclusion

Megaripples are effective microplastic filters. Since they cover large areas of the continental shelf, megaripple filtration may be an important mechanism for removing microplastics from the water column and thereby reducing their negative effect.

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References

Huettel, M., Berg, P., & Kostka, J.E. (2014) Benthic Exchange and Biogeochemical Cycling in Permeable Sediments. *The Annual Review of Marine Science* , 6:23-51. 10.1146/annurev-marine-051413-012706