An atlas of depth-gridded and density-gridded interpolated and un-interpolated oxygen deficient zones (ODZs) in the Eastern tropical and subtropical Pacific Ocean

Website: https://www.bco-dmo.org/dataset/865316
Data Type: Other Field Results
Version: 1
Version Date: 2021-11-30

Project
» Solving Microbial Mysteries with Autonomous Technology (Microbial Mysteries)
» EAGER: Testing the Galápagos as a long-term monitoring site for nitrous oxide emissions from the Pacific oxygen deficient zones (ETP ODZ mapping)
» A microbe's perspective on the marine nitrogen budget (Microbe Perspective)

Contributors	Affiliation	Role
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Abstract
This dataset is made up of four NetCDF files, comprising an atlas of depth-gridded and density-gridded interpolated and un-interpolated Pacific oxygen deficient zones.

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Coverage

Spatial Extent: **N**:57 **E**:-65.5 **S**:-70.5 **W**:-180

Dataset Description

This dataset includes four NetCDF files, nc_density.nc, nc_density_DIVA.nc, nc_depth.nc, and nc_depth_DIVA.nc. A description of the data files is attached as a Supplemental File.

Acquisition Description

Data from Clark-style electrode and optode sensors from CTD and Argo deployments were compiled for the eastern tropical North and South Pacific oxygen deficient zones. Data were compiled from all cruises

that uploaded their data to R2R or CCHDO before April 2019, and all Argo profiles with O2 measurements from January 2000 to August 2021. The Argo data were downloaded via the Argo data selection tool at https://dataselection.euro-argo.eu/. We included both delayed-mode and real-time adjusted profiles for which there was oxygen, temperature, and salinity data. Only measurements that were flagged as good quality were downloaded.

The specific depths of functional anoxia were defined as the locations where the derivative of oxygen with respect to depth and the concentration itself were sufficiently low. The data were then gridded with respect to depth (pressure) at 20 dbar intervals or density at 0.1 kg/m3 intervals, and either interpolated with DIVA (version 4.7.2) or not. For full methods, please see the relevant manuscript written by Kwiecinski and Babbin.

Primary depth data were gridded on a 0.5º x 0.5º x 20 dbar grid.
Primary density data were gridded on a 0.5º x 0.5º x 0.1 kg/m^3 (sigma-theta) grid.

The non-interpolated data span the rectangles bounded at the NW and SE by (57N, -65.5E) and (-70.5N, -180E). The interpolated (DIVA) data NW and SE bounds are (37N, -70.5E) and (-32N, -156.5E). Grids cells that are in the Atlantic, on land, or beyond the minimum and maximum latitudes and longitudes of the oxygen deficient zones are marked with NaN.

Processing Description

Data were processed using R version 4.0.0.

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Data Files

File	Version
nc_density.nc (NetCDF, 28.53 MB) MD5:c85024897d6472cfa668b450f483434d *Description: Atlas of density-gridded, un-interpolated Pacific oxygen deficient zones from data compilation. Primary data were gridded on a 0.5º x 0.5º x 0.1 kg/m^3 (sigma-theta) grid.* *NetCDF header information:* *netcdf nc_density {* *dimensions:* *Latitude = 256 ;* *Longitude = 230 ;* *Sigma\ Theta = 25 ;* *variables:* *double Latitude(Latitude) ;* *Latitude:units = "degrees" ;* *Latitude:long_name = "Latitude" ;* *double Longitude(Longitude) ;* *Longitude:units = "degrees" ;* *Longitude:long_name = "Longitude" ;* *double Sigma\ Theta(Sigma\ Theta) ;* *Sigma\ Theta:units = "kg/m^3" ;* *Sigma\ Theta:long_name = "Sigma Theta" ;* *float fODZ(Sigma\ Theta, Longitude, Latitude) ;* *float O2(Sigma\ Theta, Longitude, Latitude) ;* *O2:units = "umol/kg" ;* *float deriv(Sigma\ Theta, Longitude, Latitude) ;* *deriv:units = "umol/(kg*dbar)" ;* *float IR(Sigma\ Theta, Longitude, Latitude) ;* *float topDensity(Longitude, Latitude) ;* *topDensity:units = "kg/m^3" ;* *float maxDerivDensity(Longitude, Latitude) ;* *maxDerivDensity:units = "kg/m^3" ;* *float numObs(Sigma\ Theta, Longitude, Latitude) ;* *}* *Variable descriptions:* *Name,Description,Units* *deriv,vertical derivative of O2 with depth,umol/kg / dbar* *fODZ,fraction of observations identified as ODZ,[fraction 0-1]* *IR,intrusion rate of O2 into ODZ,[fraction 0-1]* *Latitude,spatial variable for latitude,degrees* *Longitude,spatial variable for longitude,degrees* *maxDerivDensity,density of maximum vertical O2 derivative,kg/m^3* *numObs,number of observations in a grid cell,[unitless]* *O2,oxygen concentration from literature,umol/kg* *Sigma_Theta,spatial variable for density (sigT units),kg/m^3* *topDensity,density of top of ODZ,kg/m^3*	1

File	Version
nc_density_DIVA.nc (NetCDF, 4.31 MB) MD5:6554864818ff65232a355439b6c4ef38 *Description: Atlas of density-gridded, interpolated Pacific oxygen deficient zones from data compilation. Primary data were gridded on a 0.5º x 0.5º x 0.1 kg/m^3 (sigma-theta) grid.* *NetCDF header information:* *netcdf nc_density_DIVA {* *dimensions:* *Longitude = 173 ;* *Latitude = 139 ;* *Density = 22 ;* *variables:* *double Longitude(Longitude) ;* *Longitude:units = "degrees" ;* *Longitude:long_name = "Longitude" ;* *double Latitude(Latitude) ;* *Latitude:units = "degrees" ;* *Latitude:long_name = "Latitude" ;* *double Density(Density) ;* *Density:units = "kg/m^3" ;* *Density:long_name = "Density" ;* *float fODZ(Density, Latitude, Longitude) ;* *float fODZError(Density, Latitude, Longitude) ;* *float topDensity(Latitude, Longitude) ;* *topDensity:units = "kg/m^3" ;* *float botDensity(Latitude, Longitude) ;* *botDensity:units = "kg/m^3" ;* *float MaxfODZ(Latitude, Longitude) ;* *}* *Variable descriptions:* *Name,Description,Units* *botDensity,density of bottom of ODZ,kg/m^3* *Density,spatial variable for density (sigT units),kg/m^3* *fODZ,fraction of observations identified as ODZ,[fraction 0-1]* *fODZError,reported DIVA error in fODZ interpolation,[fraction 0-1]* *Latitude,spatial variable for latitude,degrees* *Longitude,spatial variable for longitude,degrees* *MaxfODZ,maximum fODZ for each grid cell,[fraction 0-1]* *topDensity,density of top of ODZ,kg/m^3*	1

File	Version
nc_depth.nc (NetCDF, 56.83 MB) MD5:d0afb623a8d1146f8815cdeb9fbfb797 *Description: Atlas of depth-gridded, un-interpolated Pacific oxygen deficient zones from data compilation. Primary data were gridded on a 0.5º x 0.5º x 20 m grid.* *NetCDF header information:* *netcdf nc_depth {* *dimensions:* *Latitude = 256 ;* *Longitude = 230 ;* *Depth = 50 ;* *variables:* *double Latitude(Latitude) ;* *Latitude:units = "degrees" ;* *Latitude:long_name = "Latitude" ;* *double Longitude(Longitude) ;* *Longitude:units = "degrees" ;* *Longitude:long_name = "Longitude" ;* *double Depth(Depth) ;* *Depth:units = "dbar" ;* *Depth:long_name = "Depth" ;* *float fODZ(Depth, Longitude, Latitude) ;* *float O2(Depth, Longitude, Latitude) ;* *O2:units = "umol/kg" ;* *float deriv(Depth, Longitude, Latitude) ;* *deriv:units = "umol/(kg*dbar)" ;* *float IR(Depth, Longitude, Latitude) ;* *float topDepth(Longitude, Latitude) ;* *topDepth:units = "dbar" ;* *float maxDerivDepth(Longitude, Latitude) ;* *maxDerivDepth:units = "dbar" ;* *float thickness(Longitude, Latitude) ;* *thickness:units = "dbar" ;* *float numObs(Depth, Longitude, Latitude) ;* *}* *Variable descriptions:* *Name,Description,Units* *Depth,spatial variable for depth,dbar* *deriv,vertical derivative of O2 with depth,umol/kg / dbar* *fODZ,fraction of observations identified as ODZ,[fraction 0-1]* *IR,intrusion rate of O2 into ODZ,[fraction 0-1]* *Latitude,spatial variable for latitude,degrees* *Longitude,spatial variable for longitude,degrees* *maxDerivDepth,depth of maximum vertical O2 derivative,dbar* *numObs,number of observations in a grid cell,[unitless]* *O2,oxygen concentration from literature,umol/kg* *thickness,thickness of ODZ,dbar* *topDepth,depth of top of ODZ,dbar*	1

File	Version
nc_depth_DIVA.nc (NetCDF, 9.36 MB) MD5:9ebd4443727a61ec589f54f18f16ff7e *Description: Atlas of depth-gridded, interpolated Pacific oxygen deficient zones from data compilation. Primary data were gridded on a 0.5º x 0.5º x 20 m grid.* *NetCDF header information:* *netcdf nc_depth_DIVA {* *dimensions:* *Longitude = 173 ;* *Latitude = 139 ;* *Depth = 49 ;* *variables:* *double Longitude(Longitude) ;* *Longitude:units = "degrees" ;* *Longitude:long_name = "Longitude" ;* *double Latitude(Latitude) ;* *Latitude:units = "degrees" ;* *Latitude:long_name = "Latitude" ;* *double Depth(Depth) ;* *Depth:units = "dbar" ;* *Depth:long_name = "Depth" ;* *float fODZ(Depth, Latitude, Longitude) ;* *float fODZError(Depth, Latitude, Longitude) ;* *float topDepth(Latitude, Longitude) ;* *topDepth:units = "dbar" ;* *float botDepth(Latitude, Longitude) ;* *botDepth:units = "dbar" ;* *float thickness(Latitude, Longitude) ;* *thickness:units = "dbar" ;* *float maxFODZ(Latitude, Longitude) ;* *}* *Variable descriptions:* *botDepth,depth of bottom of ODZ,dbar* *Depth,spatial variable for depth,dbar* *fODZ,fraction of observations identified as ODZ,[fraction 0-1]* *fODZError,reported DIVA error in fODZ interpolation,[fraction 0-1]* *Latitude,spatial variable for latitude,degrees* *Longitude,spatial variable for longitude,degrees* *maxFODZ,maximum fODZ for each grid cell,[fraction 0-1]* *thickness,thickness of ODZ,dbar* *topDepth,depth of top of ODZ,dbar*	1

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Supplemental Files

File
ODZ_data_file_descriptions.txt filename: Babbin_ODZ_data_file_descriptions.txt (Octet Stream, 6.24 KB) MD5:e36adf7644e7d4c7f3a5f5dcf693cb68 *Description of the four NetCDF files associated with dataset 865316 (PI: Andrew Babbin)*

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Related Publications

GHER-Diva, Troupin, C., Watelet, S., Jmbeckers, & Barth, A. (2018). Gher-Ulg/Diva: V4.7.2. Zenodo. https://doi.org/10.5281/ZENODO.1407062 https://doi.org/10.5281/zenodo.1407062
Software

Kwiecinski and Babbin (in review). A high-resolution atlas of the eastern tropical Pacific oxygen deficient zones, Global Biogeochemical Cycles.
Results

R Core Team (2020). R: A language and environment for statistical computing. R v4.0.0. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
Software

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Solving Microbial Mysteries with Autonomous Technology (Microbial Mysteries)

Website: https://schmidtocean.org/cruise/solving_microbial_mysteries_with_autonomous_technology/

Coverage: Eastern Tropical North Pacific Ocean

Phytoplankton form the base of the marine food web. These microscopic, single-celled organisms float in seawater, taking in carbon dioxide and using light energy to make carbohydrates. Like land plants, phytoplankton need other elements and compounds (fertilizer) to perform photosynthesis in order to survive and thrive: Nitrogen is one of these key ingredients for phytoplankton growth.

Nitrogen is fascinating and somewhat unique because it cycles through many oxygenation states. This means that there is plenty of energy for organisms to harness and the nitrogen cycle can be used as a lens to understand microbial communities. The quantity of “fixed nitrogen” in the ocean, usually nitrate (NO3–) and ammonium (NH4+), is critical for the existence and development of phytoplankton, and plays a role in the biological carbon pump sequestering carbon dioxide from the atmosphere.

Being able to recognize the role of fixed nitrogen in ocean processes is important for understanding low-oxygen areas in the world’s oceans. Insight into microbial interactions in oxygen deficient waters will allow researchers to better predict the marine response to increased nutrient runoff, eutrophication, and hypoxia – all of which currently threaten the livelihoods of many coastal communities as a warming climate leads to the expansion of low oxygen “dead” zones.

Data Management Plan: The resulting shipboard dataset is being archived at Rolling Deck to Repository and is now available. ADCP data is curated and processed by University of Hawaii.Iodine Speciation measurements are archived in BCO-DMO

EAGER: Testing the Galápagos as a long-term monitoring site for nitrous oxide emissions from the Pacific oxygen deficient zones (ETP ODZ mapping)

Coverage: Eastern tropical and subtropical Pacific Ocean

NSF Award Abstract:

Nitrous oxide is a potent greenhouse gas and agent of ozone destruction. Atmospheric concentrations are rising, but the role of natural marine sources is poorly understood due to a lack of data. High rates of oceanic production are localized to remote areas, impeding direct data acquisition from oxygen minimum zones especially. Correct attribution of sources is key to interpreting observations, establishing mitigation policies, and predicting future climate feedbacks. The investigators aim to quantify marine nitrous oxide fluxes through a continuous monitoring site in the eastern Pacific that can identify hotspots and mechanisms of production. Such a station will permit the ocean's role in this greenhouse gas budget to be refined and its variability across space and time to be assessed. The data will be publicly accessible and maintained at a bilingual web portal in English and Spanish. The work will further educate and train a graduate student in oceanic and climate sciences and help establish an early career investigator.

The project will establish an atmospheric chemistry monitoring station at the Galapagos Science Center in Ecuador to continuously measure nitrous oxide and carbon monoxide. The measurements will be linked specifically to ocean outgassing via atmospheric inversion modeling. This new methodology complements sea-going research, permitting the assessment of emissions across the entire eastern tropical Pacific Ocean region from a single well-sited monitoring station. The investigators will specifically deploy a cavity ring-down laser spectrometer onsite, maintain the instrument, and analyze the continuous data. By the end of this initial 2-year study, a multi-year record of primary atmospheric concentrations of nitrous oxide will be established and tied to emissions from specific ocean sources. The researchers will map the data via inversion modeling, paying particular attention to cross-shelf variability and any roles of sub-mesoscale eddies in modifying the rate of nitrous oxide loss from the ocean. Carbon monoxide will be utilized as a diagnostic molecule for terrestrial influence on nitrous oxide. Overall, this project will elucidate the emissions from a critical yet under-sampled production region and reduce the level of uncertainty in data products and modeled syntheses. These measurements will aid in interpreting global observations, ground-truth current and future sampling campaigns, and improve forecasting of climate scenarios into the future.

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.

This award is funded in whole or in part under the American Rescue Plan Act of 2021 (Public Law 117-2).

A microbe's perspective on the marine nitrogen budget (Microbe Perspective)

During this project, PI Andrew Babbin will be investigating the availability of fixed nitrogen, predominantly in the forms of ammonium and nitrate. This fixed nitrogen limits primary production across much of the global oceans. The standing stock of this bioavailable pool is in turn regulated by the balance of marine microorganisms producing ammonium from dinitrogen gas (diazotrophy) and reforming dinitrogen from nitrate and nitrite (denitrification). Strikingly, the specific factors regulating the rates and efficiency of nitrogen transformation processes remain poorly constrained.

The research group will work to unravel the complexities of the microbial nitrogen cycle to better understand the mechanisms by which these climatically critical bacteria reshape the chemical environment for themselves and for all marine organisms. The laboratory system utilizes exquisitely controlled chemical and microbial compositions, seeding microbes into novel droplet-based microfluidic incubators. By integrating both environmental isolates and genetically modified mutants, the Babbin team will systematically determine the range of conditions under which each nitrogen metabolic transformation can occur. Complementary chemostat experiments will extend the parameters extracted from the droplet-based batch cultures to real-world climate simulations and metabolic models. This approach to empirically and theoretically constrain the kinetic and thermodynamic characteristics of each nitrogen transformation step will enable a mechanistic framework of community nitrogen metabolism and species interactions. Through these targeted experiments and analyses, we will connect metabolic activities at the micro-scale to global nitrogen biogeochemistry.

[Project description excerpted from: https://eapsweb.mit.edu/news/2019/microbes-perspective-marine-nitrogen-budget]

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Funding

Funding Source	Award
Schmidt Ocean Institute (SOI)	No Award Number
Simons Foundation (Simons)	622065

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