On the fate of sinking diatoms: the transport of active buoyancy-regulating cells in the ocean

Jorge Arrieta and Pilar Roig
Dept. of Marine Ecology, IMEDEA (UIB-CSIC),
Miquel Marques 21, 07190 Esporles, Balearic Islands, Spain

Raphaël Jeanneret
Laboratoire de Physique de l’Ecole Normale Supérieure,
ENS, Université PSL, CNRS, Sorbonne Université,
Université de Paris, F-75005 Paris, France

Idan Tuval
Dept. of Marine Ecology, IMEDEA (UIB-CSIC),
Miquel Marques 21, 07190 Esporles, Balearic Islands, Spain and
Dept. of Physics, University of the Balearic Islands,
Ctra. Valdemossa Km 7.5, 07122 Palma, Balearic Islands, Spain
Abstract

Diatoms are one of the most abundant, diverse and ecologically relevant phytoplanktonic group, contributing enormously to global biogeochemical processes like the carbon and silica cycles. This large success has been partly attributed to the mechanical and optical properties of the silica shell (the frustule) that envelops their body. But since they lack motility it is difficult to conceive how they cope with the fast-fluctuating environment they live in and where distributions of resources are very heterogeneous and dynamical. This pinpoints an important but yet poorly understood feature of diatoms physiology: buoyancy regulation that helps them controlling their sinking speed and position in the water column. While buoyancy regulation by light and nutrients availability has been well studied, the effect of hydro-mechanical stress via fluid shear has been rather overlooked when considering diatoms dynamics.

Here we aim to start filling this gap by first presenting direct experimental evidences for buoyancy control in response to hydro-mechanical stress and then review recent theoretical models where simple couplings between local shear and buoyancy control always result in heterogeneous cell distributions, specific accumulation regions within complex flows, and increased sedimentation times to the depths, features of direct ecological relevance. We conclude by suggesting future experiments aiming to unveil such coupling and therefore gain better understanding on the fate of these fascinating micro-organisms in their natural habitat.