A long-term series of species occupying fixed points on the middle intertidal (mussel-dominated) zone of a rocky intertidal shoreline, for use in studying species replacement patterns through time

Website: https://www.bco-dmo.org/dataset/873599
Data Type: Other Field Results
Version: 1
Version Date: 2022-07-11

Project
» The Role of Regenerated Nitrogen for Rocky Shore Productivity (Regenerated Nitrogen)
» Effects of Demography and Genetics on Extinction in Small Populations: Experiments with an Exploited Kelp (Experiments with an Exploited Kelp)
» Field Parameterization and Experimental Tests of the Neutral Theory of Biodiversity (Neutral Theory of Biodiversity)
» LTREB: Ecological Dynamics in an Experimentally-Tractable Natural Ecosystems (LTREB Ecological Dynamics)

Contributors	Affiliation	Role
Wootton, Timothy	University of Chicago	Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset comprises a long-term series of species occupying fixed points on the middle intertidal (mussel-dominated) zone of a rocky intertidal shoreline. Data are relevant to studies of species replacement patterns through time.

Table of Contents

Coverage

Spatial Extent: **N**:48.3944 **E**:-124.7241 **S**:48.3899 **W**:-124.7394
Temporal Extent: 1993-05 - 2022-07

Dataset Description

Acknowledgement of the Makah Tribal Council for permission to allow these data to be collected on their lands should be made where possible when the data are an essential part of the publication.

These data series are being actively extended and analyzed by the data provider, and interested investigators may wish to contact the data provider regarding these data, the ecological context under which these data were collected, whether planned use of these data represents redundant efforts, and any details of the data collection process the data provider may have inadvertently neglected to include here. As a rule of thumb for any data made publicly available, including these, investigators intending to use these data for publication should consider the considerable effort made to gather and organize them, and whether publication would reasonably be possible without including these data. If not, then it may be appropriate to explore involving the author in the publication process.

In addition to the NSF awards cited under "Funding" below, these data were funded through awards from the Andrew Mellon Foundation, the University of Chicago, and Olympic Natural Resource Center.

Methods & Sampling

Data are taken 1-2 times per year (every year in late May-early June and occasionally late August-early September) from 1993-2022 at the same points on the intertidal shoreline of Tatoosh Island, Washington, USA using either a 30-meter metal transect with fixed sampling points, suspended from two or more fixed eye screws, or using a 65 x 65 cm quadrat with 100 points defined by the crossing of 10 equidistant monofilament lines in horizontal and vertical directions, placed at fixed locations defined by stainless steel screws embedded in the rock. See references below for details. All visual sampling was conducted by the same individual (JTW).

Known Issues: Sampling gaps in 2013 and 2020.

Notes:
- Polysiphonia and Endocladia were lumped before Aug. 1996.
- SP4 was disturbed while trying to find marker to Q11 during spring 1996.
- Callithamnion was lumped with Polysiphonia until 2002.
- Irridea (Mazzaella) was lumped with Mastocarpus before Aug 1995.
- Data are from permanent transects (points defined by single numbers) and quadrats (Q#, points defined by number and letter coordinate pair).
- Quadrat plot size is 0.65 x 0.65 m, subdivided into a 10 x 10 grid of fixed points.
- Data were taken in late spring and late summer from 1993-2000, then just in late spring thereafter.
- Q7 was lost after the first census. Retained in data series in case spacing is needed for data analysis.
- Transects are 9.1 m long, with 30 points initially placed at random.
- Transects may be approximately linear and approximately paralleling the shore, or may switch directions to remain within the site.
- All transects and plots are located in the middle intertidal zone, dominated by *Mytilus californianus*.
- All transects have a beginning and end, so there are a minimum of two coordinates to describe them. Some transects are not linear to stay within the habitat and the particular rock bench, and there can be up to 4 coordinates for these. For the purposes of this dataset, we've provided the starting coordinate.
- Tide heights vary throughout each transect and are thus not provided.

Data Processing Description

BCO-DMO Processing:
- Created location_table from site locations provided in metadata form and via email.
- Created taxon_table from information provided in metadata form and via email.
- Converted latitude and longitude values to decimal degrees; rounded both to 4 decimal places.
- Joined the site locations and taxon information to the sampling data.
- Renamed fields to comply with BCO-DMO naming conventions.
- Re-formatted the data so dates are in a single column rather than one date per column; created the "taxon_code" and "taxon_name" columns.
- Unpivoted the data by creating a "sampling_date" column and a "taxon_code" column.
- Changed date format to YYYY-MM.
- Sorted by: {Quadrat_or_transect}{Site}{Sub_site}{Point_Number}{Point_Letter}{sampling_date}.
- Replaced spaces with underscores and removed apostrophes from Site and Sub_site values.
- Replaced commas with semi-colons in the taxon_name column.
- Where approved by the PI, original taxon names have been changed in the dataset to match the World Register of Marine Species' (WoRMS) accepted names.

[table of contents | back to top]

Data Files

File
intertidal_transitions_flat.csv (Comma Separated Values (.csv), 6.36 MB) MD5:0f1036cc0eee4b40d22aed60cf1b9228 Primary data file for dataset ID 873599

[table of contents | back to top]

Related Publications

Maynard, D. S., Wootton, J. T., Serván, C. A., & Allesina, S. (2019). Reconciling empirical interactions and species coexistence. Ecology Letters, 22(6), 1028–1037. Portico. https://doi.org/10.1111/ele.13256
Results

Wootton, J. T. (2001). Causes of species diversity differences: a comparative analysis of Markov models. Ecology Letters, 4(1), 46–56. https://doi.org/10.1046/j.1461-0248.2001.00190.x
Results

Wootton, J. T. (2001). Local interactions predict large-scale pattern in empirically derived cellular automata. Nature, 413(6858), 841–844. https://doi.org/10.1038/35101595
Results

Wootton, J. T. (2001). Prediction in Complex Communities: Analysis of Empirically Derived Markov Models. Ecology, 82(2), 580. https://doi.org/10.2307/2679881
Results

Wootton, J. T. (2005). Field parameterization and experimental test of the neutral theory of biodiversity. Nature, 433(7023), 309–312. https://doi.org/10.1038/nature03211
Results

Wootton, J. T. (2010). Experimental species removal alters ecological dynamics in a natural ecosystem. Ecology, 91(1), 42–48. https://doi.org/10.1890/08-1868.1
Results

Wootton, J. T. (2013). An Experimental Test of Multi-species Markov Models: Are Barnacles Long-term Facilitators of Mussel Bed Recovery? Bulletin of Marine Science, 89(1), 337–346. https://doi.org/10.5343/bms.2011.1125
Results

Wootton, J. T. (2016). A 20-year data set of species replacement patterns in the middle-intertidal zone of Tatoosh Island, Washington, USA. Ecology, 97(3), 810–810. Portico. https://doi.org/10.1890/15-1396.1
Results

Wootton, J. T., & Forester, J. D. (2013). Complex Population Dynamics in Mussels Arising from Density-Linked Stochasticity. PLoS ONE, 8(9), e75700. https://doi.org/10.1371/journal.pone.0075700
Results

Wootton, J. T., Pfister, C. A., & Forester, J. D. (2008). Dynamic patterns and ecological impacts of declining ocean pH in a high-resolution multi-year dataset. Proceedings of the National Academy of Sciences, 105(48), 18848–18853. https://doi.org/10.1073/pnas.0810079105
Results

Wootton, J. Timothy (2004). Markov chain models predict the consequences of experimental extinctions. Ecology Letters, 7(8), 653–660. https://doi.org/10.1111/j.1461-0248.2004.00621.x
Results

[table of contents | back to top]

Related Datasets

IsRelatedTo

Wootton, T. (2022) **A long-term series of species occupying fixed points on the middle intertidal (mussel-dominated) zone of a rocky intertidal shoreline, for use in studying species replacement**

patterns through time. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-07-11 doi:10.26008/1912/bco-dmo.875177.1 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
Quadrat_or_transect	Quadrat or transect identifier. Quadrats begin with "Q".	unitless
Point_Number	Fixed sampling point	unitless
Point_Letter	Point letter (within quadrats only; an X in this columns means it's a transect)	unitless
Site	Site name	unitless
Sub_site	Sub-site name	unitless
Tide_Height	Tide height	m LLW
Latitude	Latitude of quadrat or transect. For transects, the value provided is the starting coordinate.	decimal degrees North
Longitude	Longitude of quadrat or transect. For transects, the value provided is the starting coordinate.	decimal degrees North
sampling_date	Sampling date in format YYYY-MM (year and month)	unitless
taxon_code	Taxon code	unitless
taxon_name	Taxon name	unitless

[table of contents | back to top]

Project Information

The Role of Regenerated Nitrogen for Rocky Shore Productivity (Regenerated Nitrogen)

Website: http://pfisterlab.uchicago.edu

Coverage: coastal northeast Pacific Ocean

NSF Award Abstract:
A fundamental and persistent question in a multitude of ecosystems is the extent to which new versus regenerated nutrients support ecosystem productivity. In coastal marine systems, nitrate derived from upwelling (= new nitrogen) and ammonium regeneration in coastal waters and sediments (= regenerated nitrogen) are major nitrogen sources that fuel coastal ocean productivity. Because inorganic nitrogen availability clearly regulates production in a large number of areas, understanding nitrogen supply is essential. In open coast regions away from river mouths, nitrate inputs are determined by large-scale physical processes promoting upwelling of deep, nutrient-rich water including wind direction and intensity. In contrast, regenerated nitrogen (mainly ammonium) is generally the result of local animal and microbial processes. Along marine rocky shores, where upwelling is typically used as a proxy for productivity, we know very little about the dynamics of regenerated nutrients and their potential contribution to productivity at larger scales; only upwelling is typically used as a proxy for productivity. Associations of the abundant California mussel, Mytilus californianus, with water nutrients, algal productivity, stable isotope signatures, and microbial genetics indicate potentially strong regeneration of nitrogen by these animals and suggest an important secondary role of nitrifying microbes affiliated with these animals.

In this project, the investigators will quantify the relative contribution of regenerated nitrogen on rocky shores through censuses and experiments across a gradient of mussel abundance. They will use stable nitrogen and oxygen isotopes of ammonium, nitrite, and nitrate to disentangle the contribution of different biological processes versus upwelling to the nitrogen supply and uptake of rocky shore regions. This includes both natural abundance and tracer addition studies.

Broader Impacts. Regenerated nitrogen supply, as opposed to new nitrogen via upwelling, is a local process dependent upon an intact animal community. However, mussels and other nearshore animals may be particularly vulnerable to a changing thermal environment, toxic algal blooms, and ocean acidification. Given the dramatic changes to the coastal nitrogen cycle in recent years, and potential changes to currents, upwelling, ocean chemistry, and El Niño frequencies portended by global changes to our climate, we to know the relative effect of local versus larger scale oceanic events on the nitrogen cycle. The proposed work links biological interactions in situ with its implications for coastal productivity.

In addition to expected publications in high quality journals, educational activities will continue to focus on graduate and undergraduate education and mentoring. The proposal will fund two graduate students and two undergraduates per year. The PI's will work closely with government (Olympic Marine National Sanctuary) and tribal (Makah Tribe) representatives to communicate this research. We will also work with Makah Museum Board of Trustees and the Makah Higher Education Committee to identify Makah students as research assistants. All three PI's teach broadly across their respective campuses, instructing almost every type of undergraduate major.

Effects of Demography and Genetics on Extinction in Small Populations: Experiments with an Exploited Kelp (Experiments with an Exploited Kelp)

Coverage: Tatoosh Island, Washington, United States of America, and the surrounding shores of Cape Flattery, Washington, United States of America

NSF Award Abstract:
The process of species extinction represents both a basic ecological and societal concern. Despite interest in extinction processes, there is little empirical information on mechanisms leading to extinction, particularly in marine systems, because extinction events involve small population sizes and are infrequent. Small population size is thought to increase the risk of extinction through several different mechanisms. Ecological mechanisms include increased variation in population growth rates due to chance events (demographic stochasticity), and positive density dependence (i.e., reduced population growth at low density). Genetic mechanisms include loss of favorable alleles due to chance events (genetic drift) and inbreeding depression.

This project will experimentally disentangle the effects of different mechanisms associated with small population size in a commercially-harvested marine kelp, the sea palm Postelsia palmaeformis. To test effects of genetic variation, experimental populations will be established from either a single founder, multiple founders from the same population, or multiple founders from different source populations. The genetic treatment will be combined with a density manipulation (large and small populations) to test for ecological effects of population size. Experimental populations will be monitored for times to extinction, and the underlying processes will be studied in detail by marking individual plants and measuring survival, fecundity, and growth rates. These data will be incorporated into a population model to determine the relative sensitivity of population growth to different effects of small population size and to different life stages. Concurrent monitoring of genetic structure of the experimental populations using AFLP fingerprinting techniques will provide an independent measurement of genetic dynamics and effects on population performance, and will validate basic assumptions of the study. The study will increase our understanding of the effects of small population size on extinction risk, help to characterize the life cycle of marine kelps, and provide important information for developing effective conservation and remediation strategies for exploited marine species.

Field Parameterization and Experimental Tests of the Neutral Theory of Biodiversity (Neutral Theory of Biodiversity)

Coverage: Tatoosh Island, Washington, United States of America

NSF Award Abstract:
A persistent challenge for ecology is to connect a mechanistic understanding of population dynamics with the

generation of large-scale aggregate patterns of community structure, such as species-abundance and species-area relationships. Hubbell's Neutral Theory of Biodiversity has shown promise in its ability to do this in both marine and non-marine systems. If the theory is correct, then a radical shift is needed in the perspective of how communities are organized, with minimal role for species differences (niche variation) and an emphasis on metacommunity dynamics, dispersal/recruitment control, and the interplay of speciation and extinction dynamics. Past evaluations of the theory have depended on asking whether the neutral theory can fit aggregate patterns, such as species-abundance distributions. This approach is relatively weak, involving tuning of two critical model parameters. This project will provide a strong test of the theory in a rocky intertidal community by reformulating the theory to make it more empirically accessible, extending a dataset on the transition dynamics of space use, parameterizing the model with this dataset, and then using several species deletion experiments to provide an independent test of the theory. The experimental approach will also relax several key assumptions of the neutral theory, including no recruitment limitation or variation and differences in species and their interactions, and explore the consequences of these assumptions. Aside from providing a strong test of an important synthetic theory, the research will expand knowledge of metacommunity dynamics, which are particularly relevant for understanding marine systems with oceanic transport, and will provide empirical information on the consequences of chronic species deletion in nearshore environments. Broader Impacts. This project will train undergraduate, graduate, and post-Ph.D. scientists at the interface of quantitative and field-based ecology, will involve interaction with tribal natural resource managers, and will facilitate access to a unique long-term multi-species dataset for probing transition-based approaches to environmental science that may provide some predictive insight into the consequences of biodiversity loss.

LTREB: Ecological Dynamics in an Experimentally-Tractable Natural Ecosystems (LTREB Ecological Dynamics)

Coverage: Tatoosh Island, Washington, United States of America

NSF Award Abstract for DEB-0919420:

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5).

A core challenge for ecologists is to develop frameworks to predict how complex natural communities and ecosystems will respond to environmental impacts such as species extinction and global change. Because ecological interactions are comprised of complex networks, meeting this challenge requires an integration of mathematical frameworks with empirical data. In this project, the investigator will extend several long-term multi-species data sets for marine rocky intertidal organisms and environmental conditions, and use these data to estimate species interaction strengths in dynamic, multi-species models. These results will then be used to test for general patterns of interaction strength and to generate predictions for different potential environmental impacts. Long-term species manipulation experiments in this intertidal habitat will be used to validate predictions generated by multi-species models.

Results of this study will significantly enhance the ability to address an urgent societal need - the prediction of natural ecosystem responses to global change, including climate change. In the process, the study will increase collaboration and data sharing among university researchers and governmental management agencies (Tribal and NOAA National Marine Sanctuary staff), provide advanced training for Ph. D. students, and facilitate research experience for undergraduate in ecological science. Data associated with the project will be publicly available through the University of Chicago, the Knowledge Network for Biocomplexity, and through the Ecological Society of America's Ecological Archives.

NSF Award Abstract for Continuing Award DEB-1556874:

A central goal for ecology is to document if and how the environment is changing, to determine the causes of these changes, and to predict what the consequences of these changes will be to ecological systems. This is a challenge because of the complex network of connections among the living organisms and the non-living parts of ecosystems. Mathematical models are essential tools to keep track of these ecological interactions and to predict how they will respond to environmental changes. However, models need to be linked to data from nature. Two major challenges in developing predictive models of environmental change are 1) collecting sufficient data on how interactions among a complete set of species and environmental factors change over time, and (2) rigorously testing model predictions with experiments. This study will combine a quarter-century long series of data on 100+ species and relevant environmental variables in the rocky shoreline of Tatoosh Island in Washington state, with a long-term field experiment that mimics the extinction of a key species, the

California mussel. The long term data will be applied to several different modeling approaches and predictions from these models will subsequently be tested with the long-term field experiment. The research will identify the most promising modeling approaches for making ecological prediction, and make them available to ecosystem managers and policy makers interested in the consequences of environmental impacts such as species extinction and global change. The comprehensive data series also will be made available to other scientists to be used as a platform for additional studies. This project will also engage undergraduate students in field research, data management, mathematical modeling, and in communicating with the public, managers, and policy makers. Furthermore, because the challenge of understanding networks of species interactions is shared with other scientific disciplines that deal with complex networks, project results will be of general value in other disciplines.

The researcher will conduct annual surveys of replicated permanent plots for plants and animals on the shoreline in two ways: 1) by documenting the species identities under 2,600 fixed points over a 5-year period and generating annual transition probabilities among species, and 2) by generating abundance estimates in permanent 60 x 60 cm census plots. Fifteen experimental plots will be maintained by selectively removing individuals of Mytilus californianus when they appear, leaving all other species undisturbed. Environmental data will be collected every 30 minutes using a submersible data logger and a land-based weather station. Water chemistry, including critical nutrients, will be monitored. These data will be analyzed in several ways, including 1) parameterizing transition-based models (Markov chain models, spatially-explicit cellular automata) with environmental dependencies, 2) parameterizing multi-species population dynamic models from plot counts, 3) applying multi-spatial cross-convergent mapping and testing whether it accurately detects key species known to have strong causal effects from independent experiments, 4) applying neural network models and testing their predictions about the consequences of species extinction, and 5) testing whether there is a relationship between the variability of a species' abundance through time and its importance to the ecosystem as assessed by independent experiments. The community modeling projects enabled by the rich long term data sets have a strong potential to advance our understanding of mechanisms underlying community dynamics and their response to environmental change.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0928232
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851489
NSF Division of Ocean Sciences (NSF OCE)	OCE-0117801
NSF Division of Ocean Sciences (NSF OCE)	OCE-0452687
NSF Division of Environmental Biology (NSF DEB)	DEB-0919420
NSF Division of Environmental Biology (NSF DEB)	DEB-1556874

[table of contents | back to top]