

Methods and data processing report for bulk flux determinations from neutrally buoyant sediment trap (NBST) deployments in the North Pacific

Instrument: Neutrally buoyant sediment trap (NBST)

Model: SOLO-NBST

SN: NBST-200

Purchase date: 2014

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I) Introduction

Neutrally buoyant sediment traps (NBST) are used to directly collect sinking particles at discrete, sub-mixed layer depths (Valdes and Price, 2000; Estapa et al., in review). NBSTs carried four cylindrical sediment trap tubes, each with a collection area of 0.0113 m^2 , and an upward-facing beam transmissometer (c-Rover 6b, WETLabs) arranged around a modified Sounding Oceanographic Lagrangian Observer profiling float with customized controllers and top cap assemblies (built at Woods Hole Oceanographic Institution). The NBST was programmed to descend to a predetermined depth, drift while collecting settling particles until a burn wire mechanism closes the trap tube lids, and then ascend to the surface at a programmed time for recovery.

Collected particles were analyzed for particulate carbon (PC), particulate inorganic carbon (PIC), biogenic silica (bSi), and mass. Particulate organic carbon (POC) is determined as the difference between PC and PIC. Fluxes are determined by normalizing to the trap collection area and length of deployment. Bulk compositional analysis does not discriminate among sinking particles from different export pathways (single cells, aggregates, zooplankton products), so this method provides an estimate of the sum of all “sinking particle” pathways.

II) Deployment / Sample collection

Samples were collected at three process stations occupied during *R/V Falkor* cruise FK170124 from Honolulu, HI to Portland, OR in January 2017 (Table 1).

Station	Depth (m)	Deployment location	Recovery location	Deployment date (GMT)	Deployment length (d)
1	150	22.3288, -151.9033	21.5918, -151.7792	1/28/2017 18:05	2.87
2	170	27.7120, -139.5138	27.7308, -139.7155	2/5/2017 16:24	2.86
3	150	34.6768, -123.4767	34.4224, -123.5456	2/12/2017 4:36	2.35

Table 1. NBST deployment dates and locations.

Prior to deployment, three trap tubes were filled with filtered seawater from beneath the mixed layer. 500 mL of formalin-poisoned brine (70 ppt) was gravity-fed through tubing to form a layer below the filtered seawater to preserve settling particulate matter for carbon analysis. The fourth trap tube was not used for bulk flux determination.

NBSTs were programmed to descend to a single measurement depth (150 or 170 m), sample for 2–3 days until a burn wire mechanism closed the tube lids, and then ascend to the surface for recovery (Table 1). NBSTs were programmed to hold depth within ± 25 m of the measurement depth. A replicate set of trap tubes was prepared as described above, held in the shipboard laboratory during the deployment, and then analyzed in parallel to provide a process blank determination (Table 2).

Analysis	Method	Mean	SD	Replicates	Units
PC	UC Davis Stable Isotope Facility IR-MS	351.23	75.74	3	$\mu\text{g C}$
PC	URI IR-MS on polycarbonate membranes	24.49	16.56	4	$\mu\text{g C}$
PIC	Calcium by flame AA spectroscopy	1.48	0.48	2	$\mu\text{g CaCO}_3$
bSi	Alkaline extraction and colorimetric detection	0.46	0.05	2	$\mu\text{mol Si}$
mass	Gravimetry	0.10	0.03	4	mg

Table 2. Mean process blank values per sediment trap tube.

Upon recovery, NBST tubes were allowed to settle for at least 1 h in the laboratory. The overlying seawater layer was vacuumed out of the tops of all tubes. The remaining brine layers from the three tubes were drained through a single, acid-cleaned, 350- μm nylon mesh screen and combined into a 4-L bottle. The screen was picked clean of zooplankton under a dissecting microscope, and the remaining screen contents rinsed back into the 4-L bottle with filtered seawater. The 4-L bottle was split into eight fractions using a custom-built rotary splitter (Lamborg et al. 2008). One fraction was further split into two fractions to provide a subsample for collaborators. Laboratory space limitations prohibited the use of a shaker table to mix the 4-L bottle during splitting, and instead the bottle was agitated by hand. The volume of each split was marked on the outside of the sample bottles and measured using a graduated cylinder after filtration was complete. The relative volume fraction of each split was computed from these measurements.

Three splits were filtered onto precombusted GF/F filters (Whatman) and dried at $45 \pm 5^\circ\text{C}$ using a consumer-grade food dehydrator (blank comparisons vs. a standard laboratory oven showed no difference). Filters were stored dry at room temperature until analysis on shore. On shore, filters were gravimetrically split and half of each filter was analyzed for particulate carbon (PC) at the UC Davis Stable Isotope Facility. Split-to-split reproducibility was poor, possibly due to lack of a shaker table during splitting.

Six splits (including the two 1/16th splits) were filtered onto pre-weighed, 25-mm diameter, 0.2- μ m pore size polycarbonate membrane filters (Nuclepore) and rinsed with pH 8.5 borate-buffered Milli-Q water. All were dried as described above. Four of the six splits were stored dry at room temperature until analysis on shore for CaCO_3 and biogenic silica (bSi). Two of the six splits were shared with collaborators.

On shore, all polycarbonate filters were re-dried and weighed to constant mass on a microbalance with ± 0.01 mg precision to determine mass flux. To increase the number of PC replicates and partially remedy the poor reproducibility of the PC splits (likely due to splitter variability stemming from hand agitation of the sample bottle), approximately $\frac{1}{4}$ of each polycarbonate filter was gravimetrically split and used for a second set of PC analyses at the University of Rhode Island Elemental Analysis facility. The specific carbon content (mass C per mass filter) of clean Nuclepore filters was determined empirically. The mass fraction of each $\frac{1}{4}$ split was used to calculate the carbon content of that split from the original sample filter tare mass. Then the sample carbon was determined by difference between the total carbon and the calculated filter carbon.

Two of the four $\frac{3}{4}$ polycarbonate splits remaining were analyzed for particulate inorganic carbon (PIC). Filters were extracted overnight in 5% nitric acid with 2% La (as La_2O_3) releasing agent. Extracts were analyzed using flame atomic absorption spectrometry for Ca (422.7 nm, air-acetylene flame) and Na (589 nm, air-acetylene flame). Sodium levels were used to correct Ca for residual sea salts, then PIC was calculated assuming all Ca was present as CaCO_3 .

The remaining two $\frac{3}{4}$ polycarbonate splits were analyzed for bSi. Filters were extracted in 0.2 N NaOH for a total of 2 hours at 95°C, then neutralized with 1 N HCl. Subsamples were taken for immediate analysis for dissolved silicate following standard spectrophotometric methods.

III) Data processing

The mean process blank value was subtracted from the corresponding sample value (Table 2), and blank-corrected values were then divided by the trap collection area (0.0113 m^2) and the deployment length to yield flux (Table 1). The fluxes of each replicate sample at a given depth were averaged to yield the mean flux. Particulate organic carbon (POC) flux was computed as the difference between the mean PC flux and the mean PIC flux.

IV) Additional information

Station 1 was interrupted by a medical emergency requiring 48 hours to return to Honolulu. While the NBST lids closed on time, the trap sat at the surface an additional 48 hours prior to recovery.

During Station 2, the NBST failed to stabilize at depth, oscillating between depths of 50 and 250 m. Upon recovery this was found to be due to a malfunction in the trap's ability to retract its buoyancy piston, following saltwater leakage onto the controller. Station 2 flux observations are suspect but reported in order to illustrate consistency of analytical methods.

References

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Lamborg, C.H., K.O. Buesseler, J. Valdes, C.H. Bertrand, R. Bidigare, S. Manganini, S. Pike, D. Steinberg, T. Trull, S. Wilson. The flux of bio- and lithogenic material associated with sinking particles in the mesopelagic “twilight zone” of the northwest and North Central Pacific Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography* 55, 1540–1563 (2008). <https://doi.org/10.1016/j.dsr2.2008.04.011>.

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