Heights and stages of Zostera marina flowering shoots determined from from weekly-biweekly surveys in shallow and deep zones at two sites in Massachusetts, USA in 2019

Website: https://www.bco-dmo.org/dataset/846985
Data Type: Other Field Results
Version: 1
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Project
» RUI: Collaborative Research: Trait differentiation and local adaptation to depth within meadows of the foundation seagrass Zostera marina (ZosMarLA)

Contributors	Affiliation	Role
Hughes, A. Randall	Northeastern University (NEU)	Principal Investigator
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Abstract
This dataset includes heights and stages of Zostera marina from weekly-biweekly surveys in the shallow and deep zones at two sites in Massachusetts, USA in 2019. Eleven surveys of two different eelgrass beds were conducted every 1-2 weeks starting June 4th and ending August 27th during the summer of 2019. The two sites were West Beach in Beverly (N 42.55921, W 70.80578) and Curlew Beach in Nahant (N 42.42009, W 70.91553).

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Coverage

Spatial Extent: **N**:42.55921 **E**:-70.80578 **S**:42.42009 **W**:-70.91553
Temporal Extent: 2019-06-04 - 2019-08-27

Acquisition Description

We conducted eleven surveys of two different eelgrass beds in Massachusetts every 1-2 weeks starting June 4th and ending August 27th during the summer of 2019. The two sites were West Beach in Beverly (N 42.55921, W 70.80578) and Curlew Beach in Nahant (N 42.42009, W 70.91553). Each survey consisted of a 20 m transect being laid out parallel to shore in both the shallow and deep zone. These zones were defined as being along the respective edges of the eelgrass beds. The exact depths of the zones varied from bed to bed.

During each survey, we measured the height of up to 3 flowering shoots per quadrat. In addition to measuring the height, we measured the height of the oldest and youngest spathes, the inflorescence height, and the flowering stage of the oldest and youngest spathes for each shoot. We defined flowering stages following De Cock (1980): 1 (styles erect out of spadix); 2 (styles bend back into spadix after pollination); 3 (half-anthers release pollen); 4 (half-anthers have been released, seeds maturing); 5 (seeds have started to release); and 6 (post-seed release when the flowering shoot begins to wither; Fig. 2 of von Staats et al., 2020). We also included two additional stages that occur before the flowering of the pistils based on our observations in the field: pre-spathe (PS; when a spathe is present, but pistils and anthers have not yet formed) and 0 (pistils and anthers have formed, but styles have not yet erected).

Processing Description

Data Processing:
We examined flowering shoot height and spathe number per flowering shoot using separate linear mixed effects models with site, depth, and time (week) as fixed factors and unique quadrat as a random effect to account for non-independence of measurements within the same quadrat. All models included all possible interactions.

To look at the timing of flowering across sites and depths, we compared the developmental stages of the youngest and oldest spathes separately. For our analyses, we combined stages 1-3 into a single stage since relatively few of these stages were found over the course of our study and because flowers only remain in these stages for a few hours to one week at most. Furthermore, the sequence of these stages is not always linear, as stage 3 can begin at the same time as stage 1 or before stage 2 if the flower has not yet been pollinated (De Cock 1980). We used linear regression to assess whether flowering phenology differed among locations (site), with time (measured in days since June 1st, a few days before we began our surveys) as our response variable, site, depth, and developmental stage (treated as a categorical factor) as our predictors, and including all possible interactions.

We also compared the timing of development between the oldest and youngest spathes across sites and depths. For this analysis we looked at the time it took spathes to reach stage 4, the stage in which seeds begin to develop. If stage 4 is reached it means (for the most part) that a given spathe can contribute to the proliferation of the Z. marina population. We used a linear regression with days since June 1 as our response variable, site, depth, and spathe identity (youngest or oldest) as our predictors, and including all possible interactions.

BCO-DMO Processing:
- changed date format to YYYY-MM-DD;
- renamed fields to conform with BCO-DMO naming conventions;
- replaced "NA" with "nd" to indicate "no data".

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Related Publications

De Cock, A. W. A. M. (1980). Flowering, pollination and fruiting in Zostera marina L. Aquatic Botany, 9, 201–220. doi:10.1016/0304-3770(80)90023-6
Methods

Von Staats, D. A., Hanley, T. C., Hays, C. G., Madden, S. R., Sotka, E. E., & Hughes, A. R. (2020). Intra-Meadow Variation in Seagrass Flowering Phenology Across Depths. Estuaries and Coasts, 44(2), 325–338. doi:10.1007/s12237-020-00814-0
Results

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Parameters

Parameter	Description	Units
Date	The date of sample collection; format: YYYY-MM-DD	unitless
Days_Since_June_1	The number of days since June 1st that data was collected (June 1st was a few days before our first survey)	unitless
Week	The assigned collection week number. Numbers start at 1 for the first week of collection and go up 1 each collection week.	unitless
Site	The site of collection. Either West (West Beach, Beverly, MA) or Dorothy (Curlew Beach, Nahant, MA).	unitless
Depth	SH (shallow zone) or DP (deep zone)	unitless
Quadrat	For each transect, quadrats will be in order with 1 being the first quadrat of each transect at 2m and 10 being the last at 20m. Some weeks go higher than 10 quadrats if we sampled more or had empty quadrats. Week 4 quadrat numbers do not correspond to transect position/sampling order.	unitless
Max_Height	The height of the flowering shoot measured to the nearest half centimeter.	centimeters (cm)
Inflorescence_Height	The height of the inflorescence of the flowering shoot (the height from the first branch to the top of the shoot); measured to the nearest half centimeter.	centimeters (cm)
number_of_spathes	The total number of spathes found on a given shoot.	number of spathes
youngest_stage	The flowering stage that the youngest spathe on a given flowering shoot is in at time of collection. The youngest spathe is considered the topmost spathe on a shoot. Stages were defined following De Cock (1980); see metadata for description.	unitless
oldest_stage	The flowering stage that the oldest spathe on a given flowering shoot is in at time of collection. The oldest spathe is considered the bottommost spathe on a shoot. If there is only one spathe on a flowering shoot, then it is filled in as the oldest spathe and the youngest is left blank. Stages were defined following De Cock (1980); see metadata for description.	unitless
youngest_height	The height from the base of the shoot to the branch of the youngest spathe on a shoot; measured to the nearest half centimeter.	centimeters (cm)
oldest_height	The height from the base of the shoot to the branch of the oldest spathe on a shoot; measured to the nearest half centimeter.	centimeters (cm)
Unique_Quadrat	A unique number assigned to each quadrat.	unitless

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Project Information

RUI: Collaborative Research: Trait differentiation and local adaptation to depth within meadows of the foundation seagrass Zostera marina (ZosMarLA)

Coverage: Massachusetts, USA

NSF Award Abstract:

Understanding how species cope with spatial variation in their environment (e.g. gradients in light and temperature) is necessary for informed management as well as for predicting how they may respond to change. This project will examine how key traits vary with depth in common eelgrass (Zostera marina), one of the most important foundation species in temperate nearshore ecosystems worldwide. The investigators will use a combination of experiments in the field and lab, paired with fine-scale molecular analyses, to determine the genetic and environmental components of seagrass trait variation. This work will provide important information on the microevolutionary mechanisms that allow a foundation species to persist in a variable environment, and thus to drive the ecological function of whole nearshore communities. The Northeastern University graduate and Keene State College (KSC) undergraduate students supported by this project will receive training in state-of-the-art molecular techniques, as well as mentorship and experience in scientific communication and outreach. A significant portion of KSC students are from groups under-represented in science. Key findings of the research will be incorporated into undergraduate courses and outreach programs for high school students from under-represented groups, and presented at local and national meetings of scientists and stakeholders.

Local adaptation, the superior performance of "home" versus "foreign" genotypes in a local environment, is a powerful demonstration of how natural selection can overcome gene flow and drift to shape phenotypes to match their environment. The classic test for local adaptation is a reciprocal transplant. However, such experiments often fail to capture critical aspects of the immigration process that may mediate realized gene flow in natural systems. For example, reciprocal transplant experiments typically test local and non-local phenotypes at the same (often adult) life history stage, and at the same abundance or density, which does not mirror how dispersal actually occurs for most species. In real populations, migrants (non-local) often arrive at low numbers compared to residents (local), and relative frequency itself can impact fitness. In particular, rare phenotypes may experience reduced competition for resources, or relative release from specialized pathogens. Such negative frequency dependent selection can reduce fitness differences between migrants and residents due to local adaptation, and magnify effective gene flow, thus maintaining greater within-population genetic diversity. The investigators will combine spatially paired sampling and fine-scale molecular analyses to link seed/seedling trait variation across the depth gradient at six meadows to key factors that may drive these patterns: local environmental conditions, population demography, and gene flow across depths. The team will then experimentally test the outcome of cross-gradient dispersal in an ecologically relevant context, by reciprocally out-planting seeds from different depths and manipulating relative frequency in relation to both adults and other seedling lineages. The possible interaction between local adaptation and frequency-dependence is particularly relevant for Zostera marina, which represents one of the best documented examples of the ecological effects of genetic diversity and identity. Further, a better understanding of seagrass trait differentiation is not simply a matter of academic interest, but critical to successful seagrass restoration and conservation.

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-1851043

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