

Results of a study examining how foundation species loss alters fDOM and heterotrophic bacteria counts based on sampling of tidepools in the Otter Rock Marine Reserve (ORMR) and Marine Garden, Oregon USA from June to August 2019

Website: <https://www.bco-dmo.org/dataset/1009817>

Data Type: Other Field Results

Version: 1

Version Date: 2026-10-13

Project

» [CAREER: Predicting ecosystem metabolism of rocky intertidal communities in warming and acidifying oceans.](#)
(TIDES)

Contributors	Affiliation	Role
Silbiger, Nyssa	University of Hawai'i at Mānoa (HIMB)	Principal Investigator
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Abstract

Benthic–pelagic coupling, the reciprocal exchange of materials between benthic and pelagic habitats, has traditionally emphasized pelagic influences on benthic systems. Yet, the role of benthic biological processes in shaping pelagic microbial dynamics remains under explored. We investigated how surfgrass and mussels regulate nitrogen and dissolved organic matter (DOM) cycling and their cascading effects on heterotrophic bacteria in Oregon tide pools. We quantified biogeochemical fluxes and bacterial responses before and after foundation species removal during contrasting upwelling regimes. Mussel-dominated pools released high concentrations of ammonium and nitrate, while surfgrass pools transformed DOM that fueled bacterial growth; upwelling intensified these benthic–pelagic linkages. Removing foundation species dampened nutrient release in mussel pools and reduced DOM-fueled bacterial growth in surfgrass pools, ultimately decoupling benthic productivity from pelagic microbial growth. Our results demonstrate the critical role of foundation species to pelagic microbial processes and underscore the vulnerability of coastal microbial dynamics to their global decline. Here we present the fDOM and heterotrophic bacteria data.

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Coverage

Location: Otter Rock Marine Reserve (ORMR) and Marine Garden, Oregon USA (44° 45' 09.1", N, 124° 03' 58.0" W)

Spatial Extent: Lat:44.752528 Lon:-124.066111
Temporal Extent: 2019-07-09 - 2019-08-06

Methods & Sampling

fDOM samples were stored in amber glass vials at 4 °C until further processing. Heterotrophic bacterial counts were taken from 1.5 mL unfiltered seawater and stored in 0.5% paraformaldehyde (amended with 100 µL 8% ampulated paraformaldehyde, Electron Microscopy Sciences, Hatfield, PA, USA) in a 2 mL polypropylene cryovial, mixed briefly and then frozen to -20 °C. All storage vials were triple rinsed with sample water prior to sample storage. fDOM samples were processed on a Horiba Aqualog scanning fluorometer with 1 cm quartz cuvettes at the University of Hawai'i at Mānoa following Nelson et al. (2015).

All samples were brought to room temperature prior to analysis. Prior to running samples, cuvettes were washed thoroughly with DI water and wiped clear with Kim wipes. Cuvettes were triple rinsed with DI between each sample. A DI blank was run after every 7 samples. Excitation-Emission Matrices (EEMS) were generated with excitation values ranging from 240 nm to 500 nm and emission values were measured ranging from 250 nm to 825 nm.

Excitation wavelengths were increased at 5 nm increments and measurements were integrated over 4 s at each increment. Inner filter correction was applied to account for fluorescence quenching by absorbance (Kothawala et al. 2013). Fluorescence values were scaled to Raman Units by dividing by the integrated emission range of 381 nm to 426 nm at an excitation of 350 nm in averaged DI blanks. The average blank EEMs, from DI blanks run immediately before and after each set of samples, were subtracted from the sample EEMs.

Two biogeochemical informative indices were calculated for this study which included M:C (the relative amount of marine to terrestrial humics) (Burdige et al. 2004) and BIX (biological index) (Huguet et al. 2009). Heterotrophic bacterial counts were analyzed using flow cytometry on an Attune Acoustic Focusing Cytometer with Autosampler Attachment (Life Technologies, Eugene, OR, USA) with methods following Nelson et al. (2015).

Flow cytometry samples were analyzed on fixed 1ml samples run on a Cytoflex Flow Cytometer stained with 7 µL of 40 µL mL⁻¹ Hoechst 34580 (1 µg mL⁻¹, final concentration) following standard protocols (Nelson et al. 2015; Selph 2021).

Stained cells were distinguished from instrument noise using stained and unstained blank water, and autofluorescent cells containing phytopigments were subtracted from the total to derive the subset of heterotrophic bacterioplankton.

Data Processing Description

R code and data files used for statistical analysis and figure generation for the results publication Silbiger et al. (2025). The fDOM and heterotrophic bacteria in this BCO-DMO dataset were incorporated into the joined data file used for analysis and plotting. All data and code are available at <https://github.com/njsilbiger/Intertidal-Benthic-Pelagic> and at <https://doi.org/10.5281/zenodo.17717287> on Zenodo (Silbiger 2025).

BCO-DMO Curation Notes

Curation Actions Performed on Data File

- Loaded fDOM_bacteria_Silbiger2026.csv using the first row as headers and treating empty strings and NA as missing values. The table was named 1009817_v1_tidal_fdom_and_heterotrophic_bacteria_counts.
- Converted sampling_day to a date formatted as %Y-%m-%d and sampling_time to a time formatted as %H:%M:%S. Renamed these fields to sampling_date and sampling_time_local, respectively.
- Combined the local sampling date and time, interpreted in the Canada/Pacific timezone, into a new ISO_DateTime.UTC field formatted as %Y-%m-%dT%H:%M:%SZ.
- Standardized column order and assigned appropriate data types, including strings for categorical and identifier fields, numbers for bacterial counts and fluorescence-related measurements, and date, time, and datetime types for temporal fields.

- Added taxonomic metadata based on foundation_spp: LSIDs and AphialDs for Mytilus and Phyllospadix, with "none" for Ocean samples. Taxonomic level and status values were also evaluated during processing.
- Removed the intermediate taxon_level, status, and rand columns and finalized the column order and data types.
- Updated parameter metadata, including descriptions, standard names, and units, and designated ISO_DateTime_UTC as a primary parameter.
- Saved the processed data as 1009817_v1_tidal_fdom_and_heterotrophic_bacteria_counts.csv.

Problem Description

Any NA's in the dataset are from missing values or contamination.

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Data Files

File
1009817_v1_tidal_fdom_and_heterotrophic_bacteria_counts.csv (Comma Separated Values (.csv), 20.51 KB) MD5:85e2b120379bef22e31f56803e73f49f Primary data file for dataset ID 1009817, version 1

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Related Publications

Burdige, D. J., Kline, S. W., & Chen, W. (2004). Fluorescent dissolved organic matter in marine sediment pore waters. *Marine Chemistry*, 89(1-4), 289-311. <https://doi.org/10.1016/j.marchem.2004.02.015>
Methods

Huguet, A., Vacher, L., Relexans, S., Saubusse, S., Froidefond, J. M., & Parlanti, E. (2009). Properties of fluorescent dissolved organic matter in the Gironde Estuary. *Organic Geochemistry*, 40(6), 706-719.
doi:[10.1016/j.orggeochem.2009.03.002](https://doi.org/10.1016/j.orggeochem.2009.03.002)
Methods

Kothawala, D. N., Murphy, K. R., Stedmon, C. A., Weyhenmeyer, G. A., & Tranvik, L. J. (2013). Inner filter correction of dissolved organic matter fluorescence. *Limnology and Oceanography: Methods*, 11(12), 616-630. doi:[10.4319/lom.2013.11.616](https://doi.org/10.4319/lom.2013.11.616)
Methods

Nelson, C. E., Donahue, M. J., Dulaiova, H., Goldberg, S. J., La Valle, F. F., Lubarsky, K., ... Thomas, F. I. M. (2015). Fluorescent dissolved organic matter as a multivariate biogeochemical tracer of submarine groundwater discharge in coral reef ecosystems. *Marine Chemistry*, 177, 232-243.
doi:[10.1016/j.marchem.2015.06.026](https://doi.org/10.1016/j.marchem.2015.06.026)
Methods

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

Silbiger, N. J., Fields, J. B., Nelson, C. E., & Kelly, L. W. (2025). Foundation Species Modulate Microbial Benthic-Pelagic Coupling in the Rocky Intertidal. *Ecology Letters*, 28(12). Portico. <https://doi.org/10.1111/ele.70301>
Results

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Related Datasets

IsRelatedTo

Silbiger, N., Fields, J. (2022) **Results of a study examining how foundation species loss alters multiple ecosystem functions based on community surveys and biogeochemical sampling of tidepools in the Otter Rock Marine Reserve (ORMR) and Marine Garden, Oregon USA from June to August 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-09-07 doi:10.26008/1912/bco-dmo.878413.1 [[view at BCO-DMO](#)]

Relationship Description: The associated nutrient dataset contains complementary measurements of nutrient concentrations and fluxes that provide biogeochemical context for the fDOM and heterotrophic bacteria measurements presented here.

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Parameters

Parameter	Description	Units
ISO_DateTime_UTC	Datetime of sample collection in UTC derived from the local date and time values.	unitless
pool_id	Unique identifier for each experimental tide pool or ocean reference sample.	unitless
foundation_spp	Dominant foundation species associated with the sampling location (e.g., <i>Phyllospadix</i> , <i>Mytilus</i> , Ocean).	unitless
LSID	LSID of foundation_spp value.	unitless
aphialD	AphialD of foundation_spp value	unitless
day_night	This field indicates if sampling took place during the day or at night.	unitless
before_after	Sampling period before or after experimental foundation species removal.	unitless
removal_control	Experimental treatment indicating removal or control plot.	unitless
time_point	Unique sampling event indicating the start or end of low tide	unitless
sampling_date	Calendar day on which the sample was collected.	unitless
sampling_time_local	Time of sample collection. Pacific Time.	unitless
heterotrophic_bacterioplankton_micro_I	Abundance of heterotrophic bacterioplankton measured by flow cytometry.	cells uL ⁻¹
m_c	Freshness Index (M:C) ratio derived from fluorescence excitation-emission matrices measured with a HORIBA Aqualog fluorometer.	unitless
bix	Biological Index (BIX) calculated from fluorescence excitation-emission matrices as an indicator of recently produced dissolved organic matter.	unitless

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Instruments

Dataset-specific Instrument Name	Cytoflex Flow Cytometer
Generic Instrument Name	Flow Cytometer
Dataset-specific Description	Used for flow cytometric quantification of microbial cells in water samples based on fluorescence and light scatter characteristics. Data acquisition and analysis were performed using CytExpert software. The CytoFLEX platform utilizes avalanche photodiode (APD) detectors for high-sensitivity fluorescence detection. Calibration: Instrument performance was verified using the manufacturer's daily quality control (QC) procedures with fluorescent calibration beads according to Beckman Coulter recommendations prior to sample analysis.
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	Fluorometer
Dataset-specific Description	Manufacturer: HORIBA Scientific Model: Aqualog® Scanning Fluorometer Purpose: Used to measure excitation-emission matrices (EEMs) and absorbance spectra of fluorescent dissolved organic matter (fDOM) in water samples. Calibration: Instrument calibration was performed using HORIBA-recommended procedures, including quinine sulfate fluorescence standardization and wavelength/intensity calibration as appropriate. Instrument software automatically applies corrections for inner-filter effects and Rayleigh/Raman scattering.
Generic Instrument Description	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

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Project Information

CAREER: Predicting ecosystem metabolism of rocky intertidal communities in warming and acidifying oceans. (TIDES)

Coverage: California, USA

NSF Award Abstract:

This award is funded in whole or in part under the American Rescue Plan Act of 2021 (Public Law 117-2).

The devastating impacts of global warming and ocean acidification (OA) on rocky intertidal ecosystems are expected to increase as the oceans continue to warm and acidify. Further, loss of critical foundation species as a result of anthropogenic stressors lead to changes in local conditions that alter ecosystem functioning. While data exist on the physiological response of individual organisms to OA and warming in rocky systems, far less research has been conducted on community and ecosystem-scale metabolic responses. The proposed work

provides a critical step in understanding how altered environmental conditions affect ecosystem functioning in rocky intertidal systems through the combination of controlled laboratory studies, field experiments, and a synthetic modeling approach integrating experimental results with pre-existing time-series data. The proposed work is focused on the overarching question: How does shifting environmental variability and loss of foundation species interact to affect ecosystem functioning in rocky intertidal communities? The PI is integrating research with ecological and quantitative educational opportunities including classroom and hands-on training in lab/field methods in marine ecology, and data science and coding bootcamps for undergraduate students. Importantly, these opportunities financially and educationally support traditionally underrepresented students at one of the largest minority-serving institutions in the country. This project provides support for intensive mentoring and training for 35 undergraduate students (25 in data science and 10 in field/lab science, all paid), 2-3 masters students, and hands-on marine ecology opportunities in the classroom (~125 students). In addition to formal education, the PI is collaborating with an artist-in-residence to communicate science to the broader public through interactive and immersive art installations in Los Angeles.

Because rocky intertidal systems provide important ecosystem services including food production, coastal protection, and tourism, it is critical to understand how warming (both air and ocean), acidification, and altered community states affect reef-scale ecosystem metabolism. While information exists on responses of a variety of individual intertidal taxa to temperature stress, ocean acidification, and habitat loss, there is notably less on the response of ecosystem metabolism (e.g. NEP and NEC) to these stressors. This proposed work is focused on a series of conceptual knowledge gaps and tests mechanisms through which different warming regimes, lowered pH, and community disturbance lead to altered community metabolism and ultimately affect ecosystem function. Specifically, this study: 1) Describes community thermal performance curves of multiple ecosystem functions under differing pH conditions in experimental mesocosms, 2) characterizes drivers of ecosystem functioning (e.g. Net Ecosystem Production [NEP] and Net Ecosystem Calcification [NEC]) in situ using natural changes in environmental variability before and after a disturbance, and 3) integrates 16 years of publicly available community composition and environmental time-series data with lab and field data to hindcast ecosystem metabolic rates and predict how ecosystem metabolism may change in the future.

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-2044837

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