Biogeochemical and microbial parameters collected during diel surveys on a coral reef at Mo'orea's North Shore in French Polynesia in 2021, 2022, and 2023

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Project
» Collaborative Research: Diel dynamics of dissolved organic matter production and remineralization as a driver of coral reef nutrient recycling (Coral Diel)

Contributors	Affiliation	Role
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Abstract
These data include biogeochemical and microbial parameters collected during diel surveys on a coral reef at Mo'orea's North Shore (French Polynesia). Sampling took place in August 2021, March to April of 2022, and August 2023. Seawater samples were collected overlying the coral reef every three hours for three or more consecutive days from ocean-facing forereef sites to backreef sites in the north shore lagoon. A variety of methods were used including colorimetric detection of inorganic nutrients, high-temperature combustion/oxidation, or chemical oxidation for the analysis of dissolved organic carbon (DOC) and particulate organic carbon and nitrogen (POC and PON) concentrations, scanning excitation-emissions fluorescence measurements of whole seawater to quantify fluorescent dissolved organic matter (fDOM), flow cytometry-based cell counts to quantify bacterial abundance, and liquid chromatography coupled to tandem mass spectrometry to identify individual chemical features within marine DOM. These data help to quantify how biogeochemical parameters change over a diel period. This work helps us to better identify external nutrients to the reef and how reef organisms modify and cycle carbon, nitrogen, and phosphorus over the reef. The results may be of use to physical, chemical, and biological oceanographers who study tropical reef systems and could inform other studies in the region, including those conducted as part of the Mo'orea Coral Reef (MCR) Long Term Ecology Research (LTER) program. The samples were collected, measured, and analyzed by Dr. Linda Wegley Kelly (Scripps Institution of Oceanography) and Dr. Craig Nelson (SOEST, University of Hawaii).

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Coverage

Location: Mo'orea North Shore, French Polynesia
Spatial Extent: **Lat**:-17.47722 **Lon**:-149.84258
Temporal Extent: 2021-08-11 - 2023-08-25

Methods & Sampling

Sampling Dates:
2021:
Gump Station, Moorea, French Polynesia
Aug 10 to Aug 19, 2021
Chief Scientist - Linda Wegley Kelly (SIO, lwegley@ucsd.edu)

2022:
Gump Station, Moorea, French Polynesia
Mar 29 to Apr 15, 2022
Chief Scientist - Linda Wegley Kelly

2023:
Gump Station, Moorea, French Polynesia
Aug 17 to Aug 25, 2023
Chief Scientist - Linda Wegley Kelly

Sample Collection. At every site on the fore- or backreef, salinity and temperature were measured using Manta Probes multi-parameter sondes (Eureka Instruments). Approximately 1.2 liters (L) of reef water was collected via peristalsis through 0.2 micrometer (µm) polyethersulfone filter cartridges (Sterivex, Millipore, UK) directly into durable, food-grade, flexible pouches (1.5 liter, blended foil and EVOH (ethylene vinyl alcohol) plastic, AstraPouch) before being transported to the laboratory for further processing. Ten milliliters (mL) of whole seawater was also collected into a syringe using peristalsis and immediately fixed with paraformaldehyde at a final concentration of 0.5% for subsequent flow cytometry analysis of microbial abundances. The Sterivex filtrate was used to rinse bottles to collect samples for inorganic nutrients, which were frozen and stored at -40 degrees Celsius (°C). For dissolved organic carbon (DOC) measurements, Sterivex filtrate was used to triple sample-rinse borosilicate vials with Teflon septa caps before collecting 40 mL (for deployment 2 and 3 in duplicates). Additionally, 500 mL of filtrate was transferred to triple-rinsed polycarbonate bottles for solid-phase dissolved organic matter (DOM) extraction. DOC and DOM samples were acidified to pH 2 using trace metal grade HCl. Acidified DOM samples were solid-phase extracted using the multichannel pump operating at a flow rate of 18 mL per minute onto Bond Elut PPL resin cartridges (200 milligrams (mg) bed mass, Agilent 2105005, USA). After desalinating the resin with LC-MS grade water (Fisher Chemical, Belgium), the cartridges were dried using Ultra High Purity compressed N_2 gas and kept frozen at -40°C.

Biogeochemical Measurements. Inorganic nutrients were analyzed using a Seal AA3 Segmented Flow Injection Autoanalyzer at the University of Hawai'i SOEST Laboratory for Analytical Biogeochemistry: Nitrate+nitrite (N+N) and silicate concentrations, ammonium, phosphate. Additionally, total dissolved nitrogen and total dissolved phosphorus were determined through separate injections, with UV and alkaline or acid persulfate in-line oxidation, respectively. DOC samples were analyzed using high-temperature platinum catalytic oxidation on a Shimadzu TOC-V at the University of Hawaii SOEST Laboratory. The analysis of fluorescent dissolved organic matter (fDOM) was conducted using a Horiba Aqualog scanning fluorometer. Samples for microbial cell concentrations were thawed and 200 microliters (µL) of each sample was stained with SYBR Green I stain for a final concentration of 1X. Bacterial cell counts were enumerated using an Attune Acoustic Focusing Cytometer (Applied Biosystems).

Note that while the instruments were the same from year to year, samples were not all run at the same time.

Data Processing Description

The shared data is unprocessed.

BCO-DMO Processing Description

- Imported three original CSV files, Diel2021_BCODMO_Wegley_Kelly_Nelson.17Dec2025.csv, Diel2022_BCODMO_Wegley_Kelly_Nelson.17Dec2025.csv, and Diel2023_BCODMO_Wegley_Kelly_Nelson.17Dec2025.csv into the BCO-DMO data processing system.
- Treated "NA" as a missing data value (missing data are empty/blank in the final CSV file).
- Added a constant integer column Survey_Year with values 2021, 2022, and 2023 to their respective rows.

- Renamed multiple columns to standardize names across files and to comply with BCO-DMO naming conventions.
- Concatenated all three tables into a single combined table, mapping all 40 columns by name.
- Computed a new "ISO_DateTime_Local" datetime column by combining "Time" (format %H:%M) and "Date" (format %m/%d/%Y) columns, output formatted as %Y-%m-%dT%H:%M.
- Computed a new "ISO_DateTime_UTC" datetime column by combining the same "Time" and "Date" columns, interpreting the input as HST timezone and converting output to UTC, formatted as %Y-%m-%dT%H:%MZ.
- Added constant Latitude column ("-17.47722") and Longitude column ("-149.84258") to all rows, representing the general sampling area coordinates.
- Saved the final file as "1003286_v1_moorea_n_shore_diel_2021-2023.csv".

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Data Files

File
1003286_v1_moorea_n_shore_diel_2021-2023.csv (Comma Separated Values (.csv), 186.92 KB) MD5:e71134104fb70686f54e9e042251fb2b Primary data file for dataset ID 1003286, version 1

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Related Datasets

IsRelatedTo

Kelly, L. W. (2021). *MassIVE MSV000088164 - Moorea2021_Diel_PearlJam_Recharge* [Dataset]. MassIVE. https://doi.org/10.25345/C5NZ7Q

Kelly, L. W. (2025). *MassIVE MSV000099559 - GNPS - Coral Reef Seawater DOM Moorea, French Polynesia (2024)* [Dataset]. MassIVE. https://doi.org/10.25345/C5QB9VJ9R

Lihini Aluwihare. (2022). MassIVE MSV000090798 - GNPS Mo'orea 2022 DOM Positive and Negative Mode [Data set]. MassIVE. https://doi.org/10.25345/C5S46HB1G

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Parameters

Parameter	Description	Units
Survey_Year	Year of sample collection	unitless
MooreaCode	Numeric identifier for each individual sample	unitless
SampleID	Unique identifier for each individual sample	unitless
Experiment	Name of Experiment	unitless
Location	Sampling Location	unitless

Campaign	Name of the Campaign in which the Experiment was done	unitless
ISO_DateTime_Local	Local date and time converted to ISO 8601 format; Time zone = HST (UTC-10)	unitless
ISO_DateTime_UTC	Date and time converted to ISO 8601 format and converted to UTC time zone	unitless
Time	Time of collection	unitless
Date	Date of collection	unitless
MASSIVE_mass_spec_sample_code	Identification number for mass spectrometry data deposited on MassIVE (https://massive.ucsd.edu/)	unitless
PPLVol	Volume of seawater collected onto solid phase extraction resin	milliliters
Notes	Notes on sampling	unitless
Replicate	Codes A and B or open and closed to denote paired samples	unitless
Syringe_Autosampler	Name of Autosampler used for Syringe FCM sample	unitless
Syringe_Channel	Channel of Autosampler used for Syringe FCM sample	unitless
Bag_Autosampler	Name of Autosampler used for Bag chemistry sample	unitless
Bag_Channel	Channel of Autosampler used for Bag chemistry sample	unitless
Total_N	Total Nitrogen concentration in micromoles per liter (umol/L)	micromoles per liter
Total_P	Total Phosphorus concentration in micromoles per liter (umol/L)	micromoles per liter
Phosphate	Phosphate concentration in micromoles per liter (umol/L)	micromoles per liter

Silicate	Silicate concentration in micromoles per liter (umol/L)	micromoles per liter
N_N	Nitrate + Nitrite concentration in micromoles per liter (umol/L)	micromoles per liter
Ammonia	Ammonia concentration in the water sample in micromoles per liter (umol/L)	micromoles per liter
NPOC	Dissolved Organic Carbon concentration in micromoles per liter (umol/L)	micromoles per liter
Stdev_NPOC	Standard deviation of Dissolved Organic Carbon concentration, micromoles per liter (umol/L)	micromoles per liter
M_to_C	Humic to Protein-like ratio in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
BIX	Biological Index in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
HIX	Humification Index in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
FI	Fluorescence Index in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
CobleA	Ultra Violet Humic-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
CobleM	Marine Humic-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
CobleC	Visible Humic-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
CobleT	Tyrosine-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
CobleB	Tryptophan-like: Tryptophan-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
Fpeak	Generic Humic-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water

Stedmon_D	Fulvic Acid-like: Fulvic Acid-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
Lignin	Lignin-like component in Raman Fluorescence Units of Water	Raman Fluorescence Units of Water
HBact	Heterotrophic bacterioplankton concentration in cells per microliter (cells/uL)	cells per microliter
PEuk	PicoEukaryotes cell concentration in cells per microliter (cells/uL)	cells per microliter
Syn	Synechococcus cell concentration in cells per microliter (cells/uL)	cells per microliter
Pro	Prochlorococcus cell concentration in cells per microliter (cells/uL)	cells per microliter
Latitude	Latitude of the general sampling area	decimal degrees
Longitude	Longitude of the general sampling area	decimal degrees

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Instruments

Dataset-specific Instrument Name	Seal AA3 Segmented Flow Injection Autoanalyzer
Generic Instrument Name	Bran+Luebbe / SEAL Analytical AutoAnalyzer 3 (AA3) continuous-flow analyzer
Dataset-specific Description	Inorganic nutrients were analyzed using a Seal AA3 Segmented Flow Injection Autoanalyzer at the University of Hawai'i SOEST Laboratory for Analytical Biogeochemistry.
Generic Instrument Description	The AutoAnalyzer 3 (AA3) is a segmented continuous-flow analyzer (continuous flow analyzer, CFA) used for automated colorimetric analysis of dissolved nutrients and other analytes in environmental, seawater, freshwater, wastewater, soil, and agricultural samples. The AA3 was originally manufactured by Bran+Luebbe and, following acquisition of the product line in 2006, has continued to be manufactured and supported by SEAL Analytical. The AA3 is the third-generation instrument in the Technicon AutoAnalyzer family and is widely used for determination of nitrate, nitrite, ammonium, phosphate, silicate, and other dissolved nutrients. See the description from the manufacturer.

Dataset-specific Instrument Name	Attune Acoustic Focusing Cytometer (Applied Biosystems)
Generic Instrument Name	Flow Cytometer
Dataset-specific Description	Bacterial cell counts were enumerated using an Attune Acoustic Focusing Cytometer (Applied Biosystems).
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. Description from: http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm

Dataset-specific Instrument Name	Horiba Aqualog scanning fluorometer
Generic Instrument Name	Horiba Aqualog spectrofluorometer
Dataset-specific Description	The analysis of fluorescent dissolved organic matter (fDOM) was conducted using a Horiba Aqualog scanning fluorometer.
Generic Instrument Description	A benchtop optical spectrometer suitable for measuring coloured dissolved organic matter (CDOM). Outputs include absorbance spectra, fluorescence emission spectra, and fluorescence excitation-emission matrices. This instrument simultaneously measures absorbance spectra and fluorescence Excitation-Emission Matrices. It employs the Absorbance-Transmission Excitation Emission Matrix (A-TEEM) technique to acquire an Excitation Emission Matrix.

Dataset-specific Instrument Name	Shimadzu TOC-V
Generic Instrument Name	Shimadzu TOC-V Analyzer
Dataset-specific Description	DOC samples were analyzed using high-temperature platinum catalytic oxidation on a Shimadzu TOC-V at the University of Hawaii SOEST Laboratory.
Generic Instrument Description	A Shimadzu TOC-V Analyzer measures DOC by high temperature combustion method.

Dataset-specific Instrument Name	Manta Probes multi-parameter sondes (Eureka Instruments)
Generic Instrument Name	Water Quality Multiprobe
Dataset-specific Description	Salinity and temperature were measured using Manta Probes multi-parameter sondes (Eureka Instruments).
Generic Instrument Description	An instrument which measures multiple water quality parameters based on the sensor configuration.

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Project Information

Collaborative Research: Diel dynamics of dissolved organic matter production and remineralization as a driver of coral reef nutrient recycling (Coral Diel)

Coverage: Mo'orea, Moorea-Maiao, French Polynesia

This project develops a core understanding of diel microbial ecology and biogeochemistry in coral reef ecosystems. It contextualizes how crucial nutrient recycling processes vary across gradients of coral cover and nutrient availability, two factors highlighted as the main drivers of reef decline in the Anthropocene, making the results useful to managers seeking to enhance ecosystem-based approaches to reef restoration. The investigators are collecting diel measurements of microbial and biogeochemical processes at coral reefs around Mo'orea at the Long Term Ecological Research site there (MCR-LTER). They are using established spatial gradients of benthic cover, from coral to macroalgal dominance, and nutrient inputs. Overall the research improves our understanding of how these key environmental factors influence diel microbe-DOM interactions and nutrient recycling. The ongoing macroalgal phase shifts observed at Mo'orea are hypothesized to be related to nutrient pollution, and this work directly informs understanding of how these changes are impacting nutrient cycling in the reefs of Mo'orea. The training of several undergraduate students and two graduate students, one in Biology and one in Oceanography is shared between two minority serving institutions of higher education. The project also supports active outreach programs with the Ocean Discovery Institute focused on engaging underrepresented high school students in ocean-oriented careers in San Diego, and with the UH College Sea Grant Program to support coral reef resilience initiatives locally in Hawai'i.

Coral reefs exhibit some of the highest rates of primary production and decomposition of any ecosystem type yet persist in some of the most oligotrophic waters on the planet, implying tight recycling of macronutrients through organic matter. The last half century of work on the biogeochemistry of reefs have highlighted this bacterial decomposition of organic matter as a likely mechanism for maintaining nutrient retention and reef productivity. This project applies modern metagenomics and untargeted metabolomics to test clearly defined hypotheses of how diel microbe-DOM interactions drive nutrient recycling and retention in reefs. The investigators are first resolving coupled in situ diel dynamics of organic and inorganic C, N and P (using bulk elemental and spectroscopic methods), microbial abundances and population structures (using DNA sequencing and flow cytometry) and the chemical composition of DOM (using untargeted tandem mass spectrometry) in multiple reef habitats across a gradient of benthic cover and nutrient availability. These patterns inform the second in situ diel sampling campaign resolving the dynamic coupling of metabolic pathways (using metagenomics), exoenzymatic activity (using transcriptomics and enzyme assays) and transformations of specific metabolites (tracked via molecular networking) to distill common mechanisms of microbial organic matter decomposition that play a role in nutrient cycling. This project is being conducted within the Moorea Coral Reef Long Term Ecological Research program, leveraging a wealth of time series data on multiple reef habitats as well as contextualizing our in situ sampling with ongoing physical, geochemical and biological monitoring programs. By integrating cutting edge molecular approaches with well-established techniques in field ecology and microbial oceanography, this research program identifies key microbial and molecular players in the nutrient decomposition and remineralization processes long hypothesized to be central to maintaining healthy reefs.

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-2118617
NSF Division of Ocean Sciences (NSF OCE)	OCE-1949033

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