Lobster *(Homarus americanus)* size distribution in relation to proximity to eelgrass (*Zostera marina)* beds in Frenchman Bay

Shannon White[1], Shira Bleicher[1,2], Elias Peirce[1,3], George Kidder[1] and Jane Disney[1]
[1]Mount Desert Island Biological Laboratory, Salisbury Cove, ME 04672
[2]Wellesley College, Wellesley, MA 02481
[3]Bowdoin College, Brunswick, ME 04011

Eelgrass beds are productive and structurally complex habitats which broaden the array of organisms that can inhabit an area, and serve as nursery grounds for invertebrates and fish and as resting and feeding grounds for other organisms, including migrating seabirds. We examined lobster size distribution near eelgrass beds, while accompanying a local lobsterman as he checked his traps. These data revealed a relationship between lobster size and proximity to eelgrass beds, and between lobster size and proximity to shore. These results are helpful for understanding the importance of near-shore habitats in Frenchman Bay for a commercially targeted species at different life stages.

Eelgrass (*Zostera marina*) is a subtidal flowering plant with great ecological value[2]. It provides a place of attachment for various organisms and also creates shelter, increasing the variety of organisms that can inhabit an area. Seagrass beds serve as nursery grounds for invertebrates and fish, including commercially targeted species, and are resting and feeding grounds for other organisms, including migrating seabirds[6]. A study in the Piscataqua River explored the use of eelgrass beds as habitat for the American lobster (*Homarus americanus*) and demonstrated their importance as habitat for adolescent (pre-reproductive) lobsters. In this study a mesocosm experiment revealed a preference by adolescents for burrowing in vegetated habitat over bare mud, likely related to the added structure provided by the eelgrass. In addition, 80% of the lobsters collected from eelgrass beds in this study were adolescents, with a carapace length (CL) of 40 to 70 mm[5]. In the Pemaquid area of mid-coast Maine, Wahle and Steneck[7] found that eelgrass supported low densities of lobsters of all sizes, but noted the particular importance of cobble as shelter-providing habitat for early benthic phase (EBP) lobsters (< 40 mm CL). Larger lobsters occurred more frequently than EBP lobsters on featureless soft or bedrock substrata, which reflects the shift of adolescent and maturing lobsters to a more mobile existence, in contrast to the early shelter-dependent life stage. While a few fish were captured in the lobster traps during the course of this study, large numbers of crabs and lobsters were captured in the traps. Since lobstermen must distinguish between size classes of captured lobsters, we acquired a large amount of data for lobsters of different size classes at the sampled sites. This allowed for the relationship between lobster size distribution and near-shore habitats to be explored, in order to understand the potential importance of this habitat and surrounding areas for different life stages of a commercially targeted species.

Eelgrass in Frenchman Bay was mapped in 2008 by Seth Barker (Maine Department of Marine Resources). In 2011, we confirmed eelgrass locations in our study area by kayaking the Bar Harbor shoreline and taking coordinates in eelgrass areas using hand-held GPS devices. Coordinates were overlaid on GIS maps depicting eelgrass coverage in 2008, using ArcGIS 9.3.

Lobsters and bycatch were collected by boat from lobster traps set and hauled by a local lobsterman on three different fishing trips over a three-week period in July 2011. Data were collected from between 125 to 170 traps per trip. As each lobster trap was drawn up, a GPS coordinate was taken when the boat was directly above the trap. Observations of plants on the trap were recorded. The lobsters from each trap were scored into five categories: 'keepers' (3.25-5 in carapace length (CL)), 'smalls' (CL $\leq$ 3.25 in), 'too large' (CL $\geq$ 5 in), 'v-notched females', and 'females with eggs'. (A v-notched female is one that has been permanently marked on the tail when it is found with eggs and is returned to the ocean to continue reproducing[1].) 'Too large' lobsters, 'v-notched females', and 'females with eggs' were represented by very few individuals and were therefore not included in the data analysis.

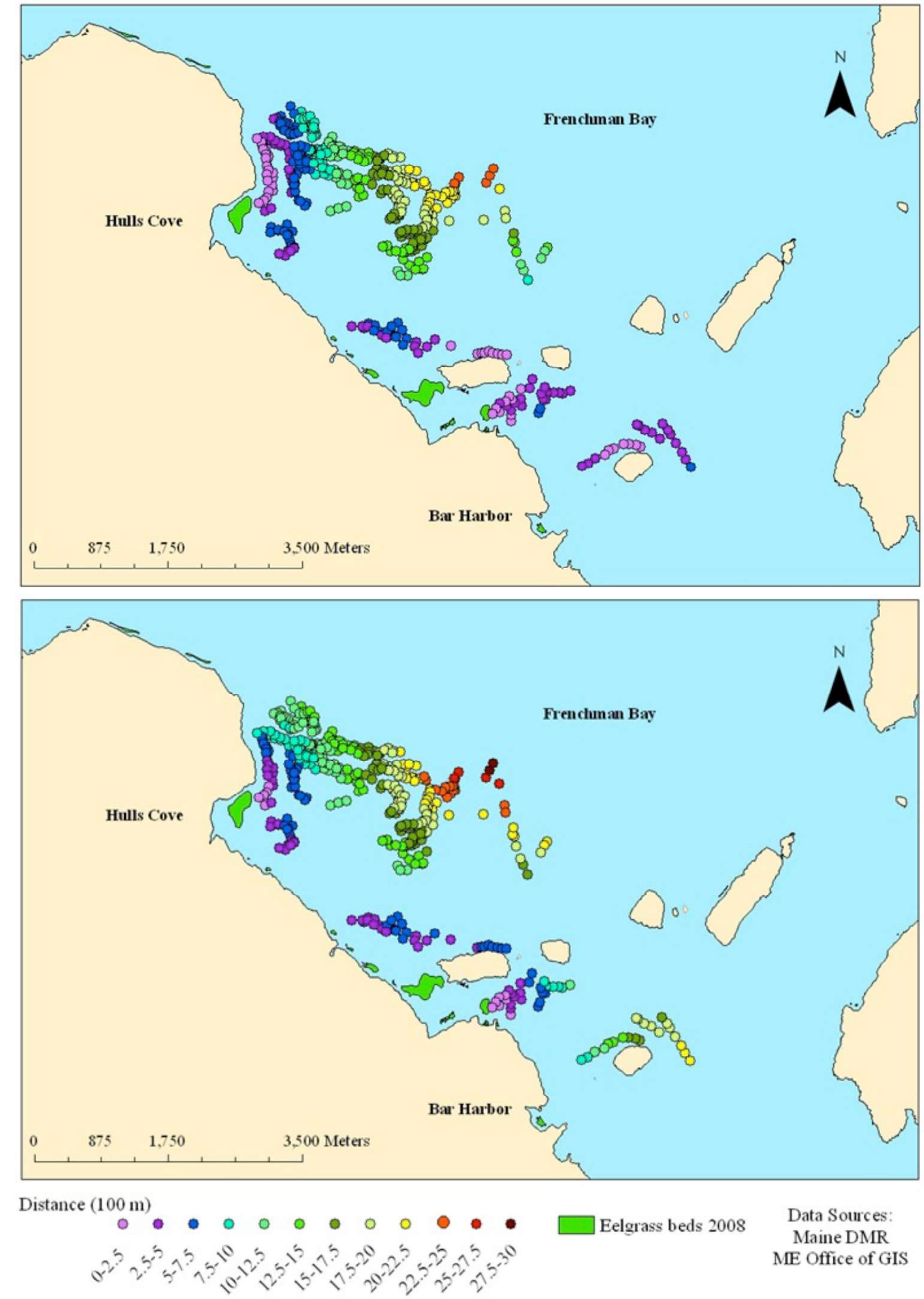

Figure 1. Lobster trap sites sampled during the summer of 2011 in Frenchman Bay. Distance of each sample site from shore (A) and from eelgrass beds (B) is depicted by color. A total of 506 traps were sampled over the duration of three fishing trips in three weeks. Eelgrass beds are represented by green dots.

Using ArcGIS 9.3 software, the lobster trap GPS coordinates from each of the three trips were compiled onto one map of Frenchman Bay (Fig 1). Using a selection tool in ArcGIS 9.3, the distance of each trap from an eelgrass bed was categorized by 250 m intervals. Subsequently, some distance categories were combined to ensure that each category contained a similar number of sampled traps for data analysis. The distance of each trap from the shoreline was also categorized so that the relationship between lobster size distribution and proximity to the shore could be examined. While our primary interest was to examine the relationship of lobster size with distance from eelgrass, it is likely that some environmental factors co-vary with distance from eelgrass and distance from shore. We were therefore interested in whether or not the same trends existed in lobster size distribution with respect to these two explanatory variables and if the effects of each on lobster size distribution could be resolved. Using R software[4], a generalized linear model (GLM) was used to identify relationships between counts of ‘smalls’ and ‘keepers’ and proximity to eelgrass beds, as well as the relationships between lobster counts and proximity to shore. As the response variable was represented by count data, and in order to account for overdispersion, the error structure specified for the GLM was quasi-Poisson[3].

Table 1. Total number of individuals of different classes of lobster and bycatch observed in 506 lobster traps set in Frenchman Bay in the summer of 2011. Mean counts per trap ± standard deviation are also presented. Total organisms includes 'smalls', 'keepers', 'lobsters with eggs', 'bycatch' (mostly crabs with a few small fish), as well as 'v-notched females' and 'large'; the latter two groups are not shown individually.

	Smalls (≤3.25 in)	Keepers (3.25 - 5 in)	Lobsters with Eggs	Bycatch	Total Organisms
Total individuals	993	1178	12	787	2989
Mean per trap (±SD)	1.96 ± 2.09	2.33 ± 1.91	0.02 ± 0.15	1.56 ± 2.22	5.91 ± 3.71

Table 2. Results from the generalized linear model . Estimates of the linear coefficient and associated t-test results are shown and indicate that this coefficient was significantly different from zero for each of the four relationships. Parameter estimates are in logs, as GLM with Poisson errors uses a log link function[3].

Relationship	Estimate of the linear coefficient (b)	t-value	df (residual)	p-value
Keepers ~ Distance from eelgrass	0.033	2.242	504	0.025
Smalls ~ Distance from eelgrass	-0.054	2.874	504	0.004
Keepers ~ Distance from shore	0.028	2.021	504	0.044
Smalls ~ Distance from shore	-0.072	3.959	504	<0.001

Table 1 presents the composition of the catch. Results of the GLMs suggested that the relationships between lobster count and distance were significant for each of the four relationships examined (Table 2). The number of 'keepers' peaked at 750-1750 m and was highest at 1000-1250 m from eelgrass and from shore, while the lowest numbers were found at the shortest and farthest distances with respect to each (Fig 2). The number of 'smalls' was lowest at the distances farthest from eelgrass and from shore. The number of 'smalls' peaked at 750-1500 m with respect to eelgrass and was highest at 750-1000 m. The number of 'smalls' peaked closest to shore (0-500 m) and at 1000-1500 m.

Although similar trends in the lobster size distribution were seen with respect to proximity to eelgrass and to shore, further investigation would be necessary to disentangle the effects of one from the other. For example, in traps 750-1000 m from eelgrass, numbers of 'smalls' were highest, but many of the traps in this distance range were also 0-500 m from shore (see Figure 2), where the highest number of 'smalls' was found with respect to shore. Proximity to shore could be the reason for the observed high number of 'small' lobsters. Alternately, many of the traps 750-1000 m from eelgrass were clustered in an area to the northeast of Hulls Cove where high numbers of both size classes were observed at 750-1750 m from eelgrass and shore. Therefore, the observed high number of 'smalls' in this area might better be explained by factors other than proximity to shore or to eelgrass.

Young lobsters are dependent on shelter-providing habitat and become more mobile as they mature[7]. Therefore, it was expected that the highest number of small lobsters would be in the closest proximity to eelgrass and to shore. While this was the case with respect to shore, there were peaks in the number of 'smalls' and 'keepers' at intermediate distances from shore and from eelgrass beds. The majority of traps that were sampled during this study were clustered to the east and northeast of Hulls Cove. Traps in this area, particularly within 1000-1250 m from eelgrass and from shore (for which many points corresponded), supported the highest numbers of lobsters. t would be of interest to explore the habitat in this area, particularly with respect to substratum, vegetation, and depth, to better understand how lobsters in this area use the habitat.

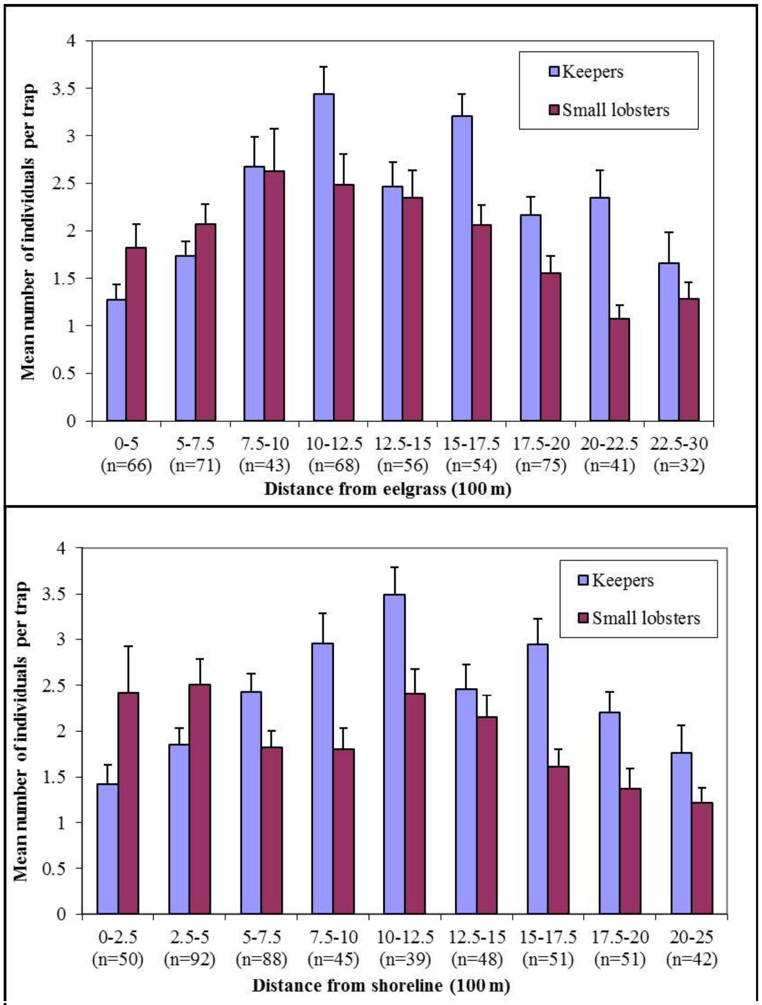

Figure 2. Mean (±SE) number of 'small' lobsters and 'keepers' recorded per trap. Above – against distance from eelgrass. Below – against distance from shore. Totals: number of traps = 506, number of 'keepers' = 1178, number of 'small' lobsters = 993.

While the purpose of this study was to investigate the importance of eelgrass beds in Frenchman Bay for commercially targeted species, there are limitations in using fishery-dependent data to try to understand this relationship. Because lobsterman set traps where they hope to maximize catch, the data were collected using a non-uniform sampling strategy, which was reflected in the clustering of sample sites to the east and northeast of Hulls Cove, and the majority of the traps sampled were not in or even near eelgrass beds. This hindered the comparisons that could be made between areas with and without eelgrass. Consequently, the results of the GLMs are preliminary and merely suggestive of the relationships between lobster size distribution and distance from shore and from eelgrass. Future work should involve a fishery-independent sampling strategy so that there is sufficient sampling within and around eelgrass beds and other factors, like depth and region, could be controlled for by experimental design. Despite the limitations of this study, nearshore habitats were identified as important for small lobsters and the area east and northeast of Hulls Cove appeared to be an important habitat for lobsters of both size classes.

We thank Phil Corson and Lee Brewer for allowing us to accompany them on their lobster boat, Ted Taylor, Molly Miller, Carrie LeDuc and Anica Miller-Rushing for assisting with mapping of coastal eelgrass, Benjamin King for assisting with data analysis, and David Clare for his helpful discussions about the work and the analysis.

This work was supported by REU site at MDIBL NSF DBI 0453391 and STEER NIH R25-ES016254.

1. **Acheson, J and Gardner, R.** The evolution of the Maine lobster V-notch practice: cooperation in a prisoner's dilemma game. *Ecology and Society* 16: 41, 2011.
2. **Borum, J and Greve, TM.** The four European seagrass species. In: *European seagrasses: an introduction to monitoring and management*. Edited by Borum, J, Duarte, CM, Krause-Jensen, D, Greve, TM. The M&MS project, 2004, p. 1-7.
3. **Crawley, MJ.** *The R Book*. John Wiley & Sons Ltd, 2007, p. 1-942.
4. **R Development Core Team**. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2011. ISBN 3-900051-07-0, URL http://www.R-project.org/.
5. **Short, FT, Matso, K, Hoven, HM, Whitten, J, Burdick, DM and Short, CA.** Lobster Use of Eelgrass Habitat in the Piscataqua River on the New Hampshire/Maine Border, USA. *Estuaries* 24: 277-284, 2001.
6. **Terrados, J and Borum, J.** Why are seagrasses important? - Goods and services provided by seagrass meadows. In: *European seagrasses: an introduction to monitoring and management*. Edited by Borum, J, Duarte, CM, Krause-Jensen, D, Greve, TM. The M&MS project, 2004, p. 8-10.
7. **Wahle, RA, and Steneck, RS**. Recruitment habitats and nursery grounds of the American lobster *Homarus americanus*: a demographic bottleneck? *Marine ecology progress series* 69:231–243, 1991.