Mixed-layer averaged O2 and optically-based POC from Profiling Floats in the North Pacific from R/V Kilo Moana from June to September 2017

Website: https://www.bco-dmo.org/dataset/808903
Data Type: Cruise Results
Version: 0
Version Date: 2020-04-10

Project
» Collaborative Research: Measuring Ocean Productivity from the Diurnal Change in Oxygen and Carbon (ProdChangeO2Carb)

Contributors	Affiliation	Role
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Abstract
Time series of Winkler calibrated mixed-layer averaged O2 concentrations obtained from repeated float profiles. The cruise (KM1713) transited from Seward, AK to Honolulu, HI from 3-26 September 2017 onboard the R/V Kilo Moana. Six extended stations (Stn), three in subpolar waters (Stn 1 at 55°N, Stn 2 at 50°N, and Stn 3 at 46°N), one in the transition zone between subpolar and subtropical waters (Stn 4 at 42°N), and two in the subtropical gyre (Stn 5 at 34°N, and Stn 6 at 24°N) were occupied for 2-3 day periods during which continuous measurements of conductivity, temperature, O2, O2/Ar and beam attenuation were measured continuously on surface seawater supplied via the ships' intake line and using CTD profiles of conductivity, temperature, pressure, oxygen, and the particulate beam attenuation coefficient conducted at ~2-hr intervals. An autonomous profiling float was deployed for ~ 2 days at four stations, retrieving CTD and oxygen profiles at approximately 3-hour intervals. Another float with same mission design was deployed near station ALOHA (22.45° N, 158° W) during July 2017 to provide mixed-layer averaged O2 near station 6. When available, the ship followed the trajectory of the profiling float, yielding a near-Lagrangian sampling strategy with the aim to minimize horizontal mixing effects.

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Coverage

Spatial Extent: **N**:49.976 **E**:-144.968 **S**:22.609 **W**:-160.072
Temporal Extent: 2017-06-23 - 2017-09-22

Dataset Description

The cruise (KM1713) transited from Seward, AK to Honolulu, HI from 3-26 September 2017 onboard the R/V Kilo Moana. Six extended stations (Stn), three in subpolar waters (Stn 1 at 55°N, Stn 2 at 50°N, and Stn 3 at 46°N), one in the transition zone between subpolar and subtropical waters (Stn 4 at 42°N), and two in the subtropical gyre (Stn 5 at 34°N, and Stn 6 at 24°N) were occupied for 2-3 day periods during which continuous measurements of conductivity, temperature, O2, O2/Ar and beam attenuation were measured continuously on surface seawater supplied via the ships' intake line and using CTD profiles of conductivity, temperature, pressure, oxygen, and the particulate beam attenuation coefficient conducted at ~2-hr intervals. An autonomous profiling float was deployed for ~ 2 days at four stations, retrieving CTD and oxygen profiles at approximately 3-hour intervals. Another float with same mission design was deployed near station ALOHA (22.45° N, 158° W) during July 2017 to provide mixed-layer averaged O2 near station 6. When available, the ship followed the trajectory of the profiling float, yielding a near-Lagrangian sampling strategy with the aim to minimize horizontal mixing effects.

Methods & Sampling

Mixed-layer averaged O2 and optically-based POC from Profiling Floats

A profiling float (#12592; APEX, Webb Research Inc., Falmouth, USA) equipped with an oxygen optode sensor (Model 4330, Aanderaa Data Instruments, Bergen, Norway) as well as a SBE-41 CTD instrument (Sea-Bird Electronics Inc., Bellevue/WA, USA) was deployed at stations 2, 3, 4, and 5 for ~2 days. The profiling float was recovered by small boat operations at the end of each station. The mission was programmed to allow float to surface every 3 hours and profile from 200 m depth to surface (i.e. 8 profiles per day). At each surfacing event, the optode collected measurements in air to allow post-calibration.

Raw float oxygen optode data were corrected for pressure and salinity following Uchida et al. [2008] and Garcia and Gordon [1992], as outlined in the Aanderaa manual. Float optode oxygen data were calibrated using optode air measurements taken at the time of each float surfacing following methods described in Bushinsky et al. [2016]. Briefly, air calibration relies on the estimate of a gain factor G, such that $O_{2\_corrected} = G \times O_{2\_raw}$. In practice, G is an average gain factor for each float profile determined from the ratio of the expected partial pressure of oxygen in air (pO_2) to the partial pressure of oxygen in air measured by the optode (pO_{2_optode}), i.e. $g_i = pO_2/pO_{2\_optode}$. Optode air measurements were first filtered to remove outliers (e.g. measurements taken underwater or with high variance), and mean values per surfacing were recorded. pO_{2_optode} was calculated from optode phase and temperature as in the Aanderaa Manual. Atmospheric pO_2 was calculated as in Bushinsky et al. [2016] using float-derived water vapor pressure estimates (pH_20) at the time of each float surfacing (Aanderaa Manual) as well as the 6-h NOAA NCEP atmospheric pressure and surface relative humidity data interpolated to the time and location of each float surfacing (https://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.surface.html). An average G value of 1.24 was then calculated based on the g_i estimates from each surfacing at each station, and applied to all optode profiles. Float mixed-layer depth was calculated using the 0.125 kg m^{-3} potential density change threshold relative to 10 m depth.

Float mixed-layer averaged gain-corrected O_2 concentrations were further calibrated by multiplying mean Winkler concentrations per station to float percent deviation estimates at each station (Eq. 1). Similar procedures were applied to optode data from an identical profiling float (#12593) with same mission design deployed near station ALOHA (22.45° N, 158° W) on June 29 2017 and recovered at the end of the cruise near station 6. Exceptions included that only air calibrations were carried since no simultaneous Winkler measurements were available. Importantly, the large number of daily profiles and relative shallow depths reached by the float led to obvious biofouling of the oxygen sensor after ~ 30 days at sea. Thus, only data from the month of July 2017 are made available.

Data Processing Description

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- added ISO Date format generated from date and time values

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Parameters

Parameter	Description	Units
year	year of observation	unitless
decimal_day_of_year	decimal day of the year in UTC	unitless
ISO_DateTime_UTC	Date and time formatted according to ISO8601 in UTC	yyyy-MM-dd'T'HH:mm:ss'Z'
lon	longitude with negative values indicating West	decimal degrees
lat	latitude with positive values indicating North	decimal degrees
sta	station number	unitless
float_number	float number	unitless
MLD	Mixed Layer Depth	meters (m)
salinity	mixed-layer averaged salinity	psu
temp	mixed-layer averaged temperature	degrees Celsius (C)

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Instruments

Dataset-specific Instrument Name	oxygen optode sensor (Model 4330, Aanderaa Data Instruments, Bergen, Norway)
Generic Instrument Name	Aanderaa Oxygen Optodes
Dataset-specific Description	APEX Profiling Floats: #12592 and # 12593 (APEX, Webb Research Inc., Falmouth, USA) equipped with an oxygen optode sensor (Model 4330, Aanderaa Data Instruments, Bergen, Norway).
Generic Instrument Description	Aanderaa Oxygen Optodes are instrument for monitoring oxygen in the environment. For instrument information see the Aanderaa Oxygen Optodes Product Brochure.

Dataset-specific Instrument Name	SBE-41 CTD
Generic Instrument Name	CTD Sea-Bird 41
Dataset-specific Description	APEX Profiling Floats: #12592 and # 12593 (APEX, Webb Research Inc., Falmouth, USA) equipped with a SBE-41 CTD instrument (Sea-Bird Electronics Inc., Bellevue/WA, USA)
Generic Instrument Description	The Sea-Bird SBE 41 CTD module was originally developed in 1997 for integration with sub-surface oceanographic floats. It uses MicroCAT Temperature, Conductivity, and Pressure sensors.

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Deployments

KM1713

Website	https://www.bco-dmo.org/deployment/808683
Platform	R/V Kilo Moana
Start Date	2017-09-01
End Date	2017-09-26

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Project Information

Collaborative Research: Measuring Ocean Productivity from the Diurnal Change in Oxygen and Carbon (ProdChangeO2Carb)

Coverage: North Pacific Ocean, from ~ 22 N to ~ 55 N, surface and mixed-layer

NSF Award Abstract:

The rate of primary production in the ocean is fundamental to the ocean's food web and the movement of carbon from surface waters to the deep ocean, known as the biological pump. Yet spatial and temporal variations in primary productivity are poorly known because the effort required for the current method of measuring primary productivity is significant, limiting its application, and the method has biases that are difficult to quantify. Using a novel combination of approaches, the investigators will estimate daily primary productivity in the ocean at three ecologically distinct sites. The research will significantly improve understanding of primary productivity variations and their impact on the ocean's biological pump, which will benefit the broader ocean community involved in carbon cycle modeling and benefit society via the impact of ocean primary productivity on atmospheric carbon dioxide uptake and future climate change. The research results will be incorporated into both undergraduate and graduate course curricula and outreach talks at the two institutions. There will be active undergraduate student participation in the project at both Oregon State University and the University of Washington.

Within the last decade, an in-situ primary productivity method based on measuring the isotopic composition of dissolved oxygen (O2) gas has gained traction within the oceanographic community because it yields a primary production estimate from a simple water sample collection. This method has yielded basin-wide snapshots of primary productivity based on underway sampling of the surface ocean by ships of opportunity. However, accurate estimates of oxygen/particulate organic carbon (O2/POC) produced during primary productivity are needed to convert oxygen-based primary production rates to carbon production. In this project, daily in-situ rates of primary production in the surface ocean at three ocean sites will be estimated from continuous measurements of diurnal cycles in the oxygen/argon dissolved gas ratio and POC and compared to simultaneous in vitro primary productivity estimates. Variations in the O2/POC produced during primary production will be determined. Autonomous float-based estimates of primary production based on measurements of diurnal cycles in O2 and POC will be validated using ship based measurements. Estimates of primary production based on autonomous measurements resulting from this research have the potential to revolutionize our knowledge on the spatial and temporal variations in primary productivity in the ocean.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1849012
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536121

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