FK170124 neutrally buoyant sediment trap and WireWalker deployments

P.I.s:
Colleen Durkin (Moss Landing Marine Laboratories), Melissa Omand (University of Rhode Island), Margaret Estapa (Skidmore College)

The objective of this work is to comprehensively determine which plankton are exported from the surface ocean and by what mechanisms using particle-resolving optical and molecular techniques embedded within a sampling scheme that characterizes export events at high time and space resolution. This work tests the hypothesis that different plankton types in the surface waters are transported out of the surface ocean by distinct export pathways. This cruise enabled a successful use of novel approaches and techniques to achieve this objective.

Instruments and configuration:

NBST and OST:

A neutrally buoyant sediment trap (NBST, Fig. 1; Valdes and Price 2000) was deployed during FK170124. The NBST is designed to sink to a target depth, remain at that depth for a specified period of time, and then return to the surface for recovery. Four sediment trap tubes (12 cm diameter, 70 cm tall , 0.0133 m^2 collection area) were mounted on the NBST. Three tubes contained a layer of 0.1%, 70 ppt formalin brine solution for the purpose of collecting and preserving sinking particles in bulk. The fourth tube contained a layer of 12% polyacrylamide gel in a jar. The gel layer preserves the original properties (size, abundance, identity) of individual particles because particles remain distinctly separated from one another when they settling into the gel. The NBST also carried an optical sediment trap (OST; Estapa et al. 2017). The OST is a vertically-mounted transmissometer that collects a continuous proxy for carbon flux based on changes in measured attenuance caused by particles settling on the sensor window. See Tables 1 and 2 for a list of the samples and data collected by the NBST.

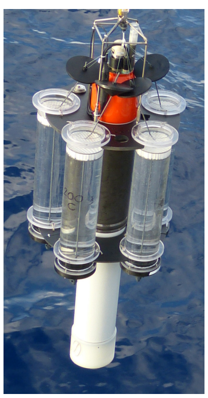

Figure 1. NBST

Wirewalker:

The upper 125m of the water column was characterized with a free-drifting, surface-tethered Wirewalker (WW, Fig. 2), which uses wave-driven movement to power a vertically-profiling instrument. Highly resolved vertical profiles of the water column physical and optical properties were conducted every 7 minutes. In total, nearly 2000 profiles were collected. The WW walked very well, and glided smoothly to the surface every time. The WW instrument was outfitted with multiple sensors (Table 1) in order to

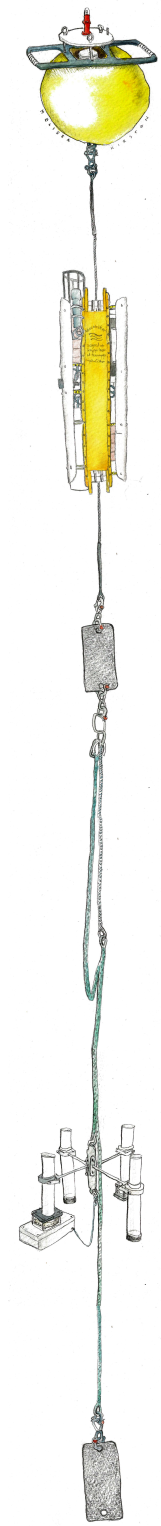

Figure 2. WW platform illustrated by Melissa Omand and Kirsten Carlson

characterize the physical and chemical properties of the upper water column at high temporal and vertical resolution.

The particles sinking out of the surface were captured by a traditional particle interceptor trap array (PIT) attached 25m below the profiling component of the WW wire - this will be referred to as the WW trap. Twenty-five meters of combined bungee and spectra line was attached to the weight at the bottom of the WW wire and a gimballed sediment trap frame holding 4 tubes was attached to the spectra line. A subset of tubes collected particles in bulk, preserved in RNAlater or unpreserved (8 cm diameter, 45 cm tall, 0.005 m^2 collection area). Another subset of tubes contained a polyacrylamide gel layer in a removable jar (7 cm diameter, 0.0038 m^2 collection area). The samples collected by the WW trap provided material for molecular analysis, either in bulk collected samples or from individual particles collected in the gel layers (Table 2). Additionally, an upward-facing iPhone camera in a watertight pressure housing was attached to the bottom of one WW trap tube containing a gel layer. The iPhone was programed to collect in situ images of particles within the gel every 20 minutes. This iPhone-attached trap tube was attached to the trap frame during the first deployment. At stations 2 and 3, a PIT with a gel cup was mounted on an aluminum shelf fabricated by the Falkor Engineer team about 6m below the PIT array.

Upon arrival at a station location, water was filtered from the CTD Niskin bottles from a depth of 150 m to prepare the sediment trap tubes for deployment. During this overnight preparation period, the Falkor performed short ADCP surveys of the region to determine the current speed and direction. At dawn the instruments were deployed and the Falkor continued to perform ADCP surveys around the drifting platforms with positions tracked by the WW buoy location.

Cruise Tracks: Submesoscale Zigzags around the WW buoy

While on station, a zig zag pattern was designed to cross the path of the WW buoy and map out the 20-30km box in the vicinity of both the WW and NBST. The tracks nominally had 7-8 waypoints, with a size that accommodated the ship speed. The ship speed varied due to the ADCP pole being deployed (4.5 kts max), weather and optimized spatial resolution on the flow through system. Sewage and food scraps were released every evening at or after 4am when Phil started watch. These were released upstream and about 5km outside of the circle encompassing the survey box. Upon arrival at a station, the ADCP pole was lowered and the ship sailed in a bow-tie pattern at 4.5 knots with nominally 8km length sides. This was designed to take about 10 hours to complete. Based on this survey, we would evaluate the direction of the mean current and use a MatLab script “Plot_SurveyBox.m” created by Estapa and Omand to create the zigzag pattern for the day.

Data and Samples

Table 1. Sensor data collected by platforms

Platform	Instrument	Product	Sample Details
NBST	Optical Sediment Trap	continuous carbon flux proxy	
WW	iPhone camera	particle flux time-lapse images	20 min intervals (Data from sta 2 and 3 only)
WW	WetLabs C-Star beam transmissometer	Beam attenuation at 650 nm	1 Hz sample rate. Data from Sta 2 and 3 only. (separate logger and battery pack)

WW	RBR Maestro Fast CTD	Temp, Salinity, Depth	6 Hz sample rate (except deployment 2 at 2 Hz).
WW	JFE Advantech miniature PAR sensor	PAR (400-700nm) units in W/m^2	1 Hz sample rate (on profiling platform)
WW	JFE Advantech miniature PAR sensor	PAR (400-700nm) units in W/m^2	1 Hz sample rate (Sta 1 only, smashed during recovery Sta 2) (on buoy)
WW	WetLabs ECOTriplet	chlorophyll, CDOM, optical backscattering at 700 nm	6 Hz sample rate (except deployment 2)
WW	Rinko dissolved oxygen sensor	Oxygen	6 Hz sample rate (except deployment 2)
WW	JFE Advantech miniature Temp sensor (on PIT array)	Temperature - used to diagnose the vertical motion of the PIT array	1 Hz sample rate

Table 2. Samples collected by each platform

Platform	Analyte	Method
NBST	Total particulate carbon/nitrogen flux and stable isotopes	EA-IRMS Optical Sediment Trap
NBST	Total organic carbon/nitrogen flux and stable isotopes	EA-IRMS after HCl fuming EA-IRMS by difference TC-IC
NBST	Total inorganic carbon/nitrogen flux and stable isotopes	EA-IRMS by difference TC-OC Coulometry (Antonio Mannino) Ca^{2+} after acidification (Flame AA or ICP-MS)
NBST	Biogenic silica flux	Weak alkaline extraction and silicate analysis (or possibly ICP-MS)
NBST	Mass flux	Gravimetric
NBST	coccolithophore and diatom fluxes	SEM (Zrinka Ljubesic)
NBST	optical attenuance cross-sections of sinking particles	Calibrated brightfield microscopy
NBST, WW trap	Sinking particle size distribution/identity	Microscopy
WW trap	18s and 16s rRNA sequence identity in preserved bulk sinking particles	DNA extraction from RNAlater trap tube, PCR, Illumina sequencing
WW trap	18s and 16s rRNA sequence identity in fresh bulk sinking particles	DNA extraction from fresh trap tube, PCR, Illumina sequencing
WW trap	18s and 16s rRNA sequence identity in individual particles	DNA extraction from picked geltrap particles, PCR, Illumina sequencing
WW trap	Eukaryotic gene expression in bulk sinking particles	RNA extraction from RNAlater, Illumina sequencing
Niskin bottles	Eukaryotic gene expression in from surface, mixed layer depth, and chlorophyll max depth (>5 µm and 0.2 – 5 µm sizes)	RNA extraction from RNAlater, Illumina sequencing
Niskin bottles	18s and 16s rRNA sequence identity in seawater from surface, mixed layer depth, and chlorophyll max depth (>5 µm and 0.2 – 5 µm sizes)	DNA extraction, PCR, Illumina sequencing

NBST Deployments:

Table 3. NBST deployment time and locations, in UTC.

Station	target depth (m)	actual depth (m)	Deployment		Recovery		deploy period (days)	collect period (days)
			deploy date/time	deploy location	Recovery Date/time	Recovery location		
1	150	150	1/28/2017 18:05	22.329°N 151.903°W	2/2/2017 4:42	21.592°N 151.779°W	4.438	2.875
2	170	50-225	2/5/2017 16:24	27.712°N 139.513°W	2/8/2017 18:45	27.731°N 139.717°W	3.083	2.938
3	150	150	2/12/2017 4:36	34.677°N 123.477°W	2/14/2017 17:15	34.422°N 123.546°W	2.542	2.438

Notes on NBST deployments:

The NBST was successfully deployed and recovered at all stations. A large number of the crew and science party were on hand to assist in spotting the NBST after it resurfaced. At station 1, the NBST remained at the surface awaiting recovery for ~1.5 days because the ship had to transit back to Honolulu due to a medical evacuation. This did not appear to adversely affect the samples and data retrieved. At station 2 the NBST had an instrument malfunction and oscillated between 50 m and 225 m. The samples collected from station 2 are therefore considered to have integrated over these depths, and OST data are not available. Upon recovery, it was discovered that several drops of water had entered the hull and caused corrosion of electronic components. The NBST was repaired and achieved correct ballast at station 3. One of the NBST trap tube caps was lost during the deployment period at station 3 due to a break in the bungee holding the cap on. The instrument was briefly rolled sideways during recovery, so this tube without a cap was not sampled.

WW deployments:

Table 4. WW deployment time and locations, in UTC.

Station	Trap depth (m)	Deployment		Recovery		deploy period (days)
		deploy date/time	deploy location	Recovery Date/time	Recovery location	
1	150	1/28/2017 17:45	22.326°N 151.912°W	2/2/2017 5:43	21.609°N 151.756°W	4.5
2	170	2/5/2017 16:06	27.713°N 139.510°W	2/8/2017 17:20	27.715°N 139.504°W	3.063
3	150	2/12/2017 4:23	34.674°N 123.475°W	2/13/2017 16:42	34.443°N 123.533°W	1.677
3	150	2/13/2017 17:48	34.435°N 123.529°W	2/14/2017 18:46	34.300°N 123.550°W	1.042

Notes on WW platform deployments:

Station 0: Run-time 0.5 hrs, ~3 profiles

Great weather. Smooth deployment. Buoy bumped along side of ship during recovery. C-Star was not functioning due to RBR cable problem. Optical sensors were taped to get dark profiles.

Station 1: Run-time 108 hrs, ~900 profiles

Deployment and recovery went smoothly. **External battery pack was lost**. WW had lots of new scratches - possible shark attack. A broken shark tooth was found in the spectra at the same distance as the broken bungee. **Bungee was broken** likely half way through the deployment, based on the T record on the trap array. **All four tubes were smashed**, with three missing. **No sediment trap samples were collected**. The iPhone box was dangling by the spectra tether. Only 7 iPhone pictures were recorded because of a defect in the iPhone battery pack. **The dissolved oxygen sensor showed a weird pattern that looked like a nonlinear drift over time. It may be possible to correct this using the CTD-rosette and Seaver's underway dissolved oxygen**. **The Cstar did not collect data**. Test cable worked, but the straight through cable from RBR seemed to short the sensor. Wayne cut it and spliced just the three wires needed - analog out, power in, gnd.

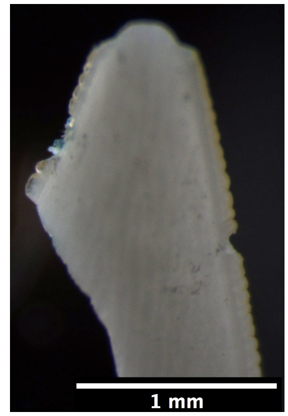

Figure 3. Shark tooth fragment found in damaged line. Identified as White, Silky, or Oceanic Whitetip.

Between stations: Engineers built a separate shelf for the iPhone box. They fabricated new collars for the tubes and bent the sediment rack back into shape. Toro (ETO) found a fault in the wiring of the battery pack and fixed it. The CStar cable problem was diagnosed and fixed. We briefly spent time planning to log Cstar with a micro controller inside the RBR virtuoso logger housing.

<u>Station 2: Run-time 50 hrs, ~400 profiles</u>
Deployment went smoothly, except was a little delayed due to working out kinks in the new iPhone shelf. Recovery was in rough windy weather. The wind blew the aft of the ship over the buoy and it got stuck underneath for 10 min. It released when the captain turned the ship ~180 degrees using mainly the bow and starboard thrusters. **The PAR sensor and strobe on the buoy got smashed.** The tubes were fine. The iPhone box was likely a little tilted in the water. **Dissolved oxygen showed nearly the exact same drifting pattern.**

<u>Station 3: Run-time 37.3 hrs (dep 1) ~300 profiles</u>
Deployment and recovery (fast turnaround) went smoothly. Ryan played guitar on deck. Tubes fine after deployment 1. iPhone was still flashing.. seemed quite dim, but it could be how it looks out in the sun. **The dissolved oxygen still probably has drift issues but the 'real' dynamic range is large enough that it is not as noticeable.**

Sample Analysis during and after the cruise

All gel layers containing particles were imaged on the ship after recovery. Gels were imaged extensively at 7x, 20x, 50x, and 115x magnifications, across multiple focal planes, and under both brightfield and oblique illumination. A total of 83 individual particles were pippeted out of the gel and frozen for further molecular analysis on shore.

After each deployment, all NBST trap tubes (excluding the tube whose lid was lost at Station 3) were combined and then split using a rotary splitter (Lamborg et al. 2008). All bulk sediment trap samples (NBST and WW trap) were filtered on the ship. Filters were either frozen or dried, depending on the downstream analysis (Table 2) that will occur on shore. Surface seawater was also collected from the CTD Niskin bottles during the occupation of each station. Size-fractionated particles and organisms (>5 μm and 0.2-5 μm) were collected onto filters and frozen for later molecular analysis onshore.

References:

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