Blue mussel (*Mytilus edulis*) settlement on restored eelgrass (*Zostera marina*) is not related to proximity of eelgrass beds to a bottom mussel aquaculture lease site in Frenchman Bay.

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Eelgrass beds in Frenchman Bay, Hancock County, ME are rich in species diversity, but the predominant organisms on eelgrass blades during the summer months are blue mussel larvae. We found larval mussels in high abundance, with no difference in their prevalence, when comparing eelgrass blades from a restored area near a bottom mussel aquaculture lease site at Hadley Point in Frenchman Bay and self-established eelgrass beds near-by and elsewhere. Serving as substrate is one important function of eelgrass, among a myriad of services it provides in subtidal areas of estuaries and bays. Another important function of eelgrass is water clarification through sediment stabilization and nutrient uptake. We found increasing water clarity in the years after eelgrass restoration at Hadley Point. These results indicate that at least some habitat functions are restored as an outcome of restoring eelgrass.

Eelgrass plants (*Zostera marina*) form important biogenic habitat for many marine organisms in the Gulf of Maine, serving as nursery, refuge, and feeding grounds for organisms such as fish, crustaceans, gastropods, bivalves and other invertebrates[1]. Eelgrass beds help protect the shoreline and clarify the water by stabilizing sediments and taking up nutrients from land-based activities[1]. Eelgrass in Frenchman Bay has declined significantly since 1996 (Figure 1), possibly due to dragging for shellfish and other commercially important sessile species. We commenced eelgrass restoration efforts at Hadley Point in 2007 and have documented a steady increase in eelgrass coverage at Hadley Point each year since then[2]. In 2008, a single day study of eelgrass colonizers revealed that the dominant species on eelgrass plants was the blue mussel (*Mytilus edulis*) in both our recently restored eelgrass area and in a near-by, self-established eelgrass bed at Hadley Point. Mussel larvae accounted for the majority of organisms on young and old blades (98% for the restored eelgrass area and 95% for the self-established eelgrass area). We did find more mussel larvae on the older (longer, outer) blades, and decided to focus on the outer blades of the plant in subsequent studies. The mussels were present as pediveligers, the larval stage that precedes metamorphosis into the first post-larval or spat stage called the plantigrade[3]. Blue mussel pediveligers use the eelgrass blades to suspend themselves in the water column where they feed on phytoplankton and suspended organic matter.

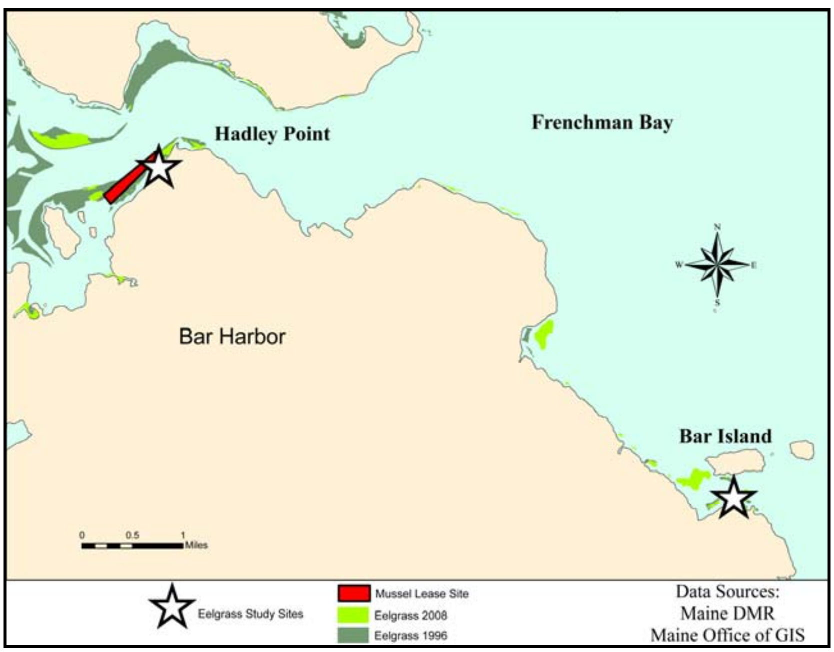

Figure 1: Sample sites were located at Hadley Point near a 47 acre bottom mussel aquaculture lease site, and near Bar Island in Bar Harbor, Maine. Note the decline of eelgrass between 1996 and 2008 in the upper bay.

We hypothesized that proximity of the restored and self established eelgrass areas to a bottom mussel aquaculture lease site might account for the abundance of mussel larvae in the 2008 study.

During the summers of 2009 and 2010, we tested the hypothesis that proximity to a mussel aquaculture lease site influenced the abundance of mussel larvae on eelgrass by setting up a comparison site inside a self-established eelgrass bed near Bar Island, approximately 7.5 nautical miles from the restoration site at Hadley Point (Figure 1). During low tide we collected six older (longer, outer) eelgrass blades from both Hadley Point and Bar Island. The blades were placed in separate sample bags or collection jars. Salinity and temperature were measured at each site on each sample day. Samples were taken back to the laboratory; blade length was measured and the numbers of blue mussel larvae and other organisms were determined.

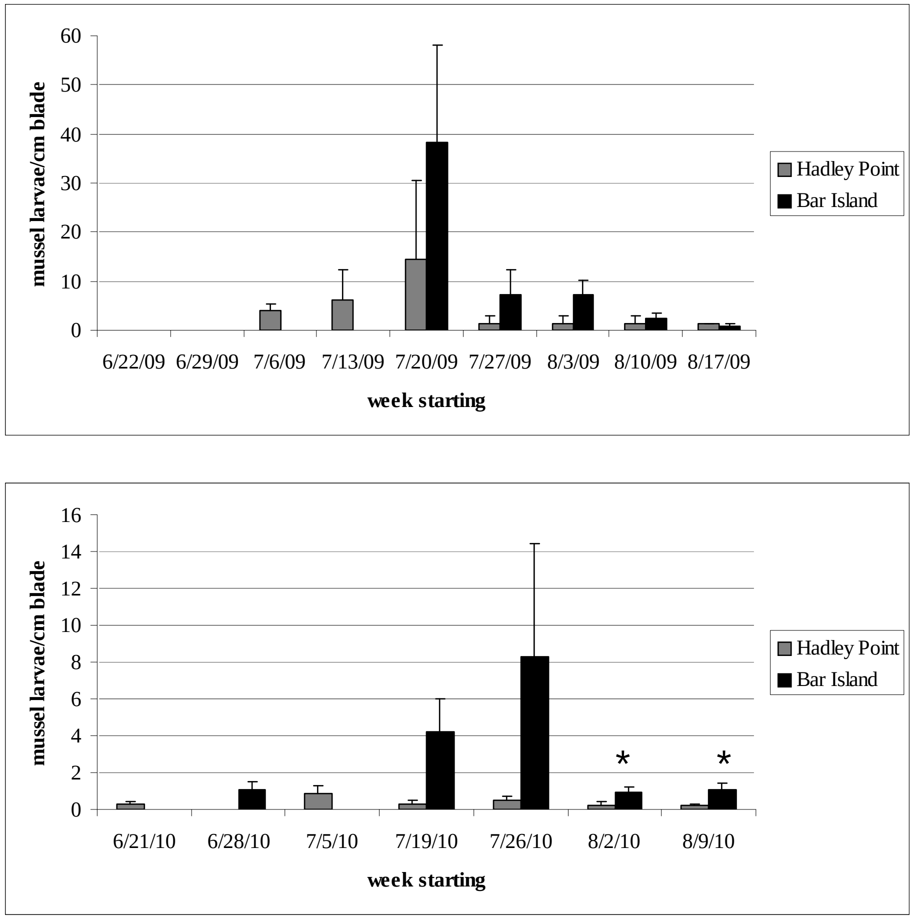

Figure 2: Average mussel larvae on eelgrass blades (leaves) throughout the summers of 2009 and 2010. There is no significant difference between Hadley Point and Bar Island sites until the end of summer 2010. * denotes significant difference between Hadley Point and Bar Island average mussel larvae (t-test, $p<.05$, $n=6$ for each sample week).

We calculated the number of organisms per centimeter of blade in order to make comparisons between sites (Figure 2). Mussel larvae were the predominant organism inhabiting the surface of eelgrass blades both from plants in the restored eelgrass area at Hadley Point and the self-established area near Bar Island (Table 1, Figure 3). There was no significant difference in the overall number of mussel larvae per cm. of blade at the two sites. However, there was a difference in how long mussel larvae persisted on plants in the two locations. There were significantly more mussel larvae on eelgrass blades at the Bar Island site than on eelgrass blades in the Hadley Point eelgrass restoration area as the summer progressed ($p<0.05$). The length of time that blue mussels remain in the pediveliger stage ranges from 2 to 46 days in an inverse relation to temperature[6]. Salinity can also affect the length of time spent as a pediveliger, the delay being longer at lower salinities[6]. However, we

	2009	2010
Hadley Point	92.9 ±1.8%	92.6 ± 3.9%
Bar Island	94.0 ± 0.7%	97.6 ± 0.67%

Table 1: Average relative abundance of mussel larvae (total mussels/ total organisms) on eelgrass blades.

cannot attribute the difference in the number of mussel pediveligers on eelgrass blades at the end of the summer in 2010 to variances in temperature or salinity, as there were no significant differences between these variables at the two sites.

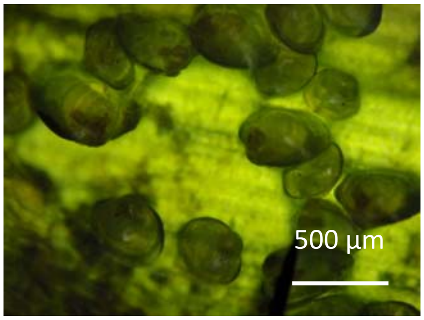

Figure 3: Mussel larvae on an eelgrass blade.

The numbers of mussel larvae were significantly higher than the combined numbers of other organisms (periwinkles, whelks, chink shells, mysid shrimp, nudibranchs, amphipods, polychaetes, and nemotodes) per cm. of blade in both areas ($p < 0.05$). When mussel larvae decreased over the course of the summer, they were not replaced by other organisms. In other words, mussel larvae did not compete with other organisms for space; they were most likely more plentiful in the water column.

In Frenchman Bay, mussel larvae and other suspension feeders may be serving the function of clearing the overlying water column in eelgrass beds, controlling the amount of suspended organic matter in the eelgrass areas. This has been documented for other types of seagrass beds in other locations[4,5]. We measured turbidity in triplicate at Hadley Point on two occasions at two sites over three summers, beginning with the first year of eelgrass restoration. In 2007, turbidity was measured at 1.11 ± 0.17 Nephelometric Turbidity Units (NTU); in 2008, turbidity was measured at 1.11 ± 0.05 NTU. In 2009, we measured 0.80 ± 0.07 NTU, while in 2010 the value was 0.79 ± 0.02 NTU; these latter measurements ($n = 12$ in 2009 and $n = 3$ in 2010) were not different from each other, but were significantly ($p<0.01$) lower than in previous years. The decrease in turbidity may be related to the increased presence of suspension feeders supported by re-established eelgrass combined with sediment stabilization by spreading eelgrass rhizomes. Eelgrass coverage increased from <1% in 2007 when we commenced eelgrass restoration, to 8% by 2009[2] and jumped to over 30% in 2010.

Comparison of organisms on eelgrass blades at our two study sites suggests that large numbers of mussel larvae might be a naturally occurring phenomenon throughout Frenchman Bay in the summer. There was no relationship between proximity to a mussel aquaculture site and the abundance of mussels on eelgrass plants. Future studies include assessing the distribution of organisms in the water column as compared to organisms settling on eelgrass blades, documenting juvenile mussel settlement in and near restored eelgrass beds, and continued monitoring of water quality both inside and outside our restoration area.

Project funding came from Gulf of Maine Council on the Marine Environment, US Fish and Wildlife Foundation and private sources. We thank undergraduate interns Molly Miller, Casie Reed, Kevin Lanza, and Hannah Clemente (supported by NSF REU DBI-0453391) and high school interns Ellen Daily and Dacie Manion (supported by NIEHS STEER R25-E5016254).

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