Underway/continuous measurements of O2, O2/Ar and optically-based POC in the North Pacific from 2017-09-05 to 2017-09-27

Website: https://www.bco-dmo.org/dataset/808834
Data Type: Cruise Results
Version: 0
Version Date: 2020-04-09

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

Contributors	Affiliation	Role
White, Angelicque E.	Oregon State University (OSU)	Principal Investigator
Quay, Paul	University of Washington (UW)	Co-Principal Investigator
Biddle, Mathew	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Time series of Winkler calibrated continuous (from uncontaminated seawater intake line located at ~7m depth) dissolved oxygen (Aandera optode), O2/Ar (EIMS) and O2/Ar* (O2/Ar normalized by variations in N2/Ar). The O2/Ar* time series should be the most reliable one since it corrects for additional bubble injections. Data are binned hourly. Time series of continuous (from uncontaminated seawater intake line located at ~7m depth) particulate beam-attenuation coefficients (cp) calibrated to particulate organic carbon (POC) concentrations. Data are binned hourly. 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**:55 **E**:-145 **S**:24 **W**:-160
Temporal Extent: 2017-09-05 - 2017-09-27

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

Underway/continuous measurements of O2, O2/Ar and optically-based POC

Continuous measurements of surface O2, O2/Ar, POC, and beam attenuation coefficients used seawater supplied from an uncontaminated seawater intake line located at ~7m depth. All continuous measurements were binned into hourly averages at each station. Continuous measurements of dissolved O2 concentration using an Optode (Aanderaa) and the dissolved O2/Ar gas ratios using an equilibrator inlet mass spectrometer (EIMS) system [Cassar et al., 2009] were obtained at each station. Dissolved oxygen data (Optode) were corrected for pressure and salinity following Uchida et al. [2008]. O2/Ar measured by the EIMS were calibrated to O2/Ar measurements by mass spectrometer on discrete water samples collected in the mixed layer during the cruise (n=58). Saturated O2 concentrations and O2/Ar values were calculated using the solubility equations of García and Gordon [1992] for O2 and Hamme and Emerson [2004] for Ar. Diurnal changes in O2/Ar data measured by the EIMS instrument were corrected for fluctuations in total gas pressure based on concurrent changes in N2/Ar, yielding O2/Ar*, (i.e., % deviation in O2/Ar* = % deviation O2/Ar – a*% deviation N2/Ar, where 'a' represents a calibration factor between N2/Ar and O2/Ar deviations determined at each station). Diurnal changes in O2 were determined by multiplying the relative deviation from the mean O2 measured by the Optode by the mean surface Winkler O2 concentration measured at each station (Eq. 1), where i refers to each datapoint in time, and overbars denotes the mean values while on each station. The diurnal changes in O2/Ar and O2/Ar* were calibrated to Winkler concentrations using the same procedure.

Continuous measurements of the beam attenuation coefficient (660 nm) were obtained with a C-Star instrument (Sea-Bird Scientific). A debubbler and a valve control device were used to divert water to a 0.2 µm membrane filter for the first 10 minutes of every hour to provide background estimates of beam attenuation due to water and dissolved substances [Slade et al., 2010]. These blank values were linearly interpolated throughout the cruise and subtracted from the raw measurements to provide particulate beam attenuation coefficient (cp, m-1).

Discrete water samples (collected on combusted GF/F filters with filter blank corrections following the Hawaiian Ocean Time Series (HOT) protocols, http://hahana.soest.hawaii.edu/hot/methods/pcpn.html) were collected from the ship's uncontaminated seawater system to determine particulate organic carbon (POC) concentrations every ~2.5 hours (n=107 in total) using a semi-automated filtration device [based on the design of Holser et al., 2011]. Underway POC were scaled to mean near-surface (<10 m) samples collected at each station (n=12; r2=0.92) and these corrected values were then used to convert cp measurements to POC using Eq. 2, where is the mean in situ POC measured at each station.

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
- combined POC and O2 continuous data

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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
beam_attenuation_coeff_POC	continuous surface particulate beam attenuation coefficient calibrated to particulate organic carbon concentrations (POC)	miligrams Carbon per meter cubed (mg C/m3)
O2_Ar	continuous surface Winkler-calibrated O2/Ar (mmol/m3)	millimole per meter cubed (mmol/m3)
O2	continutous surface Winkler-calibrated O2 (from Optode)	millimole per meter cubed (mmol/m3)
MLD	Mixed Layer Depth	meters (m)
O2_Ar_norm_N2_Ar	continuous surface Winkler-calibrated O2/Ar normalized by N2/Ar (O2/Ar*; see manuscript)	millimole per meter cubed (mmol/m3)

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Instruments

Dataset-specific Instrument Name	Optode (Aanderaa Data Instruments, Bergen, Norway)
Generic Instrument Name	Aanderaa Oxygen Optodes
Dataset-specific Description	Dissolved oxygen: Optode (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	inlet mass spectrometer system (EIMS)
Generic Instrument Name	Equilibrator Inlet Mass Spectrometer
Dataset-specific Description	O2/Ar ratio: inlet mass spectrometer system (EIMS)
Generic Instrument Description	Cassar N, Barnett BA, Bender ML, Kaiser J, Hamme RC, Tilbrook B., Continuous high-frequency dissolved O2/Ar measurements by equilibrator inlet mass spectrometry. Anal Chem. 2009 Mar 1;81(5):1855-64. doi: 10.1021/ac802300u. Source: Department of Geosciences, Princeton University, Princeton, New Jersey 08544, USA. ncassar@princeton.edu Abstract The oxygen (O(2)) concentration in the surface ocean is influenced by biological and physical processes. With concurrent measurements of argon (Ar), which has similar solubility properties as oxygen, we can remove the physical contribution to O(2) supersaturation and determine the biological oxygen supersaturation. Biological O(2) supersaturation in the surface ocean reflects the net metabolic balance between photosynthesis and respiration, i.e., the net community productivity (NCP). We present a new method for continuous shipboard measurements of O(2)/Ar by equilibrator inlet mass spectrometry (EIMS). From these measurements and an appropriate gas exchange parametrization, NCP can be estimated at high spatial and temporal resolution. In the EIMS configuration, seawater from the ship's continuous intake flows through a cartridge enclosing a gas-permeable microporous membrane contactor. Gases in the headspace of the cartridge equilibrate with dissolved gases in the flowing seawater. A fused-silica capillary continuously samples headspace gases, and the O(2)/Ar ratio is measured by mass spectrometry. The ion current measurements on the mass spectrometer reflect the partial pressures of dissolved gases in the water flowing through the equilibrator. Calibration of the O(2)/Ar ion current ratio (32/40) is performed automatically every 2 h by sampling ambient air through a second capillary. A conceptual model demonstrates that the ratio of gases reaching the mass spectrometer is dependent on several parameters, such as the differences in molecular diffusivities and solubilities of the gases. Laboratory experiments and field observations performed by EIMS are discussed. We also present preliminary evidence that other gas measurements, such as N(2)/Ar and pCO(2) measurements, may potentially be performed with EIMS. Finally, we compare the characteristics of the EIMS with the previously described membrane inlet mass spectrometry (MIMS) approach. PMID: 19193192 [PubMed - indexed for MEDLINE]

Dataset-specific Instrument Name	C-Star, Sea-Bird Scientific
Generic Instrument Name	WET Labs {Sea-Bird WETLabs} C-Star transmissometer
Dataset-specific Description	Beam attenuation at 660 nm: (C-Star, Sea-Bird Scientific).
Generic Instrument Description	The C-Star transmissometer has a novel monolithic housing with a highly intgrated opto-electronic design to provide a low cost, compact solution for underwater measurements of beam transmittance. The C-Star is capable of free space measurements or flow-through sampling when used with a pump and optical flow tubes. The sensor can be used in profiling, moored, or underway applications. Available with a 6000 m depth rating. More information on Sea-Bird website: https://www.seabird.com/c-star-transmissometer/product?id=60762467717

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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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