An archive of the fish and inveterate data from the Rhode Island Department of Environmental Management (RIDEM) juvenile fin-fish survey across 6 Rhode Island salt ponds from 2010-2015

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Project
» CAREER: Linking genetic diversity, population density, and disease prevalence in seagrass and oyster ecosystems (Seagrass and Oyster Ecosystems)

Contributors	Affiliation	Role
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Abstract
An archive of the fish and inveterate data from the Rhode Island Department of Environmental Management (RIDEM) juvenile fin-fish survey across 6 Rhode Island salt ponds from 2010-2015.

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Coverage

Spatial Extent: **N**:41.3998 **E**:-71.5056 **S**:41.3311 **W**:-71.7689
Temporal Extent: 2010 - 2015

Dataset Description

This dataset is an archive of the fish and inveterate data from the RIDEM juvenile fin-fish survey across 6 of the Rhode Island salt ponds.

Methods & Sampling

Fish and invertebrate surveys:
The Rhode Island Department of Environmental Management (RIDEM) provided us with the fish and invertebrate survey data for this study. Beginning in 2010, RIDEM established permanent monitoring stations throughout all six coastal ponds (points on Fig. 1A of Yeager et al., 2020). Communities were sampled monthly from May to October each year via 150 ft beach seine net. Fish and macroinvertebrate individuals were counted, measured, and identified to species. Communities were composed of fishes and invertebrates from multiple trophic levels. Across all ponds, species richness ranged from and 11 to 39 and trophic level ranged

from 2.01 – 4.65 (Appendix S1 of Yeager et al., 2020). For the community analysis, we examined species and their abundances averaged across sampling stations to account for dependence within each pond and averaged across months to account for seasonal differences of species presence. To ensure even community sampling across ponds which varied in number of sampling stations, we conducted a species rarefaction test, examining both the rarefaction curves as well as the relationship between the rarefied and observed number of species (Appendix S2 of Yeager et al., 2020).

Data Processing Description

Community stability:
We examined the temporal dynamics across six years (2010-2015) of the six coastal pond fish and invertebrate communities in ordination space using non-metric multidimensional scaling (nMDS). Testing for statistical differences in community composition across pond and year, we used a permutational multivariate analysis of variance (PERMANOVA). We used the functions 'metaMDS' and 'adonis' of the vegan R package to produce and plot the nMDS and calculate PERMANOVA respectively (R Development Core Team 2013). To calculate community instability, we examined variation in ordination space, with 2D Euclidean distance representing the change in the community composition (identity and abundance) across years (Clarke 1993, Kroeker et al. 2013, Lamothe et al. 2019). We adapted the three metrics of community instability from Mellin et al. (2010): (1) convex hull area, (2) average year-to-year distance, and (3) average year-to-centroid distance. The first metric, convex hull area, is the smallest possible convex polygon drawn in ordination space that encompasses all communities through time for each pond. Convex hull area gives one overarching instability value for each pond and thus quantifies the total change in community composition over time. The second metric, year-to-year distance, is the average year-to-year Euclidean distance for each pond community. Because this metric tracks changes in community composition from year-to-year, small annual shifts in the trajectory of the community due to incremental but directional environmental change will yield a low instability value, even if these small annual shifts yield a large change in community composition across all years. Hence, this metric quantifies the degree of incremental change in community composition over time. The third instability metric is the average year-to-centroid distance, which is the average distance between annual community structure and the mean community structure across all years (centroid). This metric thus tracks how much a community deviates annually from its average composition across all years.

After calculating the instability metrics, we then examined the relationships between pond size or ocean distance and each metric. We fit linear regressions to the pond size-/ocean distance-convex hull instability relationship. Because both year-to-year and year-to-centroid distance produced estimates for each pond in each year, we fit an ANCOVA to determine the strength and the persistence of the relationship between these instability metrics and both pond size and ocean distance (covariates) across years (factor). To confirm that data are not correlated across sampling events, we ran a Durbin-Watson temporal autocorrelation test as well as plotted the residuals of the linear models using the 'acf' function (Appendix S3 of Yeager et al., 2020). For all instability analysis, both pond size and ocean distance were log transformed.

Path analysis:
To understand whether community instability was directly affected by pond size and ocean distance or whether it was mediated through the relationship with species richness, we conducted path analysis using the lavaan R package (R Development Core Team 2013). Path analysis is a procedure that estimates the direct and indirect relationships between the exogenous variables pond size and ocean distance and the endogenous variables species richness and instability by computing standardized (path) coefficients using a series of multiple linear regressions (Grace and Bollen 2005, Grace et al. 2012).

We conducted two path analyses based on two of the three calculated instability metrics: (1) year-to-year distance and (2) year-to-centroid distance. Due to their intrinsic properties, these metrics provided different information about community instability. Year-to-year distance describes how instability changes incrementally with time, whereas year-to-centroid distance represents total instability across all years. For each path analysis, we calculated the direct effects of both pond size and ocean distance on instability. The indirect effects of pond size and ocean distance on instability were obtained by computing the product of the standardized coefficient linking pond size or ocean distance to species richness and the standard coefficient linking species richness to instability. To understand the degree to which the relationship between pond properties and instability was driven by direct or indirect effects, we calculated the total effect of pond size and ocean distance by summing their direct and indirect effects. For both path analyses, we determined whether the observed and the predicted covariance matrices differed (Appendix S4 of Yeager et al., 2020) by computing the summary statistic and its statistical significance based on 1,000 iterations using the Yuan bootstrap method (Yuan et al. 2007). Additionally, we ran the path analyses using the rarefied species richness values to ensure that our results were not a product of variation in the number of sampling stations across ponds (Appendix S2 of Yeager et al., 2020).

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Data Files

File
RI_community.csv(Comma Separated Values (.csv), 65.32 KB) MD5:1d8c9c7b65d1ffb59b79c852094c6783 Primary data file for dataset ID 805252

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Related Publications

CLARKE, K. R. (1993). Non-parametric multivariate analyses of changes in community structure. Austral Ecology, 18(1), 117–143. doi:10.1111/j.1442-9993.1993.tb00438.x
Methods

Grace, J. B., & Bollen, K. A. (2005). Interpreting the Results from Multiple Regression and Structural Equation Models. Bulletin of the Ecological Society of America, 86(4), 283–295. doi:10.1890/0012-9623(2005)86[283:itrfmr]2.0.co;2 https://doi.org/10.1890/0012-9623(2005)86[283:ITRFMR]2.0.CO;2
Methods

Grace, J. B., Schoolmaster, D. R., Guntenspergen, G. R., Little, A. M., Mitchell, B. R., Miller, K. M., & Schweiger, E. W. (2012). Guidelines for a graph-theoretic implementation of structural equation modeling. Ecosphere, 3(8), art73. doi:10.1890/es12-00048.1 https://doi.org/10.1890/ES12-00048.1
Methods

Kroeker, K. J., Gambi, M. C., & Micheli, F. (2013). Community dynamics and ecosystem simplification in a high-CO2 ocean. Proceedings of the National Academy of Sciences, 110(31), 12721–12726. doi:10.1073/pnas.1216464110
Methods

Lamothe, K. A., Somers, K. M., & Jackson, D. A. (2019). Linking the ball-and-cup analogy and ordination trajectories to describe ecosystem stability, resistance, and resilience. Ecosphere, 10(3), e02629. doi:10.1002/ecs2.2629
Methods

Mellin, C., Huchery, C., Caley, M. J., Meekan, M. G., & Bradshaw, C. J. A. (2010). Reef size and isolation determine the temporal stability of coral reef fish populations. Ecology, 91(11), 3138–3145. doi:10.1890/10-0267.1
Methods

Yeager, M. E., Gouhier, T. C., & Hughes, A. R. (2020). Predicting the stability of multitrophic communities in a variable world. Ecology. doi:10.1002/ecy.2992
Results

Yuan, K.-H., Hayashi, K., & Yanagihara, H. (2007). A Class of Population Covariance Matrices in the Bootstrap Approach to Covariance Structure Analysis. Multivariate Behavioral Research, 42(2), 261–281. doi:10.1080/00273170701360662
Methods

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Parameters

Parameter	Description	Units
Year	Year the organism was collected	unitless
Pond	Name of pond where the organism was collected	unitless
Latitude	Latitude of the pond	decimal degrees
Longitude	Longitude of the pond; negative values = West	decimal degrees
Common_Name	The scientific name of the organism to lowest taxonomic level possible	unitless
Scientific_Name	The common name of the organism	unitless
Frequency	The abundance of the organism collected. Frequency was calculated by summing individuals across stations within a pond per sampling event and averaging across year.	individuals

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Seine Net
Generic Instrument Description	A seine net is a very long net, with or without a bag in the centre, which is set either from the shore or from a boat for surrounding a certain area and is operated with two (long) ropes fixed to its ends (for hauling and herding the fish). Seine nets are operated both in inland and in marine waters. The surrounded and catching area depends on the length of the seine and of the hauling lines. (definition from: fao.org)

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Project Information

CAREER: Linking genetic diversity, population density, and disease prevalence in seagrass and oyster ecosystems (Seagrass and Oyster Ecosystems)

Coverage: Coastal New England

NSF Award Abstract:
Disease outbreaks in the ocean are increasing, causing losses of ecologically important marine species, but the factors contributing to these outbreaks are not well understood. This 5-year CAREER project will study disease prevalence and intensity in two marine foundation species - the seagrass Zostera marina and the Eastern oyster Crassostrea virginica. More specifically, host-disease relationships will be explored to understand how genetic diversity and population density of the host species impacts disease transmission and risk. This work will pair large-scale experimental restorations and smaller-scale field experiments to examine disease-host relationships across multiple spatial scales. Comparisons of patterns and mechanisms across the two coastal systems will provide an important first step towards identifying generalities in the diversity-density-disease relationship. To enhance the broader impacts and utility of this work, the experiments will be conducted in collaboration with restoration practitioners and guided by knowledge ascertained from key stakeholder groups. The project will support the development of an early career female researcher and multiple graduate and undergraduate students. Students will be trained in state-of-the-art molecular techniques to quantify oyster

and seagrass parasites. Key findings from the surveys and experimental work will be incorporated into undergraduate courses focused on Conservation Biology, Marine Biology, and Disease Ecology. Finally, students in these courses will help develop social-ecological surveys and mutual learning games to stimulate knowledge transfer with stakeholders through a series of workshops.

The relationship between host genetic diversity and disease dynamics is complex. In some cases, known as a dilution effect, diversity reduces disease transmission and risk. However, the opposite relationship, known as the amplification effect, can also occur when diversity increases the risk of infection. Even if diversity directly reduces disease risk, simultaneous positive effects of diversity on host density could lead to amplification by increasing disease transmission between infected and uninfected individuals. Large-scale field restorations of seagrasses (Zostera marina) and oysters (Crassostrea virginica) will be utilized to test the effects of host genetic diversity on host population density and disease prevalence/intensity. Additional field experiments independently manipulating host genetic diversity and density will examine the mechanisms leading to dilution or amplification. Conducting similar manipulations in two marine foundation species - one a clonal plant and the other a non-clonal animal - will help identify commonalities in the diversity-density-disease relationship. Further, collaborations among project scientists, students, and stakeholders will enhance interdisciplinary training and help facilitate the exchange of information to improve management and restoration efforts. As part of these efforts, targeted surveys will be used to document the perceptions and attitudes of managers and restoration practitioners regarding genetic diversity and its role in ecological resilience and restoration.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1652320

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