DOP concentration observations from the global ocean between 1990 and 2021 (DOP N2 fixation and export production project)

Website: https://www.bco-dmo.org/dataset/855139
Data Type: Cruise Results
Version: 4
Version Date: 2023-08-15

Project
» Collaborative Research: Dissolved organic phosphorus controls on marine nitrogen fixation and export production (DOP N2 fixation and export production)

Contributors	Affiliation	Role
Knapp, Angela N.	Florida State University (FSU - EOAS)	Principal Investigator
Letscher, Robert T.	University of New Hampshire (UNH)	Co-Principal Investigator
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Abstract
DOP (Dissolved Organic Phosphorus) concentration observations in the global ocean between 1990 and 2021 over multiple deployments. DOP concentrations in this study were calculated as the difference between TDP concentrations and SRP concentrations of samples. For DOP concentrations reported here, TDP concentrations were measured by the ash/hydrolysis method based on Monaghan and Ruttenberg, 1999.

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Coverage

Spatial Extent: **N**:58.9995 **E**:179.922 **S**:-66.5003 **W**:-180
Temporal Extent: 2004-10-28 - 2021-03-05

Dataset Description

DOP (Dissolved Organic Phosphorus) concentration observations in the global ocean between 1990 and 2021.

Methods & Sampling

Sampling and analytical procedures:

For samples in this study, Whatman glass-fiber filters (GF/F) with a nominal 0.7 µm pore size were used to filter

samples collected on the P18-2016 and GOA2013 cruises. Polycarbonate filters with a nominal 0.4 µm pore size were used to filter samples collected on the CoFeMUG and WebbPacific2007 cruises. Polyesthersulfone (PES) filters with a nominal 0.2 µm pore size were used to filter samples collected from SCALE, SWINGS, P06-2017, ETSP2010, ETSP2011 and GOM2019 cruises. All samples were stored in high density polyethylene bottles at -20 ˚C until measuring total dissolved phosphorus (TDP) concentration.

DOP (Dissolved Organic Phosphorus) concentrations in this study were calculated as the difference between TDP concentrations ([TDP]) and SRP concentrations ([SRP]) of samples ([DOP] = [TDP] - [SRP]). For DOP concentrations reported here, TDP concentrations were measured by the ash/hydrolysis method based on Monaghan and Ruttenberg, 1999. Briefly, for samples collected >1 year prior to analysis, the sample pH was reduced to 1 by adding ~150 µL 6 M ACS-grade HCl to the sample bottle and placing the bottle in a reciprocal shaker overnight. Then, 6 ml of the acidified sample was added to an acid washed, 500 ˚C combusted glass vial, and 0.6 ml of 4.3 M NaCl/0.3 M MgSO4 solution was added to the acidified sample. Subsequently, vials were put into a drying oven at 70 ˚C until appearing dry (often 4-5 days). Then, each vial was covered with aluminum foil and transferred to a muffle oven to bake at 130 ˚C for 3 hours and then at 500 ˚C for 4.5 hours. Afterwards, 1.8 mL 0.75 M ACS-grade HCl was added to each vial and capped tightly with Teflon-lined caps, then heated at 80 ˚C for 20 min to hydrolyze the polyphosphate left after ashing. After heating, 4.2 mL ultra-pure water (18.2 MΩ_ cm) was added to each vial and heated at 80 ˚C for 10 min to dissolved all remaining solids. I assume quantitative conversion of DOP to SRP and the resulting SRP concentration was measured by using the colorimetric phosphomolybdate-blue method (Hansen and Koroleff, 1999). The final DOP concentration was calculated by the difference between SRP concentration and TDP concentration ([DOP] = [TDP] - [SRP]).

TDP concentrations collected from the published literature were measured by three methods: ash/hydrolysis, UV oxidation, and wet oxidation. The ash/hydrolysis method was also used on samples from the Pulse-26, STN F, KT00A, B, KT01Eq, EN391 and SJ0609 cruises. Wet oxidation is a chemical oxidation where a persulfate reagent is added to seawater and then heated to 120 ˚C for 30 minutes to convert DOP to SRP (Hansen and Koroleff, 1999). Wet oxidation methods were employed to determine TDP concentrations on cruises including BIOSOPE, OUTPACE, KH-11-10, KH-12-3, KH-13-7, KH-14-3, KH-17-4, SATL2004, KM0415, Line P and Latitude II cruises, and at the BATS site. UV oxidation is a photochemical oxidation method using UV radiation to covert DOP to SRP (Armstrong et al., 1966). UV oxidation methods were used to measure the TDP concentrations on cruises including AMT 10, AMT 12, AMT 14, AMT 15, AMT 16, D279, 36N, Line P, GB 93, MAB 94, MAB 96, Cavender-Barres cruises, and at Station ALOHA

Data Processing Description

Processing notes from researchers:

Any reported negative DOP concentration (DOP concentrations <0 µM) is marked as “BDL”(below detection limits) in this dataset. A quality flag is added to the DOP concentration by using WOCE Water Sample Quality Codes. In this dataset, DOP concentrations with “BDL” are flagged with code 3 (“questionable measurements”) and other DOP concentrations are flagged with code 2 (“acceptable measurement”).

Version 2 dataset updates:

Data quality flag column added

The PO4 column has been renamed to SRP (soluble reactive phosphorus) to improve accuracy

Version 3 dataset updates:

Metadata (e.g. sampling date, Salinity, Temperature, NO3+NO2 and SRP) have been added for the cruise Gulf of Alaska 2013, AMT10, AMT12, AMT14, AMT15, AMT17, KH-11-10, KH-12-3, KH-13-7, KH-14-3, KH-17-4, OC279, OC297, OC318, and OC325.

Version 4 dataset updates:

Dr. Kaycie Lanpher shared DOP concentration observations from the GO-SHIP P06-2017 cruise based on the published article (Lanpher & Popendorf, 2021) with the Contact Zhou Liang, and these DOP concentration observations were added into the DOPv2021 dataset with their authorization.

BCO-DMO Processing Description

Fields renamed to conform with BCO-DMO standard data practices

Date format converted to yyyy-mm-dd from mm/dd/yy

Removed commas from the reference field

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Data Files

File
dopv2021v4-1.csv (Comma Separated Values (.csv), 1.11 MB) MD5:35ec0b3ba7be8fd5d7ec2bbf4d90daab Primary data file for dataset: DOPv2021 (855139)

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Supplemental Files

File
Adenosine triphosphate concentration testing results filename: ATPconcentration.csv (Comma Separated Values (.csv), 557 bytes) MD5:0896d81c54f00012535b7ba5e5ef5b01 Adenosine triphosphate (ATP) with known concentrations (0.5 to 2 µM) was prepared at the same time as the seawater samples with the same analytical procedure to determine its concentration.
Glyphosate concentration testing results filename: GLYconcentration.csv (Comma Separated Values (.csv), 618 bytes) MD5:86f5bc895f4119bf7b7291e4f0b19e4a Glyphosate (GLY) with known concentrations (0.5 to 2 µM) was prepared at the same time as the seawater samples with the same analytical procedure to determine its concentration.
Gulf of Mexico TDP surface seawater concentration testing results filename: GOMconcentration.csv (Comma Separated Values (.csv), 448 bytes) MD5:867ede6c562f471160c729c34f86d3af We used Gulf of Mexico (GOM) surface seawater as an internal TDP lab standard and GOM surface seawater was prepared as the same as the seawater samples with the same analytical procedures to determine its concentration.
Results from re-analysis of TDP concentrations filename: TDPreproducibility.csv (Comma Separated Values (.csv), 939 bytes) MD5:c236b2f7d8c56aa4918e9bd71e7f7a7f Selected samples with a range of SRP concentrations and re-analyzed their TDP concentrations five months after the original analysis of their TDP concentrations
Supplemental data file descriptions filename: Supplementalfiledescription.pdf (Portable Document Format (.pdf), 114.86 KB) MD5:424ef3d3ac4a77d949b2c0b1e19081e7 A single pdf containing descriptions and parameter details related to data quality files attached to this metadata landing page.
Ultra-pure water TDP concentration testing results filename: waterconcentration.csv (Comma Separated Values (.csv), 649 bytes) MD5:37f0dfbc3f4a9d6b50d77f833c3811d1 Ultra-pure water (18.2 MΩ*cm) was prepared at the same time as the seawater samples with the same analytical procedures to determine its TDP concentration.

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Related Publications

ARMSTRONG, F. A. J., WILLIAMS, P. M., & STRICKLAND, J. D. H. (1966). Photo-oxidation of Organic Matter in Sea Water by Ultra-violet Radiation, Analytical and Other Applications. Nature, 211(5048), 481–483. doi:10.1038/211481a0
Methods

Hansen, H. P., & Koroleff, F. (n.d.). Determination of nutrients. Methods of Seawater Analysis, 159–228. doi:10.1002/9783527613984.ch10
Methods

Lanpher, K. B., & Popendorf, K. J. (2021). Variability of Microbial Particulate ATP Concentrations in Subeuphotic Microbes Due to Underlying Metabolic Strategies in the South Pacific Ocean. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.655898
Methods

Monaghan, E. J., & Ruttenberg, K. C. (1999). Dissolved organic phosphorus in the coastal ocean: Reassessment of available methods and seasonal phosphorus profiles from the Eel River Shelf. Limnology and Oceanography, 44(7), 1702–1714. doi:10.4319/lo.1999.44.7.1702
Methods

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Parameters

Parameter	Description	Units
EXPOCODE	expedition code	unitless
cruise	sampling cruise	unitless
date	sampling date (UTC); YYYY-MM-DD	unitless
StationID	sampling station	unitless
BottleID	sampling bottle	unitless
LATITUDE	latitude	decimal degrees
LONGITUDE	longitude	decimal degrees
depth	sampling depth	meters (m)
Temperature	temperature	degrees Celsius
Salinity	salinity	psu
NO3_plus_NO2	nitrate + nitrite concentration	uM
SRP	soluble reactive phosphorus concentration	uM
DOP	DOP concentration	uM
DOP_flag	WOCE bottle quality codes; 2: acceptable measurement; 3: questionable measurement	unitless
region	sampling ocean basin	unitless
method	methods employed to measure DOP concentration	unitless
reference	data source	unitless

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Instruments

Dataset-specific Instrument Name	CTD/Niskin Rosette bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

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Deployments

KN192-05

Website	https://www.bco-dmo.org/deployment/57852
Platform	R/V Knorr
Report	http://bcodata.whoi.edu/CoFeMUG/CruiseReport_KN192-5.pdf
Start Date	2007-11-16
End Date	2007-12-13
Description	The South Atlantic subtropical gyre and Benguela Upwelling region were sampled for chemistry and biological properties relating to the trace metal nutrition and phytoplankton diversity and productivity. Specifically cobalt and iron dissolved seawater concentrations will be measured and related to the abundance of cyanobacteria including nitrogen fixers and eukaryotic phytoplankton. The phytoplankton of the Benguela Upwelling region were also examined to determine if their growth was iron or cobalt limited. A total of 27 station locations were occupied in the study area to collect the water chemistry and biological samples for these analyses (see cruise track). Iron and cobalt analyses will be conducted using inductively coupled plasma mass spectrometry and cathodic stripping voltammetry electrochemical methods. The sample preparation and subsequent analyses are technically demanding, but data generated from the cruise samples are being contributed beginning in mid 2009. The CoFeMUG KN192-5 cruise was supported by NSF OCE award # 0452883http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0452883 A station map showing the 27 sampling locations is available as a PDF file. Original cruise data are available from the NSF R2R data catalog CoFeMUG - South Atlantic 2007 Cruise Participant List 1. Mak Saito (Chief Scientist/WHOI) 2. Abigail Noble (Saito/WHOI) 3. Alysia Cox (Saito/WHOI) 4. Whitney Krey (Delong/Saito/MIT/WHOI) 5. Carl Lamborg (clamborg AT whoi.edu/WHOI) 6. Phoebe Lam (pjlam AT whoi.edu WHOI) 7. Chad Hammerschmidt (chammerschmidt AT whoi.edu, Wright State) 8. Caitlin Frame (cframe AT whoi.edu, WHOI/Casciotti Student) 9. Tyler Goepfert (tgoepfert AT whoi.edu Webb/Saito) 10. Jill Sohm (sohm AT usc.edu) 11. Maria Intermaggio 12. Jack DiTullio (leep AT cofc.edu U. Charleston) 13. Peter Lee (DiTullio U. Charleston) 14. Sarah Riseman (DiTullio U. Charleston) 15. Amanda McLenan (amanda.mclennon AT gmail.com, DiTullio U. Charleston) 16. Mike Seracki (Bigelow) 17. Nicole Poulton (Bigelow) 18. Juan Alba, juanalba AT usp.br (Bigelow) 19. Jane Heywood (Bigelow) 20. Gabrielle Rocap (rocap AT whoi.edu, U. Washington) 21. Emily Nahas (enahas AT u.washington.edu) 22. Michele Wrable (mlw22 AT u.washington.edu) 23. Bob Morris (rmorris AT lifesci.ucsb.edu) 24. Christian Frazar (Chris, U. Washington, Morris lab) 25. Jason Hilton (Zehr, UCSC) 26. Reserved for Angolan Observers 27. Reserved for Angolan Observers Collecting GEOTRACES-compliant samples for: 1. Laura Robinson (Pa Th isotopes) 2. Bob Anderson (Pa Th isotopes - intercalibration) 3. Olivier Rouxel (Se and Fe isotopes) 4. Karen Casciotti (N isotopes) 5. Ben Reynolds (Si and Fe isotopes) 6. Chris Measures (Al) 7. Kristin Buck (FeL)

KM0701

Website	https://www.bco-dmo.org/deployment/58165
Platform	R/V Kilo Moana
Report	http://bcodata.whoi.edu/WP2/wp2_cruise_report.pdf
Start Date	2007-01-03
End Date	2007-02-12
Description	A cruise aboard the R/V Kilo-Moana from Hawaii to Brisbane, Australia through the stratified WPWP during January – February 2007. For additional information on KILO MOANA data/data formats see: Formats_of_data_2007.pdf Cruise information and original data are available from the NSF R2R data catalog.

MV1104

Website	https://www.bco-dmo.org/deployment/555585
Platform	R/V Melville
Start Date	2011-03-23
End Date	2011-04-23
Description	See more information at R2R: https://www.rvdata.us/search/cruise/MV1104

AT15-61

Website	https://www.bco-dmo.org/deployment/58785
Platform	R/V Atlantis
Start Date	2010-01-29
End Date	2010-03-03
Description	See more information at R2R: https://www.rvdata.us/search/cruise/AT15-61

MV1310

Website	https://www.bco-dmo.org/deployment/526876
Platform	R/V Melville
Report	http://dmoserv3.whoi.edu/data_docs/NorthPacific_RDOC/MV1310_Preliminary_Report_2.pdf
Start Date	2013-08-04
End Date	2013-08-23
Description	Original data are available from the NSF R2R data catalog

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Project Information

Collaborative Research: Dissolved organic phosphorus controls on marine nitrogen fixation and export production (DOP N2 fixation and export production)

Coverage: Global scope (see Description box for details)

This study was global in nature, but included significant numbers of analyses from: GO-SHIP cruises (P06-2017, P18-2016, I08S-2016, I09N-2016); Eastern Tropical South Pacific; Atlantic, Pacific, and Indian Ocean sectors of the Southern Ocean; Gulf of Alaska; and the western Pacific.

NSF Award Abstract:
Phytoplankton play an important role in the Earth's elemental cycles of carbon and nitrogen. In addition to sunlight, phytoplankton living in the surface waters of the oceans require the elements nitrogen and phosphorus for growth. Much of these nutrients are supplied in their inorganic forms from mixing of deep waters towards the surface during the winter months when vertical stability of the water column breaks down. However much of the low latitude oceans, 45degS45degN, suffer from limited nutrient input to sunlit surface waters due to strong thermal stratification (vertical stability) of the upper water column. As a consequence, tropical and subtropical phytoplankton have devised alternative ways of acquiring nitrogen and phosphorus. Marine nitrogen fixation is a process by which specialized microbes utilize the abundant nitrogen gas from the atmosphere to convert elemental nitrogen into the bioavailable form ammonia. These nitrogen fixing phytoplankton and many others also use organic forms of phosphorus in the low latitude ocean where inorganic nutrients are often scarce. This project will significantly increase the number of dissolved organic nitrogen and dissolved organic phosphorus concentration measurements, especially from the currently under-

sampled Pacific and Indian Oceans. Changes in the concentration of organic nutrients across the surface ocean will be used to infer rates of organic nutrient use by phytoplankton in numerical models. Specifically, the role for the biological uptake of dissolved organic phosphorus to stimulate the processes of marine nitrogen fixation and photosynthesis in the low latitude ocean will be quantified from the combined data and model output. The project will train one graduate student and several undergraduate students in both laboratory chemical analysis techniques and numerical simulation of ocean biological and chemical processes. New scientific knowledge will be shared with the public via a social media campaign and will inform the development of the next generation of global climate models.

The marine biogeochemical modeling community has identified the lack of dissolved organic nitrogen (DON) and especially dissolved organic phosphorus (DOP) concentration measurements from the upper 300 m of the global ocean as crucial gaps in our ability to accurately model export production and N2 fixation rates in the subtropics. The proposed work will significantly increase global data coverage of marine DON and DOP concentration measurements, in particular from under-sampled ocean regions in the Indian Ocean, western, central, and eastern tropical South Pacific, Gulf of Alaska, eastern subtropical and subpolar South Pacific, Southern Ocean, subtropical North Atlantic, and tropical South Atlantic Ocean basins. These new measurements will be assimilated in state-of-the-art biogeochemical models to constrain the relative cycling rates of DOP and DON and to quantify the role of preferential DOP consumption as a P source supporting export production and N2 fixation in the low latitude ocean. Model output will solve for the regionally-resolved fraction of new production that accumulates as DON and DOP, autotrophic DOP uptake rates, as well as the remineralization rates for DON and DOP. The model output will also include the first regionally variable rate estimates of euphotic zone DOP consumption sustaining export production and N2 fixation to be constrained by observations from the Pacific and Indian Oceans. Thus, the new concentration measurements and diagnostic modeling will allow us to evaluate the quantitative role for regional variability in DOP consumption and recycling that supports export production and N2 fixation in the low latitude ocean.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1829797
NSF Division of Ocean Sciences (NSF OCE)	OCE-1829916

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