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EDITED AND REVIEWED BY
Stelios Katsanevakis,
University of the Aegean, Greece

*CORRESPONDENCE
Jeff Shimeta
jeff.shimeta@rmit.edu.au

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Editorial: Mechanisms and ecology of suspended-particle capture in marine systems

Jeff Shimeta[1*], Marco Ghisalberti[2], Nicole Rita Posth[3] and Stuart Humphries[4]

[1]School of Science, RMIT University, Melbourne, VIC, Australia, [2]School of Engineering, University of Western Australia, Perth, WA, Australia, [3]Department of Geosciences and Natural Resource Management, University of Copenhagen, Frederiksberg, Denmark, [4]Lincoln Institute for Advanced Studies, University of Lincoln, Lincoln, United Kingdom

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Editorial on the Research Topic
Mechanisms and ecology of suspended-particle capture in marine systems

The movements of water and suspended particles (inert or alive) are among the most fundamental dynamical aspects of oceans, underlying numerous biological, physical, chemical, and geological processes. The mechanisms by which particles make contact with and adhere to surfaces are major determinants of animal feeding, trophic interactions, larval and propagule settlement, seagrass pollination, viral infection, microbe-mineral interaction, fates of microplastics, particle aggregation, sediment deposition, and more. Research in all these areas is united by the need to understand fundamental aspects of hydrodynamics and particle dynamics that drive contact of particles with surfaces or with each other, and factors that constrain the net capture of particles. Suspended particle capture is a rich, interdisciplinary field of study, drawing on fluid and particle dynamics, filtration theory, cell and animal behaviour, surface chemistry, and modelling and experimentation with marine organisms.

The papers in this Research Topic review and present advances on the diverse topics of particle capture by suspension feeding in marine animals from invertebrates to fishes and whales; hydromechanics of and around feeding structures; the roles of predator and prey behaviours in feeding interactions; and hydromechanics of sediment deposition in marine vegetation canopies.

Comprehensive reviews by Sanderson and Werth and Potvin critically evaluate recent progress in understanding particle-capture mechanisms in suspension-feeding fishes and baleen whales, respectively, focusing on improved understanding of morphology-flow interactions and key emerging directions for future research. Sanderson presents the first literature synthesis on the particle separation mechanisms of marine, estuarine, and freshwater suspension-feeding fishes. The review addresses eight particle separation mechanisms in fishes, identifies key unresolved questions, enables comparisons with invertebrate suspension-feeding processes and offers perspectives on future research priorities. Werth and Potvin focus on baleen filter feeding and explain how recent advances have expanded our understanding of this process. Such advances challenge the view of baleen as a static sieve and recognize: (i) the mechanism of cross-flow filtration, (ii) the flow-dependence of the filter porosity, and (iii) the biomechanical complexity and variation of the baleen metafilter.

The reviews of vertebrate feeding are extended by the experimental study of Hamann et al., which elucidates mechanisms of cross-flow and dead-end filtration in the gill arch system of diverse ram-feeding fish species. The results reveal how the morphologies of gill rakers and denticles constrain fluid flow and ultimately particle retention, explaining important aspects of feeding ecology and suggesting biomimetic applications to filtration engineering in non-biological systems.

Three papers continue on the theme of fish feeding with experimental studies of zooplankton capture by both swimming and anchored fishes. In all three, flow is shown to be a significant determinant of capture success. Genin et al. show that for coral-reef fishes, capture efficiency declines with increasing flow speed due to reduced manoeuvrability, as the fish orient more narrowly head-on into the flow, and that high prey density and low flow lead to higher capture rates. Ella and Genin further show that site-attached coral reef fishes adjust their strike dynamics based on the flow speed and prey path, suggesting that they assess the prey's drifting speed and path to effectively intercept them. Responses from strongly anchored garden eels (*Gorgasia sillneri*) are compared to Genin et al.'s results by Khrizman et al. Garden eels show a qualitatively similar response but with lower efficiency, presumably due to a fixed location and limited manoeuvrability.

Two experimental papers address particle capture by cylindrical collectors: Beaudry and Cameron on the capture of oil droplets by polychaete feeding structures, and Sewak et al. on the role of mechanical flexibility of morphological structures in hydromechanics and particle capture. Beaudry and Cameron present evidence that oil droplets behave essentially as solid particles in terms of capture, with direct interception and sieving driving most droplet capture. Neither species of polychaete appears to show much selectivity based on oil type, suggesting mechanical processes dominate. Sewak et al. demonstrate that the flexibility of particle collectors can impact their ability to capture suspended particles when large-scale vortex-induced oscillations of the collector are generated. Many aquatic biological collectors have significant flexibility; their capture efficiency may indeed be underpredicted by modelling approaches that assume a rigid collector.

Finally, Deitrick et al. also experiment with biological morphology that influences flow and particle separation, in this case for vegetation canopies such as mangrove pneumatophores that generate turbulence which influences sediment deposition. With a combination of modelling and flume experiments, they found that the turbulence reduces local sediment deposition, which can increase the distance that sediment travels into a mangrove forest.

These papers are united by applying fundamental aspects of fluid dynamics, particle dynamics, and fluid-morphology interactions to make advances in predictive understanding of particle capture processes. They furthermore illustrate the cross-discipline inspiration potential of these principles across a wide range of ecological systems, as well as potential bioinspired applications in engineered systems.

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Conflict of interest

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