Carbon and nitrogen isotope data from zooplankton and fish larvae collected on the SR2114 expedition in the Eastern Tropical North Pacific aboard the R/V Sally Ride from December 2021 to January 2022

Website: https://www.bco-dmo.org/dataset/936689
Data Type: Cruise Results
Version: 1
Version Date: 2024-09-06

Project
» Collaborative Research: Multiyear autonomous measurement of N-loss in the ETNP ODZ (N-loss in the ETNP ODZ)

Contributors	Affiliation	Role
Gutiérrez-Bravo, Juan Gerardo	University of Massachusetts Dartmouth (UMass Dartmouth)	Principal Investigator
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Abstract
This dataset includes carbon and nitrogen isotope data from zooplankton and fish larvae collected on the SR2114 expedition onboard the RV Sally Ride from December 2021 to January 2022. Samples were collected using a MOCNESS (Multiple Opening-Closing Net and Environmental Sensing) system. The vertical sampling strategy followed five specific oxypleths (referred to as sampling levels) using horizontal tows. The zooplankton samples were preserved in ethanol 95%. The stable isotope ratios of carbon (13C/12C) and nitrogen (15N/14N) were measured on 39 samples of zooplankton, 44 samples of fish larvae, and 8 samples of fish adults. Carbon and nitrogen isotope ratios were measured at the Boston University Stable Isotope Laboratory using a GV Instruments IsoPrime isotope ratio mass spectrometer coupled with an elemental analyzer. The results were compared to international standards (Pee Dee Belemnite for 13C and atmospheric nitrogen for 15N) and presented as delta notation. This methodology was followed to gather information on the trophic structure of the ecosystem and its ontogenic changes during early fish development.

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Coverage

Location: Eastern Tropical North Pacific
Spatial Extent: **N**:21.87 **E**:-89.14 **S**:8.59 **W**:-114.67
Temporal Extent: 2021-12-26 - 2022-01-17

Methods & Sampling

An oceanographic survey was performed onboard the RV Sally Ride from Puntarenas, Costa Rica to San Diego, USA. Forty-nine CTD-rosette stations and 8 MOCNESS tows (Multiple Opening-Closing Net and Environmental Sensing System; Wiebe et al. 1985) were conducted along the cruise track (see Figure 1 of Gutiérrez-Bravo, et al. 2024). The CTD-rosette system used for water sampling and water column profiling included a SeaBird SBE9+ CTD and calibrated Seapoint-Fluorescence and SBE 43-DO sensors. A MOCNESS system was used for zooplankton and fish sampling and was equipped with 10 nets of 1 square meter (m^2) mouth opening and 333 micrometer (µm) mesh size, a SeaBird SBE9+ CTD, a SeaBird SBE 43 DO sensor, and flow meter and angle sensors.

The vertical sampling strategy followed five specific oxypleths (referred to as sampling levels) using horizontal tows. The deep level followed the 10 micromoles per kilogram (µmol/kg) oxypleth below the anoxic core (~900 meters (m) depth). The anoxic level followed the center of the anoxic core, with DO <1 µmol/kg and depth of ~450 m. The suboxic and hypoxic levels followed the 10 and 100 µmol/kg oxypleths above the anoxic core, with varying depths. The oxic level followed the >200 µmol/kg oxypleth near the surface (~20 m). Abrupt vertical oxygen gradients and the lagged depth control of the MOCNESS tow caused DO values to be less than half or more than double the desired DO values in seven out of 40 nets (M1-Oxic, M1-Hypoxic, M6-Hypoxic, M3-Suboxic, M6-Suboxic, M7-Suboxic and M8-Anoxic). These nets were considered outliers and were removed from the inter-level comparison statistics.

The zooplankton samples were preserved in ethanol 95%. Fish larvae were separated and identified to the most specific taxonomic level possible. The larval stages (preflexion, flexion, postflexion, and transformation) were defined according to Moser (1996). Juveniles and adults were separated, counted, and identified to the most specific taxonomic level possible. A more comprehensive description of the sample processing is described in Gutiérrez Bravo et al. (2024). The habitat type of each taxon was consulted in specialized literature (Moser 1996; Aceves-Medina et al. 2003; Froese and Pauly 2010).

The stable isotope ratios of carbon (13C/12C) and nitrogen (15N/14N) were measured on 39 samples of zooplankton (sample M5-Suboxic presented issues), 44 samples of fish larvae, and 8 samples of fish adults. For zooplankton, a wide-mouth 1.5 milliliter (mL) pipette was used to separate an aliquot from each of the 40 zooplankton samples. This approach was used to assess the integrated isotopic signature of the whole zooplankton community, and does not resolve species-specific differences. For fish, on the other hand, individuals of the same species, same development stage, and same net, were separated using a stereoscope and tweezer to obtain a critical weight of >2 milligrams (mg). Adjacent development stages were pooled if the sample weight was lower than 2mg.

The samples were rinsed to remove ethanol with deionized water, and then dried at 60 degrees Celsius (°C) for 24 hours. The dried samples were then ground to a fine powder using a mortar and pestle. The samples were loaded into tin cups and weighed to ~2mg using an analytical balance. Carbon and nitrogen isotope ratios were measured at the Boston University Stable Isotope Laboratory using a GV Instruments IsoPrime isotope ratio mass spectrometer coupled with an elemental analyzer.

Data Processing Description

The results were compared to international standards (Pee Dee Belemnite for 13C and atmospheric nitrogen for 15N) and presented as delta notation. MOCNESS data were analyzed using SBE Data processing.

BCO-DMO Processing Description

- Imported original file "Supp material.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Converted Date column to YYYY-MM-DD format.
- Saved the final file as "936689_v1_sr2111_fish_larvae_isotope_data.csv".

Problem Description

Abrupt vertical oxygen gradients and the lagged depth control of the MOCNESS tow caused DO values to be less than half or more than double the desired DO values in seven out of 40 nets (M1-Oxic, M1-Hypoxic, M6-

Hypoxic, M3-Suboxic, M6-Suboxic, M7-Suboxic and M8-Anoxic).

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Data Files

File
936689_v1_sr2111_fish_larvae_isotope_data.csv (Comma Separated Values (.csv), 11.02 KB) MD5:24ffd254c23950433ac465f4eac79ca2
Primary data file for dataset ID 936689, version 1

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Related Publications

Aceves-Medina, G., Jiménez-Rosenberg, S. P. A., Hinojosa-Medina, A., Funes-Rodríguez, R., Saldierna, R. J., Lluch-Belda, D., Smith, P. E., & Watson, W. (2003). Fish larvae from the Gulf of California. Scientia Marina, 67(1), 1–11. https://doi.org/10.3989/scimar.2003.67n11 https://doi.org/10.3989/SCIMAR.2003.67N11
Methods

Froese, R. & Pauly, Daniel. (2001). Fishbase 99: A global information system on fishes. 25.
Methods

Gutierrez-Bravo, et al. (2024). Midwater anoxia disrupts the trophic structure of zooplankton and fish in an oxygen deficient zone. Limnology & Oceanography (submitted)
Results

Gutiérrez-Bravo, J. G., Sánchez-Velasco, L., Jiménez-Rosenberg, S. P. A., Altabet, M. A., Méndez-Mendez, S., & Cambronero-Solano, S. (2024). Anoxic waters constrain the vertical distribution of fish developmental stages in an oxygen minimum zone. Limnology and Oceanography. Portico. https://doi.org/10.1002/lno.12594
Results

Moser, H. G. (Ed.). (1996). The early stages of fishes in the California Current region. US Department of the Interior, Minerals Management Service, Pacific OCS Region.
Methods

Wiebe, P. H., Morton, A. W., Bradley, A. M., Backus, R. H., Craddock, J. E., Barber, V., … Flierl, G. R. (1985). New development in the MOCNESS, an apparatus for sampling zooplankton and micronekton. Marine Biology, 87(3), 313–323. doi:10.1007/bf00397811 https://doi.org/10.1007/BF00397811
Methods

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Parameters

Parameter	Description	Units
MOCNESS	Sequential MOCNESS number under the sampling strategy	unitless
Level	Sampling level identifier. 1=Oxic ---> 5=Deep.	unitless
Level_Outlier	Sampling level identifier denoting outliers. 1=Oxic ---> 5=Deep. 0 = Outlier. Abrupt vertical oxygen gradients and the lagged depth control of the MOCNESS tow caused DO values to be less than half or more than double the desired DO values in seven out of 40 nets (M1-Oxic, M1-Hypoxic, M6-Hypoxic, M3-Suboxic, M6-Suboxic, M7-Suboxic and M8-Anoxic). These are the outliers, marked as 0.	unitless

LevelName	Name of the MOCNESS sampling level	unitless
Date	Date of sampling	unitless
Latitude	Latitude of sampling	decimal degrees North
Longitude	Longitude of sampling	decimal degrees East
Depth	Distance from surface ocean in meters	meters (m)
Sal_SA	Absolute salinity	PSU
Temperature	Temperature, conservative TEOS 10	degrees Celsius
Oxygen	Dissolved oxygen	micromoles per kilogram (umol/kg)
Species	Identified species name	unitless
Hab	Habitat according to Moser 1996 and FishBase 2024	unitless
Stage	Fish larvae development stage according to Moser 1996	unitless
Stage1PreFlex	Sequential development stage number (1=flexion, 5=adult). X indicates zooplankton (stage does not apply). Stage 1 is preflexion. 2 is flexion. 3 is postflexion. 4 is transformation. 5 is juveniles/adult.	unitless
Wt	Weight	milligrams (mg)
pcnt_C	Percentage of carbon by elemental analyzer	unitless
d13C	delta C-13	per mil
pcnt_N	Percentage of nitrogen by elemental analyzer	unitless
d15N	delta N-15	per mil
C_N_ratio	Carbon to nitrogen ratio	unitless

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Instruments

Dataset-specific Instrument Name	MOCNESS, SeaBird SBE9+ CTD
Generic Instrument Name	CTD MOCNESS
Dataset-specific Description	A MOCNESS system was used for zooplankton and fish sampling and was equipped with 10 nets of 1 m^2 mouth opening and 333 µm mesh size, a SeaBird SBE9+ CTD, a SeaBird SBE 43 DO sensor, and flow meter and angle sensors.
Generic Instrument Description	The CTD part of the MOCNESS includes 1) a pressure (depth) sensor which is a thermally isolated titanium strain gauge with a standard range of 0-5000 decibars full scale, 2) A Sea Bird temperature sensor whose frequency output is measured and sent to the surface for logging and conversion to temperature by the software in the MOCNESS computer (The system allows better than 1 milli-degree resolution at 10 Hz sampling rate), and 3) A Sea Bird conductivity sensor whose output frequency is measured and sent to the surface for logging and conversion to conductivity by the software in the computer (The system allows better than 1 micro mho/cm at 10 Hz sampling rate). The data rate depends on the speed of the computer and the quality of the cable. With a good cable, the system can operate at 2400 baud, sampling all variables at 2 times per second. One sample every 4 seconds is the default, although the hardware can operate much faster. (From The MOCNESS Manual)

Dataset-specific Instrument Name	elemental analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Carbon and nitrogen isotope ratios were measured at the Boston University Stable Isotope Laboratory using a GV Instruments IsoPrime isotope ratio mass spectrometer coupled with an elemental analyzer.
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	flow meter
Generic Instrument Name	Flow Meter
Generic Instrument Description	General term for a sensor that quantifies the rate at which fluids (e.g. water or air) pass through sensor packages, instruments, or sampling devices. A flow meter may be mechanical, optical, electromagnetic, etc.

Dataset-specific Instrument Name	GV Instruments IsoPrime isotope ratio mass spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Carbon and nitrogen isotope ratios were measured at the Boston University Stable Isotope Laboratory using a GV Instruments IsoPrime isotope ratio mass spectrometer coupled with an elemental analyzer.
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	SeaBird SBE 43 DO sensor
Generic Instrument Name	Sea-Bird SBE 43 Dissolved Oxygen Sensor
Generic Instrument Description	The Sea-Bird SBE 43 dissolved oxygen sensor is a redesign of the Clark polarographic membrane type of dissolved oxygen sensors. more information from Sea-Bird Electronics

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Deployments

SR2114

Website	https://www.bco-dmo.org/deployment/931391
Platform	R/V Sally Ride
Start Date	2021-12-23
End Date	2022-01-21
Description	Additional cruise information is available from R2R: https://www.rvdata.us/search/cruise/SR2114

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Project Information

Collaborative Research: Multiyear autonomous measurement of N-loss in the ETNP ODZ (N-loss in the ETNP ODZ)

NSF Award Abstract:
Several regions of the deep ocean naturally contain almost no oxygen. Because of this lack of oxygen, microbes living in these regions live in ways that differ from those in oxygenated waters consuming nitrate ions instead of oxygen for respiration. Use of nitrate for microbial respiration results in the production of nitrogen gas which is called denitrification. The resulting removal of nitrate has consequences for the whole ocean as nitrogen is an important nutrient controlling plant growth; however, whereas plants can use nitrogen in the form of nitrate, they cannot, with a few exceptions, use nitrogen gas. There remains a number of uncertainties regarding how much denitrification occurs in the ocean, what controls it, and how it varies in time and space.

Traditional studies of ocean denitrification have been limited by the time ships can be at sea and the relatively small proportion of the ocean they can observe. Our project plans to remedy this problem by using vehicles called floats that can operate autonomously in the ocean for three years or more as they drift with currents over hundreds of kilometers. We will outfit ten floats with sensors to measure oxygen and nitrogen gas which will be placed throughout the oxygen-depleted region of the Pacific Ocean to the west of Mexico. This is the largest such region in the ocean from which we have two years of results from a prototype float which validated our approach. This study may well transform our understanding of ocean denitrification and ultimately benefit society as a whole through greater confidence in predictions of the ocean's nitrogen cycle and capacity to fix carbon dioxide under current and future conditions. Application and further development of float systems using commercially available technology will directly benefit successor studies, and more broadly showcase the use of water-following platforms to tackle difficult oceanographic problems. Advances from this study are expected to carry over to other disciplines including ocean biogeochemical modeling. Outreach activities, support for an early career scientist, and student training are included in the project. For the outreach activities, the investigators plan to tie into well-established after-school programs serving underrepresented populations in Massachusetts and established opportunities for public presentations using float related display materials at the University of Washington.

Oxygen deficient zones (ODZs), despite constituting a small fraction of total oceanic volume, play important roles in regulating global ocean carbon and nitrogen cycles including hosting 30 to 50% of the global loss of fixed nitrogen. Unfortunately, current uncertainty in ODZ nitrogen loss derives from substantial temporal and spatial variability in rates that remain under-sampled by ship-based measurements. While local regulation of nitrogen loss by oxygen and organic matter availability are well accepted, temporal/spatial variability in the nitrogen flux is likely a result of the influence of physical forcings such as remote ventilation, seasonal variability, and mesoscale eddies. Understanding how the impact of physical forcings on nitrogen loss as mediated through oxygen and organic flux will be required to fully understand the causes and consequences of any future ODZ expansion. To improve our understanding of ODZ nitrogen loss, we will carry out a multiyear, autonomous float-based observational program to address outstanding questions regarding bioavailable nitrogen loss in ODZs. As the largest ODZ and region of our pilot deployments, our operation area will be the Eastern Tropical N. Pacific (ETNP) where our study will determine over a multi-year period, in-situ nM-level oxygen and biogenic nitrogen on float profiles spanning geographic gradients in oxygen and surface productivity. For the first time, our study will also determine in situ nitrogen loss rates from changes in nitrogen concentration during 1 to 2 week Lagrangian float drifts along a constant density surface. A pilot 2 yr float deployment in the ETNP documents our ability to do so. Critically, our float-based approach more closely matches the frequency and distribution of observations to the expected variability in biogenic nitrogen production as compared to prior work and will dramatically increase the data density for this region by acquiring >500 profiles/drifts for nitrogen and >1000 profiles for nM oxygen.

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
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851361

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