Fine Scale Substrate Characteristics of the Pacific Coast from June of 2022 to July of 2023

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Project
» OCE-PRF: Understanding substrate mobility as a disturbance in hard rock marine communities (PRF substrate mobility)

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Abstract
These data include substrate strength (N) and community membership measurements collected from June 2022 to July 2023. Fine scale surveys collected both geological and biological data, measuring rock friability using a mechanical sclerometer and community membership via point sampling in quadrats. Broad scale surveys collected only geologic data, measuring rock friability using a mechanical sclerometer at sites previously sampled by the Multi-Agency Rocky Intertidal Network (MARINe) research consortium. Data were collected to better understand the role of substrate mobility in structuring marine communities. Collection was done by Dr. Alli Cramer, Olivia Bible, Canon Cline, Grace Leuchtenberger, and Casey Smith. Data cleaning and preparation was done by Evan Hopps.

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Coverage

Location: East Pacific, intertidal zones of the Salish Sea, Washington and Central to Southern California.
Spatial Extent: **N**:48.69187 **E**:-121.9031 **S**:36.52301 **W**:-123.1509
Temporal Extent: 2022-06-14 - 2023-07-17

Methods & Sampling

Quadrats

** *We used half meter quadrats locate fine scale sampling locations*.*** Quadrats were made by creating a half-meter square of PVC pipe and threading the pipes with nylon rope to create a grid every 10 cm. Samples were taken for each rock category within the quadrat.

Rock Strength
We quantified the strength (friability) of intertidal rock substrates using a mechanical sclerometer configured as a scratch tester. This approach resembles Mohs hardness testing, however instead of switching between materials of varying hardness, we used a constant scratching tool—a 1 mm diameter tungsten carbide tip—and increased the applied force until the tip produced a visible scratch. For each trial, we aimed to create a scratch approximately 2 cm in length, although surface conditions sometimes required shorter passes. We repeated each test at progressively higher forces to identify the minimum force necessary to initiate a scratch.

We measured friability on a fine scale at 14 sites along the Pacific coastline of California and Washington (see map). Sites were selected based on three criteria: accessibility, presence on geologic maps, and prior sampling of marine community composition, which allowed us to link our measurements with regional monitoring programs (aka MARINe). At each site, we targeted mid-intertidal bench habitats with low to moderate slopes and sampled during low tide to maximize surface dryness. We identified fine scale sampling locations using half-meter length ($0.25m^2$) quadrats. Quadrats were placed in a "T" shape, with the coordinates of the site at the intersection of the T (see *T Shaped Survey Drawing* and *Quadrat Organization Diagram*). The T shape was orthogonal to the orientation of the approaching waves - in other words the cross bar was parallel to shore while the stem was pointing towards the waves. There were four quadrats on each spoke - four to the left side of the T, four on the stem, and four on the right side of the T. Each quadrat was surveyed for visible rock categories. Each identified rock category was sampled three times (where possible) to obtain an average strength value for that rock category in that quadrat.

In the field, we assigned each surface to a broad rock categories. Although we consulted geologic maps when available, these maps typically describe formations above the high-tide line and often fail to resolve intertidal substrates, which can differ substantially and are frequently labeled as undifferentiated “bedrock.” To maintain consistency, we classified rocks into the following categories: **black, striated black, grey, green, striated green, conglomerate, metamorphic, sandstone, granodiorite, mudstone, siltstone, embedded cobblestone, and rounded cobble.** Rocks were then described in more detail in the notes.

Analog Sclerometer
We used the Elcometer 3092 analog Sclerometer Hardness Tester in this study. This instrument is designed to evaluate the hardness of manufactured coatings and surfaces, such as those applied to automobile bodies for protection. As an inspection device, the sclerometer specifically measures the force required to scratch or abrade a surface. The instrument resembles a large pen and determines coating hardness by drawing a tungsten carbide tip across the surface under a controlled, pre-set load.

To operate the sclerometer, we first set a target force by compressing an internal spring to a predetermined length. As we increased compression, the applied force increased accordingly ($F_{spring} = k_{stiffness} \times x_{compression}$). A tightening screw attached to the collar held the spring in place. We then tested the selected force by pressing the tip against a surface and moving it in a short, straight pass (~2 cm over 1 s), simulating a scratch. We followed an iterative procedure, adjusting the applied force and repeating passes until we identified the minimum force (N) required to produce visible abrasion.

In addition to the pen-like sclerometer body, the instrument includes a case, a 0.75-mm diameter tungsten carbide tip, and three interchangeable springs—grey, red, and blue—with stiffness values corresponding to force ranges of 0 to 3 N, 10 N, and 20 N, respectively. For harder materials, the system also offers an optional green spring rated from 0 to 30 N. The instrument supports additional tips, including 0.5- and 1.0-mm diameter tungsten carbide tips and a diamond-capped tip. Larger diameter tips apply lower pressure, while the diamond-capped tip enables testing of extremely hard surfaces, such as crystalline materials.

Data Processing Description

No pre-processing beyond data cleaning was performed on these data.

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Apple iPhone 13 camera
Generic Instrument Name	Camera
Dataset-specific Description	Images of the quadrats and sampling locations were taken with an Apple iPhone 13, Google Pixel 5, and Nikon Coolpix B500 cameras
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Google Pixel 5 camera
Generic Instrument Name	Camera
Dataset-specific Description	Images of the quadrats and sampling locations were taken with a Google Pixel 5, Apple iPhone 13, and Nikon Coolpix B500 cameras
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Nikon Coolpix B500 camera
Generic Instrument Name	Camera
Dataset-specific Description	Images of the quadrats and sampling locations were taken with an Apple iPhone 13, Google Pixel 5, and Nikon Coolpix B500 cameras
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	half meter quadrats
Generic Instrument Name	quadrat
Dataset-specific Description	Half-meter length (0.25 square meter) quadrats were placed in a "T" shape for the fine scale sampling location.
Generic Instrument Description	A square or rectangular rigid frame of known area, often home-made, that is placed on the substrate to be sampled to mark a fixed area for sampling flora or fauna.

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Project Information

OCE-PRF: Understanding substrate mobility as a disturbance in hard rock marine communities

(PRF substrate mobility)

NSF Award Abstract

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

Human actions impact marine ecosystems in a variety of ways, including shifting wave and current dynamics through global warming and altering the composition of the ocean floor. These changes, in turn, affect the location and distribution of marine communities. For soft-sediment communities, such as sandy beaches, the interaction between fluid forces and sediment disturbance is well understood. This allows scientists to measure sediment mobility and to create detailed predictions of the impact of human activities on these ecosystems. To date there are no measurements analogous to sediment mobility available for marine hard rock ecosystems. This research will investigate a potential measurement system which connects the forces of waves and currents to the resulting erosion of hard rock substrates and will test and evaluate how these disturbance patterns govern the distribution of communities themselves. By developing and testing this substrate mobility metric, this research will open new avenues of investigation for core ecological hypotheses. In addition, this work will allow managers, conservationists, and engineers to better predict the impact of human-generated change on hard rock marine communities. This project will also support the training and education of groups underrepresented in the geosciences through (1) field and data analysis experience via Research Experiences for Undergraduates summer programs, (2) professional development via mentoring relationships between the fellow and undergraduate trainees, and (3) the expansion of their professional network via cross-institutional coordination.

Disturbance, including fluid forces via waves on rocky shores, is well understood as a community organizing and structuring force. Foundational concepts within ecology, such as Connell’s Intermediate Disturbance Hypothesis and Menge and Sutherland’s Competition/Predation/Disturbance model, recognize that communities exist within a complex mosaic of physical and biological disturbance. This mosaic presents challenges when measuring disturbance regimes since the scales, causes, and consequences of disturbance vary between systems. However, in the marine environment, substrate mobility represents an explicit measure of disturbance impact present across marine ecosystems. This project will determine how to measure substrate mobility on hard substrates through collaboration with USGS geologists. In addition, this research will investigate a mechanism for disturbance via substrate mobility on benthic organisms through lab experiments and use field surveys to compare patterns of substrate mobility with the distribution of benthic communities and species functional groups. Explicitly quantifying the realized movement of hard substrate in response to fluid forcing integrates hard substrates into the already well understood sediment disturbance paradigm. This results in a universal framework of marine disturbance that is potentially revolutionary as it allows for comparative questions spanning a huge diversity of marine ecosystems, from coral reefs to the abyssal plain. This mechanistic framework provides a new connection between the disciplines of geomorphology and marine ecology.

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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