

Dataset: Carbon and nitrogen flux measurements from the Sargasso Sea from 2013-2014.

Project(s): Rapid, Autonomous Particle Flux Observations in the Oligotrophic Ocean (RapAutParticleFlux)

Abstract: Nearly-continuous, optical sediment trap proxy measurements of particle flux were obtained in the Sargasso Sea over nearly a year by a beam transmissometer mounted vertically on quasi-Lagrangian profiling floats. Fluxes measured directly with neutrally-buoyant, drifting sediment traps co-deployed with the floats during a series of five BATS cruises prior to this year-long deployment provide a calibration for the float-based optical measurements. A well-correlated, positive relationship ($R^2=0.66$, $n=15$) exists between the optical flux proxy and the particulate carbon flux measured directly using NBSTs. For a complete list of measurements, refer to the supplemental document 'Field_names.pdf', and a full dataset description is included in the supplemental file 'Dataset_description.pdf'. The most current version of this dataset is available at: <http://www.bco-dmo.org/dataset/728383>

Description: Carbon and nitrogen flux measurements.

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Acquisition Particle flux measurements and images of settled particles were obtained from

Description: neutrally-buoyant sediment trap (NBST) deployments during a series of five short cruises in conjunction with the Bermuda Atlantic Time-series Study (BATS) in the Sargasso Sea from July 2013 to March 2014. The NBST platforms were constructed around Sounding Oceanographic Lagrangian Observer (SOLO) profiling floats and carried four sediment trap tubes with areas of 0.0113 m^2 (see <http://www.bco-dmo.org/instrument/632>). NBSTs were programmed to descend to a single measurement depth (150, 200, 300 or 500 m), sample for a 2–3 d period, and then ascend to the surface for recovery. Details are described fully in Durkin et al. (2015) and Estapa et al. (2017).

To preserve settling particulate matter for carbon analysis, three trap tubes were filled with filtered seawater from beneath the mixed layer and 500 mL of formalin-poisoned brine was then added to the bottom through a tube. After trap recovery and a settling period of >1 h, the upper seawater layer was siphoned off each tube and the lower brine layer was drained through a $350\text{-}\mu\text{m}$ screen to separate the sinking fraction from zooplankton presumed to have actively entered the trap (Lamborg et al., 2008; Owens et al., 2013). Owens et al. (2013) found no significant difference between wet-picked and screened trap samples collected over multiple seasons at BATS. The $<350\text{-}\mu\text{m}$ and screened zooplankton fractions were filtered onto separate, precombusted GF/F filters, immediately frozen at -20°C , dried overnight at $45 \pm 5^\circ\text{C}$ on shore, and analyzed for total carbon (TC) and total nitrogen (TN) content via combustion elemental analysis (note that

particulate inorganic carbon fluxes at the BATS site are typically low, on average 5% of TC at 150 m; Owens et al., 2013). One TC and TN measurement was made per trap tube. One additional trap tube was identically prepared and processed, but was kept covered in the ship's lab during the deployment period to serve as a process blank.

A fourth tube on each NBST was loaded with a polyacrylamide gel insert to preserve sizes and shapes of settling particles for imaging. Polyacrylamide gel layers were prepared in 11-cm diameter polycarbonate jars using methods described in previous studies (Ebersbach and Trull, 2008; Lundsgaard, 1995; McDonnell and Buesseler, 2010) with slight modifications. To prepare 12% polyacrylamide gel, 7.5 g of sea salts was dissolved into 400 mL of surface seawater from Vineyard Sound, MA, USA and filtered through a 0.2- μm polycarbonate filter. The filtered brine was boiled for 15 min to reduce the oxygen content and reduce the brine volume to 350 mL. The solution was bubbled with nitrogen gas through glass pipet tips attached to a pressurized tank while the solution cooled to room temperature. The container of brine was then placed in an ice bath on a stir plate and 150 mL of 40% acrylamide solution and 1 g of ammonium persulfate was added to the solution while stirring. After the ammonium persulfate dissolved, 1 mL of tetramethylethylenediamine was added to catalyze polymerization. Gels were stored at 4 °C until use. Prior to deployment, a jar containing a layer of polyacrylamide gel was fitted to the bottom of the trap tube and the tube was filled with filtered seawater. Upon recovery and a settling period of >1 h, the overlying seawater was pumped down to the top of the gel jar and the gel insert was removed and stored at 4 °C until analysis. One additional gel trap tube was identically prepared and processed, but was kept covered in the ship's lab during the deployment period to serve as a process blank.

A series of photomicrographs was taken of each gel trap at 7 \times , 16 \times , and 63 \times magnifications using an Olympus SZX12 stereomicroscope with an Olympus Qcolor 5 camera attachment and QCapture imaging software. At a magnification of 7 \times , 49–67% of the gel surface area was imaged in 16–22 fields of view (0.1 pixels per μm) in a single focal plane. At 16 \times , 17–38% of the gel surface area was imaged in randomly distributed fields of view (0.236 pixels per μm) across the entire gel surface. At this magnification, a single focal plane could not capture every particle within one field of view; large particles typically accumulated toward the bottom of the gel layer and relatively small particles were distributed in more focal planes throughout the gel layer. To reduce the underestimation of small particle abundance, two images were taken from different focal planes in each field of view (27–60 fields, 54–120 images). At 63 \times , 0.5–0.8% of the total gel surface area was imaged (12–20 fields of view). Images were taken in cross-

sections spanning the diameter of the gel. The purpose of imaging a small percentage of the gel at high magnification was to accurately quantify the abundance of small particles. Between 11 and 15 focal planes were imaged in each field of view (0.746 pixels per μm), depending on the depth of the gel and how many distinct focal planes contained particles. Imaging the same particle twice within one field of view was avoided by ensuring that focal planes did not include overlapping particles. Between 132 and 220 images were captured of each gel at 63 \times magnification. By imaging at three magnifications, between 240 and 360 images were captured of each gel. Image files are named as 'month_trapdepth_magnification_fieldofview_focalplane.tiff', with field of view represented as sequential integers and focal plane represented as sequential letters. Recognizable zooplankton, presumed to have actively entered the gel traps, were also counted manually in 40 fields of view per gel at 32 \times magnification.

Flux measurements and images are not available at 200 m for the July 5, 2013 deployment due to failure of the lid closure mechanisms on all tubes. Occasionally a single tube sample was compromised during collection or analysis and only two replicate flux measurements are reported.

Related References:

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Processing BCO-DMO Data Processing Description:

Description:

- Reformatted column names to comply with BCO-DMO standards.
- Reformatted date to yyyy/mm/dd

Project Information

Rapid, Autonomous Particle Flux Observations in the Oligotrophic Ocean

Particles settling into the deep ocean remove carbon and biologically-important trace elements from sunlit, productive surface waters and from contact with the atmosphere over short timescales. A shifting balance among physical, chemical, and biological processes determines the ultimate fate of most particles at depths between 100 and 1,000 m, where fluxes are hardest to measure. Our challenge is to expand the number of particle flux observations in the critical “twilight zone”, something that has proven elusive with ship-based “snapshots” that have lengths of, at most, a few weeks. Here, we propose an optical, transmissometer-based method to make particle flux observations from autonomous, biogeochemical profiling floats. Novel developments in data interpretation, sensor operation, and platform control now allow flux measurements at hourly resolution and give us observational access to the water-column processes driving particle flux over short timescales. The sensors and float platforms that we propose to use are simple, robust, and commercially-available, making them immediately compatible with community-scale efforts to implement other float-based biogeochemical

measurements. We have two main goals: First, we will quantify particulate organic carbon (POC) flux using float-based optical measurements by validating our observations against fluxes measured directly with neutrally-buoyant, drifting sediment traps. Second, we will evaluate the contribution of rapid export events to total POC fluxes in the oligotrophic ocean by using a biogeochemical profiling float to collect nearly-continuous, depth-resolved flux measurements and coupled, water-column bio-optical profiles. To achieve these goals, we will implement a work plan consisting of 1) a set of laboratory-based sensor calibration experiments to determine detection limits and evaluate sensitivity to particle size; 2) a series of four sediment trap and biogeochemical float co-deployments during which we will collect POC flux and field calibration data; and 3) a long-term sampling and analysis period (approximately 1 year) during which data will be returned by satellite from the biogeochemical float. We will conduct calibration fieldwork in conjunction with monthly Bermuda Atlantic Time-series Study (BATS) cruises, taking advantage of the timeseries measurements and the context provided by the 25-year record of POC flux at that site. The data returned by the float will comprise the first quantitative particle flux observations made at high-enough temporal resolution to interpret in the context of short-term, upper-ocean production events.

Deployment Information

Deployment description for R/V Atlantic Explorer AE1315

BATS cruise

Deployment description for R/V Atlantic Explorer AE1318

BATS cruise

Deployment description for R/V Atlantic Explorer AE1320

BATS cruise

Deployment description for R/V Atlantic Explorer AE1323

BATs cruise

Deployment description for R/V Atlantic Explorer AE1402

BATS cruise

Instrument Information

Instrument	NBST
Description	Used to measure particles
Generic Instrument Name	Neutrally Buoyant Sediment Trap
Generic Instrument Description	<p>In general, sediment traps are specially designed containers deployed in the water column for periods of time to collect particles from the water column falling toward the sea floor. The Neutrally Buoyant Sediment Trap (NBST) was designed by researchers at Woods Hole Oceanographic Institution. The central cylinder of the NBST controls buoyancy and houses a satellite transmitter. The other tubes collect sediment as the trap drifts in currents at a predetermined depth. The samples are collected when the tubes snap shut before the trap returns to the surface. (more: http://www.whoi.edu/instruments/viewInstrument.do?id=10286)</p>

Instrument	Olympus SZX12 stereomicroscope with an Olympus Qcolor 5 camera attachment
Description	Used to take photomicrographs
Generic Instrument Name	Microscope-Optical
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

Instrument	Combustion Elemental Analyzer
Description	Used to measure TC and TN
Generic	

Instrument Name	Elemental Analyzer
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.