Phytoplankton growth and grazing from flow cytometry in the eastern Indian Ocean

Website: https://www.bco-dmo.org/dataset/852569
Data Type: Cruise Results
Version: 1
Version Date: 2021-05-28

Project
» Collaborative Research: Mesoscale variability in nitrogen sources and food-web dynamics supporting larval southern bluefin tuna in the eastern Indian Ocean (BLOOFINZ-IO)

Program
» Second International Indian Ocean Expedition (IIOE-2)

Contributors	Affiliation	Role
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Abstract
This dataset is from CTD hydrocasts and dilution experiments conducted in the eastern Indian Ocean on R/V INVESTIGATOR cruise IN2019_V03 in May-June 2019, which was part of the IIOE-2 Program. These data are meant to be used in interregional comparisons and modeling as part of the BLOOFINZ-IO study of larval tuna habitat in the eastern IO.

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Coverage

Spatial Extent: **N**:-11.5 **E**:111.4 **S**:-39.5 **W**:110
Temporal Extent: 2019-05-11 - 2019-06-08

Methods & Sampling

We sampled 21 stations, most on a south-to-north transect from 39.5 to 11.5°S along longitude 110°E, west of Australia. Stations were occupied on successive days, with sampling done on a consistent daily schedule, followed by late-night transit between stations. Mean light extinction coefficients determined from morning CTD hydrocasts were used to compute sampling depths corresponding to the transmission characteristics of light-calibrated shipboard incubators. Experimental water was collected on the evening (~21:00 local) hydrocasts at depths corresponding to 75.6, 31.7, 18.0, 7.6, 2.6 and 1.3% Io.

For each depth, we prepared a two-treatment dilution experiment (Landry et al. 2008, 2011), with one polycarbonate bottle (2.7 L) containing unfiltered seawater (100%) and the second (diluted) bottle consisting of ~33% whole seawater with filtered water from the same depth. Seawater was filtered directly from the Niskin

bottles using a peristaltic pump, silicone tubing and an in-line 0.2-µm Suporcap filter capsule that had previously been acid washed. Each bottle was subsampled for flow cytometry (FCM) analysis (2 mL) for initial microbial concentrations, and the bottles were placed in their respective light boxes for 24 h, cooled with constant high flow from the ship's running seawater line. The incubators were covered to protect from deck lighting during nighttime operations and received full solar lighting during the daytime.

Picoplankton FCM samples were preserved with 1% paraformaldehyde and frozen at –80°C. Thawed samples were stained with Hoechst 34580 (1 µg mL-1) and analyzed at a flow rate of 30 µL min-1 with a Beckman-Coulter CytoFLEX-S instrument with 4 lasers (Selph, in review). Side scatter, forward angle light scatter (FALS) and fluorescence signals were collected using laser excitation (EX)/emission (EM) filters of EX375/EM450±45 for Hoechst-stained DNA, EX488/EM690±50 for chlorophyll, and EX561/EM585±42 for phycoerythrin. Listmode files (FCS 3.0) were analyzed with FlowJo software (v.10.6.1) for abundances of *Prochlorococcus* (PRO), *Synechococcus* (SYN), photosynthetic (pico-)eukaryotes (EUK) and heterotrophic bacteria (HBact).

We determined rate profiles for phytoplankton growth (µ, d-1) and microzooplankton grazing (m, d-1) from each pair of dilution experiment bottles and for each FCM population according to the following equations:

$m = (kd - k)/(1 - D)$
and
$\mu = k + m,$

where kd and k are the measured net rates of change between initial and final concentrations in the diluted and undiluted treatments, respectively, and D is the portion of unfiltered water in the dilution treatment (Landry et al., 2008; Selph et al., 2011).

Data Processing Description

Data were processed using FlowJo software (v.10.6.1).

BCO-DMO Processing:
- renamed fields to comply with BCO-DMO naming conventions;
- changed years of '2017' to '2019';
- converted date to YYYY-MM-DD format;
- converted latitude values to negative (to indicate South direction).

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Data Files

File
fcm_in2019.csv (Comma Separated Values (.csv), 15.59 KB) MD5:ca88a98f3548d7e060c0b1e2f93da754 Primary data file for dataset ID 852569

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Related Publications

Landry, M. R., Brown, S. L., Rii, Y. M., Selph, K. E., Bidigare, R. R., Yang, E. J., & Simmons, M. P. (2008). Depth-stratified phytoplankton dynamics in Cyclone Opal, a subtropical mesoscale eddy. Deep Sea Research Part II: Topical Studies in Oceanography, 55(10-13), 1348–1359. doi:10.1016/j.dsr2.2008.02.001
Methods

Landry, M. R., Selph, K. E., Hood, R. R., Davies, C. H., & Beckley, L. E. (2021). Low temperature sensitivity of picophytoplankton P : B ratios and growth rates across a natural 10°C temperature gradient in the oligotrophic Indian Ocean. Limnology and Oceanography Letters, 7(2), 112–121. Portico. https://doi.org/10.1002/lol2.10224
Results

Landry, M. R., Selph, K. E., Taylor, A. G., Décima, M., Balch, W. M., & Bidigare, R. R. (2011). Phytoplankton growth, grazing and production balances in the HNLC equatorial Pacific. Deep Sea Research Part II: Topical Studies in Oceanography, 58(3-4), 524–535. doi:10.1016/j.dsr2.2010.08.011
Methods

Landry, M., Hood, R., & Davies, C. (2020). Mesozooplankton biomass and temperature-enhanced grazing along a 110°E transect in the eastern Indian Ocean. Marine Ecology Progress Series, 649, 1–19. doi:10.3354/meps13444
Results

Selph, K. E. (2021). Enumeration of marine microbial organisms by flow cytometry using near-UV excitation of Hoechst 34580-stained DNA. Limnology and Oceanography: Methods, 19(10), 692–701. Portico. https://doi.org/10.1002/lom3.10454
Methods

Selph, K. E., Landry, M. R., Taylor, A. G., Yang, E.-J., Measures, C. I., Yang, J., … Bidigare, R. R. (2011). Spatially-resolved taxon-specific phytoplankton production and grazing dynamics in relation to iron distributions in the Equatorial Pacific between 110 and 140°W. Deep Sea Research Part II: Topical Studies in Oceanography, 58(3-4), 358–377. doi:10.1016/j.dsr2.2010.08.014
Methods

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Parameters

Parameter	Description	Units
Cruise	Cruise identifier	unitless
Station	Station number	unitless
Date	Sampling date (local); format: YYYY-MM-DD	unitless
Lat	Latitude	degrees North
Long	Longitude	degrees East
CTD	CTD cast number	unitless
pcnt_Io	Light depth (% of incident PAR)	percent
Depth	Depth of sample	meters (m)
Temp	Temperature at collection depth	degrees Celsius
Abun_Pro	Abundance of Prochlorococcus	cells per milliliter (cells/mL)
Grow_Pro	Growth of Prochlorococcus	per day (d-1)
Graz_Pro	Grazing mortality of Prochlorococcus	per day (d-1)
Abun_Syn	Abundance of Synechococcus	cells per milliliter (cells/mL)
Grow_Syn	Growth of Synechococcus	per day (d-1)
Graz_Syn	Grazing mortality of Synechococcus	per day (d-1)
Abun_Euk	Abundance of (pico-)eukaryotes	cells per milliliter (cells/mL)
Grow_Euk	Growth of (pico-)eukaryotes	per day (d-1)
Graz_Euk	Grazing mortality of (pico-)eukaryotes	per day (d-1)
Abun_Hbact	Abundance of heterotrophic bacteria	cells per milliliter (cells/mL)
Grow_HBact	Growth of heterotrophic bacteria	per day (d-1)
Graz_HBact	Grazing mortality of heterotrophic bacteria	per day (d-1)

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Instruments

Dataset-specific Instrument Name	CTD hydrocasts
Generic Instrument Name	CTD - profiler
Generic Instrument Description	The Conductivity, Temperature, Depth (CTD) unit is an integrated instrument package designed to measure the conductivity, temperature, and pressure (depth) of the water column. The instrument is lowered via cable through the water column. It permits scientists to observe the physical properties in real-time via a conducting cable, which is typically connected to a CTD to a deck unit and computer on a ship. The CTD is often configured with additional optional sensors including fluorometers, transmissometers and/or radiometers. It is often combined with a Rosette of water sampling bottles (e.g. Niskin, GO-FLO) for collecting discrete water samples during the cast. This term applies to profiling CTDs. For fixed CTDs, see https://www.bco-dmo.org/instrument/869934.

Dataset-specific Instrument Name	Beckman-Coulter CytoFLEX-S Flow Cytometer
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	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.

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Deployments

IN2019_V03

Website	https://www.bco-dmo.org/deployment/852581
Platform	R/V Investigator
Start Date	2019-05-14
End Date	2019-06-14
Description	Additional voyage details, reports, data, and metadata are available from CSIRO at https://www.marine.csiro.au/data/trawler/survey_details.cfm?survey=IN201... A voyage summary and description of outcomes are available at https://mnf.csiro.au/en/Voyages/IN2019_V03 Summary: Research voyage to the Indian Ocean to conduct an extensive deep ocean survey in support of the 2nd International Indian Ocean Expedition (IIOE-2). Sixty years ago, researchers aboard vessels from 14 countries combined their efforts to explore the largest unknown area on Earth, the deep waters and seabed of the Indian Ocean. This world-first expedition generated a wealth of information and provided a baseline that formed the foundation of our scientific understanding about the Indian Ocean basin. This voyage is a repeat of the 110°E line survey from 1963, which was completed by HMAS Diamantina visiting stations on voyages undertaken every six weeks for a year. RV Investigator will visit 20 stations along a 3000 km transect off the coast of Western Australia during this one month voyage. This will be an integrated whole-of-ocean ecosystem study that includes physical processes, biogeochemistry, nitrogen sources, microbes, primary production, zooplankton, mesopelagic fishes, food webs and whales. The voyage is a major part of Australia's contribution to the UNESCO-led IIOE-2 mission and will provide data to examine the effects of climate change on the waters of the Indian Ocean. The voyage includes only the primary research project but involves significant international collaboration. The science team on this voyage includes 40 participants from 18 institutions - including international participation - as well as scientists and postgraduate students from seven Australian universities.

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Project Information

Collaborative Research: Mesoscale variability in nitrogen sources and food-web dynamics supporting larval southern bluefin tuna in the eastern Indian Ocean (BLOOFINZ-IO)

Coverage: Eastern Indian Ocean, Indonesian Throughflow area, and the Gulf of Mexico

NSF Award Abstract:
The small area between NW Australia and Indonesia in the eastern Indian Ocean (IO) is the only known spawning ground of Southern Bluefin Tuna (SBT), a critically endangered top marine predator. Adult SBT migrate thousands of miles each year from high latitude feeding areas to lay their eggs in these tropical waters, where food concentrations on average are below levels that can support optimal feeding and growth of their larvae. Many critical aspects of this habitat are poorly known, such as the main source of nitrogen nutrient that sustains system productivity, how the planktonic food web operates to produce the unusual types of zooplankton prey that tuna larvae prefer, and how environmental differences in habitat quality associated with ocean fronts and eddies might be utilized by adult spawning tuna to give their larvae a greater chance for rapid growth and survival success. This project investigates these questions on a 38-day expedition in early 2021, during the peak time of SBT spawning. This project is a US contribution to the 2nd International Indian Ocean Expedition (IIOE-2) that advances understanding of biogeochemical and ecological dynamics in the poorly studied eastern IO. This is the first detailed study of nitrogen and carbon cycling in the region linking Pacific and IO waters. The shared dietary preferences of SBT larvae with those of other large tuna and billfish species may also make the insights gained broadly applicable to understanding larval recruitment issues for top consumers in other marine ecosystems. New information from the study will enhance international management efforts for SBT. The shared larval dietary preferences of large tuna and billfish species may also extend the insights gained broadly to many other marine top consumers, including Atlantic bluefin tuna that spawn in US waters of the Gulf of Mexico. The end-to-end study approach, highlights connections among physical environmental variability, biogeochemistry, and plankton food webs leading to charismatic and economically valuable fish production, is the theme for developing educational tools and modules through the

"scientists-in-the-schools" program of the Center for Ocean-Atmospheric Prediction Studies at Florida State University, through a program for enhancing STEM learning pathways for underrepresented students in Hawaii, and through public outreach products for display at the Birch Aquarium in San Diego. The study also aims to support an immersive field experience to introduce talented high school students to marine research, with the goal of developing a sustainable marine-related educational program for underrepresented students in rural northwestern Florida.

Southern Bluefin Tuna (SBT) migrate long distances from high-latitude feeding grounds to spawn exclusively in a small oligotrophic area of the tropical eastern Indian Ocean (IO) that is rich in mesoscale structures, driven by complex currents and seasonally reversing monsoonal winds. To survive, SBT larvae must feed and grow rapidly under environmental conditions that challenge conventional understanding of food-web structure and functional relationships in poor open-ocean systems. The preferred prey of SBT larvae, cladocerans and Corycaeidae copepods, are poorly studied and have widely different implications for trophic transfer efficiencies to larvae. Differences in nitrogen sources - N fixation vs deep nitrate of Pacific origin - to sustain new production in the region also has implications for conditions that may select for prey types (notably cladocerans) that enhance transfer efficiency and growth rates of SBT larvae. The relative importance of these N sources for the IO ecosystem may affect SBT resiliency to projected increased ocean stratification. This research expedition investigates how mesoscale variability in new production, food-web structure and trophic fluxes affects feeding and growth conditions for SBT larvae. Sampling across mesoscale features tests hypothesized relationships linking variability in SBT larval feeding and prey preferences (gut contents), growth rates (otolith analyses) and trophic positions (TP) to the environmental conditions of waters selected by adult spawners. Trophic Positions of larvae and their prey are determined using Compound-Specific Isotope Analyses of Amino Acids (CSIA-AA). Lagrangian experiments investigate underlying process rates and relationships through measurements of water-column 14C productivity, N2 fixation, 15NO3- uptake and nitrification; community biomass and composition (flow cytometry, pigments, microscopy, in situ imaging, genetic analyses); and trophic fluxes through micro- and mesozooplankton grazing, remineralization and export. Biogeochemical and food web elements of the study are linked by CSIA-AA (N source, TP), 15N-constrained budgets and modeling. The project elements comprise an end-to-end coupled biogeochemistry-trophic study as has not been done previously for any pelagic ecosystem.

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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Program Information

Second International Indian Ocean Expedition (IIOE-2)

Website: https://web.whoi.edu/iioe2/

Coverage: Indian Ocean

Description from the program website:
The Second International Indian Ocean Expedition (IIOE-2) is a major global scientific program which will engage the international scientific community in collaborative oceanographic and atmospheric research from coastal environments to the deep sea over the period 2015-2020, revealing new information on the Indian Ocean (i.e. its currents, its influence upon the climate, its marine ecosystems) which is fundamental for future sustainable development and expansion of the Indian Ocean's blue economy. A large number of scientists from research institutions from around the Indian Ocean and beyond are planning their involvement in IIOE-2 in accordance with the overarching six scientific themes of the program. Already some large collaborative research projects are under development, and it is anticipated that by the time these projects are underway, many more will be in planning or about to commence as the scope and global engagement in IIOE-2 grows.

Focused research on the Indian Ocean has a number of benefits for all nations. The Indian Ocean is complex and drives the region's climate including extreme events (e.g. cyclones, droughts, severe rains, waves and storm surges). It is the source of important socio-economic resources (e.g. fisheries, oil and gas exploration/extraction, eco-tourism, and food and energy security) and is the background and focus of many of the region's human populations around its margins. Research and observations supported through IIOE-2

will result in an improved understanding of the ocean's physical and biological oceanography, and related air-ocean climate interactions (both in the short-term and long-term). The IIOE-2's program will complement and harmonise with other regional programs underway and collectively the outcomes of IIOE-2 will be of huge benefit to individual and regional sustainable development as the information is a critical component of improved decision making in areas such as maritime services and safety, environmental management, climate monitoring and prediction, food and energy security.

IIOE-2 activities will also include a significant focus on building the capacity of all nations around the Indian Ocean to understand and apply observational data or research outputs for their own socio-economic requirements and decisions. IIOE-2 capacity building programs will therefore be focused on the translation of the science and information outputs for societal benefit and training of relevant individuals from surrounding nations in these areas.

A Steering Committee was established to support U.S. participation in IIOE-2. More information is available on their website at https://web.whoi.edu/iioe2/.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851558

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