Multiple Unit Large Volume in-situ Filtration System (MULVFS) data from R/V Roger Revelle cruise ZHNG09RR to site K2 in the northwest Pacific in 2005 (VERTIGO project)

Website: https://www.bco-dmo.org/dataset/2952
Data Type: Cruise Results
Version: 2
Version Date: 2020-12-01

Project
» VERtical Transport In the Global Ocean (VERTIGO)

Program
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
Bishop, James K.B.	E.O. Lawrence Berkeley (LBNL)	Principal Investigator
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Abstract
This dataset includes concentrations of particulate inorganic carbon, particulate nitrogen, particulate carbon, particulate phosphorus, particulate thorium, and other measurements from a Multiple Unit Large Volume in-situ Filtration System (MULVFS) from the R/V Roger Revelle cruise ZHNG09RR to site K2 in the northwest Pacific in 2005.

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Coverage

Spatial Extent: **N**:47.05 **E**:161.01 **S**:47.001 **W**:161
Temporal Extent: 2005-07-30 - 2005-08-12

Dataset Description

As part of the VERTIGO project, Multiple Unit Large Volume in-situ Filtration System (MULVFS) sampling took place during two week-long intensive study periods at ALOHA (in 2004) and K2 (in 2005). This dataset includes data from K2.

Final review by the data submitter was not received after it was imported into the BCO-DMO data system. Data have been published "as is".

Associated Publication:

Bishop, J.K.B.and Wood, T.J. (2008) Particulate Matter Chemistry and Dynamics in the Twilight Zone at VERTIGO ALOHA and K2 Sites. Deep-Sea Research I 55, 1684-1706. doi: [10.1016/j.dsr.2008.07.012](10.1016/j.dsr.2008.07.012)

Methods & Sampling

As part of the VERTIGO project, Multiple Unit Large Volume in-situ Filtration System (MULVFS) sampling took place during two week-long intensive study periods at ALOHA (in 2004) and K2 (in 2005). This dataset includes data from K2.

MULVFS was first described in Bishop et al., 1985. MULVFS consists of 12 ship-electricity powered pump units deployed simultaneously to kilometer depths using a dedicated (unified) 1000 m long electromechanical cable and winch system. MULVFS sample depths were 10, 35, 60, 85, 135, 185, 235, 310, 460, 560, 660, 760, and 810 m at K2. The shallowest sample was always within the surface mixed layer. VERTIGO casts were timed to capture particles near local noon and midnight to investigate the effects of diurnal zooplankton migrations on particle distributions. At K2, 2 day/night pairs were obtained.

Each pump unit can collect samples of particulate and dissolved species using three flow paths. Check and gas release (de bubbler) valves protect filter samples from the effects of back flow, contamination, and disruption due to trapped air on deployment and degassed air expansion on recovery. The later is a problem in shallow samples.

Depending on depth and particle concentration, 2000–16 000 L volumes of seawater are filtered under a suction of ~0.8 atmospheres over 4–5 h through the main multi-stage (3 anti-washout baffles and two filter stages) filter holder. The first anti-washout baffle is a heavy polyethylene plastic cover with incised 1 cm scale triangular flaps centered over each of the 52 tubes of the second baffle stage and was added to ensure particle retention under strong current shears.

The main filter series (with an effective filtration diameter of 24.5 cm) consists of a 51 um polyester weave mesh prefilter supported by 149 um polyester mesh and 1.2 cm spaced 1.2 cm thick plastic grid in the prefilter stage, followed by two identical Whatman QMA quartz fiber filters supported by 149 um polyester mesh and 149 um porous polyethylene frit. All filters and components are acid cleaned. The three particle size fractions represented by prefilter and QMA filters are >51, 1–51, and <1 um. Fiber flters are 'depth' filters and particles are captured from the flow by the fibers, not pores. Thus a second filter captures additional small particles that pass through the first (Bishop and Edmond, 1976). The "<1 um" fraction, thus represents some of particles in the larger submicron particle class (Bishop et al., 1977, 1985).

The second flow path, with 500–2000 L water flow capacity was used for separate multi-stage filter assemblies and in-line Mn radionuclide adsorption cartridges (Charette et al., 1999). Refer to the Supplemental Document "VERTIGO MULVFS Methods" for the filter assembly used by T. Trull (University of Tasmania, UTAS) The third ('side arm') flow path was used for simultaneous attachment of up to six 47 mm filter holders or smaller absorbers. We used two for separate quantification of >0.4 um Si and for >0.4 um Ba and Mn (Poretics Polycarbonate, 0.4 um, Osmonics, Inc.). About 30% of the time all side arm filter holders had a common 0.4 um filter and the volume was apportioned by number of samples collected. When different filters/adsorbers were used we estimated flow through each type apportioned by flows measured under suction aboard ship.

Blank samples (filters mounted on a non-operating pump and lowered to depth for the cast duration) were processed identically to all other samples.

Aboard ship, MULVFS samples were photographed under controlled lighting using a NIKON COOLPIX 5700 digital camera (Lam and Bishop, 2007) and processed in depth order within 2 hours of the end of cast. All work was performed in a class 100 laminar- flow bench; non-contaminating gloves, sub sampling templates, scalpels, and tweezers were used. QMA filters were sub sampled for up to six other investigators using sharpened acid leached ~45 mm diameter acrylic tubes; "pie slice" sub samples equivalent to 1/8 to 1/4 of each >51 um sample were cut using a stainless steel scalpel. When rare, larger zooplankton and small fish were removed from the MULVFS prefilter samples prior to sub sampling. The remaining sample was lightly "misted" with 15 mL of 18.2 MOhm Milli-Q water under weak suction (<10 cm Hg) to reduce salt loading, oven dried at 60°C for 1-2 days, and then stored flat in trace metal certified polyethylene bags.

The "Side Arm" 0.4 um filter samples were misted under mild vacuum with ~1.5 mL of Milli-Q water, and then transferred directly to acid leached 125 mL polyethylene bottles in which they were later analyzed. This eliminates fractionation of major sea salt components (e.g., Na from Ca).

Sample processing at Lawrence Berkeley National Laboratory (LBNL) was performed in a class-100 laminar flow fume hood in a class-10000 laboratory environment and followed Bishop et al., (1977, 1985). For analysis by Inductively Coupled Plasma Mass Spectrometer (ICP-MS), ~1/50th of each QMA filter was sub sampled following Bishop et al. (1985) and ~1/40th of each 51 um prefilter was cut using a stainless steel scalpel (guided by eye to avoid zooplankton) using a rectangular acrylic template with recessed center. Sub samples were transferred to separate 125 mL acid leached - dried Nalgene® polyethylene bottles, flooded with 10 mL of 0.6 N ultra pure HCl (Seastar Chemicals Baseline Acid), and heated at 60°C overnight (~16 hours). Each leach solution was filtered (0.4 um) and then diluted with 18.2 MOhm Milli-Q water to 50 grams weight. Solutions were further diluted (1:4) with Milli-Q water and treated with an indium spike (final In conc ~0.7 ppb) and then analyzed using a Finnigan Element II ICP-MS. Mixed element standards, and CASS III seawater, were prepared at multiple dilutions in the same 0.12 N HCl matrix. Elements determined were Li*, Na, Mg*, Al, P, K*, Ca*, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, Sr*, Y, Cd, I, Cs, Ba, Tl, Pb, Bi, Ce, Nd, U*. Elements marked with asterisks (*) were corrected for sea salt components using Na (Bishop et al., 1977).

Groups from Woods Hole Oceanographic Institution (WHOI) and University of Tasmania (UTAS) were provided fresh filter sub samples for 234Th, C and N, and for Corg, N, δ13Corg, and δ15N, respectively. The >51 um material was rinsed from the polyester "pie slices" using 0.8 um filtered seawater onto 25 mm diameter 0.4 um silver filters, dried at 50 °C, and analyzed as described by Trull et al. (2008). A drying oven mishap resulted in loss of many of the QMA Corg samples from Cast M03 at ALOHA. The 234Th samples were air-dried after/during counting aboard ship and stored frozen in Petri dishes for later analysis for C and N at WHOI. QMA in-situ sample blanks (~3 mg C per 25.4 cm diameter filter) were applied to the data. The use of in-situ blanks compensates for adsorption of dissolved species onto filters during filtration (Turnewitsch et al., 2007).

WHOI Corg and N data for QMA samples from cast M07 and M08 were low by factors of two to three compared with UTAS results. The M08 sub samples analyzed at WHOI had sat wet for considerable time before CN analysis (John Andrews, notes) and the same problem must have impacted their M07 sub samples. Similar problems may have affected some ALOHA samples from Cast M04, which also were not oven dried. We report all data but use the WHOI Corg QMA data for ALOHA (M1, M2, M4, M5) and the UTAS (combined <1 and 1-51 um results) QMA Corg and N data for K2; The <1 um WHOI results were retained for casts M07, 09, and 10 for comparison purposes. All >51 um Corg samples at K2 and ALOHA were UTAS processed.

Notes from dataset file header:
Bishop CN calcs as of April 29 2007 results nearly final.
QMA blanks 25.4 cm diameter filter - all dipped blanks (averaged except for cast 8).
Trull Filter data as calculated by Buesseler.
Nitrogen results: many dipped MULVFS sample blanks below detection. The results shown here are an upper limit of N.

Note nearest surface samples in >51 um size fraction from casts 8 and 10 at night are contaminated with significant numbers of copepods (see Bishop and Wood (2008)).
treat cast 7 and 8 lt1 and 1-51 PC and PN with caution.
gt0.4 Corresponds to analysis of a side-arm filter.
gt51, 1-51, lt1 designations correspond to filtration order as water passes through a 51 um prefilter and paired QMA filters. A single QMA filter quantitatively captures particles >1.2 um; a pair of QMA filters traps particles to 0.8 um size.
lt51 - sum of paired QMA filter data.
samples identified by T_ were samples from a separate filter holder.

Data Processing Description

Quality Flag Definitions:
0 = sample is ok.
1 = possibility of over estimate of flow 10-20%.
2 = samples were wet when stored CN anomlously high C and N anomalously low.
3 = samples may be mixed up.
4 = main MULVFS flow volume adjusted based on consistency with other analyses.
5 = CN anomalously low.
6 = sample not run.

BCO-DMO Processing history:
Version 1:

2008-07-07 - contributed by Jim Bishop.
2008-11-12 - Cruise_ID added manually; date, event, ev_code, lon, lat from cruise logs merged with original data.
2008-11-12 - added to OCB database; Steve Gegg, BCO DMO.

Version 2:
2020-12-01 - processed revised data contributed by Jim Bishop in November 2020; made the following edits:
- added locations and dates from separate locations file;
- renamed fields to conform with BCO-DMO naming conventions;
- removed duplicate columns;
- replaced missing data values with 'nd' ('no data').

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Data Files

File
mulvfs_CNP_234Th_v2.csv (Comma Separated Values (.csv), 18.67 KB) MD5:091a8fed96b875b6260334ee075acd56 Primary data file for dataset ID 2952

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Supplemental Files

File
VERTIGO MULVFS Methods filename: MULVFS_Methods.pdf (Portable Document Format (.pdf), 555.62 KB) MD5:76e4a26d69a8de389be3b9b1d9e6a1eb Detailed description, with figures, of the Multiple Unit Large Volume in-situ Filtration System (MULVFS) deployment and sampling methods used in the VERTIGO project at station ALOHA and site K2.

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Related Publications

Bishop, J. K. B., & Wood, T. J. (2008). Particulate matter chemistry and dynamics in the twilight zone at VERTIGO ALOHA and K2 sites. Deep Sea Research Part I: Oceanographic Research Papers, 55(12), 1684–1706. doi:10.1016/j.dsr.2008.07.012
Results

Bishop, J. K. B., Edmond, J. M., Ketten, D. R., Bacon, M. P., & Silker, W. B. (1977). The chemistry, biology, and vertical flux of particulate matter from the upper 400 m of the equatorial Atlantic Ocean. Deep Sea Research, 24(6), 511–548. doi:10.1016/0146-6291(77)90526-4
Methods

Bishop, J. K. B., Schupack, D., Sherrell, R. M., & Conte, M. (1985). A Multiple-Unit Large-Volume In Situ Filtration System for Sampling Oceanic Particulate Matter in Mesoscale Environments. In Mapping Strategies in Chemical Oceanography (pp. 155–175). American Chemical Society. https://doi.org/10.1021/ba-1985-0209.ch009
Methods

Bishop, J.K.B., Edmond, J.M., 1976. A new large volume filtration system for the sampling of oceanic particulate matter. Journal of Marine Research 34, 181–198. URL: http://images.peabody.yale.edu/publications/jmr/jmr34-02-05.pdf
Methods

Charette, M. A., Bradley Moran, S., & Bishop, J. K. B. (1999). as a tracer of particulate organic carbon export in the subarctic northeast Pacific Ocean. Deep Sea Research Part II: Topical Studies in Oceanography, 46(11-12), 2833–2861. doi:10.1016/s0967-0645(99)00085-5

Methods

Lam, P. J., & Bishop, J. K. B. (2007). High biomass, low export regimes in the Southern Ocean. Deep Sea Research Part II: Topical Studies in Oceanography, 54(5-7), 601–638. doi:10.1016/j.dsr2.2007.01.013
Methods

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Related Datasets

IsRelatedTo

Bishop, J. K. (2021) **Multiple Unit Large Volume in-situ Filtration System (MULVFS) data from R/V Kilo Moana cruise KM0414 from the Hawaiian Islands, HOT Site (Station ALOHA) in 2004 (VERTIGO project).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 2) Version Date 2020-11-30 doi:10.26008/1912/bco-dmo.2951.2 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Location	Cruise location (K2 = site K2 in the northwest Pacific)	unitless
cast	Cast number	unitless
Year	Year; format: YYYY	unitless
Start_Day	Julian day at start of sampling. This description is an assumption made by BCO-DMO as no explicit definition was provided by the data submitter.	unitless
End_Day	Julian day at end of sampling. This description is an assumption made by BCO-DMO as no explicit definition was provided by the data submitter.	unitless
Day_Night	Indicates dat (D) or night (N)	unitless
Lat	Latitude	degrees North
Long	Longitude	degrees East
depth	Sample depth	meters (m)
liters_main	Liters of water filtered	liters (L)
liters_main_flag	Quality flag for liters_main	unitless
pump	MULVFS pump ID	unitless
PIC_1_53_uM	Particulate Inorganic Carbon (PIC= Ca_measured - Na_measured*Ca/Na_seawater); particle size between 1 and 53um	micromolar (uM)
gt51_PIC_uM	Particulate Inorganic Carbon (PIC= Ca_measured - Na_measured*Ca/Na_seawater); particle size greater than 51um	micromolar (uM)
TOT_PIC_uM	Total Particulate Inorganic Carbon (PIC= Ca_measured - Na_measured*Ca/Na_seawater)	micromolar (uM)
FRACTION_lt51_PIC	Fraction of PIC with particle size less than 51um	unitless
lt1_flag_PCPN	Quality flag for PC and PN with particle size less than 1um	unitless
lt1_PC_uM	Particulate Carbon (organic + inorganic); particle size less than 1um	micromolar (uM)
lt1_PC_uM_sd	Standard deviation of lt1_PC_uM	micromolar (uM)

lt1_PN_uM	Particulate Nitrogen; particle size less than 1um	micromolar (uM)
lt1_PN_uM_sd	Standard deviation of lt1_PN_uM	micromolar (uM)
flag_PCPN_1_51	Quality flag for PC and PN with particle size between 1 and 51um	unitless
PC_1_51_uM	Particulate Carbon (organic + inorganic); particle size between 1 and 51um	micromolar (uM)
PC_1_51_uM_sd	Standard deviation of PC_1_51_uM	micromolar (uM)
PN_1_51_uM	Particulate Nitrogen; particle size between 1 and 51um	micromolar (uM)
PN_1_51_uM_sd	Standard deviation of PN_1_51_uM	micromolar (uM)
POC_1_51_uM	Particulate Organic Carbon (POC = PC - PIC); particle size between 1 and 51um	micromolar (uM)
lt51_POC	Particulate Organic Carbon (POC = PC - PIC); particle size less than 51um	micromolar (uM)
lt51_POC_sd	Standard deviation of lt51_POC	micromolar (uM)
lt51_PN	Particulate Nitrogen; particle size less than 51um	micromolar (uM)
lt51_PN_sd	Standard deviation of lt51_PN	micromolar (uM)
Trull_POC_lt51_uM	Particulate Organic Carbon (POC = PC - PIC); particle size less than 51um	micromolar (uM)
Trull_POC_lt51_uM_sd	Standard deviation of Trull_POC_lt51_uM	micromolar (uM)
Trull_POC_gt51_uM	Particulate Organic Carbon (POC = PC - PIC); particle size greater than 51um	micromolar (uM)
Trull_POC_gt51_uM_sd	Standard deviation of Trull_POC_gt51_uM	micromolar (uM)
Trull_lt51_PN_uM	Particulate Nitrogen; particle size less than 51um	micromolar (uM)
Trull_lt51_PN_uM_sd	Standard deviation of Trull_lt51_PN_uM	micromolar (uM)
Trull_gt51_PN_uM	Particulate Nitrogen; particle size greater than 51um	micromolar (uM)
Trull_gt51_PN_uM_sd	Standard deviation of Trull_gt51_PN_uM	micromolar (uM)
Tr_POC_FRACTION_lt51	Fraction of Particulate Phosphorus with particle size less than 51um	unitless
lt1_PP_pM	Particulate Phosphorus; particle size less than 1um	picomolar (pM)
lt1_PP_sd	Standard deviation of lt1_PP_pM	picomolar (pM)
PP_1_51_pM	Particulate Phosphorus; particle size between 1 and 51um	picomolar (pM)
PP_1_51_pM_sd	Standard deviation of PP_1_51_pM	picomolar (pM)
gt51_PP_pM	Particulate Phosphorus; particle size greater than 51um	picomolar (pM)
gt51_PP_pM_sd	Standard deviation of gt51_PP_pM	picomolar (pM)
TOTAL_P_pM	Total Particulate Phosphorus	picomolar (pM)
TOTAL_PP_nM	Total Particulate Phosphorus	nanomolar (nM)
FRACTION_lt51_PP	Fraction of Particulate Phosphorus with particle size less than 51um	unitless
gt51_Si_nM	Si; particle size greater than 51um	nanomolar (nM)
gt51_Si_nM_sd	Standard deviation of gt51_Si_nM	nanomolar (nM)
gt_0point4_Si_nM	Si; particle size greater than 0.4um (analysis of a side-arm filter)	nanomolar (nM)
Trull_lt51_POCPN	[Definition not provided by data submitter]	unknown
Trull_lt51_POCPN_sd	Standard deviation of Trull_lt51_POCPN	unknown
Trull_gt51_POCPN	[Definition not provided by data submitter]	unknown

Trull_gt51_POCPN_sd	Standard deviation of Trull_gt51_POCPN	unknown
PTh_1_51_dpml	Particulate Thorium; particle size between 1 and 51um	disintegrations per minute per liter (dpm/L)
PTh_1_51_dpml_sd	Standard deviation of PTh_1_51_dpml	disintegrations per minute per liter (dpm/L)
lt1_PTh_dpml	Particulate Thorium; particle size less than 1um	disintegrations per minute per liter (dpm/L)
lt1_PTh_dpml_sd	Standard deviation of lt1_PTh_dpml	disintegrations per minute per liter (dpm/L)
Target_Depth	Target depth	meters (m)
T_gt1_5_PTh	[Definition not provided by data submitter]	unknown
T_gt1_5_PTh_sd	Standard deviation of T_gt1_5_PTh	unknown
T_gt5_20_PC	[Definition not provided by data submitter]	unknown
T_gt5_20_PN	[Definition not provided by data submitter]	unknown
T_gt5_20_PTh	[Definition not provided by data submitter]	unknown
T_gt5_20_PTh_sd	Standard deviation of T_gt5_20_PTh	unknown
T_gt20_55_PC	[Definition not provided by data submitter]	unknown
T_gt20_55_PN	[Definition not provided by data submitter]	unknown
T_gt20_55_PTh	[Definition not provided by data submitter]	unknown
T_gt20_55_PTh_sd	Standard deviation of T_gt20_55_PTh	unknown
T_gt55_330_PC	[Definition not provided by data submitter]	unknown
T_gt55_330_PN	[Definition not provided by data submitter]	unknown
T_gt55_330_PTh	[Definition not provided by data submitter]	unknown

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Instruments

Dataset-specific Instrument Name	MULVFS
Generic Instrument Name	Multiple Unit Large Volume Filtration System
Generic Instrument Description	The Multiple Unit Large Volume Filtration System (MULVFS) was first described in Bishop et al., 1985 (doi: 10.1021/ba-1985-0209.ch009). The MULVFS consists of multiple (commonly 12) specialized particulate matter pumps, mounted in a frame and tethered to the ship by a cable (Bishop et al., 1985; Bishop and Wood, 2008). The MULVFS filters particulates from large volumes of seawater, although the exact protocols followed will vary for each project.

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Deployments

ZHNG09RR

Website	https://www.bco-dmo.org/deployment/57848
Platform	R/V Roger Revelle
Start Date	2005-07-21
End Date	2005-08-27
Description	VERTIGO 2005 expedition to the K2site in the NW Pacific near 45° N and 160° E Funded by: NSF OCE-0301139 Cruise information from the VERTIGO project site: https://cafethorium.whoi.edu/projects/vertigo/vertigo-k2/ Original cruise data for the Revelle are available from the NSF R2R data catalog: http://www.rvdata.us/catalog/ZHNG09RR

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Project Information

VERtical Transport In the Global Ocean (VERTIGO)

Website: https://cafethorium.whoi.edu/projects/vertigo/

Coverage: HOT site and subarctic NW Pacific

NSF Award Abstract:
In this study, researchers at the Woods Hole Oceanographic Institution, Virginia Institute of Marine Science, University of California - Santa Cruz, University of California - Santa Barbara, University of Tasmania, and NIWA-Australia will work collaboratively to answer a difficult question in marine biogeochemistry: What controls the efficiency of particle transport between the surface and deep ocean? More specifically, what is the fate of sinking particles leaving the upper ocean and what factors influence remineralization length scales for different sinking particle classes? Knowing the efficiency of particle transport is important for an accurate assessment of the ocean carbon sink. Globally, the magnitude and efficiency of the biological pump will in part modulate levels of atmospheric carbon dioxide.

The research team intends to test two basic hypotheses about remineralization control, namely: (1) particle source characteristics are the dominant control on the efficiency of particle transport; and/or that (2) mid-water processing, either by zooplankton or bacteria, controls transport efficiency. To do so, they will conduct process studies at sea focused on particle flux and composition changes in the upper 500-1000m of the ocean. The basic approach is to examine changes in particle composition and flux with depth within a given source region using a combination of approaches, many of which are new to the field. These include neutrally buoyant sediment traps, particle pumps, settling columns and respiration chambers, along with the development of new biological and geochemical tools for an integrated biogeochemical assessment of the biological pump. Two sites will be studied extensively on three-week process study cruises: the Hawaii Ocean Time-series site (HOT) and a new moored time-series site in the subarctic NW Pacific (Japanese site K2; 47oN 160oE). There are strong contrasts between these sites in rates of production, export, particle composition and expected remineralization length scales.

Evidence for variability in the flux vs. depth relationship of sinking particles is not in dispute, but the controls on particle transport efficiency through the twilight zone remain poorly understood. A lack of reliable flux and particle characterization data within the twilight zone has hampered our ability to make progress in this area, and no single approach is likely to resolve these issues. The proposed study will apply quantitative modeling to determine the net effects of the individual particle processes on the effective transport of carbon and other elements and to place the shipboard observations in the context of spatial and temporal variations in these processes

Besides the obvious contributions to the study of the oceanic and planetary carbon cycles, there are broader outcomes and impacts forthcoming from this project. Graduate and undergraduate students will be included in all aspects of the research, and the involvement of non-US PIs will encourage exchange of students and post-docs between labs in different countries. In addition, the component groups will continue to maintain science web sites designed for both public and scientific exchange where the broader and specific goals and outcomes of this work can be communicated.

Original PI-provided project description:
The main goal of VERTIGO is the investigation of the mechanisms that control the efficiency of particle transport through the mesopelagic portion of the water column.

Question: What controls the efficiency of particle transport between the surface and deep ocean? More specifically, what is the fate of sinking particles leaving the upper ocean and what factors influence remineralization length scales for different sinking particle classes? VERTIGO researchers have set out to test two basic hypotheses regarding remineralization control, namely:
1. particle source characteristics are the dominant control on the efficiency of particle transport; and/or that
2. mid-water processing, either by zooplankton or bacteria, controls transport efficiency.

To test their hypotheses, they will conduct process studies in the field focused on particle flux and composition changes in the upper 500-1000m of the ocean. The basic approach is to examine changes in particle composition and flux with depth within a given source region using a combination of approaches, many of which are new to the field. These include neutrally buoyant sediment traps, particle pumps, settling columns and respiration chambers, along with the development of new biological and geochemical tools for an integrated biogeochemical assessment of the biological pump. Three week process study cruises have been planned at two sites - the Hawaii Ocean Time-series site (HOT) and a new moored time-series site in the subarctic NW Pacific (Japanese site K2; 47oN 160oE) - where there are strong contrasts in rates of production, export, particle composition and expected remineralization length scales.

Evidence for variability in the flux vs. depth relationship of sinking particles is not in dispute but the controls on particle transport efficiency through the twilight zone remain poorly understood. A lack of reliable flux and particle characterization data within the twilight zone has hampered our ability to make progress in this area, and no single approach is likely to resolve these issues. The proposed study will apply quantitative modeling to determine the net effects of the individual particle processes on the effective transport of carbon and other elements, and to place the shipboard observations in the context of spatial and temporal variations in these processes. For rapid progress in this area, we have organized this effort as a group proposal taking advantage of expertise in the US and international community.

The efficiency of particle transport is important for an accurate assessment of the ocean C sink. Globally, the magnitude and efficiency of the biological pump will in part modulate levels of atmospheric CO2. We maintain that to understand present day ocean C sequestration and to evaluate potential strategies for enhancing sequestration, we need to assess possible changes in the efficiency of particle transport due to climate variability or via purposeful manipulations of C uptake, such as via iron fertilization.

*VERTIGO Acknowledgments: (*from K.O. Buesseler, et al / Deep-Sea Research II 55 (2008) 1522-1539) We thank the officers, crew and shore-based support teams for the R/V Kilo Moana (2004) and R/V Roger Revelle (2005). Funding for VERTIGO was provided primarily by research grants from the US National Science Foundation Programs in Chemical and Biological Oceanography (KOB, CHL, MWS, DKS, DAS). Additional US and non-US grants included: US Department of Energy, Office of Science, Biological and Environmental Research Program (JKBB); the Gordon and Betty Moore Foundation (DMK); the Australian Cooperative Research Centre program and Australian Antarctic Division (TWT); Chinese NSFC and MOST programs (NZJ); Research Foundation Flanders and Vrije Universiteit Brussel (FD, ME); JAMSTEC (MCH); New Zealand Public Good Science Foundation (PWB); and internal WHOI sources and a contribution from the John Aure and Cathryn Ann Hansen Buesseler Foundation (KOB). A number of individuals at sea and on shore, helped make the VERTIGO project a success, including: J. Andrews, C. Bertrand, R. Bidigare III, S. Bray, K. Casciotti, M. Charette, R. Condon, J. Cope, E. Fields, M. Gall, M. Gonneea, P. Henderson, T. Kobari, D. Kunz, S. Saitoh, S. Manganini, C. Moy, S. Okamoto, S. Pike, L. Robertson, D. Ruddick and Y. Zhang. Suggestions by three anonymous reviewers and help by the editor, R. Lampitt, are also greatly appreciated.

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Program Information

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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