Fluid dynamics around natural marine snow visualized by Particle Image Velocimetry

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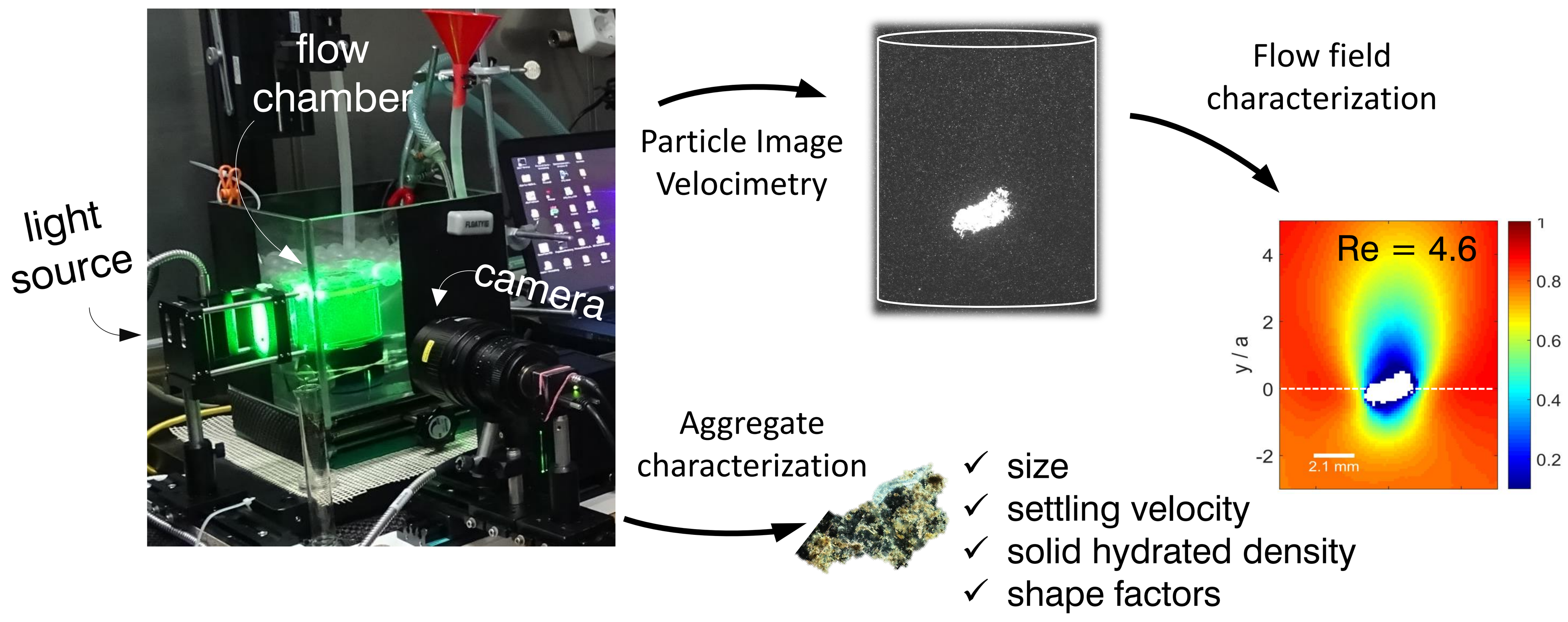
INTRODUCTION

The amount of biotic remineralization, and thus the attenuation of carbon flux, is largely dependent on aggregate settling velocity, which determines how much carbon can potentially be degraded per meter settled. Failure to accurately predict settling using Stokes' law means that no single relationship between size and settling exists. It is, however, possible that general relationships can be identified when testing Stokes' settling for different types of aggregates, which would allow extrapolation of carbon fluxes from camera profiles of particle type, size, and abundance.

In this study, we visualized the flow field around in situ-collected particles with Particle Image Velocimetry (PIV) and examined the relationship between flow field appearance, settling velocity, and other selected aggregate descriptors with the goal to determine the validity of Stokes' law for predicting marine snow settling velocity.

METHOD



RESULTS

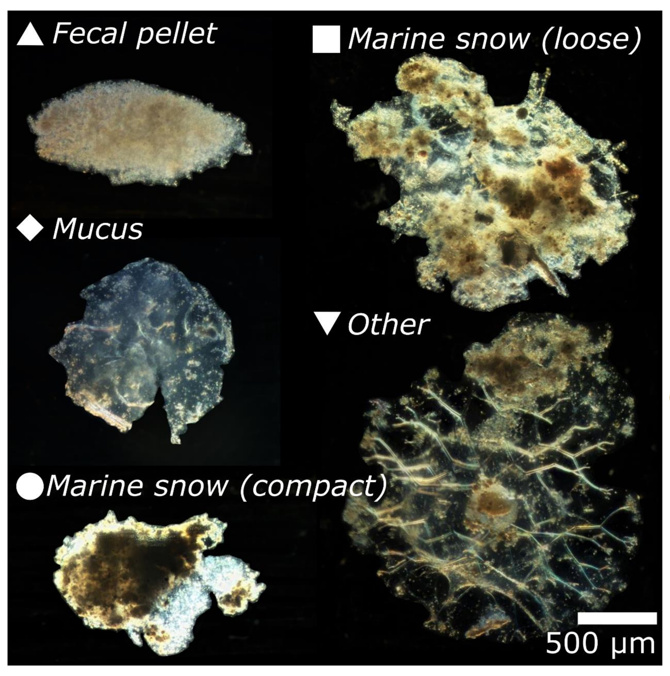


Fig. 1. Aggregate types collected during the study

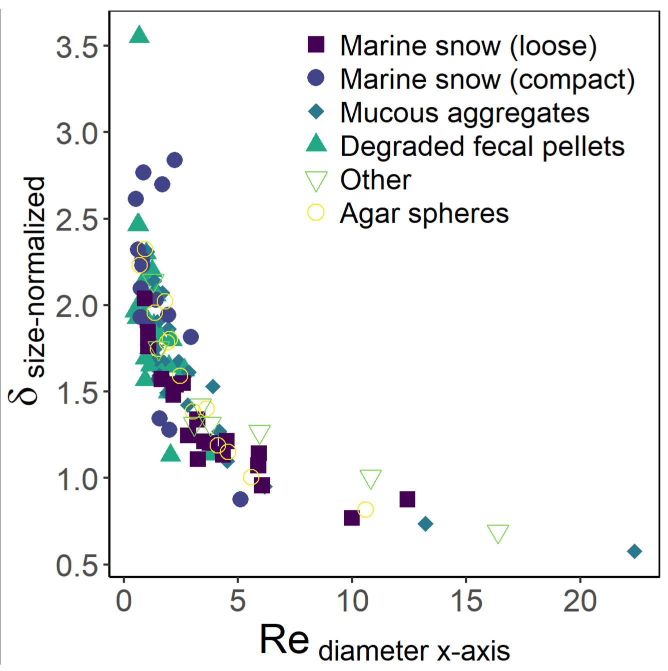


Fig. 2. Scaling of Reynolds number (Re) against boundary layer (δ)

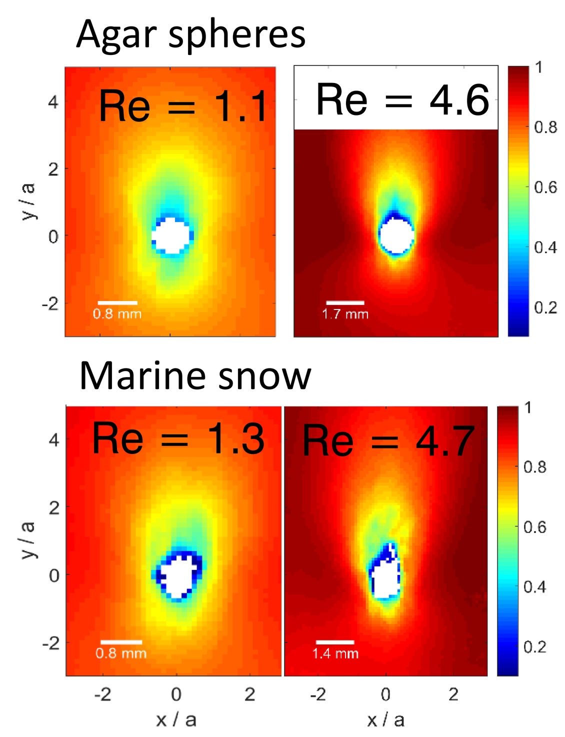


Fig. 3. Comparison of flow fields around agar spheres and marine snow

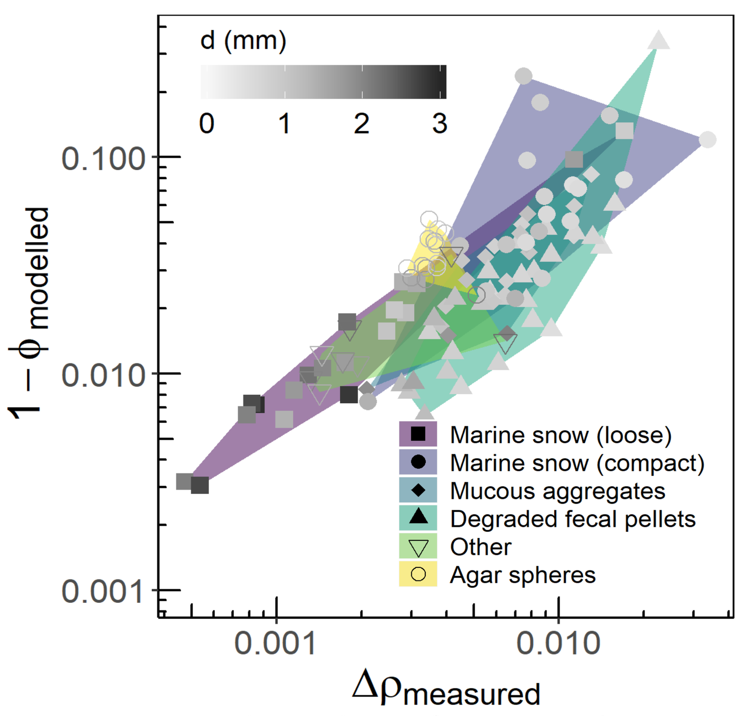


Fig. 4. Log-log plot of excess density over 1 – porosity (ϕ)

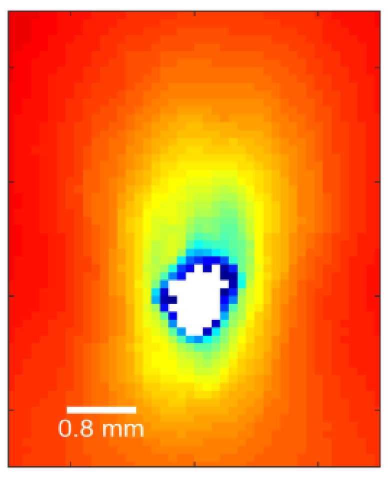
Main results

- Identified four categories of aggregates with differing size:settling velocity relationships (data not shown)
- Good scaling of Reynolds number against boundary layer thickness, irrespective of aggregate type (fig. 1 & 2)
- Behaviour very similar to agar spheres (fig. 2 & 3)
- Excess density scales with porosity (fig. 4)
- Decreasing excess density with increasing aggregate size (fig. 4)
- potentially compensates expected increase in SV with increasing size

POTENTIAL IMPLICATIONS FOR THE PHYCOSPHERE

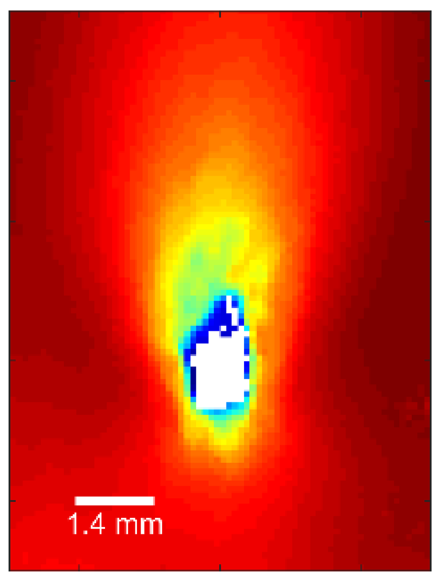
Differences in flow field appearance and settling behaviour that can affect bacterial colonization

Low Re regime



- thick boundary layer
- weak shear forces surrounding the aggregate
- low settling velocity
- long reaction time for potential attachment
- long persistence of solute plume
- laminar flow

High Re regime



- thin boundary layer
- strong shear forces surrounding the aggregate
- high settling velocity
- short reaction time for potential attachment
- short persistence of solute plume
- potential vortex formation at back of aggregate

FRESH IDEAS

DISCUSSION

In this study, we used four independent measurements, (i) aggregate size, (ii) settling velocity, (iii) the fluid boundary layer, and (iv) solid hydrated density to characterize the settling behavior of marine particles.
Using Particle Image Velocimetry (PIV), we could show that the equatorial fluid boundary layer scaled negatively with Reynolds number across all *in situ* collected aggregates and laboratory-produced agar spheres. This suggests that advection through the natural aggregates collected in this study was negligible. This finding has important implications for mass transfer and for the bacterial colonization of settling aggregates, as it effects that bacteria have to actively attach.
Furthermore, the accordance of aggregates settling bahavior with Stokes' law can aid in the development of improved Earth System Model frameworks (see poster by **März et al.**).

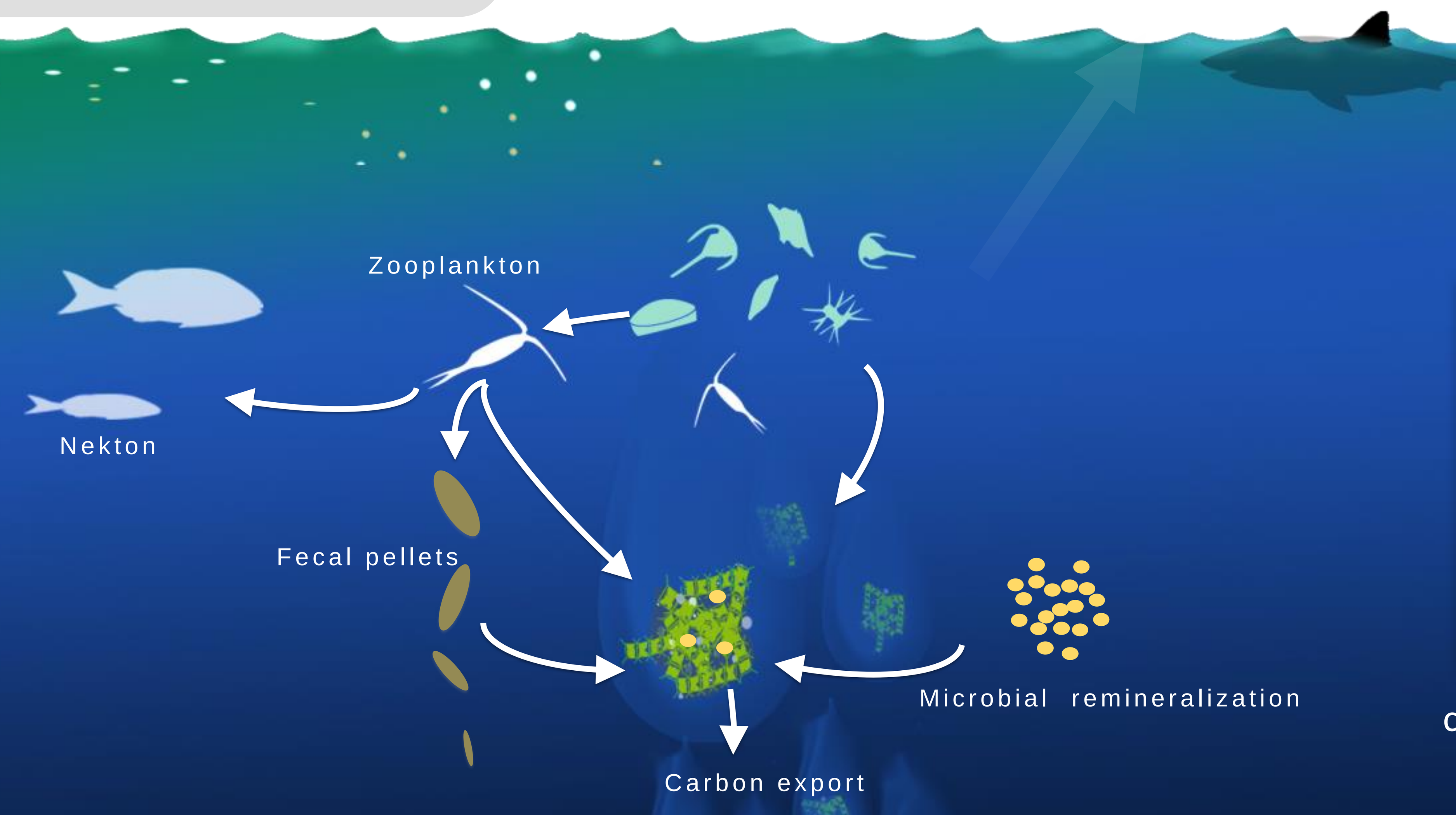


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Image credit: S. Ahmerkamp