

GBF-OOI: Rationale: Current Knowledge and Motivation

The difference between export production (EP), the organic carbon export from the euphotic zone, and the flux of POC arriving at the top of bathypelagic zone (~ 1.5 to 2 km) corresponds to the amount of POC that is remineralized to dissolved inorganic carbon (DIC) or transformed to dissolved organic carbon (DOC) during its descent through the mesopelagic zone (Honjo, 2008). Globally, this difference between POC flux at the mesopelagic/bathypelagic boundary and EP indicates the total CO_2 that is stored in the world ocean. This corresponds to the ultimate impact of the oceanic biological pump and represents a critical component of the global carbon cycle. Based on our current rudimentary understanding of the biological pump, its capacity is estimated at 411 teramolC y^{-1} .

Greater than 90% of the POC flux is typically mineralized in mesopelagic waters. However, variability in flux attenuation is large, and caused by the extremely complex interplay between biological, biogeochemical and physical processes. POC mineralization stems from community metabolism of zooplankton and bacteria/archaea during its transit through mesopelagic zone. However, it is generally understood that zooplankton activity ceases between 1.5 to 2 km, whereupon ballasted POC settles toward the sea floor exclusively via gravitational forces (“terminal gravitational transport”, Honjo et al., 2008) while attenuation of POC flux by microbial metabolism persists.

Our understanding of the rate of POC attenuation in the bottom boundary layer, as well as the lateral supply of POC within intermediate and bottom nepheloid layers, and associated changes in quality and quantity of organic matter, remains poor. Moreover, production of POC from DOC and DIC via deep-ocean microbial heterotrophy and autotrophy, respectively, may further complicate the picture. Attenuation and modification of POC flux continues upon arrival at the sea floor, mediated by diverse benthic organisms.

These complex processes must be characterized in order constrain the global burial rate of carbon and other biogenic/lithogenic elements. Despite the critical importance of constraining the overall gradient in POC flux throughout the world’s oceans, remarkable uncertainty persists in these assessments due the complex, heterogeneous, and diverse processes involved.

To take the next major step forward in advancing our understanding of the oceanic biological pump, a global observation program is required that: (i) greatly improves constraints on global marine primary production (PP) as this represents a critical factor in understanding the global CO_2 cycle and is essential for developing accurate estimates of EP - the source of the biological pump; (ii) explores the spatiotemporal links between PP, EP, and the biogeochemistry of the oceanic interior, and the processes that attenuate POC flux; (iii) characterizes microbial community structure and dynamics both in the surface and deep ocean; (iv) develops a comprehensive picture of processes that take place from the surface ocean to the sea floor; (v) provides unique time-series samples for detailed laboratory-based chemical and biological characterization and tracer studies that will enable connections to be made to the operation of the biological pump in the geologic past.

The overarching goal is to provide high quality biological and biogeochemical observational data for the entire OOI research community. We believe the above-mentioned information will greatly advance our understanding of, and ability to characterize the oceanic biological pump, and will also satisfy a pressing need for fundamental studies of biological, biochemical and biogeochemical processes throughout the oceanic water column.

[The US Joint Global Ocean Flux Study \(JGOFS\)](#), which took place between 1989 and 1999 and was supported by the National Science Foundation (NSF), yielded critical new insights into the ocean’s role in the global carbon cycle. This international program made unprecedented contributions to ocean science, and in particular helped establish “biogeochemistry” as a major genre of ocean and earth science. The program led not only to conceptual advances in our understanding of oceanic processes, but also to technological innovations in electro-mechanics, robotics and fluidics, enabling entirely new observations.

Currents global estimates of the attenuation of POC with depth incorporate critical uncertainties in (a) EP derived from modeled PP and POC export, (b) the global POC export flux to the deep ocean, and (c) the provenance and mode(s) of supply of POC to the deep ocean, as well as the processes acting upon this material. A second major knowledge gap concerns the biological community structure, both in surface waters and throughout the oceanic water column, and how this influences the efficacy of the biological pump, and its variation in response to climate forcing.

We suggest that the above uncertainties and information gaps can be greatly reduced through implementation of a concerted biogeochemical observation program aligned with the [Global OOI](#). Specifically, more accurate and precise measurements of EP are possible by improving constraints on PP and by acquisition of synoptic measurements of fluxes and particle properties within the mesopelagic (Buesseler et al., 2007) and bathypelagic zones, and near the sea floor. Coupled with parallel observations of biological community variability, this program will greatly improve both our understanding of the overall controls on the biological pump, and our ability to predict how it may respond in the future.

The above measurements are now within reach using a combination of existing and nascent mooring, time-series observation, and autonomous sampling technologies. Specifically, the deployment of several different types of time-series underwater instrumentation will provide crucial information on surface ocean primary production, the processes associated with export and remineralization of biogenic materials from the euphotic zone and to the deep ocean, and the flux and nature of materials settling to the ocean interior.

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