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Titre du projet FFCR :
Mécanismes de fragmentation de la neige marine dans la zone mésopélagique de l'océan : Implications sur la séquestration de CO_2 par la pompe biologique de carbone.

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Titre de la thèse : Mechanisms of particle fragmentation in the ocean's mesopelagic zone : Implications for CO_2 sequestration by the biological carbon pump.

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Descriptif du sujet:

The oceanic biological carbon pump (BCP) regulates the Earth carbon cycle by transporting part of the photosynthetically-fixed CO_2 into the deep ocean. The BCP occurs mainly in the form of particles rich in organic carbon (POC) sinking out the surface ocean[1]. Atmospheric CO_2 concentrations are highly sensitive to depth at which POC flux penetrates in the mesopelagic ocean (the so-called POC flux attenuation between 100 and 1000m depth)[2]. Initially, the POC flux attenuation was interpreted as resulting from the consumption of POC by heterotrophs only[3] (bacterias and zooplankton). However, direct consumption of POC by heterotrophs appears to explain only a limited part of the observed flux attenuation in the mesopelagics[4]. Recent developments in semi-autonomous observations have highlighted that the missing part in POC flux attenuation could originate from fragmentation of sinking particles into small non-sinking particles. Fragmentation of sinking particles could explain up to half of the observed POC flux attenuation[5], making particles breakdown the major process controlling biological CO_2 sequestration by the ocean.

The mechanisms leading to particles fragmentation in the mesopelagic zone are however unclear. Two main mechanisms have been proposed. 1) zooplankton activity on sinking particles may break them apart into smaller non-sinking particles[6]. Alternatively, 2) the presence of shear driven turbulence also could cause particles to fragment into smaller non-sinking particles especially when they are fragile[7]. Both, the organic nutrients content and the fragility of marine particles seem therefore crucial to consider when assessing mechanisms leading to particles fragmentation. Yet, no experiments assessing the importance of turbulence vs zooplankton activity on changes in particles size spectra have been performed.

Compounds such as C-rich transparent exopolymer (TEP) and other protein-based gel particles stainable with Coomassie Blue (CSP) are both considered as important glues binding marine particles together[8]. Both TEP and CSP are produced by phytoplankton and prokaryote exudation. This potentially occurs under various stresses such as N limitation for TEP production and P limitation for CSP[9,10]. Being an essential component of the organic matrix of marine particles and acting as binding glues, TEP and CSP could play a major role in setting the level of fragmentation induced by the mechanisms described above (turbulence and zooplankton activity).

In this context, we propose a PhD project a set a laboratory experiments aiming at:
1) Assessing the influence of TEP and CSP content of particles on their turbulence-driven fragmentation rates.
2) Assessing the influence of TEP and CSP content of particles on their fragmentation rates by zooplankton.
3) Compare field data of turbulence and zooplankton abundance to that off particle fragmentation.

For objectives 1) and 2), we will use a set of experiment involving different roller tanks systems (flow through tanks[11] and SNOWMAN[12]) with which we are equipped. Such systems mimic particle aggregation processes in surface and the behaviour of formed aggregates sinking through the water column. In addition, they enable to study zooplankton activity without intrusion[13]. Such system can also create turbulence by regulating to specific flow thresholds. Particles with contrasting TEP and CSP content will be formed from different phytoplankton communities (cyanobacteria and diatoms) under different nutrient limitations and zooplankton (copepods) will be harvested from cultures. **For objective 3)** we will use existing field measurements of zooplankton abundance and full particle size spectra obtained from Underwater Video Profiler[14], LISST and Laser Optical Plankton Counter (UVP/LISST/LOPC) as well as measurements of dissipation-scale turbulence from casts of vertical microstructure turbulence profiler[15]. In addition, the student will be involved in sea going campaigns cruises such as APERO, where numerous vertical profiles of turbulence and particles size spectra from UVP/LISST/LOPC will be done.

The results delivered by our PhD project will refine our mechanistic understanding of the biological carbon pump by directly relating particles fragmentation to biogeochemical characteristics such as turbulence level, plankton communities and potential nutrients limitation, all of which may change under climate change scenarios.

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