Role of genetic diversity and water quality in the 2013 decline of eelgrass (*Zostera marina*) populations of the Upper Frenchman Bay, ME coastlines

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To determine the role of genetic diversity in the 2013 loss of eelgrass (*Zostera marina*) in the upper Frenchman Bay, Mount Desert Island, a set of genetic markers were sequenced and compared against eelgrass density and tensile strength. While the genetic diversity of the eelgrass did not explain differences in health of eelgrass by site, some water quality parameters such as silica and nitrate/nitrite in the water column may be contributing factors to the decline.

Eelgrass beds (*Zostera marina*) serve a vital role invaluable to commercial supplies of seafood in Maine, by forming estuaries for young fish and shellfish. Since aerial fly-over imaging done in 1996, the coverage of eelgrass in the upper Frenchman Bay, ME, has diminished from 3,000 to less than 200 acres[1,2]. In the summer of 2013, major restoration areas around Mount Desert Island at Hadley Point, Berry Cove, and Thomas Island, established by ecologists to counter this loss, also declined. Genetic diversity of eelgrass may also explain differences in survival among populations, with higher genetic diversity potentially imparting more resistance to environmental change or physical disturbance. The genetic diversity of six populations (2 unhealthy: Berry Cove (BC) and Bar West (BW); 4 healthy: Bar East (BE), Ship Harbor (SH), Stave Island (SI), and Wonderland (W)) across Mount Desert Island was quantified using microsatellite size DNA analysis for six markers. The inbreeding coefficient (F_{IS}), a measure of genetic diversity, was calculated for each population and compared against eelgrass density; no correlation was found between the health of the site and the genetic diversity of the plants (Fig 1).

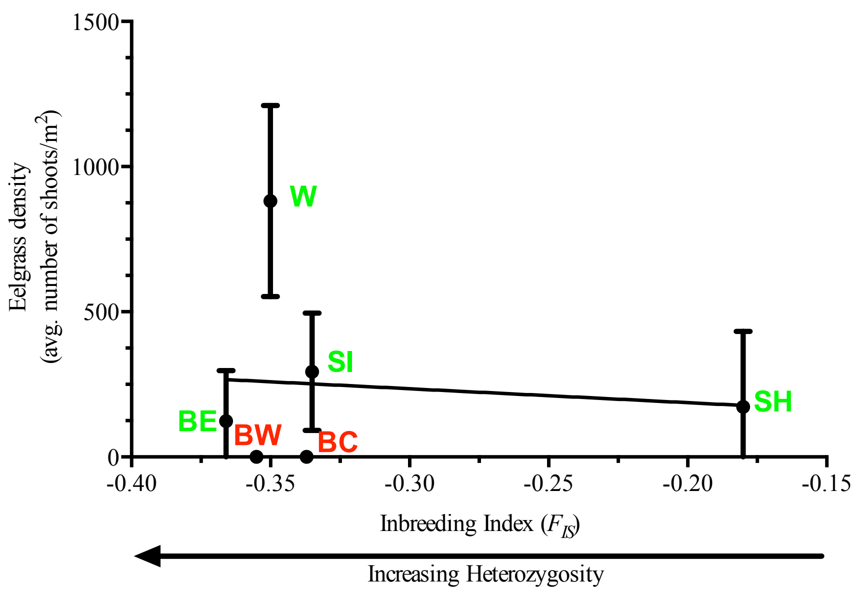

Figure 1. Linear relationship between inbreeding index (F_{IS}) and eelgrass density ($R^2 = 0.01$, $p = 0.84$). Sites in green are deemed healthy eelgrass habitats; sites in red are deemed unhealthy eelgrass habitats based on plant density.

The tensile strength of the eelgrass, perhaps a measure of resilience to physical disturbance, was compared to the genetic diversity of each site. There was no correlation found between the two variables (Fig 2), and there was no difference in healthy versus unhealthy sites in the tensile strength of the plants (Fig 3).

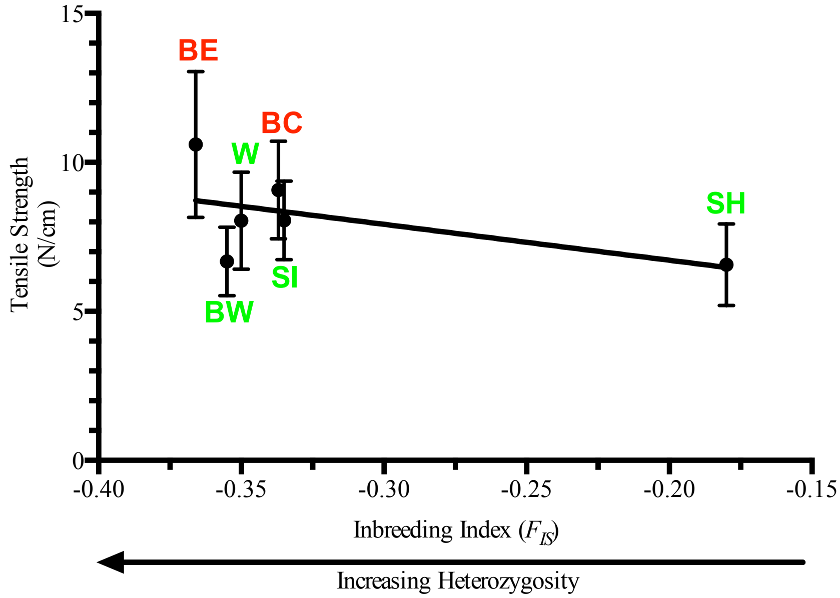

Figure 2. Linear relationship between inbreeding index (F_{IS}) and tensile strength ($R^2 = 0.31$, $p = 0.25$). Sites in green are deemed healthy eelgrass habitats; sites in red are deemed unhealthy eelgrass habitats based on plant density.

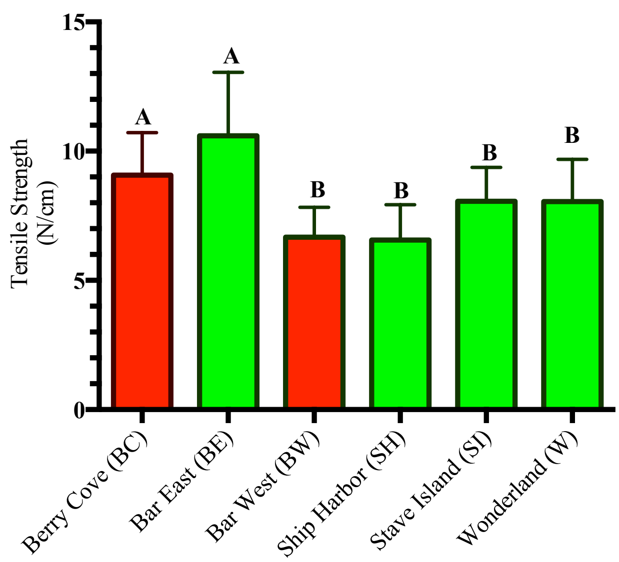

Figure 3. Average tensile strength of plants collected at healthy (green) and unhealthy sites (red). Significant differences in tensile strength was determined with a one-way ANOVA and Tukey's *posthoc* test ($\alpha = 0.05$). Letters above eelgrass habitats indicate where there were no significant difference between sites.

Genetic diversity and tensile strength did not seem to correlate with the health of eelgrass populations as was expected for Berry Cove, which had high levels of intrapopulation diversity and little differentiation from healthy sites. Nevertheless, the population at Ship Harbor, a healthy site, showed the lowest intrapopulation diversity and highest interpopulation differentiation.

To determine the role of water quality in the decline, nitrate/nitrite, ammonia, phosphorus, and silicate levels were measured using a Bran Luebbe Autoanlyzer III on four separate occasions at all sites described above, plus several additional sites, over the course of the summer. There were differences in silica in the water column among sites as determined by one-way ANOVA ($F = 2.585$, $p = 0.0125$). A comparison of all sites documented to have lost eelgrass (Jordan River, Thomas Island East, Thomas Island West, Hadley Point, Berry Cove, Lamoine Shore, and Bar West) and all sites with intact eelgrass beds (Bar East, Stave Island, Wonderland and Ship Harbor) revealed a significant difference in silica in the water column over the course of the summer (*t*-

test, $p = 0.0179$). Silica was highest where eelgrass was intact. There was also a significant difference among sites for nitrate/nitrite levels in the water column as determined by one-way ANOVA ($F = 3.00$, $p = 0.005$). A comparison of sites documented to have lost eelgrass and sites with intact eelgrass as listed above revealed a significant difference in nitrate/nitrite in the water column over the course of the summer (t-test, $p = 0.003$). Nitrate/nitrite levels were highest where eelgrass was intact. There was not a significant difference in ammonia levels among sites as determined by one-way ANOVA ($F = 0.780$, $p = 0.667$) and consequently, there was not a significant difference in total dissolved inorganic nitrogen (DIN) among sites ($F = 1.72$, $p = 0.099$). The same was true for phosphorus ($F = 0.385$, $p = 0.961$). The affect of water column nutrient levels on eelgrass health and susceptibility to disease and damage will be the subject of future research.

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2. **Bailey D, Bailey J, Kidder G, Disney J.** A citizen science approach to mapping eelgrass (*Zostera marina* L.) loss in Maine. *Bull. Mt. Desert Isl. Biol. Lab.* 53:25, 2014.