Compilation of MULVFS size-fractionated POC, PIC, and bSi data from 17 cruises conducted between 1973 and 2005

Website: https://www.bco-dmo.org/dataset/884057
Data Type: Cruise Results
Version: 1
Version Date: 2022-11-21

Project
» U.S. JGOFS Equatorial Pacific (EqPac)
» VERtical Transport In the Global Ocean (VERTIGO)

Programs
» U.S. Joint Global Ocean Flux Study (U.S. JGOFS)
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
Bishop, James K.B.	University of California-Berkeley (UC Berkeley)	Principal Investigator
Lam, Phoebe J.	University of California-Santa Cruz (UCSC)	Co-Principal Investigator, Contact
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset reports 74 profiles of <53um and >53um concentrations of particulate organic carbon (POC), particulate inorganic carbon (PIC), and biogenic silica (bSi) collected and analyzed by James K.B. Bishop from 17 cruises using ship-powered (Multiple Unit) Large Volume In-situ Filtration (LVFS, later MULVFS) between 1973 and 2005. The dataset was compiled by Phoebe Lam.

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Coverage

Spatial Extent: **N**:50 **E**:161.01 **S**:-66.4 **W**:-172
Temporal Extent: 1973-12 - 2005-08

Dataset Description

This dataset compiles size fractionated (less than 53 micrometers (<53um) and greater than 53 micrometers (>53um)) particulate organic carbon (POC), particulate inorganic carbon (PIC), and biogenic silica (bSi concentrations collected by the Large Volume in-situ Filtration System (LVFS, Bishop and Edmond, 1976) and the Multiple Unit Large Volume in-situ Filtration System (MULVFS, Bishop, et al., 1985) between 1973 and 2005. A description of the compilation is given in Lam, et al. (2011), and the >53um POC, bSi, and PIC and 1-53um

POC data were published in the supplemental information of that paper. This data submission adds 1-53um PIC and 0.4um-53um bSi to those data, as well as includes a few more coastal stations that were not reported in Lam, et al. (2011).

Methods & Sampling

Please see the original papers for detailed sampling and analytical methodology.

Briefly, size-fractionated particles were collected using the ship-powered (Multiple Unit) Large Volume in-situ Filtration System (LVFS, later MULVFS), typically in the upper 1000 m (Bishop and Edmond, 1976; Bishop, et al., 1985). Large particles were collected on a 293mm-diameter 53um mesh filter (Nitex, later 51um polyester) placed upstream of paired 293 millimeter (mm) diameter glass (LVFS) or quartz fiber (MULVFS) filters. This main flowpath filtered 2000-16000 liters (L) of seawater per pump. In later deployments, particles were also collected on 47mm diameter 0.4 um polycarbonate filters on a side-arm flow-path that filtered some tens of liters of seawater per pump.

Particulate inorganic carbon (PIC) was determined directly on a subsample of each size fraction on the main flowpath by measuring calcium (Ca) (by atomic absorption spectroscopy or Inductively coupled plasma mass spectrometry (ICP-MS)) following a weak acid leach, correcting for salt and organic matter Ca contributions, and assuming PIC was in $CaCO_3$ form.

Biogenic silica (bSi) was determined spectrophotometrically following a weak alkaline leach on a subsample of the >53um size fraction and on the >0.4um side-arm polycarbonate filter, when available. Small size fraction bSi was estimated as the difference between the >0.4um bSi and the >53um bSi when >0.4um bSi was available.

Particulate organic carbon (POC) was determined directly by combustion on subsamples of the glass fiber or quartz fiber filters for the 1-53um size fraction.Particulate organic matter (POM) on the >53um size fraction was typically estimated gravimetrically as the difference between salt-corrected dry weight and the stoichiometric masses of major phases determined chemically ($CaCO_3$, opal, $SrSO_4$, where applicable), then converted to POC assuming a biochemically-realistic plankton composition (Lam, et al., 2011).

Data Processing Description

Data Processing:
Please see Lam, et al. (2011) for more details.

BCO-DMO Processing:
- replaced "NaN" with "nd" as missing data value ("no data");
- replaced commas with semi-colons in "References" column;
- replaced "19" with "10" in the month column for rows 142-148 (cruise 8210).

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Data Files

File	
MULVFS_compilation.csv	(Comma Separated Values (.csv), 78.49 KB) MD5:11e27766ef975843d88190b828427e78
Primary data file for dataset ID 884057	

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Supplemental Files

File	
884057_References.pdf	(Portable Document Format (.pdf), 371.65 KB) MD5:060a0ae132f813983521c79d107956c0

Complete citations of references cited in the "References" column of dataset 884057, "Compilation of MULVFS size-fractionated POC, PIC, and bSi data".

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Related Publications

Bishop, J. K. B. (1999). Transmissometer measurement of POC. Deep Sea Research Part I: Oceanographic Research Papers, 46(2), 353–369. https://doi.org/10.1016/s0967-0637(98)00069-7 https://doi.org/10.1016/S0967-0637(98)00069-7
IsDerivedFrom

Bishop, J. K. B., & Fleisher, M. Q. (1987). Particulate manganese dynamics in Gulf Stream warm-core rings and surrounding waters of the N.W. Atlantic. Geochimica et Cosmochimica Acta, 51(10), 2807–2825. https://doi.org/10.1016/0016-7037(87)90160-8
IsDerivedFrom

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
IsDerivedFrom

Bishop, J. K. B., Collier, R. W., Kettens, D. R., & Edmond, J. M. (1980). The chemistry, biology, and vertical flux of particulate matter from the upper 1500 m of the Panama Basin. Deep Sea Research Part A. Oceanographic Research Papers, 27(8), 615–640. https://doi.org/10.1016/0198-0149(80)90077-1
IsDerivedFrom

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
IsDerivedFrom

Bishop, J. K. B., Ketten, D. R., & Edmond, J. M. (1978). The chemistry, biology and vertical flux of particulate matter from the upper 400 m of the Cape Basin in the southeast Atlantic Ocean. Deep Sea Research, 25(12), 1121–1161. https://doi.org/10.1016/0146-6291(78)90010-3
IsDerivedFrom

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., Stepien, J. C., & Wiebe, P. H. (1986). Particulate matter distributions, chemistry and flux in the panama basin: response to environment forcing. Progress in Oceanography, 17(1–2), 1–59. https://doi.org/10.1016/0079-6611(86)90024-8
IsDerivedFrom

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

K.B. Bishop, J., E. Calvert, S., & Soon, M. Y. S. (1999). Spatial and temporal variability of POC in the northeast Subarctic Pacific. Deep Sea Research Part II: Topical Studies in Oceanography, 46(11–12), 2699–2733. https://doi.org/10.1016/s0967-0645(99)00081-8 https://doi.org/10.1016/S0967-0645(99)00081-8
IsDerivedFrom

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
IsDerivedFrom

Lam, P. J., Doney, S. C., & Bishop, J. K. B. (2011). The dynamic ocean biological pump: Insights from a global compilation of particulate organic carbon, CaCO3, and opal concentration profiles from the mesopelagic. Global Biogeochemical Cycles, 25(3), GB3009. doi:10.1029/2010gb003868
Methods

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Related Datasets

IsDerivedFrom

Bishop, J. K.B. (1998) **Particulate Organic Carbon from MULVFS casts from R/V Thomas G. Thompson cruises TT007, TT011 in the Equatorial Pacific in 1992 during the U.S. JGOFS Equatorial Pacific (EqPac) project.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version December 9, 1998) Version Date 1998-12-09 http://lod.bco-dmo.org/id/dataset/2631 [view at BCO-DMO]
Relationship Description: Dataset 884057, "Compilation of MULVFS size-fractionated POC, PIC, and bSi data" (contributed by Phoebe Lam) includes some data from 2631, "mulvfs_POC" (contributed by James K.B. Bishop). Dataset 2631 is reference number 9 in the "References" column of 884057.

IsSourceOf

Pavia, F. J., Dong, S., Lam, P. J., Subhas, A. V. (2022) **Compiled global dataset of PIC/POC and bSi concentrations measured by in situ pumps on multiple research cruises conducted from between 1973 and 2013.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-11-18 doi:10.26008/1912/bco-dmo.883965.1 [view at BCO-DMO]
Relationship Description: Dataset 883965, "Compiled Global Dataset of PIC/POC and bSi Concentrations Measured by In Situ Pumps" (contributed by Sijia Dong & Adam Subhas), includes some data from 884057, "Compilation of MULVFS size-fractionated POC, PIC, and bSi data" (contributed by Phoebe Lam).

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Parameters

Parameter	Description	Units
StationName	short description of station	unitless
num	profile number (sequential)	unitless
lat	latitude (negative values = South)	degrees North
long	longitude (negative values = West)	degrees East
year	year of sampling	unitless
month	month of sampling	unitless
MLD	Mixed Layer Depth, as reported in original reference, or where Δσθ >0.05 kg/m3	meters (m)
zeu	Euphotic zone depth; see Lam et al., 2011 (doi: 10.1029/2010gb003868) for details	meters (m)
cruiseID	Cruise ID (cruise number if available; if not, a unique numeric cruiseID was created based on year and month of cruise)	unitless
station	Station ID as reported in original reference	unitless
depth	Depth of pump sample	meters (m)
lt53POCumolkg	1-53um POC concentration	micromoles per kilogram (umol/kg)
gt53POCumolkg	>53um POC concentration	micromoles per kilogram (umol/kg)
lt53PICumolkg	1-53um PIC concentration	micromoles per kilogram (umol/kg)
gt53PICumolkg	>53um PIC concentration	micromoles per kilogram (umol/kg)
lt53bSiumolkg	0.4-53um bSi concentration	micromoles per kilogram (umol/kg)
gt53bSiumolkg	>53um bSi concentration	micromoles per kilogram (umol/kg)
References	Numbers to full references with more information about the samples. See Supplemental File "884057_References.pdf" for a list of the full citations.	unitless

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Instruments

Dataset-specific Instrument Name	Multiple Unit Large Volume In-situ Filtration System (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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Project Information

U.S. JGOFS Equatorial Pacific (EqPac)

Website: http://usjgofs.whoi.edu/research/eqpac.html

Coverage: Equatorial Pacific

The U.S. EqPac process study consisted of repeat meridional sections (12°N -12°S) across the equator in the central and eastern equatorial Pacific from 95°W to 170°W during 1992. The major scientific program was focused at 140° W consisting of two meridional surveys, two equatorial surveys, and a benthic survey aboard the R/V Thomas Thompson. Long-term deployments of current meter and sediment trap arrays augmented the survey cruises. NOAA conducted boreal spring and fall sections east and west of 140°W from the R/V Baldridge and R/V Discoverer. Meteorological and sea surface observations were obtained from NOAA's in place TOGA-TAO buoy network.

The scientific objectives of this study were to determine the fluxes of carbon and related elements, and the processes controlling these fluxes between the Equatorial Pacific euphotic zone and the atmosphere and deep ocean. A broad overview of the program at the 140°W site is given by Murray et al. (Oceanography, 5: 134-142, 1992). A full description of the Equatorial Pacific Process Study, including the international context and the scientific results, appears in a series of Deep-Sea Research Part II special volumes:

Topical Studies in Oceanography, A U.S. JGOFS Process Study in the Equatorial Pacific (1995), Deep-Sea Research Part II, Volume 42, No. 2/3.

Topical Studies in Oceanography, A U.S. JGOFS Process Study in the Equatorial Pacific. Part 2 (1996), Deep-Sea Research Part II, Volume 43, No. 4/6.

Topical Studies in Oceanography, A U.S. JGOFS Process Study in the Equatorial Pacific (1997), Deep-Sea Research Part II, Volume 44, No. 9/10.

Topical Studies in Oceanography, The Equatorial Pacific JGOFS Synthesis (2002), Deep-Sea Research Part II, Volume 49, Nos. 13/14.

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

U.S. Joint Global Ocean Flux Study (U.S. JGOFS)

Website: http://usjgofs.whoi.edu/

Coverage: Global

The United States Joint Global Ocean Flux Study was a national component of international JGOFS and an integral part of global climate change research.

The U.S. launched the Joint Global Ocean Flux Study (JGOFS) in the late 1980s to study the ocean carbon cycle. An ambitious goal was set to understand the controls on the concentrations and fluxes of carbon and associated nutrients in the ocean. A new field of ocean biogeochemistry emerged with an emphasis on quality measurements of carbon system parameters and interdisciplinary field studies of the biological, chemical and physical process which control the ocean carbon cycle. As we studied ocean biogeochemistry, we learned that our simple views of carbon uptake and transport were severely limited, and a new "wave" of ocean science was born. U.S. JGOFS has been supported primarily by the U.S. National Science Foundation in collaboration with the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Department of Energy and the Office of Naval Research. U.S. JGOFS, ended in 2005 with the conclusion of the Synthesis and Modeling Project (SMP).

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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