DOC and DON concentrations of waters collected from the North Pacific Subtropical Gyre and Central North Atlantic

Website: https://www.bco-dmo.org/dataset/811204
Data Type: Cruise Results
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Project
» The Microbial Nitrogen Pump: Coupling 14C and Compound-specific Amino Acids to Understand the Role of Microbial Transformations in the Refractory Ocean DON Pool (DON Microbial Nitrogen Pump)

Contributors	Affiliation	Role
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Abstract
DOC and DON concentrations of waters collected from the North Pacific Subtropical Gyre and Central North Atlantic. These data were published in Broek et al. (2019) and Broek et al. (2017).

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Coverage

Spatial Extent: **N**:31.6667 **E**:-64.1667 **S**:22.75 **W**:-158
Temporal Extent: 2014 - 2016

Dataset Description

DOC and DON concentrations of waters collected from the North Pacific Subtropical Gyre and Central North Atlantic. These data were published in Broek et al. (2019) and Broek et al. (2017).

Methods & Sampling

Sample Collection
Samples were collected on two separate research cruises aboard the R/V Kilo Moana in August 2014 and May 2015. Sampling was conducted at the Hawaii Ocean Time Series Station ALOHA (A Long-Term Oligotrophic Habitat Assessment; 22° 45'N, 158° 00'W) and the Bermuda Atlantic Time Series Site (BATS; 31° 40'N, 64° 10'W) in the Central North Atlantic.

Surface water was sampled via the vessel's underway sampling system. The intake pipe is situated on the forward starboard hull section of the vessel approximately 7.5 m below the waterline. The laboratory seawater

tap was allowed to flush for 2 hours prior to each sampling. Seawater was pre-filtered through 53 µm Nitex mesh, and pumped through a 0.2 µm polyethersulfone (PES) cartridge filter (Shelco Filters, Micro Vantage, water grade, 9.75" DOE, polycarbonate housing) prior to introduction to the ultrafiltration system. Large volume subsurface water samples were collected using successive casts of a rosette equipped with 24 x 12 L Niskin bottles.

Tangential-Flow Ultrafiltration
The main UF system was constructed using a modified design of the system described in Roland et al. (2009), and expanded on by Walker et al. (2011). Briefly, the system was comprised of four-spiral wound PES UF membranes, having a nominal molecular weight cut off of 2.5 kD (GE Osmonics GH2540F30, 40-inch long, 2.5-inch diameter). The membranes were mounted in stainless steel housings, plumbed in parallel to a 100 L fluorinated HDPE reservoir, with flow driven by a 1.5 HP stainless steel centrifugal pump (Goulds Pumps, Stainless steel centrifugal pump, NPE series 1 x 1-1/4 -6, close coupled to a 1-1/2 horsepower, 3500 RPM, 60 Hz, 3 phase, Open Drip Proof Motor; 5.75 Inch Impeller Diameter, Standard Viton Mechanical Seals). All other system plumbing components contacting seawater were composed of polytetrafluoroethylene (PTFE) or stainless steel.

The system was run continuously at a membrane pressure of 40-50 psi, resulting in permeation flow rates of 1-2 L/min, depending primarily on the temperature of the feed seawater. Sample water was fed into the system using peristaltic pumps and platinum cured silicone tubing at a flow rate matched to the system permeation rates to ensure a constant system volume of approximately 100 L.

Seawater samples of 3000-4000 L were concentrated to a final retentate volume of 15-20 L, drained from the system into acid washed PC carboys and refrigerated (less than 12 hours at 2C) until the next phase of processing. Samples requiring storage for longer than 12 hours were frozen and stored at -20°C. The UF system was then reconfigured to a smaller volume system, consisting of a single membrane having a smaller nominal molecular weight cutoff (GE Osmonics GE2540F30, 40-inch long, 2.5-inch diameter, 1 kD MWCO), and a 2.5 L PES reservoir for further volume reduction and subsequent salt removal (diafiltration). Using this smaller system, samples were reduced to 2-3 L under lower pressure (25 psi, permeation rate = 250 mL/min). Samples were then diafiltered using 40 L of 18.2 MΩ Milli-Q (ultrapure) water, adding water to the sample retentate reservoir at the same rate of membrane permeation. Reduced and diafiltered samples were stored in acid washed PC bottles at -20°C for transport. In the laboratory, samples were further concentrated by rotary evaporation using pre-combusted glassware (450 °C, 5 h). A molecular sieve and a liquid nitrogen trap were placed between the vacuum pump and rotovap chamber to ensure no contamination of isolated material by back streaming of hydrocarbons or other contaminants. After reduction to 50-100 mL, samples were dried to powder via centrifugal evaporation in PTFE centrifuge tubes. Dry material was homogenized with an ethanol cleaned agate mortar and pestle, transferred to pre-combusted glass vials, and stored in a desiccation cabinet until subsequent analyses.

Solid Phase Extraction
Solid phase extraction was conducted using PPL sorbent (Agilent Bondesil PPL, 125 µm particle size, part # 5982-0026) following the general recommendations of Dittmar et al. (2008) and Green et al. (2014), including loading rates, seawater to sorbent ratios, and elution volumes and rates. Between 300 and 500 g of sorbent was used for each extraction, depending on sample volume and DOC concentration, with average loading of 4.2 ± 1.5 L UF permeate per g sorbent representing 1.9 ± 0.6 mg DOC per g sorbent or a DOC to sorbent mass ratio of 1:600 ± 200. This is in line with both the recommendations of Dittmar et al. (2008) (maximum loading = 10 L seawater per g sorbent) and Li et al. (2016) (DOC to sorbent ratio = 1:800). Permeate from the UF system was fed through PTFE tubing to a pair of 200 L HDPE barrels. The permeate water was then acidified in 200 L batches to pH 2 by adding 400 mL of 6 M HCl (Fisher Chemical, ACS Plus grade). Batch samples were mixed continuously during collection, acidification, and loading using a peristaltic pump and platinum cured Si and PTFE tubing positioned at the surface and bottom of each barrel. Acidified batches of seawater permeate were then pumped through the SPE sorbent. SPE flow rates were matched to UF permeation rates (1-2 L/min), such that a pair of 200 L barrels allowed one barrel to be filled while the contents of the other was passed through the sorbent.

Three custom SPE column configurations were used to contain the sorbent material. The column configuration was modified several times for ease of use on subsequent cruises. First, an open, gravity fed, large (49 mm ID x 1000 mm length, 1875 mL volume) glass chromatography column with 40 µm fritted disk and PTFE stopcock (Kimble-Chase, Kontes) was used. Next, we tested a custom built high-pressure SS housing (10 cm ID x 3.5 cm bed height), and finally a parallel combination of 2 medium-pressure glass chromatography columns (Kimble-Chase, Kontes, Chromaflex LC, 4.8 mm ID x 30 cm, 543 mL volume). While all designs proved to be functionally equivalent, the latter parallel combination of 2 medium-pressure glass columns ultimately provided the best configuration in order to maximize flow rates while simultaneously optimizing the ratio of sorbent bed

height to loading speed. Further, the commercial availability and ease of use associated with this configuration made it our preferred design.

Following sample loading, the SPE sorbent was desalted with 6 L of pH 2 ultrapure water at a low flow rate (250-300 mL/min). After desalting, the SPE sorbent was transferred to a glass chromatography column (75 mm ID x 300 mm length, 40 µm fritted disk, PTFE stopcock) with ultrapure water rinses to ensure quantitative transfer. Isolated organic material was then eluted from the sorbent with five to six 500 mL additions of methanol. The eluted methanol solution was stored in pre-combusted amber glass bottles at -20°C for transport. Similar to UF samples, the methanol-eluted solutions were first reduced by rotary evaporation to 50-100 mL. Samples were then dried to powder via centrifugal evaporation in PTFE centrifuge tubes. Dry material was homogenized with an ethanol cleaned agate mortar and pestle, transferred to pre-combusted glass vials, and stored in a desiccation cabinet until elemental and isotopic analyses.

Total DOM
Subsamples for dissolved organic carbon (DOC) and total dissolved nitrogen (TDN) concentration measurements were collected into pre-combusted 40 mL borosilicate glass vials following 0.2 µm-filtration. Samples were stored at -20°C until analysis. Subsamples for [DOC] and [TDN] were also taken from the UF system permeate to evaluate mass balance. An "integrated" permeate sample (e.g., Benner et al., 1997) was prepared by sampling and combining equal volumes (100 mL) collected at constant time intervals throughout the ultrafiltration. DOC and TDN concentration measurements were made using the high temperature oxidation method with a Shimadzu TOC-V in the Carlson lab at UCSB (https://labs.eemb.ucsb.edu/carlson/craig/services). DOC concentration measurement errors represent the standard deviation of n=3 replicate measurements. Total DON concentrations were determined by subtracting the sum of dissolved inorganic nitrogen (DIN) species (nitrate, nitrite, ammonia) from TDN. DIN concentrations were determined using a Lachat QuickChem 8000 Flow Injection Analyzer. Ammonia concentrations were below the limit of quantification (0.36 µM) for all samples using QuickChem® Method 31-107-06-1-B. Nitrate and nitrite concentrations were measured as the sum of the two analytes using QuickChem® Method 31-107-04-1-C. The limit of detection for [NO3+NO2] using this method was 0.5 µM and the average precision of replicate standard measurements was ± 1.4 µM. In the case of [DON], measurement errors represent the propagated analytical uncertainty from the subtraction of [DIN] from [TDN]. DOC concentrations measurements were also determined via UV oxidation, cryogenic purification and manometric determination at UC Irvine.

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Data Files

File
DOC_DON.csv (Comma Separated Values (.csv), 719 bytes) MD5:478e95d5eb964a3fca4bd092234ffda5 Primary data file for dataset ID 811204

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Related Publications

Benner, R., Biddanda, B., Black, B., & McCarthy, M. (1997). Abundance, size distribution, and stable carbon and nitrogen isotopic compositions of marine organic matter isolated by tangential-flow ultrafiltration. Marine Chemistry, 57(3-4), 243–263. doi:10.1016/s0304-4203(97)00013-3 https://doi.org/10.1016/S0304-4203(97)00013-3
Methods

Broek, T. A. B., Bour, A. L., Ianiri, H. L., Guilderson, T. P., & McCarthy, M. D. (2019). Amino acid enantiomers in old and young dissolved organic matter: Implications for a microbial nitrogen pump. Geochimica et Cosmochimica Acta, 247, 207–219. doi:10.1016/j.gca.2018.12.037
Results

Broek, T. A. B., Walker, B. D., Guilderson, T. P., & McCarthy, M. D. (2017). Coupled ultrafiltration and solid phase extraction approach for the targeted study of semi-labile high molecular weight and refractory low molecular weight dissolved organic matter. Marine Chemistry, 194, 146–157. doi:10.1016/j.marchem.2017.06.007

Results

Dittmar, T., Koch, B., Hertkorn, N., & Kattner, G. (2008). A simple and efficient method for the solid-phase extraction of dissolved organic matter (SPE-DOM) from seawater. Limnology and Oceanography: Methods, 6(6), 230–235. doi:10.4319/lom.2008.6.230
Methods

Green, N. W., Perdue, E. M., Aiken, G. R., Butler, K. D., Chen, H., Dittmar, T., … Stubbins, A. (2014). An intercomparison of three methods for the large-scale isolation of oceanic dissolved organic matter. Marine Chemistry, 161, 14–19. doi:10.1016/j.marchem.2014.01.012
Methods

Li, Y., Harir, M., Lucio, M., Kanawati, B., Smirnov, K., Flerus, R., … Hertkorn, N. (2016). Proposed Guidelines for Solid Phase Extraction of Suwannee River Dissolved Organic Matter. Analytical Chemistry, 88(13), 6680–6688. doi:10.1021/acs.analchem.5b04501
Methods

Roland, L. A., McCarthy, M. D., Peterson, T. D., & Walker, B. D. (2009). A large-volume microfiltration system for isolating suspended particulate organic matter: fabrication and assessment versus GFF filters in central North Pacific. Limnology and Oceanography: Methods, 7(1), 64–80. doi:10.4319/lom.2009.7.64
Methods

Walker, B. D., Beaupré, S. R., Guilderson, T. P., Druffel, E. R. M., & McCarthy, M. D. (2011). Large-volume ultrafiltration for the study of radiocarbon signatures and size vs. age relationships in marine dissolved organic matter. Geochimica et Cosmochimica Acta, 75(18), 5187–5202. doi:10.1016/j.gca.2011.06.015
Methods

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Related Datasets

Replaces Old Versions

McCarthy, M., & Guilderson, T. (2017). Recovery parameters, isotopic composition, and elemental composition of HMW and LMW DOM collected in the North Pacific Subtropical Gyre on R/V Kilo Moana (KM1506, KM1515) during 2015. Biological and Chemical Oceanography Data Management Office. doi:10.1575/1912/bco-dmo.711831.1

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Parameters

Parameter	Description	Units
location	Sample collection location. HOT = Hawaii Ocean Time Series station ALOHA (22° 45'N, 158° 00'W) in North Pacific Subtropical Gyre (NPSG); BATS = Hawaii Ocean Time Series station ALOHA (22° 45'N, 158° 00'W) in North Pacific Subtropical Gyre (NPSG)	unitless
year	Year of sample collection; format: YYYY	unitless
season	Season of sample collection	unitless
depth	Sample depth	meters (m)
DOC	DOC Concentration or Recovery	micromoles per liter (umol/L)
DOC_stdev	Standard deviation of DOC	micromoles per liter (umol/L)
DON	DON Concentration or Recovery	micromoles per liter (umol/L)
DON_stdev	Standard deviation of DON	micromoles per liter (umol/L)

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Instruments

Dataset-specific Instrument Name	Lachat QuickChem 8000 Flow Injection Analyzer
Generic Instrument Name	Flow Injection Analyzer
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	rosette equipped with 24 x 12 L Niskin bottles
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	underway sampling system
Generic Instrument Name	Pump - Surface Underway Ship Intake
Generic Instrument Description	The 'Pump-underway ship intake' system indicates that samples are from the ship's clean water intake pump. This is essentially a surface water sample from a source of uncontaminated near-surface (commonly 3 to 7 m) seawater that can be pumped continuously to shipboard laboratories on research vessels. There is typically a temperature sensor near the intake (known as the hull temperature) to provide measurements that are as close as possible to the ambient water temperature. The flow from the supply is typically directed through continuously logged sensors such as a thermosalinograph and a fluorometer. Water samples are often collected from the underway supply that may also be referred to as the non-toxic supply. Ideally the data contributor has specified the depth in the ship's hull at which the pump is mounted.

Dataset-specific Instrument Name	Shimadzu TOC-V
Generic Instrument Name	Shimadzu TOC-V Analyzer
Generic Instrument Description	A Shimadzu TOC-V Analyzer measures DOC by high temperature combustion method.

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Deployments

KM1506

Website	https://www.bco-dmo.org/deployment/636095
Platform	R/V Kilo Moana
Start Date	2015-05-03
End Date	2015-05-12
Description	Original cruise data are available from the NSF R2R data catalog

KM1515

Website	https://www.bco-dmo.org/deployment/657964
Platform	R/V Kilo Moana
Start Date	2015-08-15
End Date	2015-09-12

AE1520

Website	https://www.bco-dmo.org/deployment/811215
Platform	R/V Atlantic Explorer
Start Date	2015-08-21
End Date	2015-08-25

AE1608

Website	https://www.bco-dmo.org/deployment/811286
Platform	R/V Atlantic Explorer
Start Date	2016-05-03
End Date	2016-05-11

KM1418

Website	https://www.bco-dmo.org/deployment/636002
Platform	R/V Kilo Moana
Start Date	2014-08-29
End Date	2014-09-11
Description	Original cruise data are available from the NSF R2R data catalog

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Project Information

The Microbial Nitrogen Pump: Coupling 14C and Compound-specific Amino Acids to Understand the Role of Microbial Transformations in the Refractory Ocean DON Pool (DON Microbial Nitrogen Pump)

Coverage: North Pacific Subtropical Gyre (HOT station), North Atlantic Subtropical Gyre (BATS time series station), California Margin

Dissolved organic nitrogen is one of the most important - but perhaps least understood - components of the modern ocean nitrogen cycle. While dissolved organic nitrogen represents a main active reservoir of fixed and seemingly biologically-available nitrogen, at the same time most of ocean's dissolved organic nitrogen pool is also apparently unavailable for use by organisms. Recently, the idea of the "Microbial Carbon Pump" has emerged, providing a renewed focus on microbes as primary agents for the formation of biologically-available dissolved material. However, the role that microbes play in transformation of biologically-available dissolved organic nitrogen is still lacking. In order to fill gaps in this knowledge, researchers from the University of California Santa Cruz will apply a series of new analytical approaches to test the role of microbial source and transformation in formation of the ocean's biologically-available dissolved organic nitrogen pool. Results from this study will address one of the major unknowns of both chemical oceanography and the ocean nitrogen

cycle.

Broader Impacts:
This proposal will provide oceanographers new tools to test ideas of microbial organic matter sequestration in a world where the oceans are rapidly changing. High school, undergraduate, graduate and post-doctoral education will be furthered through active participation in lab, field, and data synthesis activities.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1358041

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