Water chemistry and temperature measured within and above dense aggregation of mussels from a flume experiment conducted July 2023

Website: https://www.bco-dmo.org/dataset/982681
Data Type: experimental
Version: 1
Version Date: 2025-08-18

Project
» Collaborative Research: Microscale interactions of foundation species with their fluid environment: biological feedbacks alter ecological interactions of mussels (Microscale Mussels)

Contributors	Affiliation	Role
Reidenbach, Matthew	University of Virginia (UVA)	Co-Principal Investigator
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Abstract
The project investigates how the metabolic activity of dense aggregations of marine organisms alter the water chemistry of their interstitial spaces, and how these microscale alterations feedback to affect the organisms' interactions in coastal ecosystems. The research evaluates whether corrosive chemical microclimates (such as low oxygen or low pH) are most extreme in low flow, high temperature conditions, especially for dense aggregations of mussels with large biomass and/or high respiration rates, and if they negatively impact mussel beds and the diverse biological communities they support. In order to address these questions, a flume experiment was conducted at Friday Harbor Laboratories where flow and chemical gradients were measured within and above a dense aggregation of mussels (Mytilus trossolus). Twenty profiles were taken over five days with 5 profiles taken for each of the four experimental flume speeds (0.25, 0.5, 1, and 1.5 inch/sec). Approximately 3-minute-long measurements were taken of velocity, dissolved oxygen, temperature, and pH every centimeter within the bed and two measurements were taken above the bed. Ambient conditions (dissolved oxygen, temperature, pH and conductivity) were also measured continuously using an array of HOBO loggers.

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Coverage

Location: Friday Harbor Laboratories Flume Lab, Friday Harbor Washington 98250
Spatial Extent: **Lat**:48.546342 **Lon**:-123.011393
Temporal Extent: 2023-07-24 - 2023-07-28

Dataset Description

This data is from a flume experiment undertaken at Friday Harbor Laboratories in July 2023 as part of a project investigating how the metabolic activity of marine organisms can alter the water chemistry of their interstitial spaces, and how these microscale alterations affect interactions in coastal ecosystems.

This dataset presents:

1. Bulk seawater chemistry measurements using HOBO loggers for dissolved oxygen, pH/Temp, and Conductivity
2. Interstitial water chemistry measurements using Pyroscience microsensors for oxygen, pH, and temperature

Additional data on velocity and turbulence measurements using a Nortek Vectrino can be viewed at https://www.bco-dmo.org/dataset/982717 (see also Related Datasets section below).

Methods & Sampling

A flume experiment was conducted at Friday Harbor Laboratories where flow and chemical gradients were measured within and above a dense aggregation of mussels (Mytilus trossolus). Four experimental flume speeds were examined: Q=quarter inch per second, H=half inch per second, O=one inch per second, and OH=one and a half inches per second. Data collection occurred over five days (July 24-28th, 2023) with a complete set of profiles measured at each background speed (n=4) every day. This led to a total of 20 profiles taken at 5 mussel bed locations, including 5 replicates of chemistry profiles and 3 replicates of velocity profiles at each of the background speeds: 0.25, 0.5, 1, 1.5 inch/sec or 0.6, 1.3, 2.5, 3.8 cm/sec respectively. A background velocity in inches was initially used because this was how the flume's motor was set up.

Bulk seawater chemistry sensors consisted of a collection of Onset HOBO loggers. A dissolved oxygen (U26-001), pH/Temperature (MX2501) and Conductivity (U24-002-C) logger were used to measure ambient water chemistry in the experimental flume during the trials. The array of three loggers were bound with a zip tie and placed at the downstream end of the flume's working section at a depth of approximately 5 cm.

Interstitial seawater chemistry was measured with a collection of Pyroscience microsensors. A micro-oxygen (OXROB10-CL4), pH (PHROBSC-PK8T), and temperature sensor (TSUB21) were used in tandem to quantify water chemistry within the interstitial spaces of a mussel bed. The three sensors were connected to a Firesting-PRO 2-channel, a compact USB-powered fiber-optic meter which was further connected to a laptop for data collection. The meter has an internal pressure sensor (mbar) that measures atmospheric pressure and automatically compensates for oxygen values. The measuring frequency was set to one second (1s) for all sensors. Both the pH and DO probes required calibration. For the oxygen probe, a 2-point calibration was performed with 100% and 0% air saturation. The 0% calibration came factory completed, so only the 100% calibration was performed. A small flask of experimentally relevant water (local seawater) had an air stone placed into it for 15 minutes to reach 100% air saturation, and then a calibration was performed according to the instrument manual. For the pH probe, a 2-point calibration was performed using Pyroscience pH tablets that were combined with 100mL of DI water to create standards of pH 2 and pH 11 for calibration, as stated in the instrument manual.

Data Processing Description

Data frequency was once per minute for HOBO measurements and once per second for Pyroscience measurements so columns where second by second data wasn't important for analysis have missing data due to difference in measurement frequency between the sensors. Data filled for HOBO pH was linearly interpolated in order to allow for second by second comparison of water chemistry parameters.

For both the Pyroscience (interstitial) and HOBO (ambient) dissolved oxygen sensors, the raw values were adjusted for the measured salinity. These values are labeled DO Adj. conc in the datasets. For the HOBO data, processing was done using HOBOwarePro and the raw data from the conductivity sensor. For the Pyroscience data, processing was done in the Pyroscience Data Inspector and an average salinity of 27.5 ppt was used for the measurements as this was the average salinity of the week and the salinity ranged from 27.3 - 27.6 ppt which creates an insignificant difference in the oxygen adjustment (less than 0.01).

BCO-DMO Processing Description

- Imported data from source files: VPH_Complete.xlsx, VPOH_Complete.xlsx, VPO_Complete.xlsx, VPQ_Complete.xlsx, VP2H_Complete.xlsx, VP2OH_Complete.xlsx, VP2O_Complete.xlsx, VP2Q_Complete.xlsx, PH_Complete.xlsx, POH_Complete.xlsx, PO_Complete.xlsx, PQ_Complete.xlsx, P2H_Complete.xls, P2OH_Complete.xlsx, P2O_Complete.xlsx, P2Q_Complete.xlsx, VP3H_Complete.xlsx, VP3OH_Complete.xlsx, VP3O_Complete.xlsx, VP3Q_Complete.xlsx,
- Concatenated all files into a single CSV file
- Combined Date and Time columns for both Pyro and HOBO dates.
- Added new columns for Day_of_Week and removed HOBO Day
- Added new column for Trial
- Sorted by Pyro_Date

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Related Publications

Onset Computer Corporation. (n.d.). HOBOware Pro Operating Manual (Doc #: 12730-MAN-BHW-UG). Retrieved August 21, 2025, from https://www.onsetcomp.com/support/manuals/12730-MAN-BHW-UG https://www.onsetcomp.com/resources/documentation/12730-hoboware-users-guide
Software

O'Donnell, M. (2008). Reduction of wave forces within bare patches in mussel beds. Marine Ecology Progress Series, 362, 157–167. https://doi.org/10.3354/meps07435
Methods

Pyroscience GmbH. (2021). Pyro Workbench & Data Inspector: PyroScience Logger Software [User manual/ software]. Retrieved from https://device.report/m/21614a107dcdc1398052674231d23faa15193c75ab8079154c8e14b7cd6d8889_optim.pdf
Software

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Related Datasets

IsRelatedTo

O'Donnell, K., Reidenbach, M. (2025) **Velocity and turbulence measurements around a dense aggregation of mussels from a flume experiment conducted July 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-08-18 http://lod.bco-dmo.org/id/dataset/982717 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Trial	Name of trial	unitless
Day_of_week	Day of trial	unitless
Flow_speed	Flume speed	centimeters per second (cm/s)

Elevation	Elevation above bottom where measurement was taken	centimeters (cm)
Pyro_Date_UTC	Date from Pyroscience sensor array connected to Firesting Pro	unitless
Pyro_Dissolved_Oxygen	Percent air saturation; Dissolved oxygen measured with Pyroscience micro-optode within mussel bed	percent air saturation
Pyro_Temp	Temperature measured with Pyroscience micro-optode within mussel bed	degrees Celsius (°C)
Pyro_pH	pH measured with Pyroscience micro-optode within mussel bed	dimensionless
Pyro_Adj_DO	Measurement of dissolved oxygen with Pyroscience micro-optode converted to a different unit of measurement and compensated for the average salinity during the measurements (27.5 ppt)	milligrams per liter (mg/L)
HOBO_Date_UTC	Date from HOBO sensor	unitless
HOBO_Temp_pH_sensor	Ambient HOBO pH data in standard units (NBS)	dimensionless
HOBO_pH_Millivolts	Raw data from HOBO pH sensor	millivolts (mV)
HOBO_pH	Ambient HOBO pH data in standard units (NBS)	dimensionless
HOBO_DO_conc	Ambient dissolved oxygen measured with HOBO DO sensor, not calibrated	millgrams per liter (mg/L)
HOBO_Temp_oxygen_sensor	Ambient temperature as measured by the HOBO DO sensor	degrees Celsius (°C)
HOBO_DO_Adj_Conc	Measurement of ambient dissolved oxygen with HOBO DO sensor, adjusted with measured salinity from conductivity sensor	milligrams per liter (mg/L)
HOBO_DO_Percent_Sat	Percent air saturation; Ambient dissolved oxygen measured with HOBO DO sensor	percent air saturation
HOBO_Temp_conductivity_sensor	Ambient temperature as measured by the HOBO conductivity sensor	degrees Celsius (°C)

HOBO_Specific_Conductance	Measure of specific conductance of ambient seawater	microSiemens per centimeter (uS/cm)
HOBO_Salinity	Conversion of specific conductance raw data to standard salinity units	parts per thousand (ppt)
Delta_O	Ambient DO [mg/L] - Interstitial DO [mg/L]; Difference (change) in ambient dissolved oxygen measured with HOBO and the interstital dissolved oxygen measured with Pyroscience;	milligrams per liter (mg/L)
Delta_pH	Ambient pH - Interstitial pH; Difference (change) in ambient pH measured with HOBO and the interstital pH measured with Pyroscience	dimensionless
file_name	Original file name	unitless

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Instruments

Dataset-specific Instrument Name	FireSting-PRO fiber optic meter
Generic Instrument Name	FireSting-PRO Optical Multi-Analyte Meter
Dataset-specific Description	The three sensors were connected to a Firesting-PRO 2-channel, a compact USB-powered fiber-optic meter which was further connected to a laptop for data collection.
Generic Instrument Description	The FireSting-PRO is a PC-controlled (USB) fiber-optic multi-analyte meter for optical oxygen, pH, and temperature sensors from Pyroscience. Each optical channel of the FSPRO device is freely configurable for these analytes (pH, oxygen, temperature) and multiple sensor types, giving maximum flexibility for individual experimental design. The compatible sensor heads range from microsensors (50 µm tip) to robust probes (3 mm tip), and include diverse smart contactless sensor solutions (for measurements in closed systems / respirometry, microfluidics and complex geometries, microphysiological systems, single-use applications), as well as sensors for different ranges (full and trace range O2, discrete pH ranges within pH 4-9). The available optical temperature sensors enable precision temperature compensation of especially contactless optical pH and oxygen sensors (sensor spots, sensor vials, flow cells) of the same format.

Dataset-specific Instrument Name	recirculating seawater flume
Generic Instrument Name	high-speed flume
Dataset-specific Description	Velocity profiles were taken over an experimental mussel aggregation in a recirculating seawater flume at Friday Harbor Laboratories.
Generic Instrument Description	A high-speed flume is a controlled laboratory apparatus designed to generate and sustain unidirectional water flow at adjustable velocities. It replicates aspects of open-channel flow environments at experimental scale for the purpose of studying fluid dynamics, sediment transport, aquatic organism behavior, turbulence, and hydraulic engineering under reproducible conditions.

Dataset-specific Instrument Name	Onset HOBO pH/Temperature (MX2501) data logger
Generic Instrument Name	Onset HOBO pH and Temperature data logger MX2501
Dataset-specific Description	An Onset HOBO ph/Temperature (MX2501) data logger was used to measure ambient water chemistry in the experimental flume during the trials.
Generic Instrument Description	The HOBO MX2501 pH and Temperature Data Logger is designed for long-term monitoring of pH in estuaries, lakes, streams, rivers, and oceans. Leveraging Bluetooth Low Energy® (BLE) technology, the MX2501 pH Logger communicates wirelessly with the free HOBOconnect app and your mobile device or Windows computer, making logger setup, calibration, and data offload quick and easy. A guided pH calibration process on the HOBOconnect app makes an otherwise complicated process easier to follow. This affordable and compact logger dramatically cuts the time and effort needed to collect field data, while also offering higher resolution data. (NOTE: pH electrodes should always be stored in storage solution when not deployed).

Dataset-specific Instrument Name	Onset HOBO Conductivity (U24-002-C) logger
Generic Instrument Name	Onset HOBO Saltwater Conductivity/Salinity data logger U24-002-C
Dataset-specific Description	An Onset HOBO Conductivity (U24-002-C) logger was used to measure ambient water chemistry in the experimental flume during the trials.
Generic Instrument Description	HOBO Salt Water Conductivity/Salinity Data Logger is a cost-effective data logger for measuring cost-effective data logger for measuring salinity, conductivity, and temperature in saltwater environments with relatively small changes in salinity (±5,000 µS/cm) such as saltwater bays, or to detect salinity events such as upwelling, rainstorm, and discharge events.

Dataset-specific Instrument Name	Onset HOBO dissolved oxygen (U26-001) logger
Generic Instrument Name	Onset HOBO U26-001 Dissolved Oxygen Data Logger
Dataset-specific Description	A HOBO dissolved oxygen (U26-001) logger was used to measure ambient water chemistry in the experimental flume during the trials.
Generic Instrument Description	A dissolved oxygen sensor, temperature sensor, and integrated data logger. The HOBO U26-001 can be used in freshwater and saltwater conditions, and outputs dissolved oxygen (mg/L) and temperature (degC) measurements.

Dataset-specific Instrument Name	Pyroscience TSUB21 temperature sensor
Generic Instrument Name	Pyroscience Pt100 Temperature Probe TSUB21
Dataset-specific Description	A Pyroscience temperature sensor (TSUB21) was used in tandem with an oxygen micro-sensor and a pH sensor to quantify water chemistry within the interstitial spaces of a mussel bed.
Generic Instrument Description	The PyroScience TSUB21 sensor is a flexible, Teflon-coated temperature probe that utilizes a Pt100 resistance temperature detector (RTD) element. It can automatically compensate for temperature variations in measurements of other sensors like oxygen and pH sensors.

Dataset-specific Instrument Name	Pyroscience OXROB10-CL4 micro-oxygen sensor
Generic Instrument Name	Pyroscience Robust Oxygen Probe OXROB10-CL4
Dataset-specific Description	A micro-oxygen sensor (OXROB10-CL4) was used in tandem with a pH and temperature sensor to quantify water chemistry within the interstitial spaces of a mussel bed.
Generic Instrument Description	This robust oxygen probe is based on optical detection principles (proven REDFLASH technology) and can be used for precise bulk measurements in gas samples (O2 gas), liquids (dissolved oxygen, DO) and in respirometry. The fiber-optic oxygen sensors from PyroScience feature no oxygen consumption, no stirring sensitivity, an extremely long shelf time, resistance to corrosive environments (e.g. seawater) and are suitable for multiple applications in gas, water and aqueous samples.

Dataset-specific Instrument Name	Pyroscience pH micro-sensor probe PHROBSC-PK8T
Generic Instrument Name	Pyroscience Robust pH Screw Cap Probe PHROBSC-PK8T
Dataset-specific Description	A pH sensor (PHROBSC-PK8T) was used in tandem with a micro-oxygen and temperature sensor to quantify water chemistry within the interstitial spaces of a mussel bed.
Generic Instrument Description	Pyroscience pH micro-sensor probe PHROBSC-PK8T is a robust screw cap pH probe that is fiber-based alternative to traditional pH electrodes. This new sensor format is composed of a robust cap adapter fiber with stainless-steel tip (10cm length, 4mm) and a disposable plastic screw cap with integrated pH sensor. The pH sensor cap can be screwed on the threaded tip of the robust fiber. If worn out, keep the fiber and simply exchange the pH sensor cap and continue with your pH measurements.

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Project Information

Collaborative Research: Microscale interactions of foundation species with their fluid environment: biological feedbacks alter ecological interactions of mussels (Microscale Mussels)

Coverage: University of Washington Friday Harbor Laboratories

NSF Award Abstract:
The project investigates how the metabolic activity of dense aggregations of marine organisms alter the water chemistry of their interstitial spaces, and how these microscale alterations feedback to affect the organisms' interactions in coastal ecosystems. The research team focuses on bivalve mussels, foundation species that form dense 'beds' typically known for facilitating other species by ameliorating harsh flow conditions. This ability can become a liability, however, if flow is not sufficient to flush the interstitial spaces and steep, metabolically-driven concentration gradients develop. The research evaluates whether corrosive chemical microclimates (such as low oxygen or low pH) are most extreme in low flow, high temperature conditions, especially for dense aggregations of mussels with large biomass and/or high respiration rates, and if they negatively impact mussel beds and the diverse biological communities they support. The research addresses a global societal concern, the impact of anthropogenic climate change on coastal marine ecosystems, and has potential applications to aquaculture and biofouling industries by informing adaptation strategies to "future-proof" mussel farms in the face of climate change and improved antifouling practices for ships, moorings, and industrial cooling systems. The project forges new collaborations with investigators from three campuses and integrates research and education through interdisciplinary training of a diverse group of graduate, undergraduate and high school students. STEM education and environmental stewardship is promoted by the development of a K-12 level science curriculum module and a hand's-on public exhibit of bivalve biology at a local shellfish farm. Research findings are disseminated in a variety of forums, including peer-reviewed scientific publications and research presentations at regional, national and international meetings.

The research team develops a framework that links environmental conditions measured at a coarse scale (100m-100km; e.g., most environmental observatories) and ecological processes at the organismal scale (1 cm – 10 m). Specifically, the project investigates how aggregations of foundation species impact flow through interstitial spaces, and how this ultimately impacts water chemistry immediately adjacent to the organisms. The research focuses on mytilid mussels, with the expectation that the aggregation alters the flow and chemical transport in two ways, one by creating a physical resistance, which reduces the exchange, and the other by enhancing the exchange due to their incurrent/excurrent pumping. These metabolically-driven feedbacks are expected to be strongest in densely packed, high biomass aggregations and under certain ambient environmental conditions, namely low flow and elevated temperature, and can lead to a range of negative ecological impacts that could not be predicted directly from coarse scale measures of ambient seawater chemistry or temperature. The team develops computational fluid dynamic (CFD) models to predict interstitial flows and concentration gradients of dissolved oxygen and pH within mussel beds. The CFD model incorporates mussel behavior and physiological activity (filtration, gaping, respiration) based on published values as well as new empirical work. Model predictions are compared to flow and concentration gradients measured in mussel aggregations in the laboratory and field. Finally, the team conducts several short-term experiments to quantify some of the potential negative ecological impacts of corrosive interstitial water chemistry on mussel aggregations, such as reduced growth, increased dislodgement, increased predation risk, and reduced biodiversity. Because the model is based on fluid dynamic principles and functional traits, the framework is readily adaptable to other species that form dense assemblages, thereby providing a useful tool for predicting the ability of foundation species to persist and provide desirable ecosystem services under current and future multidimensional climate scenarios.

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-2050345

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