Methods and data processing report for attenuance flux determined from optical sediment traps deployed on neutrally buoyant sediment trap (NBST) platforms during EXPORTSNP

Instrument: WETLabs C-Rover 2000 beam transmissometer deployed as upward-looking optical sediment trap (OST) on neutrally buoyant sediment trap (NBST) platform

NBST s/n	NBST model	OST s/n	Purchase date
NBST-020	SOLO-NBST	059R	N/A
NBST-200	SOLO-NBST	074	2014
NBST-302	APEX-NBST	086	2018
NBST-303	APEX-NBST	085	2018
NBST-304	APEX-NBST	083	2018
NBST-305	APEX-NBST	084	2018

Table 1. NBST models and serial numbers, OST (WETLabs C-Rover 2000 beam transmissometer) serial numbers, and dates of purchase.

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I. Introduction

An upward-looking optical attenuance sensor, or optical sediment trap (OST), is deployed on a quasi-Lagrangian platform and used to measure the accumulation rate of sinking particles while the platform drifts on a neutral surface. The rate of increase in accumulated particles' attenuance (ATN_{OST} flux) can be converted to a particulate carbon flux (PC_{ATN} flux) using an empirical calibration function. These calibration data are generated by co-deploying OSTs on the same platforms as bulk sediment traps, and measuring ATN_{OST} flux and PC flux simultaneously.

In the EXPORTS N. Pacific field campaign, upward-looking C-Rover 2000 beam transmissometers (WETLabs) installed on neutrally buoyant sediment trap (NBST) platforms served as bulk OSTs. In addition to the OST, each NBST also carried four cylindrical sediment trap tubes, each with a collection area of 0.0113 m^2, arranged around a central profiling float. NBST-020 and NBST-200 were of an older design constructed around modified Sounding Oceanographic Lagrangian

Observer profiling floats (built at Woods Hole Oceanographic Institution). The remaining NBSTs were constructed around the APEX float platform (Teledyne Webb Research) (Table 1).

II. Calibration / Maintenance

Attenuance flux is a relative measurement, and as such instrument calibration coefficients are not used. Prior to each deployment, the instrument's optical windows are rinsed with Milli-Q water and dried repeatedly until a stable air reading is achieved. Pre-and post-cruise air readings are tracked over time to monitor instrument drift.

III. Deployment / Sample collection

A goal of the EXPORTS field campaigns is to characterize export over operationally-defined time periods, termed "epochs", equivalent to the time necessary for sinking particles to exit the euphotic zone and enter sediment traps in the upper 500 m. The sample collection and analysis procedures described below were repeated during three 8-day epochs.

Prior to deployment, the sediment trap tubes on each NBST were filled with media to collect and preserve sinking particles. NBSTs were programmed to descend to a single measurement depth (95, 145, 195, or 330 m ±25 m), sample for ~5 days until a burn wire mechanism closed the tube lids, and then ascend to the surface for recovery. NBSTs were deployed with an additional ~50 g weight attached with a dissolvable release to aid in initial descent. The release dissolves in ~20 minutes and the weight separates from the package.

Epoch 2, NBST-304 (195 m): The ~50 g descent weight became entangled in the package during deployment and did not separate as planned. NBST-304 failed to resurface after completing its mission, and began a second ~5-day collection cycle at the target depth. The ~50 g weight separated from the package during the second collection cycle, and NBST-304 resurfaced and was recovered.

Epoch 3, NBST-302 (195 m) and NBST-303 (145 m): Upon resurfacing, both NBSTs failed to download recovery mission instructions and descended for a second ~5-day cycle after a short time at the surface. Both were recovered after the second cycle by personnel on *R/V Sally Ride* because *R/V Revelle* was no longer in the vicinity.

IV. Data processing

Please see Estapa et al. (2017) for details. Briefly, uncalibrated beam attenuation observations are collected at a fixed time interval during the deployment. APEX-based NBSTs collect a burst of 5 measurements (at 1 Hz) every 3 minutes or every 5 minutes, depending on the deployment configuration. SOLO-based NBSTs collect one reading every 15 minutes. For APEX-NBSTs, bursts with standard deviation:mean ratios greater than 0.1 are removed from the record. Measurements collected when the platform was not at its drift depth are also removed. Then, a running median filter with window width of 1.5 hours is used to despike the record. Negative discontinuities (defined as uncalibrated beam attenuation decreasing faster than 0.2 m^{-1} d^{-1} and interpreted as loss of accumulated material from the optical window) are removed by adding an equivalent, cumulative correction to the timeseries. The gradient vs. time of the corrected record is then computed. This gradient is divided by the instrument pathlength (0.25 m) to yield an attenuance flux timeseries (units: m^2 m^{-2} d^{-1}). The mean attenuance flux is computed over the period where the platform was at its drift depth.

Uncertainty in OST attenuance flux was computed as in Estapa et al. (2017). The uncertainty from the sensor itself is quite small – on average, 7.5×10^{-4} m^2 m^{-2} d^{-1} (Estapa et al. 2017) – and was neglected due to the orders-of-magnitude larger "counting uncertainty". Counting uncertainty stems from the randomly-timed collection of rare, sinking particles within the narrow (7.9 x 10^{-5} m^2) OST beam cross-section. To account for this, a power-law particle size distribution (PSD) function was fit to the particle counts in the much larger cross-section gel collectors (0.0113 m^2) deployed on the same platforms as the OST sensors. The mean detection rate of particles, as a function of size, within the smaller OST beam was then computed from the gel PSD parameters. We assumed that the detection rate of sinking particles followed a Poisson distribution with error equal to the square root of the rate. The mean attenuance flux uncertainty was computed by summing this counting error over all particle size classes.

V. Additional information

Related datasets

Additional datasets were generated from these NBST deployments (Table 2).

Dataset	PI	Affiliation	Platform	Collector
Bulk fluxes	M. Estapa	Skidmore	NBST, STT	brine
Particulate ^{210}Po and ^{210}Pb	K. Buesseler	WHOI	NBST, STT	brine
Particulate Ba	K. Buesseler	WHOI	NBST, STT	brine
Particulate Ti, trace element, and REE concentrations	P. Lam	UCSC	NBST, STT	brine
Stable isotopes, amino acids	H. Close	RSMAS	NBST, STT	brine
Lipidomic analysis of particles	B. Van Mooy	WHOI	NBST, STT	brine
Optical attenuance flux from gel traps	M. Estapa	Skidmore	NBST, STT	polyacrylamide gel
Images of sinking particles	C. Durkin	Moss Landing	NBST, STT	polyacrylamide gel
Cell and zooplankton number fluxes	C. Durkin	Moss Landing	NBST, STT	polyacrylamide gel
Zooplankton product flux	D. Steinberg	VIMS	NBST, STT	polyacrylamide gel
DNA sequencing	C. Durkin	Moss Landing	NBST, STT	RNA*later*

Table 2. Additional datasets generated from NBST deployments.

References

Estapa, M.L., C. Durkin, K. Buesseler, R. Johnson, and M. Feen. 2017. Carbon flux from bio-optical profiling floats: Calibrating transmissometers for use as optical sediment traps. Deep Sea Research Part I: Oceanographic Research Papers 120: 100–111. doi:10.1016/j.dsr.2016.12.003