

Biogeochemical inventories in the upper water column of the Pacific sector of the coastal Antarctic as measured on the Amundsen Sea Polynya International Research Expedition (ASPIRE) during December 2010 to January 2011

Website: <https://www.bco-dmo.org/dataset/1001499>

Data Type: Cruise Results

Version: 1

Version Date: 2026-06-23

Project

» [Amundsen Sea Polynya International Research Expedition](#) (ASPIRE)

Contributors	Affiliation	Role
Yager, Patricia Lynn	University of Georgia (UGA)	Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract

Polynyas, or recurring areas of seasonally open water surrounded by sea ice, are foci for energy and material transfer between the atmosphere and the polar ocean. They are also climate sensitive, with both sea ice extent and glacial melt influencing their productivity. The Amundsen Sea Polynya (ASP) is the greenest polynya in the Southern Ocean, with summertime chlorophyll a concentrations exceeding 20 micrograms per liter. During the Amundsen Sea Polynya International Research Expedition (ASPIRE) in the austral summer of 2010–11, we aimed to determine the fate of this high algal productivity. We collected water column profiles for total dissolved inorganic carbon (DIC) and nutrients, particulate and dissolved organic matter, chlorophyll a, mesozooplankton, and microbial biomass to make a carbon budget for this ecosystem. We also measured primary and secondary production, and community respiration rates. These data were reported as contour plots in Figures 5 through 10 of Yager et al. 2016 (doi: 10.12952/journal.elementa.000140).

Table of Contents

- [Coverage](#)
- [Dataset Description](#)
 - [Methods & Sampling](#)
 - [BCO-DMO Processing Description](#)
 - [Problem Description](#)
- [Data Files](#)
- [Related Publications](#)
- [Parameters](#)
- [Instruments](#)
- [Deployments](#)
- [Project Information](#)
- [Funding](#)

Coverage

Location: Pacific sector of coastal Antarctic

Spatial Extent: N:-71.86 E:-112 S:-73.96 W:-118.32

Temporal Extent: 2010-12-15 - 2011-01-08

Methods & Sampling

Water sampling:

Hydrographic profiles and discrete water samples were collected from each station using a conventional shipboard conductivity temperature-depth (CTD; Sea-Bird 911+) sensor and a 24 × 10 liter (L) Niskin bottle rosette sampler (General Oceanics). Potential temperature (θ) and salinity (S) were recorded continuously as a

function of depth and at the moment of Niskin bottle closure. A few samples (particulate phosphate) reported here were collected similarly using a trace-metal-clean CTD-rosette system (see Sherrell et al., 2015) that was deployed at the same location and depths just before or after the conventional CTD.

Water samples were collected and processed according to standard protocols (Knap et al., 1996; Dickson et al., 2007) for dissolved inorganic carbon (DIC), alkalinity (ALK), nutrients, chlorophyll a (Chl a), particulate and dissolved organic carbon (POC, DOC), particulate and total dissolved nitrogen (PN, TDN), and particulate phosphorus (PP; Planquette and Sherrell, 2012; Planquette et al. 2013). Samples from the same depths and stations were also collected for microbial biomass and activity (see below; Williams et al., 2016). This dataset focuses on samples collected from the upper 100 meters (m) of the water column. Seafloor depths in the area ranged from 300 to 1300 m (Nitsche et al., 2007), although the 13 stations included here were all deeper than 400 m.

Inorganic nutrients, inorganic carbon, and organic matter analysis:

Dissolved inorganic nutrient samples were pre-filtered through 0.45-micrometer (μm) polycarbonate syringe filters, kept refrigerated, and analyzed onboard the ship within 1 day of sampling. Nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+), phosphate (HPO_4^{2-}), and silicic acid ($\text{Si}(\text{OH})_4$) were measured using a five-channel Lachat Instruments QuikChem FIA+ 8000s series autoanalyzer in conjunction with a Lachat Instruments XYZ AutoSampler (ASX-500 Series), two Lachat Instruments RP-100 Series peristaltic Reagent Pumps, and Omnion Software, version 3.0.220.02. The nitrate + nitrite analysis uses the basic method of Armstrong et al. (1967), with minor improvements for greater precision and easier operation. Nitrate was first reduced to nitrite using a cadmium reduction column and imidazole buffer as described by Patton (1982). Sulfanilamide and N-(1-Naphthyl) ethylenediamine dihydrochloride react with nitrite to form a colored diazo compound. Nitrite analysis was performed on a separate channel, omitting the cadmium reductant. Ammonium was determined using the indophenol blue method modified from ALPKEM RFA methodology (EPA, 1984). Total dissolved inorganic nitrogen (DIN) was calculated by summing $\text{NO}_3^- + \text{NO}_2^- + \text{NH}_4^+$. The phosphate method was a modification of the molybdenum blue procedure of Bernhardt and Wilhelms (1967), in which phosphate was determined as reduced phosphomolybdic acid employing hydrazine as the reductant. The silicic acid method was based on Armstrong et al. (1967), as adapted by Atlas et al. (1971). Addition of an acidic molybdate reagent forms silicomolybdic acid, which was then reduced by stannous chloride. Detection limits ($\text{NO}_3^- + \text{NO}_2^- = 0.075$ micromoles per liter ($\mu\text{mol/L}$); $\text{NO}_2^- = 0.009 \mu\text{mol/L}$; $\text{NH}_4^+ = 0.040 \mu\text{mol/L}$; $\text{HPO}_4^{2-} = 0.022 \mu\text{mol/L}$; and $\text{Si}(\text{OH})_4 = 1.90 \mu\text{mol/L}$) and precision ($\text{NO}_3^- + \text{NO}_2^- = \pm 0.0076 \mu\text{mol/L}$; $\text{NO}_2^- = \pm 0.0009 \mu\text{mol/L}$; $\text{NH}_4^+ = \pm 0.0041 \mu\text{mol/L}$; $\text{HPO}_4^{2-} = \pm 0.0023 \mu\text{mol/L}$; and $\text{Si}(\text{OH})_4 = \pm 0.193 \mu\text{mol/L}$) were determined using multiple runs of standards prepared in low nutrient seawater. Samples with negative values following calibration using standard curves were converted to zeros.

Samples for DIC were preserved with mercuric chloride and sealed (Dickson et al., 2007), and then stored cool and dark until analysis using the SOMMA at UGA (Johnson et al., 1993; Cooley and Yager, 2006). Accuracy was confirmed with Certified Reference Material from University of California, San Diego (CRM; Dickson et al., 2003) and precision was determined to be better than ± 1 micromoles per kilogram ($\mu\text{mol/kg}$) using duplicate samples from surface and 200 m depths. Alkalinity measurements were made on the same samples (following DIC analysis) using a programmable open-cell potentiometric titration system (Dickson et al., 2003; Cooley and Yager, 2006). Accuracy was established by acid-calibration using multiple daily runs of CRM. Precision was determined to be $\pm 5 \mu\text{mol/kg}$ using replicate samples run on multiple days.

Samples for particulate organic carbon (POC) and nitrogen (PN) were collected by cleanly filtering 100–600 milliliters (mL) of seawater onto a 25-millimeter (mm) diameter, combusted GF/F filter (nominal pore size of $0.7 \mu\text{m}$) which was then folded sample side in and frozen at -80 degrees Celsius ($^{\circ}\text{C}$). Samples were processed at Rutgers University and analyzed using a Carlo-Erba CHN analyzer (Hedges and Stern, 1984). Precision, based on replicate filtered volumes from the same Niskin bottle, was $\pm 5\%$ for most samples, but was occasionally higher. Samples for particulate phosphate (PP) were collected separately from the same depths and locations as part of a trace metal suite and analyzed separately using a Thermo-Finnigan Element I HR-ICP-MS (Sherrell et al., 2015; Planquette and Sherrell, 2012; Planquette et al., 2013). Precision was $\pm 5\%$.

Samples for DOC and TDN were collected cleanly from the filtrate of the POC/PN samples and stored frozen until processed at the Georgia Institute of Technology by Shimadzu TOC-5000 analyzer with an associated TNM-1 Total Nitrogen Measuring Unit. Precision was $\pm 4\%$. Residual dissolved organic nitrogen (DON) was calculated by subtracting DIN from TDN. This approach involves taking the difference between two relatively large numbers, thus precision of relatively small DON concentrations is strongly affected by the precision of the DIN and TDN analyses.

Organismal abundance and biomass analysis:

Water column Chl a concentration (used as a proxy for algal biomass) was measured onboard ship using acetone extraction and a spectrofluorometer (Alderkamp et al., 2015). Shipboard values were calibrated

against a second set of samples collected similarly, flash-frozen in liquid N₂, stored at -80°C, and analyzed at Mote Marine Lab using HPLC (Wright et al., 1991; see Alderkamp et al., 2015). CHEMTAX (Mackey et al., 1996; Wright et al., 1996; 2010) was applied to determine the relative abundance of phytoplankton classes based on pigment analysis (see Alderkamp et al., 2015).

Bacterial abundance samples were collected in triplicate, preserved using 1% paraformaldehyde, and deep frozen (-80 °C) until they were counted at The University of Georgia with flow cytometry and SYBR Green I nucleic acid staining (Marie et al., 1997). Abundance was calibrated with polystyrene beads, and values were crosschecked using DAPI and epifluorescence microscopy (Porter and Feig, 1980). Abundance was converted to bacterial carbon (BAC) using a conversion factor (25 femtograms C per cell (fg C cell⁻¹); Simon and Azam, 1989). Precision was ± 3%.

Microzooplankton abundance and biovolume were determined at select depths and stations using microscopy (Goswami, 2004). Samples were gently siphoned through silicon tubes into 300 mL amber colored glass bottles, fixed in acidic Lugol's solution (2% final concentration), and kept cool and dark until analysis. Biovolume calculations followed the HELCOM (2014) manual on appropriate geometrical shapes when making length-width measurements for each individual species. Biovolumes were corrected for shrinkage due to preservation (vol × 1.33; Stoecker et al., 1994). Heterotrophic/mixotrophic microplankton cell volumes were converted to cell carbon (Menden-Deuer and Lessard, 2000) for loricate and aloricate ciliates (CIL), and dinoflagellates (DINO).

Heterotrophic nanoflagellates (HNAN) were counted by flow cytometry (Christaki et al., 2011). Each sample was stained with SYBR Green, at final concentration of 1:10000 and a minimum staining time of 10 minutes in the dark. The flow rate was ~250 microliters per minute (μL/min). Both green and red fluorescence were used to discriminate between autotrophs and heterotrophs. Data acquisition was 5–10 minutes depending on concentration of the sample (or depth). Samples with > 1200 events per second were diluted to allow a correct measurement. The detected abundance was checked against counts of DAPI filters. HNAN biomass was converted from abundance data assuming 3.5 cubic micrometer (μm³) per cell biovolume (Vaqué et al., 2002) and 220 femtograms C per cubic micrometer (fg C/μm³) (Børsheim and Bratbak, 1987).

Mesozooplankton biovolume and abundance were determined as described by Wilson et al. (2015) and converted to biomass (micromoles C per liter (μmol C/L)) for both daytime and nighttime tows using conversion factors from the literature (Gallienne et al., 2001; Forest et al., 2012; Trudnowska et al., 2014). The maximum value of day or night tows is reported here.

Biological rate measurements:

Phytoplankton net primary production (NPP) rates were determined for 6 light depths in the upper 100 m using standard ¹⁴C-bicarbonate incubations (Steeman-Nielsen, 1952; Knap et al., 1996) in on-deck incubators with light-filtering screens to match in situ light levels. Bacterial production (BP) rates were determined using ³H-leucine incorporation as described by Williams et al. (2016). Microbial community respiration (MCR) rates were determined for near-surface and subsurface depths by changes in CO₂ concentrations over 48 hours in dark incubations, as described in Williams et al. (2016).

BCO-DMO Processing Description

- Loaded original file "Yager_et_al_2016_ASPIRE_Carbon_Budget_Data.csv" into the BCO-DMO system.
- Treated "NaN" as a missing data value (missing data are empty/blank in the final CSV file).
- Renamed columns to comply with BCO-DMO naming conventions.
- Converted "Date" column from MM/DD/YY format to ISO 8601 date format (YYYY-MM-DD).
- Saved the final file as "1001499_v1_aspire_upper_water_column_inventories.csv".

Problem Description

Not all variables were measured at every station and depth. Missing data were indicated by NaN in the original data file and are blank/empty in the final CSV BCO-DMO data file.

[[table of contents](#) | [back to top](#)]

Data Files

File
1001499_v1_aspire_upper_water_column_inventories.csv (Comma Separated Values (.csv), 14.34 KB) MD5:010a87447389b23098230a2c32da2d45 Primary data file for dataset ID 1001499, version 1

[[table of contents](#) | [back to top](#)]

Related Publications

Alderkamp, A.-C., van Dijken, G. L., Lowry, K. E., Connelly, T. L., Lagerström, M., Sherrell, R. M., ... Arrigo, K. R. (2015). Fe availability drives phytoplankton photosynthesis rates during spring bloom in the Amundsen Sea Polynya, Antarctica. *Elementa: Science of the Anthropocene*, 3, 000043. doi:[10.12952/journal.elementa.000043](https://doi.org/10.12952/journal.elementa.000043)
Methods

Armstrong, F. A. J., Stearns, C. R., & Strickland, J. D. H. (1967). The measurement of upwelling and subsequent biological process by means of the Technicon Autoanalyzer® and associated equipment. *Deep Sea Research and Oceanographic Abstracts*, 14(3), 381-389. doi:[10.1016/0011-7471\(67\)90082-4](https://doi.org/10.1016/0011-7471(67)90082-4)
Methods

Atlas, E. L., Hager, S. W., Gordon, L. I., & Park, P. K. (1971). A practical manual for use of the Technicon Autoanalyzer in sea water nutrient analyses. Oregon State University, Department of Oceanography. Technical report.
Methods

Bernhardt, H., and A. Wilhelms. 1967. The continuous determination of low level iron, soluble phosphate and total phosphate with the AutoAnalyzer. *Technicon Symp.* 1:385-89.
Methods

Børshiem KY, Bratbak G. 1987. Cell volume to cell carbon conversion factors for bacterivorous *Monas* sp. enriched from seawater. *Mar Ecol-Prog Ser* 36: 171-175. <https://www.jstor.org/stable/24821984>
Methods

Christaki, U., Courties, C., Massana, R., Catala, P., Lebaron, P., Gasol, J. M., & Zubkov, M. V. (2011). Optimized routine flow cytometric enumeration of heterotrophic flagellates using SYBR Green I. *Limnology and Oceanography: Methods*, 9(8), 329-339. doi:[10.4319/lom.2011.9.329](https://doi.org/10.4319/lom.2011.9.329)
Methods

Cooley, S. R., & Yager, P. L. (2006). Physical and biological contributions to the western tropical North Atlantic Ocean carbon sink formed by the Amazon River plume. *Journal of Geophysical Research*, 111(C8). doi:[10.1029/2005JC002954](https://doi.org/10.1029/2005JC002954)
Methods

Dickson, A. G., Afghan, J. D., & Anderson, G. C. (2003). Reference materials for oceanic CO₂ analysis: a method for the certification of total alkalinity. *Marine Chemistry*, 80(2), 185-197. [https://doi.org/10.1016/S0304-4203\(02\)00133-0](https://doi.org/10.1016/S0304-4203(02)00133-0)
Methods

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices for ocean CO₂ measurements. PICES Special Publication 3, 191 pp. ISBN: 1-897176-07-4. URL: https://www.nodc.noaa.gov/ocads/oceans/Handbook_2007.html <https://hdl.handle.net/11329/249>
Methods

EPA (1984). *Methods for Chemical Analysis of Water and Wastes*, March 1984. EPA-600/4-79-020, "Nitrogen Ammonia", Method 350.1 (Colorimetric, Automated Phenate). <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30000Q10.TXT>
Methods

Forest, A., Stemann, L., Picheral, M., Burdorf, L., Robert, D., Fortier, L., & Babin, M. (2012). Size distribution of particles and zooplankton across the shelf-basin system in southeast Beaufort Sea: combined results from an Underwater Vision Profiler and vertical net tows. *Biogeosciences*, 9(4), 1301-1320. <https://doi.org/10.5194/bg-9-1301-2012>
Methods

Gallienne, C. P., Robins, D. B., & Woodd-Walker, R. S. (2001). Abundance, distribution and size structure of zooplankton along a 20° west meridional transect of the northeast Atlantic Ocean in July. *Deep Sea Research Part II: Topical Studies in Oceanography*, 48(4-5), 925-949. [https://doi.org/10.1016/S0967-0645\(00\)00114-4](https://doi.org/10.1016/S0967-0645(00)00114-4)

Methods

Goswami SC. 2004. Zooplankton methodology, collection & identification - A field manual. Dona Paula, Goa: National Institute of Oceanography: 26 pp. <https://drs.nio.res.in/drs/handle/2264/95>

Methods

HELCOM. (2014). HELCOM Monitoring Manual. Baltic Marine Environment Protection Commission (HELCOM). <https://helcom.fi/publications/manual-for-marine-monitoring-in-the-combine-programme-of-helcom/>

Methods

Hedges, J. I., & Stern, J. H. (1984). Carbon and nitrogen determinations of carbonate-containing solids1. *Limnology and Oceanography*, 29(3), 657–663. Portico. <https://doi.org/10.4319/lo.1984.29.3.0657>

Methods

Johnson, K. M., Wills, K. D., Butler, D. B., Johnson, W. K., & Wong, C. S. (1993). Coulometric total carbon dioxide analysis for marine studies: maximizing the performance of an automated gas extraction system and coulometric detector. *Marine Chemistry*, 44(2-4), 167–187. [https://doi.org/10.1016/0304-4203\(93\)90201-X](https://doi.org/10.1016/0304-4203(93)90201-X)

Methods

Knap, A. H., Michaels, A., Close, A. R., Ducklow, H., & Dickson, A. G. (1996). Protocols for the joint global ocean flux study (JGOFS) core measurements. <http://hdl.handle.net/10013/epic.27912>

Methods

Mackey, M., Mackey, D., Higgins, H., & Wright, S. (1996). CHEMTAX - a program for estimating class abundances from chemical markers: application to HPLC measurements of phytoplankton. *Marine Ecology Progress Series*, 144, 265–283. <https://doi.org/10.3354/meps144265>

Methods

Marie, D., Partensky, F., Jacquet, S., & Vaulot, D. (1997). Enumeration and Cell Cycle Analysis of Natural Populations of Marine Picoplankton by Flow Cytometry Using the Nucleic Acid Stain SYBR Green I. *Applied and Environmental Microbiology*, 63(1), 186–193. doi:[10.1128/aem.63.1.186-193.1997](https://doi.org/10.1128/aem.63.1.186-193.1997)

Methods

Menden-Deuer, S., & Lessard, E. J. (2000). Carbon to volume relationships for dinoflagellates, diatoms, and other protist plankton. *Limnology and Oceanography*, 45(3), 569–579. doi:[10.4319/lo.2000.45.3.0569](https://doi.org/10.4319/lo.2000.45.3.0569)

Methods

Nitsche, F. O., Jacobs, S. S., Larter, R. D., & Gohl, K. (2007). Bathymetry of the Amundsen Sea continental shelf: Implications for geology, oceanography, and glaciology. *Geochemistry, Geophysics, Geosystems*, 8(10). Portico. <https://doi.org/10.1029/2007gc001694>

Methods

Patton, Chas, J. (1982). *Design, characterization and applications of a miniature continuous flow analysis system* [Michigan State University]. <https://doi.org/10.25335/rmc2-tn72>

Methods

Planquette, H., & Sherrell, R. M. (2012). Sampling for particulate trace element determination using water sampling bottles: methodology and comparison to in situ pumps. *Limnology and Oceanography: Methods*, 10(5), 367–388. doi:[10.4319/lo.2012.10.367](https://doi.org/10.4319/lo.2012.10.367)

Methods

Planquette, H., Sherrell, R. M., Stammerjohn, S., & Field, M. P. (2013). Particulate iron delivery to the water column of the Amundsen Sea, Antarctica. *Marine Chemistry*, 153, 15–30.

<https://doi.org/10.1016/j.marchem.2013.04.006>

Methods

Porter, K. G., & Feig, Y. S. (1980). The use of DAPI for identifying and counting aquatic microflora. *Limnology and Oceanography*, 25(5), 943–948. doi:[10.4319/lo.1980.25.5.0943](https://doi.org/10.4319/lo.1980.25.5.0943)

Methods

Sherrell, R. M., Lagerström, M. E., Forsch, K. O., Stammerjohn, S. E., & Yager, P. L. (2015). Dynamics of dissolved iron and other bioactive trace metals (Mn, Ni, Cu, Zn) in the Amundsen Sea Polynya, Antarctica. *Elementa: Science of the Anthropocene*, 3, 000071. doi:[10.12952/journal.elementa.000071](https://doi.org/10.12952/journal.elementa.000071)

Methods

Simon, M., & Azam, F. (1989). Protein content and protein synthesis rates of planktonic marine bacteria. *Marine Ecology Progress Series*, 51, 201–213. doi:[10.3354/meps051201](https://doi.org/10.3354/meps051201)

Methods

Steeman-Nielsen E. (1952). The use of radioactive carbon (14C) for measuring organic production in the sea. *J*

Conseil 18: 117–140. <https://doi.org/10.1093/icesjms/18.2.117>
Methods

Stoecker DK, Gifford DJ, Putt M. 1994. Preservation of marine planktonic ciliates: losses and cell shrinkage during fixation. *Mar Ecol-Prog Ser* 110: 293–299. <https://www.jstor.org/stable/24847599>
Methods

Trudnowska, E., Basedow, S. L., & Blachowiak-Samolyk, K. (2014). Mid-summer mesozooplankton biomass, its size distribution, and estimated production within a glacial Arctic fjord (Hornsund, Svalbard). *Journal of Marine Systems*, 137, 55–66. <https://doi.org/10.1016/j.jmarsys.2014.04.010>
Methods

Vaqué, D., Guixa-Boixereu, N., Gasol, J. M., & Pedrós-Alió, C. (2002). Distribution of microbial biomass and importance of protists in regulating prokaryotic assemblages in three areas close to the Antarctic Peninsula in spring and summer 1995/96. *Deep Sea Research Part II: Topical Studies in Oceanography*, 49(4-5), 847–867. [https://doi.org/10.1016/S0967-0645\(01\)00127-8](https://doi.org/10.1016/S0967-0645(01)00127-8)
Methods

Williams, C. M., Dupont, A. M., Loevenich, J., Post, A. F., Dinasquet, J., & Yager, P. L. (2016). Pelagic microbial heterotrophy in response to a highly productive bloom of *Phaeocystis antarctica* in the Amundsen Sea Polynya, Antarctica. *Elementa: Science of the Anthropocene*, 4. <https://doi.org/10.12952/journal.elementa.000102>
Methods

Wilson, S. E., Swalethorp, R., Kjellerup, S., Wolverton, M. A., Ducklow, H. W., & Yager, P. L. (2015). Meso- and macro-zooplankton community structure of the Amundsen Sea Polynya, Antarctica (Summer 2010–2011). *Elementa: Science of the Anthropocene*, 3. <https://doi.org/10.12952/journal.elementa.000033>
Methods

Wright, S. W., van den Enden, R. L., Pearce, I., Davidson, A. T., Scott, F. J., & Westwood, K. J. (2010). Phytoplankton community structure and stocks in the Southern Ocean (30–80°E) determined by CHEMTAX analysis of HPLC pigment signatures. *Deep Sea Research Part II: Topical Studies in Oceanography*, 57(9-10), 758–778. <https://doi.org/10.1016/j.dsr2.2009.06.015>
Methods

Wright, S., Jeffrey, S., Mantoura, R., Llewellyn, C., Bjornland, T., Repeta, D., & Welschmeyer, N. (1991). Improved HPLC method for the analysis of chlorophylls and carotenoids from marine phytoplankton. *Marine Ecology Progress Series*, 77, 183–196. <https://doi.org/10.3354/meps077183>
Methods

Wright, S., Thomas, D., Marchant, H., Higgins, H., Mackey, M., & Mackey, D. (1996). Analysis of phytoplankton of the Australian sector of the Southern Ocean: comparisons of microscopy and size frequency data with interpretations of pigment HPLC data using the 'CHEMTAX' matrix factorisation program. *Marine Ecology Progress Series*, 144, 285–298. <https://doi.org/10.3354/meps144285>
Methods

Yager, P., Sherrell, R., Stammerjohn, S., Ducklow, H., Schofield, O., Ingall, E., ... van Dijken, G. (2016). A carbon budget for the Amundsen Sea Polynya, Antarctica: Estimating net community production and export in a highly productive polar ecosystem. *Elementa: Science of the Anthropocene*, 4, 000140. doi:[10.12952/journal.elementa.000140](https://doi.org/10.12952/journal.elementa.000140)
Results

[[table of contents](#) | [back to top](#)]

Parameters

Parameter	Description	Units
Station	Station number	unitless
Event	Event number	unitless
Cast	Cast number	unitless

Date	Date sampled	unitless
Year_Day	Year Day sampled	unitless
Lat	Latitude	decimal degrees
Lon	Longitude	decimal degrees
ASP_num	Unique Niskin bottle identifier	unitless
Depth	Water depth	meters (m)
Poten_Temp	Potential temperature	degrees C
Salinity	Practical salinity	unitless
DIC	Dissolved inorganic carbon	micromoles C per liter ($\mu\text{mol C per L}$)
DIN	Dissolved inorganic nitrogen	micromoles N per liter ($\mu\text{mol N per L}$)
DIP	Dissolved inorganic phosphorus	micromoles P per liter ($\mu\text{mol P per L}$)
POC	Particulate organic carbon	micromoles C per liter ($\mu\text{mol C per L}$)
PON	Particulate organic nitrogen	micromoles N per liter ($\mu\text{mol N per L}$)
Part_P	Particulate phosphate	micromoles P per liter ($\mu\text{mol P per L}$)
SiO4	Silicate	micromoles Si per liter ($\mu\text{mol Si per L}$)
DOC	Dissolved organic carbon	micromoles C per liter ($\mu\text{mol C per L}$)
DON	Dissolved organic nitrogen	micromoles N per liter ($\mu\text{mol N per L}$)
Chl_a	Chlorophyll a	micrograms chl a per liter ($\mu\text{g chl a per L}$)

Bacterial_biomass	Bacterial biomass	micromoles C per liter ($\mu\text{mol C per L}$)
Nanoflagellate_biomass	Nanoflagellate biomass	micromoles C per liter ($\mu\text{mol C per L}$)
Ciliate_biomass	Ciliate biomass	micromoles C per liter ($\mu\text{mol C per L}$)
Dinoflagellate_biomass	Dinoflagellate biomass	micromoles C per liter ($\mu\text{mol C per L}$)
Max_Macrozooplankton_biomass	Macrozooplankton biomass	micromoles C per liter ($\mu\text{mol C per L}$)
Primary_Production	Primary Production	micromoles C per liter per day ($\mu\text{mol C per L per day}$)
Community_Respiration	Community Respiration	micromoles C per liter per day ($\mu\text{mol C per L per day}$)
Bacterial_Production	Bacterial Production	micromoles C per liter per day ($\mu\text{mol C per L per day}$)

[[table of contents](#) | [back to top](#)]

Instruments

Dataset-specific Instrument Name	Carlo-Erba CHN analyzer
Generic Instrument Name	CHN Elemental Analyzer
Generic Instrument Description	A CHN Elemental Analyzer is used for the determination of carbon, hydrogen, and nitrogen content in organic and other types of materials, including solids, liquids, volatile, and viscous samples.

Dataset-specific Instrument Name	Sea-Bird 911+
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Generic Instrument Description	The Sea-Bird SBE 911 plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911 plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 plus and SBE 11 plus is called a SBE 911 plus. The SBE 9 plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 plus and SBE 4). The SBE 9 plus CTD can be configured with up to eight auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). more information from Sea-Bird Electronics

Dataset-specific Instrument Name	flow cytometry and SYBR Green I nucleic acid staining
Generic Instrument Name	Flow Cytometer
Generic Instrument Description	Flow cytometers (FC or FCM) are automated instruments that quantitate properties of single cells, one cell at a time. They can measure cell size, cell granularity, the amounts of cell components such as total DNA, newly synthesized DNA, gene expression as the amount messenger RNA for a particular gene, amounts of specific surface receptors, amounts of intracellular proteins, or transient signalling events in living cells. (from: http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm)

Dataset-specific Instrument Name	epifluorescence microscopy
Generic Instrument Name	Fluorescence Microscope
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of fluorescence and phosphorescence instead of, or in addition to, reflection and absorption of visible light. Includes conventional and inverted instruments.

Dataset-specific Instrument Name	On-deck incubators
Generic Instrument Name	In-situ incubator
Generic Instrument Description	A device on a ship or in the laboratory that holds water samples under controlled conditions of temperature and possibly illumination.

Dataset-specific Instrument Name	Lachat Instruments XYZ AutoSampler (ASX-500 Series)
Generic Instrument Name	Laboratory Autosampler
Generic Instrument Description	Laboratory apparatus that automatically introduces one or more samples with a predetermined volume or mass into an analytical instrument.

Dataset-specific Instrument Name	Lachat Instruments QuikChem FIA+ 8000s series autoanalyzer
Generic Instrument Name	Lachat QuikChem 8000 flow injection analyzer and Ion Chromatography (IC) system
Generic Instrument Description	The Lachat QuikChem 8000 can operate flow injection analysis and ion chromatography simultaneously and independently on the same instrument platform. Instrument includes sampler, dilutor, sampling pump, electronics unit, and data station. Analysis takes 20-60 seconds, with a sample throughput of 60-120 samples per hour. Measurements are in the range of parts per trillion to parts per hundred.

Dataset-specific Instrument Name	Niskin bottle rosette sampler (General Oceanics)
Generic Instrument Name	Niskin bottle
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.

Dataset-specific Instrument Name	Shimadzu TOC-5000 analyzer
Generic Instrument Name	Shimadzu TOC 5000A total organic carbon analyzer
Generic Instrument Description	The Shimadzu TOC-5000(A) Series instruments are capable of performing analysis on any high sensitivity applications such as pharmaceutical grade, semiconductor grade, steam power, and ultrapure waters, as well as less sensitive application such as drinking water and particulate analysis such as wastewater and industrial effluents, sea water, brines, ground water, and surface water. Shimadzu TOC-5000(A) Series instruments meet USP 23 (Fifth Supplement 643) for Pure Water (PW) and Water For Injection (WFI), Standard Methods 5310B, EPA 415.1, EPA 9060A, ASTM D2579, EPA Drinking Water ICR (D/DBP), and DIN Specifications

Dataset-specific Instrument Name	TNM-1 Total Nitrogen Measuring Unit
Generic Instrument Name	Shimadzu Total Nitrogen Monoxide 1
Generic Instrument Description	The TNM-1 is a chemiluminescence analyzer for measurement of total nitrogen. Measurements are in range 0 to 4000 mg/L, with accuracy of CV 3 percent (max) and a measurement time of 4 minutes

Dataset-specific Instrument Name	SOMMA
Generic Instrument Name	Single Operator Multi-parameter Metabolic Analyzer
Generic Instrument Description	Single Operator Multi-parameter Metabolic Analyzer (SOMMA) which was manufactured at the University of Rhode Island and standardized at the Brookhaven National Laboratory.

Dataset-specific Instrument Name	Spectrofluorometer
Generic Instrument Name	Spectrometer
Generic Instrument Description	A spectrometer is an optical instrument used to measure properties of light over a specific portion of the electromagnetic spectrum.

Dataset-specific Instrument Name	Thermo-Finnigan Element I HR-ICP-MS
Generic Instrument Name	Thermo Finnigan (Thermo Fisher Scientific) Element I inductively coupled plasma mass spectrometer
Generic Instrument Description	The Thermo Finnigan Element I is a double focusing, sector field inductively coupled plasma mass spectrometer. It uses a demountable Meinhard nebulizer for sample introduction and a magnetic sector as a mass filter. It has a scanning rate at full mass range of under 60 ms. Short term precision is 2 %. Its sensitivity is 20 Mcps/ppm at R=300 and 1 Mcps/ppm at R=3000, with a detection limit under 0.1 ng/L for In at R=300.

[[table of contents](#) | [back to top](#)]

Deployments

NBP1005

Website	https://www.bco-dmo.org/deployment/58154
Platform	RVIB Nathaniel B. Palmer
Start Date	2010-11-26
End Date	2011-01-16
Description	See more information in R2R: https://www.rvdata.us/search/cruise/NBP1005 Expedition by the USAP RV Nathaniel B. Palmer during austral summer 2010-11 to sampled the Amundsen Sea Polynya during the Amundsen Sea Polynya International Research Expedition (ASPIRE). Also identified as OSO 2010-11 (Oden Southern Ocean - two vessel operation 2010-11) The US Research Icebreaker Nathaniel B. Palmer was joined by the Swedish Icebreaker Oden for a two-vessel expedition to the Amundsen Sea. Scientists on the Palmer focused on understanding the climate-sensitive dynamics of the open water region, known as a "polynya." Oden scientists investigated the sea ice ecosystem nearby. The aim of both groups was to improve our understanding of how climate change will impact this important ecosystem. Note the following links take users to Marine Geoscience Data System (MGDS): NBP1005 NBP1005A Data at MGDS were available as NBP1005 and NBP1005A. The data are from the same expedition and are combined in BCO-DMO into the one deployment - NBP1005. Nathaniel B. Palmer Systems and Specifications

[[table of contents](#) | [back to top](#)]

Project Information

Amundsen Sea Polynya International Research Expedition (ASPIRE)

Website: <http://AntarcticASPIRE.org/>

Coverage: Amundsen Sea, South Pacific Sector of Antarctica, Southern Ocean 73 S 115 W

The Amundsen Sea Polynya is areally the most productive Antarctic polynya, exhibits higher chlorophyll levels during peak bloom and greater interannual variability than the better-studied Ross Sea Polynya ecosystem. Polynyas may be the key to understanding the future of polar regions as their extent is expected to increase with anthropogenic warming. The project will examine 1) sources of iron to the Amundsen Sea Polynya as a function of climate forcing, 2) phytoplankton community structure in relation to iron supply and mixed-layer depths, 3) the efficiency of the biological pump of carbon to depth and 4) the net flux of carbon as a function of climate and micronutrient forcing. The research also will compare results for the Amundsen Sea to existing

data synthesis and modeling efforts for the Palmer LTER and Ross Sea. The project will 1) build close scientific collaborations between US and Swedish researchers; 2) investigate climate change implications with broad societal relevance; 3) train new researchers; 4) encourage participation in research science by underrepresented groups, and 5) involve broad dissemination of results via scientific literature and public outreach, including close interactions with NSF-supported PolarTrec and COSEE K-12 teachers.

This project brings together experienced US and Swedish investigators (trace metal and carbon chemists, phytoplankton physiologists, microbial and zooplankton ecologists, and physical oceanographers) to investigate climate controls on carbon dioxide uptake by one of the most productive ecosystems in the Antarctic.

The Amundsen Sea Polynya is the most productive Antarctic polynya per square meter, and exhibits higher chlorophyll levels during peak bloom and greater interannual variability than the better-studied Ross Sea polynya ecosystem to the west.

Polynyas, or recurring areas of seasonally open water surrounded by ice, are foci for energy and material transfer between the atmosphere, polar surface ocean and deep sea. Most help take up large amounts of carbon dioxide from the atmosphere.

These polar ecosystems are characterized by high biological productivity and intense biogeochemical cycling - a bit like an oasis. Polynyas may be the key to understanding the future of polar regions since their extent is expected to increase with anthropogenic warming. On the other hand, if seasonal sea ice disappears completely, the unique nature of polynyas may also be lost.

Regional reductions or growth in sea-ice over the past decade have been extensive and are coupled to climate-sensitive global cycles such as ENSO and the Southern Annular Mode. Without many historical measurements, this regional and interannual variability is our best present-day indication for what controls or “forces” these critical polar ecosystems and their sensitivity to future change.

Variability in the productivity of Antarctic polynyas is high for reasons the science community do not currently understand. The supply of trace metals such as iron is thought to determine phytoplankton community structure and production in the Southern Ocean, particularly in conjunction with mixed-layer depth controls on light limitation. A key question is whether interannual variability is driven by these two climate-sensitive factors, and whether we can expect climate-sensitive shifts in ecosystem function and carbon flux in the future. Understanding critical feedbacks between climate and the marine biosphere becomes increasingly urgent as we project rates of change into the future.

[Special ASPIRE journal feature in ELEMENTA](#)

[[table of contents](#) | [back to top](#)]

Funding

Funding Source	Award
NSF Antarctic Sciences (NSF ANT)	ANT-0839069
NSF Antarctic Sciences (NSF ANT)	ANT-0944727
NSF Antarctic Sciences (NSF ANT)	ANT-0839012
NSF Antarctic Sciences (NSF ANT)	ANT-0838995
NSF Antarctic Sciences (NSF ANT)	ANT-0838975
Swedish Research Council	2008-6430
Swedish Research Council	2008-6429

[[table of contents](#) | [back to top](#)]