Velocity, oxygen, and pH measurements over a mussel bed in water flume at Friday Harbor Labs, Washington in July 2023

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

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Abstract
Velocity from a Nortek Vectrino, and oxygen/pH measurements from a Pyroscience probe were measured between 1 cm and 20cm within and above a mussel bed flume located at Friday Harbor Laboratory, Washington. Four flow speeds of 0.25, 0.5, 1, and 1.5 cm/s were tested. Minimum, mean, and maximum oxygen and pH are recorded in the data table, while raw velocity data are provided, collected at 50 samples per second.

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Coverage

Location: Friday Harbor Laboratories, Washington

Methods & Sampling

Velocity measurements were conducted with a Nortek Vectrino Velocimeter. Oxygen and pH measurements were collected using a Pyroscience fiber optic sensor. Raw velocity data is provided in associated files with a sampling rate of 50 Hz. The length of each velocity record varies, but typically is between 5,000 and 10,000 samples. At a location 0.5 cm away from velocity sampling, oxygen and pH was sampled at a 1 Hz sampling rate. Only min, mean, and max oxygen and pH are provided. The mussel bed was approximately 10 cm high, so measurements taken at elevations between 1 and 10 cm were within the bed, and measurements at or above 11 cm were above the bed.

The data is used to compute both mean velocity measurements and turbulence statistics and relate mixing and water exchange rates to overall oxygen and pH dynamics within and above the mussel bed.

Data Processing Description

Minimum, Mean, and Maximum oxygen and pH data are provided in data table. These are statistics sampled across the entire time period for which velocity records were taken, typically between 3 and 5 minutes

Raw velocity data at each elevation are included. From these velocities both mean and turbulence statistics are calculated.

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Parameters

Parameters for this dataset have not yet been identified

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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
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