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Sedimentation event sensor: New ocean instrument for in situ imaging and fluorometry of sinking particulate matter

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Abstract

Measuring the quantity and composition of sinking particulate matter is key to understanding biogeochemical processes in the ocean. This has been done in the past with sequencing sediment traps, which collect and store particulate matter in sample bottles for subsequent laboratory analysis. Having a limited number of bottles, these traditional traps force the user to choose between finer time resolution and longer deployment duration. We have built a new sediment trap that analyzes the collected material in situ, eliminating the need to preserve and store the samples. This new instrument, the Sedimentation Event Sensor (SES), captures macro images of the sample with front and back lighting, and takes fluorometric measurements in two bands as proxies for the presence of chlorophyll *a* and accessory pigments. The SES can process 6200 samples during a single deployment, which is the equivalent of 15 samples per day for more than a year. Here, we describe the design of the SES and present the results ofits first three deployments at 3910 m depth. Images and fluorometry data revealed high variability of sinking particulate matter composition on the order of hours. Sedimentation patterns detected by the SES largely agreed with mass flux patterns measured from traditional traps deployed concurrently nearby. Given the functional differences, the SES is best used to complement rather than replace traditional sediment traps.

Resolving biogeochemical cycling in the ocean is heavily dependent on measuring particulate matter fluxes. Funnels and cylinders have been used over the past four decades to collect particulate matter sinking through the water column and to estimate fluxes of biogenic and mineral material in all major regions of the world ocean (Knauer et al. 1979; Honjo 1980). These sediment traps can be either moored at discrete depths through the water column or on autonomous free-drifting devices set to float at predetermined depths or density surfaces (Buesseler et al. 2007). To estimate particle fluxes all of these designs require the retrieval and subsequent laboratory analysis of collected samples, which are typically chemically preserved in situ. Sequencing sediment traps, which open and close a series of collection bottles at preprogrammed times, are typically necessary for producing long time-series collections, but are limited by the number of sample bottles available (Honjo and Doherty 1988).

Our goal was to develop an instrument, the Sedimentation Event Sensor (SES), that could temporarily capture particulate matter sinking through the water column, make fluorometric measurements to estimate the chlorophyll content of collected particulates, produce high-resolution images of collected particulates, and discard rather than preserve samples for subsequent laboratory analysis. We also required the instrument to be moored at abyssal depths and work at any desired sampling frequency from hours to days for deployment periods of up to a year. The resulting time-series of high-definition images and optical data could then be processed to estimate biological origin, quantity, size distribution, and fluorescent quality of sinking particulate matter without the need to store or preserve samples, or handle toxic preservatives. For biogenic material, the organic carbon and nitrogen content could then be estimated from similar material collected concurrently in conventional sediment traps.

Here, we describe the design of the SES, developed at the Monterey Bay Aquarium Research Institute, and assess mechanical performance and scientific lessons learned from early testing and its first three deployments spanning 21 months.

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