Population genetics and abundance of the invasive European green crab (*Carcinus maenas)* and its role in eelgrass (*Zostera marina*) loss around Mount Desert Island

Mary Badger[1,2], Alden Dirks[1,3], Anna Farrell[1], Jirias Charabati[1], Kathleen Morrill[4], Jane Disney[1] and Larissa Williams[1,4]

[1] Mount Desert Island Biological Laboratory, Salisbury Cove, ME 04672

[2] Smith College, Northampton, MA 01063

[3] Swarthmore College, Swarthmore, PA 19081

[4] Bates College, Lewiston ME 04240

Following the devastating 2013 loss of eelgrass (*Zostera marina*) in the upper Frenchman Bay, Mount Desert Island, the role of the invasive green crab (*Carcinus maenas*) in the decline was investigated. Neither the genetics of the crabs nor their abundance correlated to the overall health of the eelgrass. The loss of eelgrass may be due to other factors or an interplay of abiotic and biotic factors.

Zostera marina or "eelgrass" is a common seagrass found widespread in northern coastlines across the world. Eelgrass beds serve a vital role in marine ecosystems of Maine, protecting shorelines against erosive forces and providing an ecosystem for larval and juvenile fish and shellfish. Between 1996 and 2013, the coverage of eelgrass in the upper Frenchman Bay area of Mount Desert Island, ME, was reduced from 3,174 to between 75 and 183 acres[1,2]. Contrasting sites with healthy populations to sites that have sustained significant loss is key to identifying decline causation. One potential culprit in eelgrass loss is the invasive green crab (*Carcinus maenas*); green crabs voraciously target soft shell clams[3] and damage eelgrass during their foraging behavior[4, 5]. Green crabs were first introduced to the New York Harbor from Europe in the 1800s[5], and a secondary invasion of novel northern haplotypes, hypothesized to be more voracious[7], occurred in Nova Scotia during the 1980s and 1990s[3]. To determine whether the genetics or abundance of the crabs are correlative with the health of the eelgrass, crabs were assessed at seven eelgrass sites around Mount Desert Island. Using the neutral mitochondrial genetic marker, cytochrome oxidase c I (COI), the haplotype of 15 individuals per site was ascertained. Haplotype 1, the original invading haplotype, was most frequent; novel northern haplotypes (4,5,6) were found in several individuals around the island (Fig 1).

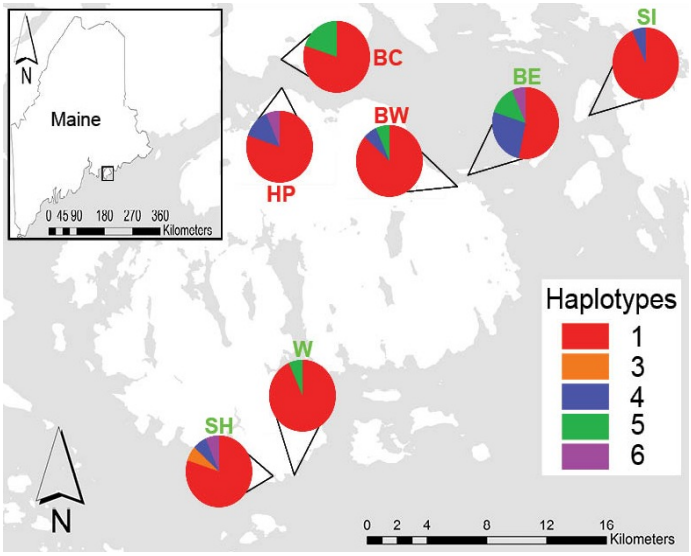

Figure 1. *C. maenas* COI haplotype frequencies per site (BC=Berry Cove; BE=Bar East; BW=Bar West; HP= Hadley Point; SH=Ship Harbor; SI= Stave Island; W=Wonderland). Sites marked in green are deemed healthy eelgrass habitats; sites in red are deemed unhealthy eelgrass habitats based on eelgrass density and biomass.

Since northern haplotypes are suspected to be more voracious, and hence cause more damage than the original invading haplotype (haplotype 1), the percent of northern haplotypes per site was compared to the health of the eelgrass, as measured by eelgrass shoot density. There was no correlation of the percent of crabs of a northern haplotype with the health of the eelgrass at that site (Fig 2).

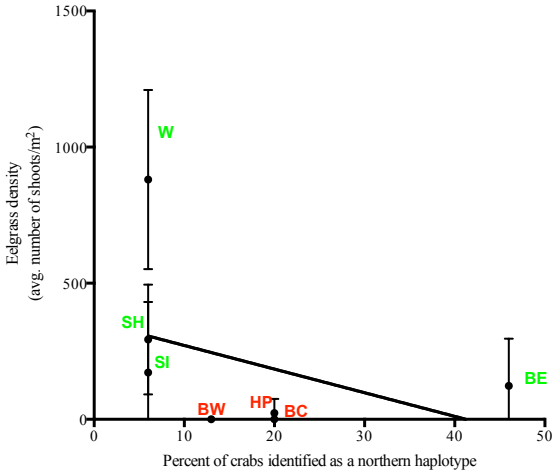

Figure 2. Linear relationship between percent of crabs identified as a northern haplotype and eelgrass density ($R^2 = 0.13$, $p = 0.38$). Sites in green are deemed healthy eelgrass habitats; sites in red are deemed unhealthy eelgrass habitats.

From green crab abundance data collected over a four-day course of sampling in September of 2014, the greatest abundances were found at Bar West, a site of considerable eelgrass loss in 2013-2014. However, green crab abundance in Berry Cove and Hadley Point, also sites of great eelgrass decline, were not significantly different from other healthy sites such as Bar East, Stave Island, and Ship Harbor (Fig 3).

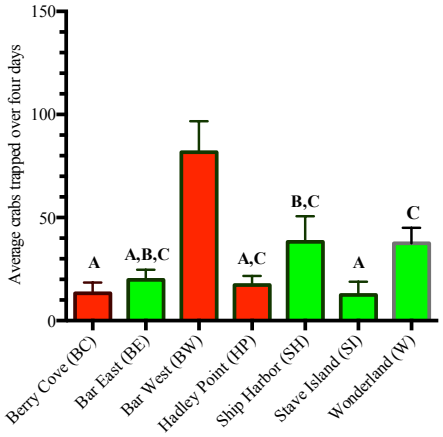

Figure 3. Average green crab (*C. maenas*) trapped over four days in September of 2014 in eelgrass habitats around Mount Desert Island. Sites in green are deemed healthy eelgrass habitats; sites in red are deemed unhealthy eelgrass habitats. Significant differences in average crabs trapped were determined with a one-way ANOVA and Tukey's *posthoc* test ($\alpha = 0.05$). Letters above eelgrass habitats indicate where there was no significant difference between sites.

While it cannot be ruled out that the presence of green crabs contributed to the 2013 eelgrass decline in Frenchman Bay, the loss of eelgrass may be due to other factors or an interplay of abiotic and biotic factors.

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1. **Disney J, Thornburn L, Kiddler G.** Possible causes of eelgrass (*Zostera marina*) loss in Frenchman Bay, Maine. *Bull. Mt. Desert Isl. Biol. Lab.* 53:26-28, 2014.
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.
3. **Roman J.** Diluting the founder effect: cryptic invasions expand a marine invader's range. *Proc. Biol. Sci.* 273:2453-2459, 2006.
4. **Neckles HA.** Loss of Eelgrass in Casco Bay, Maine, Linked to Green Crab Disturbance. *N Nat, in press.*
5. **Garbary D, Miller A, Williams J, Seymour N.** Drastic decline of an extensive eelgrass bed in Nova Scotia due to the activity of the invasive green crab (*Carcinus maenas*). *Mar. Biol.* 161:3-15, 2014.
6. **Compton TJ, Leathwick JR, Inglis GJ.** Thermogeography predicts the potential global range of the invasive European green crab (*Carcinus maenas*). *Div. Distr.* 16:243-255, 2010.
7. **Kanary L, Musgrave J, Tyson RC, Locke A, Lutscher F.** Modelling the dynamics of invasion and control of competing green crab genotypes. *Theor. Ecol.* 7:391-406, 2014.