

# Total water-column Thorium-234 measurements collected during January cruises of the Palmer LTER program along the Western Antarctic Peninsula from 2016-2020

**Website:** <https://www.bco-dmo.org/dataset/945225>

**Data Type:** Cruise Results

**Version:** 1

**Version Date:** 2024-12-04

## Project

» [Quantifying Processes Driving Interannual Variability in the Biological Carbon Pump in the Western Antarctic Peninsula](#) (WAP Carbon export)

Contributors	Affiliation	Role
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## Abstract

This dataset includes total water-column Thorium-234 measurements collected during January cruises of the Palmer LTER program along the Western Antarctic Peninsula.  $^{238}\text{U}$ - $^{234}\text{Th}$  disequilibrium is used as a proxy for sinking particle flux out of the upper ocean. Vertical profiles of  $^{234}\text{Th}$  were measured using standard small-volume techniques on 5 Palmer LTER cruises on ARSV Laurence M. Gould during 2016-2020. Measurements typically spanned from the surface to a depth of ~200 meters, although the deepest depths were variable, based on the LTER sampling program. Typically, 12 to 20 stations were sampled per year.

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## Coverage

**Location:** Western Antarctic Peninsula

**Spatial Extent:** N:-63.9653 E:-64.398014 S:-69.39223 W:-78.19839

**Temporal Extent:** 2016-01-11 - 2020-02-02

## Methods & Sampling

Total  $^{234}\text{Th}$  was measured using standard small volume techniques (Benitez-Nelson et al., 2001; Pike et al., 2005). 4-liter (L) samples for total  $^{234}\text{Th}$  were sampled using a CTD Niskin rosette (typically from eight depths spanning the epipelagic). Samples were acidified to a pH of <2 with  $\text{HNO}_3$ . A tracer addition of  $^{230}\text{Th}$  was added and samples were mixed vigorously. Samples were allowed to equilibrate for 4-9 hours and then adjusted to a pH of 8-9 with  $\text{NH}_4\text{OH}$ .  $\text{KMnO}_4$  and  $\text{MnCl}_2$  were added and samples were mixed and allowed to sit for ~12 hours as Th co-precipitated with manganese oxide. Samples were then vacuum-filtered at high pressure onto QMA filters, dried, and mounted in RISO sample holders.

Samples were beta counted on a RISO low-level background beta counter at Palmer Station and re-counted >6 half-lives later. Samples for water-column  $^{234}\text{Th}$  were then dissolved in  $\text{HNO}_3/\text{H}_2\text{O}_2$  solution and  $^{229}\text{Th}$  tracer

was added. Samples were evaporated and reconstituted in dilute nitric acid / hydrofluoric acid. They were then analyzed by inductively-coupled plasma mass spectrometry at the Woods Hole Oceanographic Institution Analytical Lab to determine the ratio of  $^{229}\text{Th}$ : $^{230}\text{Th}$  to determine the initial yield of the  $^{234}\text{Th}$  filtration.  $^{238}\text{U}$  activity (for estimating  $^{238}\text{U}$ - $^{234}\text{Th}$  deficiency) was estimated from a linear relationship with salinity (Owens et al., 2011).

## BCO-DMO Processing Description

- Imported original file "Th Logs - ForBCODMO - 2024-07-03.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Converted the local date-time column to ISO 8160 format.
- Added a date-time column in UTC.
- Saved the final file as "945225\_v1\_th-234\_wap.csv"

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## Related Publications

Benitez-Nelson, C. R., Buesseler, K. O., van der Loeff, M. R., Andrews, J., Ball, L., Crossin, G., & Charette, M. A. (2001). Journal of Radioanalytical and Nuclear Chemistry, 248(3), 795–799.

<https://doi.org/10.1023/a:1010621618652> <https://doi.org/10.1023/A:1010621618652>

*Methods*

Ducklow, H. W., Stukel, M. R., Eveleth, R., Doney, S. C., Jickells, T., Schofield, O., Baker, A. R., Brindle, J., Chance, R., & Cassar, N. (2018). Spring–summer net community production, new production, particle export and related water column biogeochemical processes in the marginal sea ice zone of the Western Antarctic Peninsula 2012–2014. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2122), 20170177. <https://doi.org/10.1098/rsta.2017.0177>

*General*

Owens, S. A., Buesseler, K. O., & Sims, K. W. W. (2011). Re-evaluating the  $^{238}\text{U}$ -salinity relationship in seawater: Implications for the  $^{238}\text{U}$ - $^{234}\text{Th}$  disequilibrium method. Marine Chemistry, 127(1-4), 31–39.

doi:[10.1016/j.marchem.2011.07.005](https://doi.org/10.1016/j.marchem.2011.07.005)

*Methods*

Pike, S. M., Buesseler, K. O., Andrews, J., & Savoye, N. (2005). Quantification of  $^{234}\text{Th}$  recovery in small volume sea water samples by inductively coupled plasma-mass spectrometry. Journal of Radioanalytical and Nuclear Chemistry, 263(2), 355–360. doi:10.1007/s10967-005-0062-9 <https://doi.org/10.1007/s10967-005-0594-z>

*Methods*

Stukel, M. R., & Ducklow, H. W. (2017). Stirring Up the Biological Pump: Vertical Mixing and Carbon Export in the Southern Ocean. Global Biogeochemical Cycles, 31(9), 1420–1434. Portico.

<https://doi.org/10.1002/2017gb005652> <https://doi.org/10.1002/2017GB005652>

*General*

Stukel, M. R., Asher, E., Couto, N., Schofield, O., Strebler, S., Tortell, P., & Ducklow, H. W. (2015). The imbalance of new and export production in the western Antarctic Peninsula, a potentially “leaky” ecosystem. Global Biogeochemical Cycles, 29(9), 1400–1420. Portico. <https://doi.org/10.1002/2015gb005211>

<https://doi.org/10.1002/2015GB005211>

*General*

Stukel, M. R., Schofield, O. M. E., & Ducklow, H. W. (2022). Seasonal variability in carbon: $^{234}\text{Th}$  ratios of suspended and sinking particles in coastal Antarctic waters: Field data and modeling synthesis. Deep Sea Research Part I: Oceanographic Research Papers, 184, 103764. <https://doi.org/10.1016/j.dsr.2022.103764>

*General*

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## Parameters

<b>Parameter</b>	<b>Description</b>	<b>Units</b>
Cruise	The identifier for the Palmer LTER cruise from which the data was collected	unitless
Event	Unique cruise event number that identifies the CTD cast from which the sample was collected	unitless
GridLine	Palmer LTER grid line from which sample was collected	unitless
GridStation	Palmer LTER grid station from which sample was collected	unitless
Latitude	Latitude of sample collection; negative values = South	decimal degrees
Longitude	Longitude of sample collection; negative values = West	decimal degrees
Niskin	Number of the Niskin bottle from which sample was collected	unitless
Depth	Sample collection depth	meters (m)
Salinity	Salinity determined from a Seabird CTD	PSU
U238	Activity of U-238 determined from a regression with salinity	decays per minute per liter (dpm/L)
ISO_DateTime_Local	Collection date and time in ISO 8601 format; Local time zone is UTC-0400	unitless
ISO_DateTime_UTC	Collection date and time in ISO 8601 format in UTC	unitless
Th234_Activity	Activity of total water-column Thorium-234	decays per minute per liter (dpm/L)
Th234_Activity_Absolute_Error	Uncertainty in Thorium-234 activity	decays per minute per liter (dpm/L)
Deficiency	238Uranium minus 234Th disequilibrium	decays per minute per liter (dpm/L)
Deficiency_Absolute_Error	Uncertainty in uranium-thorium disequilibrium	decays per minute per liter (dpm/L)

## Instruments

<b>Dataset-specific Instrument Name</b>	inductively-coupled plasma mass spectrometry
<b>Generic Instrument Name</b>	Inductively Coupled Plasma Mass Spectrometer
<b>Dataset-specific Description</b>	Samples were analyzed by inductively-coupled plasma mass spectrometry to determine the ratio of 229:230Th
<b>Generic Instrument Description</b>	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

<b>Dataset-specific Instrument Name</b>	CTD Niskin rosette
<b>Generic Instrument Name</b>	Niskin bottle
<b>Dataset-specific Description</b>	Samples for total 234Th were sampled using a CTD Niskin rosette (typically from eight depths spanning the epipelagic)
<b>Generic Instrument Description</b>	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.

<b>Dataset-specific Instrument Name</b>	RISO low-level GM beta multi-counter
<b>Generic Instrument Name</b>	Riso Laboratory Anti-coincidence Beta Counters
<b>Dataset-specific Description</b>	Samples were beta counted on a RISO low-level background beta counter
<b>Generic Instrument Description</b>	Low-level beta detectors manufactured by Riso (now Nutech) in Denmark. These instruments accept samples that can be mounted on a 25mm filter holder. These detectors have very low backgrounds, 0.17 counts per minute, and can have counting efficiencies as high as 55%. Typically used in laboratory analyses. Designed to measure low levels of beta particle emission. The systems work on the principle of anticoincidence.

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## Deployments

LMG1801

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/839984">https://www.bco-dmo.org/deployment/839984</a>
<b>Platform</b>	ARSV Laurence M. Gould
<b>Start Date</b>	2017-12-30
<b>End Date</b>	2018-02-12
<b>Description</b>	Additional cruise information is available from the Rolling Deck to Repository (R2R): <a href="https://www.rvdata.us/search/cruise/LMG1801">https://www.rvdata.us/search/cruise/LMG1801</a>

#### LMG1601

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/945279">https://www.bco-dmo.org/deployment/945279</a>
<b>Platform</b>	ARSV Laurence M. Gould
<b>Start Date</b>	2016-01-03
<b>End Date</b>	2016-02-17
<b>Description</b>	Additional cruise information is available from the Rolling Deck to Repository (R2R): <a href="https://www.rvdata.us/search/cruise/LMG1601">https://www.rvdata.us/search/cruise/LMG1601</a>

#### LMG1701

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/945281">https://www.bco-dmo.org/deployment/945281</a>
<b>Platform</b>	ARSV Laurence M. Gould
<b>Start Date</b>	2016-12-30
<b>End Date</b>	2017-02-10
<b>Description</b>	Additional cruise information is available from the Rolling Deck to Repository (R2R): <a href="https://www.rvdata.us/search/cruise/LMG1701">https://www.rvdata.us/search/cruise/LMG1701</a>

#### LMG1901

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/945284">https://www.bco-dmo.org/deployment/945284</a>
<b>Platform</b>	ARSV Laurence M. Gould
<b>Start Date</b>	2018-12-30
<b>End Date</b>	2019-02-12
<b>Description</b>	Additional cruise information is available from the Rolling Deck to Repository (R2R): <a href="https://www.rvdata.us/search/cruise/LMG1901">https://www.rvdata.us/search/cruise/LMG1901</a>

#### LMG2001

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/945288">https://www.bco-dmo.org/deployment/945288</a>
<b>Platform</b>	ARSV Laurence M. Gould
<b>Start Date</b>	2019-12-30
<b>End Date</b>	2020-02-12
<b>Description</b>	Additional cruise information is available from the Rolling Deck to Repository (R2R): <a href="https://www.rvdata.us/search/cruise/LMG2001">https://www.rvdata.us/search/cruise/LMG2001</a>

## Project Information

### Quantifying Processes Driving Interannual Variability in the Biological Carbon Pump in the Western Antarctic Peninsula (WAP Carbon export)

**Coverage:** Western Antarctic Peninsula (Palmer LTER Study Region)

#### *NSF Award Abstract:*

Algae in the surface ocean convert carbon dioxide into organic carbon through photosynthesis. The biological carbon pump transports this organic carbon from the atmosphere to the deep ocean where it can be stored for tens to hundreds of years. Annually, the amount transported is similar to that humans are currently emitting by burning fossil fuels. However, at present we cannot predict how this important process will change with a warming ocean. These investigators plan to develop a 15+ year time-series of vertical carbon transfer for the Western Antarctic Peninsula; a highly productive Antarctic ecosystem. This region is also rapid transition to warmer temperatures leading to reduced sea ice coverage. This work will help researchers better understand how the carbon cycle in the Western Antarctic Peninsula will respond to climate change. The researchers will develop the first large-scale time-series of carbon flux anywhere in the ocean. This research will also support the education and training of a graduate student and support the integration of concepts in Antarctic research into two undergraduate courses designed for non-science majors and advanced earth science students. The researchers will also develop educational modules for introducing elementary and middle-school age students to important concepts such as gross and net primary productivity, feedbacks in the marine and atmospheric systems, and the differences between correlation and causation. Results from this proposal will also be incorporated into a children's book, "Plankton do the Strangest Things", that is targeted at 5-7 year olds and is designed to introduce them to the incredible diversity and fascinating adaptations of microscopic marine organisms.

This research seeks to leverage 6 years (2015-2020) of  $^{234}\text{Th}$  samples collected on Palmer LTER program, 5 years of prior measurements (2009-2010, 2012-2014), and upcoming cruises (2021-2023) to develop a time-series of summertime particle flux in the WAP that stretches for 15 years. The  $^{238}\text{U}$ - $^{234}\text{Th}$  disequilibrium approach utilizes changes in the activity of the particle-active radio-isotope  $^{234}\text{Th}$  relative to its parent nuclide  $^{238}\text{U}$  to quantify the flux of sinking carbon out of the surface ocean (over a time-scale of ~one month). This proposal will fund  $^{234}\text{Th}$  analyses from nine years' worth of cruises (2015-2023) and extensive analyses designed to investigate the processes driving inter-annual variability in the BCP. These include: 1) physical modeling to quantify the importance of advection and diffusion in the  $^{234}\text{Th}$  budget, 2) time-series analyses of particle flux, and 3) statistical modeling of the relationships between particle flux and multiple presumed drivers (biological, chemical, physical, and climate indices) measured by collaborators in the Palmer LTER program. This multi-faceted approach is critical for linking the measurements to models and for predicting responses to climate change. It will also test the hypothesis that export flux is decreasing in the northern WAP, increasing in the southern WAP, and increasing when integrated over the entire region as a result of earlier sea ice retreat and a larger ice-free zone. The project will also investigate relationships between carbon export and multiple potentially controlling factors including: primary productivity, algal biomass and taxonomic composition, biological oxygen saturation, zooplankton biomass and taxonomic composition, bacterial production, temperature, wintertime sea ice extent, date of sea ice retreat, and climate modes.

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
<a href="#">NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)</a>	<a href="#">OPP-1951090</a>

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