Performance Progress Report - NA14NMF4270033

Title: Demonstrating Shellfish Aquaculture Technology in Pilot and Commercial Scale Projects: Creating New Opportunities for Maine’s Coastal Communities

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Organization: Downeast Institute for Applied Marine Research & Education (Beals, Maine)

Award Period: July 1, 2014 through June 30, 2016

Report Period: January 1, 2015 through June 30, 2015

The project proposed to: 1) demonstrate marine aquaculture technologies in pilot and commercial scale projects designed to create jobs in coastal communities, produce healthful, local seafood, revitalize working waterfrocks and support traditional fishing communities; and, 2) provide training for fishermen and others in coastal communities in aquaculture production methods.

The proposed project goals were to: To increase soft-shell clam harvests locally in the face of increasing threats due to invasive green crab predation, warming seawater temperatures, and ocean acidification, and to create a model shellfish management program for coastal Maine communities facing unprecedented declines in clam landings.

The proposed project objectives were to:

1) Determine spatial and temporal variability of green crabs, *Carcinus maenas*, in the Harraseeket River and intertidal areas adjacent to the river using specially designed and tested traps in an attempt to remove crabs from the ecosystem that, otherwise, would remain to prey on soft-shell clams of all age-classes;

2) Test the efficacy of “green crab fencing” of intertidal areas using methods similar to those used in the middle of the last century to deter green crabs from preying on soft-shell clam juveniles and adults;

3) Examine whether sediment buffering, under the lowest sediment pore pH conditions, will result in enhanced numbers of soft-shell clam settlers and recruits compared to control areas where no buffering occurs.
4) Examine the interactive effects of stocking density of cultured soft-shell clam juveniles (10-15 mm shell length, SL) in netted plots and crab trapping on clam survival and growth.

5) Determine whether the use of predator deterrent netting, in combination with various densities of adult soft-shell clams, will result in an enhancement of wild clam recruits; and,

6) Train clammers and other interested fishermen in the use of aquacultural techniques to improve local clam harvests.

Although the reporting period (and funding period) was to be from 1 July 2014 to 31 December 2014, the project could not wait to begin until 1 July because many of the objectives relied on the spawning cycle and major seasonal growth period of soft-shell clams. No NOAA/NMFS funds were used prior to 1 July 2014; however, the project was initiated in February 2014 with an application to the Army Corps of Engineers for a permit to place 30-ft x 30-ft x 18-inch tall fences in the intertidal to carry out Objective #2 (Appendix I). The permit was granted in March 2014 (Appendix II), and activities to initiate all objectives were carried out in April and May 2014. Funds used to carry out this work were provided by the University of Maine System (Maine Economic Improvement Fund – Small Campus Initiative; University of Maine at Machias; and, Sea Pact). The latter organization (http://www.seapact.org/) provided the Downeast Institute with funds to hire a local coordinator that could be the PI’s eyes and ears and additional fingers when the PI was unable to be on site. Specifically, the local coordinator was hired from 15 April to 1 November 2014 to: 1) work with the PI on the intertidal flats; 2) inspect the green crab predator-deterrent fences every 48-hrs for the presences of Atlantic and Short-nosed sturgeon (a requirement of the Army Corps Permit – see Appendix II); 3) communicate effectively with the PI and Freeport clammers; 4) act as a liaison between the PI, the clammers, and local elected officials; 5) be responsible for organizing a labor force to inspect and routinely maintain fenced and netted plots; and, 6) ensure the integrity of the experiments, gear, and other equipment.

The following highlights each objective separately along with preliminary results.

I. **Determine spatial and temporal variability of green crabs, Carcinus maenas, in the Harraseeket River and intertidal areas adjacent to the river using specially designed and tested traps (May to October 2014).**

This portion of the project was presented and discussed in the First Progress Report.
II. Test the efficacy of “green crab fencing” of intertidal areas using methods similar to those used in the middle of the last century to deter green crabs from preying on soft-shell clam juveniles and adults;

This portion of the project was presented in the First Progress Report; however, due to the amount of data collected, the analyses are yet to be completed, so will be presented in the next Progress Report.

III. Examine whether sediment buffering, under the lowest sediment pore pH conditions, will result in enhanced numbers of soft-shell clam settlers and recruits compared to control areas where no buffering occurs.

This field trial was designed to test the relative importance of coastal acidification vs. predation on 0-year class soft-shell clams. Increasing acidification lowers the availability of carbonate ions in water and sediments, and can impair the ability of calcium carbonate-bearing organisms, such as the soft-shell clam *Mya arenaria*, to build and maintain their shells. Small bivalves, such as newly-settled clams, may dissolve completely. This process, termed “death by dissolution,” is considered a leading cause of mortality in young clams (Green 2004, 2009).

From 6-8 May 2014, pH determinations were made near the mid-intertidal at five intertidal flats in the town of Freeport. Measurements were made by the Friends of Casco Bay who used a Fisher Scientific Accumet AP 115 pH meter and 13-620-AP50A combination electrode. Ten readings were taken at each flat by tilting the electrode at an acute angle to the mudflat surface and placing its tip approximately 6 mm into the sediments. Measurements were recorded when the meter read “STABLE.” The electrode was rinsed with distilled water between each of the ten measurements per location.

Results of the initial pH measurements appear in Table 1 and Fig. 1.

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Mean pH</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cove Road</td>
<td>43° 50’ 31.0” N</td>
<td>70° 05’ 43.0” W</td>
<td>7.34</td>
<td>0.199</td>
</tr>
<tr>
<td>Recompence</td>
<td>43° 49’ 30.0” N</td>
<td>70° 04’ 15.0” W</td>
<td>7.79</td>
<td>0.221</td>
</tr>
<tr>
<td>Sandy Beach</td>
<td>43° 49’ 52.0” N</td>
<td>70° 05’ 49.0” W</td>
<td>7.54</td>
<td>0.198</td>
</tr>
<tr>
<td>Staples Cove</td>
<td>43° 48’ 26.0” N</td>
<td>70° 06’ 33.0” W</td>
<td>7.09</td>
<td>0.193</td>
</tr>
<tr>
<td>Winslow Park</td>
<td>43° 48’ 01.0” N</td>
<td>70° 07’ 06.0” W</td>
<td>7.36</td>
<td>0.240</td>
</tr>
</tbody>
</table>
Because lowest (most acidic) mean and median readings were observed at Staples Cove, the field trial was conducted at that site (Table 1).

To determine the interactive effects of crushed soft-shell clam shells (designed to buffer sediments) and predator exclusion (using plastic, flexible netting – 4.2 mm aperture, as described above), an experiment was initiated near the mid-intertidal at Staples Cove on 18 May 2014. Thirty 2m x 2m plots were established in a 6 x 5 matrix with 5 m spacing between rows and columns. Five replicates of six treatments were used: 1) Control, no netting; 2) Control, netting; 3) 13 lbs of crushed *Mya arenaria* shells, no netting; 4) 13 lbs of crushed *Mya* shells, netting; 5) 26 lbs of crushed *Mya* shells, no netting; 6) 26 lbs of crushed *Mya* shells, netting. Treatments were randomly assigned to positions within the matrix. This was a completely randomized design.

Crushed shells of *Mya* were obtained from a recent commercial shell heap located on Great Wass Island in the town of Beals, ME that had been aging for ca. 1 year (A. Carver, A.C. Inc., Beals, ME, pers. comm.). Shells were crushed manually into pieces that varied in size from 6-25 mm (greatest length). Shells were spread by hand within each of the plots (N = 20) designated as shell treatment plots (Fig. 2). Pieces of flexible netting (2.3 m x 2.3 m) were used to cover one-half of the plots (Fig. 3). Each net was secured in place by walking along the periphery and forcing the edge (15-20 cm) into the sediments (as described above). Each net had two Styrofoam floats affixed to the side nearest the sediment (as described above).
On 6 October 2014, two pH readings were taken from the center of two replicates (chosen at random) of each treatment (Fig. 4). Prior to taking samples from netted plots, each net was peeled back exposing two-thirds of the sediment. Nets were immediately re-secured around each plot after sampling. ANOVA on the mean pH reading indicated no significant difference among the treatments.

On 4 November 2014, two pH readings were taken from the center of each plot (Fig. 5). In addition, five large benthic cores ($A = 0.01824 \text{ m}^2$) were taken from each plot. Each sample was washed separately through a 1 mm mesh sieve and all Mya, Mercenaria, and Ensis were enumerated and the SL of each taken to the nearest 0.01 mm using digital calipers.

**Figure 1.** Boxplot of pH measurements from five mid-intertidal locations in Freeport, Maine from 6-8 May 2014. Ten readings were taken from each location. Lowest median pH (and lowest mean) were observed at Staples Cove, Lower Harraseeket River.
Figure 2. Spreading crushed soft-shell clams in a 2m x 2m plot at Staples Cove on 18 May 2014.

Figure 3. Crushed shell (13 lbs) and protective netting in 2m x 2m plot at Staples Cove on 18 May 2014.
If more clam recruits (0-year class individuals) were sampled from plots with crushed shells compared to plots without shells, one explanation could be that it was the sediment buffering effects of the shell that resulted in a more chemically amenable environment for shell deposition. That is, crushed shells buffered sediments allowing clams to make shell. However, the physical environment created by the crushed shells may act as a spatial refuge from small predators. That is, there may be at least two very different reasons why small clams could be found in plots with crushed shells. The large-scale experiment could not distinguish between these two competing hypotheses.

On 18 May 2014, a small-scale experiment was conducted at Staples Cove, Freeport, Maine, adjacent to the large-scale, sediment buffering experiment in an attempt to extend and interpret results from the larger-scale experiment. Eight treatments were employed using a factorial design with a = 4 substrate amendments and b = 2 levels of predator exclusion.
The four levels of substrate amendments were: 1) control, only ambient sediments; 2) crushed shell; 3) marble chips; and, 4) small granite cobbles. The two levels of predator exclusion were: 1) control – no netting; and, 2) netted (flexible netting with 4.2 mm aperture similar to that used in the larger-scale experiment). Experimental units were plastic horticultural pots (15 cm diameter x 15 cm deep – see Beal, 2006). Units were dug into the substrate so that a 3-4 mm lip extended above the sediment surface. Units were filled with ambient sediments and for those treatments with substrate amendments, the shell, chips, or cobbles were added to top of the substrate in the units (Figure 6). A piece of flexible netting (45 cm x 45 cm) was secured around one-half of the units and was held in place with a rubber band. Ten replicates of each of the eight treatments were employed, and treatments were assigned randomly to positions within a 8 x 10 matrix. All units were removed from the mudflat on 4 November and the
Figure 6. Examples of experimental units used in the small-scale sediment buffering experiment at Staples Cove (18 May – 4 November 2014). a) Marble chips; b) crushed shell. Both treatments are without predator exclusion netting. Units are 15 cm in diameter and were filled with ambient sediments prior to the addition of the chips or shells.

contents of each sieved through a 1 mm mesh. All live *Mya* and *Mercenaria* were enumerated and the SL of each measured to the nearest 0.01 mm using digital calipers. Results of this experiment will be reported in the next Progress Report.

Results of the Large-scale sediment buffering experiment

No significant difference was detected among treatments for recruits of *Mya arenaria* (Table 2; Fig. 7).

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netting</td>
<td>1</td>
<td>0.6667</td>
<td>0.6667</td>
<td>2.38</td>
<td>0.1359</td>
</tr>
<tr>
<td>Shell</td>
<td>2</td>
<td>0.0133</td>
<td>0.0067</td>
<td>0.02</td>
<td>0.9765</td>
</tr>
<tr>
<td>Netting x Shell</td>
<td>2</td>
<td>0.3333</td>
<td>0.1667</td>
<td>0.60</td>
<td>0.5594</td>
</tr>
<tr>
<td>Plot (Netting x Shell)</td>
<td>24</td>
<td>6.7200</td>
<td>0.2800</td>
<td>2.47</td>
<td>0.0007</td>
</tr>
<tr>
<td>Error</td>
<td>120</td>
<td>13.6000</td>
<td>0.1133</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>21.3333</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 7. Results from the large-scale sediment buffering experiment at Staples Cove (18 May – 4 November 2014) for recruits of *Mya arenaria*. No significant differences were detected between the treatments (see Table 2). *(n = 5)*

For recruits of *Mercenaria mercenaria*, significant differences were observed between treatments, but these differences were associated only with plots that were protected with netting (Table 3; Fig. 8). For example, nearly 40x more hard clam recruits were observed in plots covered with netting (31.1 ± 13.9 ind. m\(^{-2}\), *n* = 15) compared to those without nets (0.7 ± 1.6 ind. m\(^{-2}\), *n* = 15).

**Table 3.** ANOVA results for large-scale sediment-buffering experiment at Staples Cove for recruits of *Mercenaria mercenaria* *(n = 5)*.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netting</td>
<td>1</td>
<td>11.760</td>
<td>11.760</td>
<td>23.68</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Shell</td>
<td>2</td>
<td>1.4533</td>
<td>0.7267</td>
<td>1.46</td>
<td>0.2514</td>
</tr>
<tr>
<td>Netting x Shell</td>
<td>2</td>
<td>1.9600</td>
<td>0.9800</td>
<td>1.97</td>
<td>0.1609</td>
</tr>
<tr>
<td>Plot (Netting x Shell)</td>
<td>24</td>
<td>11.9200</td>
<td>0.4967</td>
<td>1.42</td>
<td>0.1122</td>
</tr>
<tr>
<td>Error</td>
<td>120</td>
<td>42.0000</td>
<td>0.3500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>69.0933</td>
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**Figure 8.** Results from the large-scale sediment buffering experiment at Staples Cove (18 May – 4 November 2014) for recruits of *Mercenaria mercenaria*. Significant differences were detected only between the netted vs. unnetted treatments (see Table 3). (n = 5)

Number of recruits of *Mya* was independent of treatment (P = 0.180), but this was not the same for *Mercenaria* (P < 0.001) where nearly 98% of animals were sampled from netted plots (Fig. 9).
Results of the Small-scale sediment buffering experiment

The small-scale study demonstrated that for recruits of *Mya arenaria* the only significant effect due to the treatments was for the netted vs. unnetted experimental units (Table 4; Fig. 10). More than twice as many soft-shell clam recruits settled into units that were netted ($70.6 \pm 27.7$ ind. $m^{-2}$, $n = 40$) as opposed to units that had no predator exclusion netting ($31.2 \pm 13.5$ ind. $m^{-2}$, $n = 40$; Fig. 11).

Hard clam densities per unit were not influenced significantly by the treatments ($P = 0.4820$), and none of the orthogonal contrasts (including the netted vs. unnetted source of variation – $P = 0.2160$) were statistically significant (Table 5).

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**Figure 9.** Number of individuals of *Mya arenaria* and *Mercenaria mercenaria* recruits sampled in large-scale study plots across the sediment buffering treatments in November 2014.
Lastly, size-frequency distributions for *Mya* and *Mercenaria* are presented in Fig. 12 for individuals from both the large-scale and small-scale buffering experiment. For both species, there was no significant difference in sizes between the large- and small-scale studies. Mean shell length of *Mya* was $5.7 \pm 0.85$ mm ($n = 82$) and $4.1 \pm 0.27$ mm ($n = 61$) for *Mercenaria*.

Table 4. ANOVA results for the small-scale sediment-buffering experiment at Staples Cove for recruits of *Mya arenaria*. A series of single degree-of-freedom, orthogonal contrasts are shown below the Treatment Source of Variation. ($n = 10$).

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>7</td>
<td>518.702</td>
<td>11.7600</td>
<td>1.82</td>
<td>0.0956</td>
</tr>
<tr>
<td>(Net vs. No Net)</td>
<td>1</td>
<td>272.813</td>
<td>272.813</td>
<td>6.72</td>
<td>0.0116</td>
</tr>
<tr>
<td>(Open: Shell vs. No Shell)</td>
<td>1</td>
<td>62.499</td>
<td>62.499</td>
<td>1.54</td>
<td>0.2189</td>
</tr>
<tr>
<td>(Net: Shell vs. No Shell)</td>
<td>1</td>
<td>86.504</td>
<td>86.504</td>
<td>2.13</td>
<td>0.1488</td>
</tr>
<tr>
<td>(Open: Control vs. Granite</td>
<td>Marble)</td>
<td>1</td>
<td>10.813</td>
<td>10.813</td>
<td>0.27</td>
</tr>
<tr>
<td>(Open: Granite vs. Marble)</td>
<td>1</td>
<td>11.678</td>
<td>11.678</td>
<td>0.29</td>
<td>0.5935</td>
</tr>
<tr>
<td>(Net: Control vs. Granite</td>
<td>Marble)</td>
<td>1</td>
<td>73.096</td>
<td>73.096</td>
<td>1.80</td>
</tr>
<tr>
<td>(Net: Granite vs. Marble)</td>
<td>1</td>
<td>1.298</td>
<td>1.298</td>
<td>0.02</td>
<td>0.8587</td>
</tr>
<tr>
<td>Error</td>
<td>72</td>
<td>2924.713</td>
<td>40.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>3443.415</td>
<td></td>
<td></td>
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</table>
Figure 10. Results from the small-scale sediment buffering experiment at Staples Cove (18 May – 4 November 2014) for recruits of *Mya arenaria*. Significant differences were detected only between the netted vs. unnetted treatments (see Table 4). (n = 10)
Figure 11. Results from the small-scale sediment buffering experiment at Staples Cove (18 May – 4 November 2014) for recruits of *Mya arenaria*. Significant differences were detected only between the netted vs. unnetted treatments (see Table 4). (n = 40)
Table 5. ANOVA results for the small-scale sediment-buffering experiment at Staples Cove for recruits of *Mercenaria mercenaria*. A series of single degree-of-freedom, orthogonal contrasts are shown below the Treatment Source of Variation. (n = 10).

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>7</td>
<td>33.412</td>
<td>11.760</td>
<td>0.94</td>
<td>0.4820</td>
</tr>
<tr>
<td>(Net vs. No Net)</td>
<td>1</td>
<td>8.109</td>
<td>8.109</td>
<td>6.72</td>
<td>0.2106</td>
</tr>
<tr>
<td>(Open: Shell vs. No Shell)</td>
<td>1</td>
<td>0.216</td>
<td>0.216</td>
<td>1.54</td>
<td>0.8372</td>
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<tr>
<td>(Net: Shell vs. No Shell)</td>
<td>1</td>
<td>0.865</td>
<td>0.865</td>
<td>2.13</td>
<td>0.6811</td>
</tr>
<tr>
<td>(Open: Control vs. Granite</td>
<td>Marble)</td>
<td>1</td>
<td>6.920</td>
<td>6.920</td>
<td>0.27</td>
</tr>
<tr>
<td>(Open: Granite vs. Marble)</td>
<td>1</td>
<td>5.190</td>
<td>5.190</td>
<td>0.29</td>
<td>0.3156</td>
</tr>
<tr>
<td>(Net: Control vs. Granite</td>
<td>Marble)</td>
<td>1</td>
<td>0.433</td>
<td>0.433</td>
<td>1.80</td>
</tr>
<tr>
<td>(Net: Granite vs. Marble)</td>
<td>1</td>
<td>11.678</td>
<td>11.678</td>
<td>0.02</td>
<td>0.1339</td>
</tr>
<tr>
<td>Error</td>
<td>72</td>
<td>365.913</td>
<td>5.082</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>399.326</td>
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</table>
Figure 12. Size-frequency distribution of *Mya* and *Mercenaria* from both large- and small-scale sediment buffering studies. (3 November 2014)
IV. Examine the interactive effects of stocking density of cultured soft-shell clam juveniles (10-15 mm shell length, SL) in netted plots and crab trapping on clam survival and growth.

A comparative experiment was deployed at two lower intertidal sites (Collins Cove and Wolf Neck; Fig. 13) in the Upper Harraseeket River (19-21 April 2014) to examine effects of density and predator exclusion on the growth and survival of cultured juveniles of *Mya arenaria*. At each site, a total of forty 22-ft x 14-ft (28.6 m²) plots were established with a planting area of 20-ft x 12-ft (22.3 m²). Cultured clam seed (as described above) was planted at a density of 15 or 30 individuals ft⁻² (161-323 ind. m⁻²) within each plot. Nets were deployed in blocks of four nets (2 replicates of each planting density per block; Fig. 14) resulting in 10 blocks at each site. Within a block, netted plots were established ca. 5 m apart, and blocks were ca. 10 m apart. A green crab trap (as described above) was placed adjacent to five of the ten blocks at each site to examine whether removal of crabs in addition to deterring with netting affected clam growth or survival. Traps were fished twice weekly from 5 May to 1 October 2014. Crabs from the five traps per site were pooled and the mass of the five traps recorded to the nearest 0.1 kg using a digital balance. A 0.91 kg random subsample from the contents of the pooled five traps was taken and all green crabs enumerated, sexed, and the carapace width of each measured to the nearest 0.01 mm using digital calipers. Females were examined for egg masses. To establish ambient clam densities at the beginning of the experiment, a total of 25 benthic cores (15 cm diameter x 15 cm deep) was taken at each site. At Collins Cove, 56% of cores contained no clams, 36% contained one clam, and 4% contained either two or three clams (mean density = 30.4 ± 17.2 ind. m⁻²). Clam sizes ranged from 6.33 – 13.97 mm (n = 14). At Wolf Neck, 92% of the cores contained no clams, and 8% contained one clam. The average density of wild clams was 4.5 ± 6.5 ind. m⁻². Clams sizes ranged from 6.49 – 13.00 mm (n = 2).

Two large core samples were taken from three nets (at random) on 12 July 2014 at both sites (Fig. 15). Densities of cultured seed were generally low (0-2 clams per core) at Collins Cove, but much higher at Wolf Neck (3-14 clams per core).

Two large (A = 0.01824 m²) and five small (A = 0.0081 m²) benthic cores were taken from each netted plot at both sites from 8-10 November 2014. Each sample was washed separately through a 1.0 mm mesh and all live *Mya, Mercenaria*, and *Ensis* were enumerated. For samples from Collins Cove, all live hatchery-reared clams were measured in two linear dimensions: initial shell length and final shell length. It was possible, therefore, to obtain an individual growth rate for all live individuals even though no clam was directly marked at the beginning of the experiment. Cultured *Mya* seed clams inherently “mark themselves” when planted in any sediment; therefore, it is possible to distinguish quite easily the size of the clam when planted from the size of the clam when sampled (Beal et al., 1999; Fig. 16). Many of the core samples from Wolf Neck contained hundreds of wild, 0-year class individuals (Figs. 17-19). All of these “recruits” were counted, and 20 animals were randomly taken from samples with large numbers of small, wild seed clams and the SL of each measured to the nearest 0.01 mm using digital calipers. All cultured clams within the samples were measured as described above for
the Collins Cove site. Results presented here come from the large core samples. Results from
the smaller core samples have yet to be analyzed and will be presented in the next Progress
Report.

Figure 13. Chart of Upper Harraseeket River near South Freeport. Experiments were
established (19-21 April 2014) near the low water mark at Collins Cove, the tidal flat between
Weston Point and the docks at South Freeport, and across the River on the Wolf Neck shore.
Large core sample results

**Collins Cove**

Mean number of live cultured clams was extremely low overall (22.6 ± 12.2 ind. m$^{-2}$) and depended upon stocking density (Table 6). Compared to initial planting densities (161 or 323 ind. m$^{-2}$), estimated survival rates in the lower density plots was 1.67% (mean number per core = 2.7 ± 3.9 ind. m$^{-2}$, n = 40) and 13.2% in the higher density plots (mean number per core = 42.5 ± 23.0 ind. m$^{-2}$, n = 40). The presence of a crab trap adjacent to netted plots did not have a significant effect on number of cultured clams (P = 0.4137; Table 6). Blocks of plots adjacent to crab traps yielded an average of 27.4 ± 21.0 ind. m$^{-2}$ (n = 40) vs. 17.8 ± 13.4 ind. m$^{-2}$ (n = 40) for plots without crab traps (Fig. 20). In addition to live clams, dead clams also were discovered in the benthic cores. The distribution of animals that were found dead, with undamaged valves compared with the distribution of animals that were seeded (Fig. 21) indicated that ca. 55% had added shell prior to death. Clams that increase in shell length and then perish without signs of shell damage are likely to have been preyed upon by the nemertean, *Cerebratulus lacteus*. In
addition, a number of clams were recovered dead with damaged valves typical of crustacean (e.g., *Carcinus maenas, Cancer irroratus*; Fig. 22).

![Image](image.jpg)

**Figure 15.** Netting pulled back at Collins Cove on 12 July 2014. Two core samples (A = 0.01824 m$^2$) were taken from each of three netted plots.

Although few clams survived in the protected plots, those that did grew relatively fast compared to previous field trials in eastern Maine (see Beal et al., 2001; Beal, 2006). For example, approximately 40% of the 33 live, cultured clams sampled in the 80 cores attained commercial size (> 50.8 mm SL; Fig. 23). In addition, none of the sources of variation (see Table 6) were significant for the variable mean SL.

Wild clam recruits were observed in 17 of the 80 cores (ca. 21%) taken at Collins Cove in November 2014. Mean density of wild recruits was 48.7 ± 12.7 ind. m$^{-2}$ (n = 80), and no sources of variation were significant for mean recruit density. The density of wild recruits in November was not significantly different than initial wild recruit density taken in April (33.3 ind. m$^{-2}$).
Table 6. Analysis of variance on the mean number of cultured soft-shell clams per core within seeded plots at Collins Cove, Freeport, Maine on 8 November 2014. Clams were seeded at each of two densities (161 or 323 ind. m$^{-2}$) in two replicate 28.6 m$^2$ netted (4.2 mm aperture) plots in five blocks adjacent to a crab trap and five blocks away from a crab trap. (n = 2 cores per plot)

<table>
<thead>
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<th>Source of Variation</th>
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</table>

Wolfe Neck

Cultured clam survival was not significantly different than 100% for both stocking densities (Fig. 24). Mean percent survival in plots stocked initially at 161 m$^{-2}$ was 96.7 ± 37.5% (n = 40) compared to 107.8 ± 20.8% (n = 40) in plots initially stocked at twice that density. That is, mean number of cultured clams in the low density plots was 156.3 ± 60.6 ind. m$^{-2}$ and 348.1 ± 67.2 ind. m$^{-2}$ in the high density plots (n = 40 in both instances). Only initial stocking density had a significant effect on mean density of clams at the end of the study (10 November 2014; Table 7).

Some dead clams with undamaged valves (Fig. 25) and chipped/crushed valves (Fig. 26) were found in the benthic cores. For those with undamaged valves, approximately 97% were larger than the 20 mm SL (the largest size of the seed planted in April). This distribution is similar to that at Collins Cove and suggests that mortality agents that collectively kill clams without damage to the valves do so once they have obtained a given size. On the other hand, the distribution of clams with dead with crushed or chipped shells (Fig. 26) indicates that approximately 40% of the clams were preyed on by crustacean predators soon after planting.

Cultured clams were found in 70 of the 80 (87.5%) benthic cores taken on 10 November 2014. No significant effects of stocking density or presence of predator traps occurred with respect to mean final length (Table 8) or mean absolute growth (Final length – Initial length). Approximately 26% of cultured clams sampled in the cores attained final lengths that were greater than 50.8 mm (legal size in Maine; Fig. 27).
Figure 16. Cultured clams from a single core sample from the Wolf Neck site on 12 July 2014. A distinct “hatchery mark” occurs near the umbo of each clam that distinguishes it from a wild clam (see Beal et al. 1999). Most of the clams ranged in SL from 25-35 mm.
Wild juveniles of the soft-shell clam were extremely abundant in many of the benthic cores. For example, four of the 80 cores contained > 1,000 animals. Overall, densities of wild recruits per core ranged from 0 to 1,102, but none of the sources of variation associated with this variable were statistically significant (Table 9; Fig. 28). The mean number of wild recruits per square meter was 14830.0 ± 3597.3 (n = 80). If this estimate is extrapolated to the size of the seeded plots (22.3 m²), then the mean number of wild recruits per plot would be 330709.98 ± 80220.77. That is, for every 3.02 plots, approximately 1 million wild seed clams occurred. The size-frequency of these clams (Fig. 29) showed that approximately 75% were < 12 mm SL. Work occurring in 2015 is designed to examine if this settlement event is predictable and consistent from year-to-year.
Figure 18. Soft-shell clams taken from a single core sample in a netted plot at Wolf Neck on 10 November 2014. Most of the clams are wild and settled into the plot during the experimental period that began on 18 April 2014. One cultured clam (ca. 50 mm SL) can be seen near the bottom of the photo.
Figure 19. An example of the contents of a single benthic core from a netted plot at Wolf Neck flat (10 November 2014) washed through a 1.0 mm sieve. Approximately 12 cultured clams can be seen in the lower right hand corner of the sieve, the remaining clams are wild and were not in the netted plot at the beginning of the experiment.
**Figure 20.** Interactive effects of stocking density and presence of crab traps on mean number of live clams at Collins Cove (18 April to 8 November 2014). While trapping had no significant effect on number of live clams ($P = 0.4137$, Table 6), approximately 15x more clams occurred in the higher density plots than in the lower density plots. ($n = 20$)
Figure 21. Initial (purple) size-frequency distribution of cultured clams at Collins Cove vs. the distribution of sizes of clams found in core samples with dead, undamaged valves. Approximately 55% of individuals were > 20 mm SL, indicating that those animals likely added shell prior to death.
Figure 22. Initial size-frequency distribution of soft-shell clams planted at Collins Cove (18 April 2014) and the distribution of clams that were sampled from cores and crushed or chipped (typical of crustacean predation). Approximately 30% of crushed/chipped clams were > 20 mm SL.
Figure 23. Size-frequency distribution of live, cultured clams at Collins Cove (8 November 2014) compared to the initial size-frequency distribution on 18 April 2014. Approximately 40% of the animals attained a commercial size of 50.8 mm SL.
Figure 24. Mean percent survival of cultured soft-shell clams at Wolfe Neck (Freeport, Maine) during the period between 17 April and 10 November 2014. Mean survival was not significantly different from 100% for both stocking densities.
Table 7. Analysis of variance on the mean number of cultured soft-shell clams per core within seeded plots at Wolfe Neck, Freeport, Maine on 10 November 2014. Clams were seeded at each of two densities (161 or 323 ind. m$^{-2}$) in two replicate 28.6 m$^2$ netted (4.2 mm aperture) plots in five blocks adjacent to a crab trap and five blocks away from a crab trap. (n = 2 cores per plot)

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<td>Total</td>
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<td>1283.200</td>
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</tr>
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</table>
Figure 25. Initial size-frequency distribution of cultured soft-shell clams on 17 April 2014 at Wolfe Neck, Freeport, Maine compared to the distribution of cultured clams that were recovered dead in benthic cores with undamaged valves. The distribution indicates that most of the clams that were recovered in this state had grown prior to the mortality event.
Figure 26. Initial size-frequency distribution of soft-shell clams planted at Wolfe Neck, Freeport, Maine (17 April 2014) and the frequency distribution of the same cohort that were found dead with crushed or chipped valves that were sampled in benthic cores at the same site on 10 November 2014.
Table 8. Analysis of variance on the mean final shell length of cultured soft-shell clams per core within seeded plots at Wolfe Neck, Freeport, Maine on 10 November 2014. Clams were seeded at each of two densities (161 or 323 ind. m\(^{-2}\)) in two replicate 28.6 m\(^2\) netted (4.2 mm aperture) plots in five blocks adjacent to a crab trap and five blocks away from a crab trap. Similar results were obtained for absolute growth. (\(n = 2\) cores per plot)

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<td>14.52</td>
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Figure 27. Initial (17 April 2014) and final (10 November 2014) size-frequency distribution of cultured soft-shell clams from Wolfe Neck, Freeport, Maine. Approximately 26% of the clams attained legal shell lengths of ≥ 50.8 mm.
Analysis of variance on the mean number of wild, juvenile soft-shell clams per core within seeded plots at Wolfe Neck, Freeport, Maine on 10 November 2014. Cultured clams were seeded at each of two densities (161 or 323 ind. m⁻²) in two replicate 28.6 m² netted (4.2 mm aperture) plots in five blocks adjacent to a crab trap and five blocks away from a crab trap (n = 2 cores per plot).

<table>
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**Figure 28.** Mean number of wild soft-shell clam juveniles (+ 95% CI) in benthic core samples at Wolfe Neck, Freeport, Maine on 10 November 2014 (n = 20). No source of variation was found to be statistically significant (Table 9). Mean number of wild clams m⁻² = 14830.04 ± 3597.3 (n = 80)
Figure 29. Size-frequency distribution of wild soft-shell clam juveniles at Wolfe Neck, Freeport, Maine on 10 November 2014. Approximately 75% of individuals were < 12 mm SL.

V. Determine whether the use of predator deterrent netting, in combination with various densities of adult soft-shell clams, will result in an enhancement of wild clam recruits.

On 28-29 April 2014, a comparative experiment was established at two lower intertidal locations in the town of Freeport (Staples Cove; Recompence Flat; Fig. 30) to determine interactive effects of soft-shell clam adults and predator exclusion on clam recruitment. The experiment was completely factorial (a = 3; adult clam density: 0, 1-bushel, 2-bushel; b = 2; netting vs. no netting; n = 5) and set out as a completely randomized design at both locations (Fig. 31). Treatments were assigned randomly to positions within a 6 x 5 matrix (plots = 10-ft x
Figure 30. Chart of the two lower intertidal sites in Freeport (Spar Cove; Recompence Flat) where an experiment was initiated in late April 2014 to determine the interactive effects of adult clam density and predator exclusion on numbers of wild, 0-year class soft-shell clam juveniles (“recruits”).

10-ft, or 9.3 m$^2$) at both sites. Adult clams were purchased locally ($\bar{x}_{SL} = 67.2 \pm 2.7$ mm, $n = 35$), and pushed individually into each plot so that the ventral margin (siphonal area) was facing toward the sediment-water interface. One-half the plots were covered with plastic, flexible netting (4.2 mm aperture) equipped with five Styrofoam floats (as described above) that was secured by walking the periphery into the sediments 15-20 cm (as described above).

On 5-6 November 2014 seven benthic cores were taken from each plot at both sites (two large – $A = 0.01824$ m$^2$; five small – $A = 0.0081$ m$^2$). Larger cores were intended to provide information on survival and growth of the adult clams as well as 0-year class individuals. Smaller cores were intended to provide additional data on 0-year class recruits. The contents of each sample were washed through a 1.0 mm sieve and all live soft-shell clams enumerated and the SL of each measured to the nearest 0.01 mm using digital calipers.

*Spar Cove – Large benthic cores (A = 0.01824 m$^2$)*

Survival of adult clams initially planted in the plots was low (ca. 35%) in both protected and unprotected plots. No shell damage was apparent in these animals, and milky ribbon worms, *Cerebratulus lacteus*, were common in the cores. It is inferred that many of the adult clams were preyed upon by the worms.
**Mya arenaria recruits**

None of the four sources of variation associated with mean number of *Mya* recruits was statistically significant (Table 10); however, approximately 33x more small recruits were sampled in plots that were netted vs. those without netting (2373.2 ± 2399.3 ind. m\(^2\) vs. 70.7 ± 77.1 ind. m\(^2\), n = 15). High spatial variability in mean number of *Mya* recruits from plot-to-plot within a given treatment resulted in the lack of a statistically significant result for the netting source of variation (Table 10; Fig.32). Size-frequencies of *Mya* recruits (Fig. 33)

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>MS</th>
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<td>225958.983</td>
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**Mercenaria mercenaria recruits**

Hard clams, *Mercenaria mercenaria*, also recruited in relatively high numbers into the experimental plots and were sampled during November 2014. Approximately 20x more hard clams were sampled from plots that were netted than not netted (170.3 ± 63.7 ind. m\(^2\) vs. 7.2 ± 6.9 ind. m\(^2\), n = 15), and this was statistically significant (Table 11; Fig. 34). Size-frequency

<table>
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distribution of hard clam recruits indicated that all animals were less than 10 mm SL (Fig. 35).

Figure 31. Schematic of field experiment at the lower intertidal of Spar Cove and Recompence Flat that was initiated on 28-29 April 2014. Adult clams were added individually to twenty of the thirty 10-ft x 10-ft (9.3 m$^2$) plots. One bushel of clams = 50 lbs (22.7 kg); Number of clams per bushel varies from 650-820 (see Beal, 2002).
Figure 32. Mean number of wild juveniles of the soft-shell clam, *Mya arenaria*, in the large benthic core samples from Spar Cove (4 November 2014). (n = 5)
Figure 33. Size-frequency distribution of juveniles of *Mya arenaria* in the 30 plots in Spar Cove sampled from the large benthic cores (4 November 2014). No significant differences in mean shell length were detected across the two fixed factors (adult clams and predator exclusion netting). Approximately 90% of the clams in this distribution were sampled from netted plots.
Spar Cove – Small benthic cores (A = 0.0081 m$^2$)

The small cores were designed to provide greater resolution (more statistical power) of the main and interactive factors in the experiment. Five cores were taken from each of the thirty plots (N= 150).

**Mya arenaria recruits**

As with the large core samples, the presence of adult clams was not an important factor affecting numbers of *Mya* recruits (Table 12). Mean number of clams was approximately 40x greater in netted (3780.3 ± 3504.5 ind. m$^{-2}$, n = 15) vs. control plots (90.5 ± 62.6 ind. m$^{-2}$, n = 15), and this difference in means was statistically significant (P = 0.0462; Table 12). The size-frequency distribution was similar to that found in the large benthic cores (see Fig. 33).
Figure 35. Size-frequency distribution of individuals of *Mercenaria mercenaria* sampled on 4 November 2014 at Spar Cove, Freeport, Maine in the large benthic cores. No significant differences in mean shell length were detected across the two fixed factors (adult clams and predator exclusion).

Table 12. Analysis of variance on the mean number of wild, juvenile soft-shell clams in small benthic core within plots at Spar Cove, Freeport, Maine on 4 November 2014. Commercial size adult clams were added to 9.3 m² plots at a density of 0, 1, or 2 bushels (1 bu = 22.7 kg), then one-half of the plots were covered with a flexible, plastic netting (4.2 mm aperture) to deter predators. Five small core samples (0.0081 m²) were taken in each of the 30 plots.

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</table>
**Mercenaria mercenaria recruits**

Results similar to those observed from the large core samples were observed from the small benthic core samples. That is, the predator netting explained the highest percentage of variation in mean number of hard clam recruits per sample (ca. 35%; Table 13). Hard clam densities in netted plots (287.2 ± 101.7 ind. m\(^{-2}\), \(n = 15\)) was over 55x that in control plots (4.9 ± 5.7 ind. m\(^{-2}\), \(n = 15\)).

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**Recompence Flat – Large benthic cores (A = 0.01824 m\(^2\))**

Adult clam survival at Recompence Flat was approximately 20% from early April to 5 November 2014. As was observed at Spar Cove, many of the adults that had died had no visible damage to their valves. In addition, many nemertean ribbon worms, *C. lacteus*, were observed in the plots and in the samples.

**Mya arenaria recruits**

None of the two main factors (presence of adults, predator netting) had an effect on number of recruits of soft-shell clams (Table 14). Although there was an apparent increase in clam densities in protected vs. control plots (239.1 ± 451.5 vs. 12.1 ± 12.4 ind. m\(^{-2}\), \(n = 15\)), the variability around each mean was so large that the difference between the means was not statistically significant. The presence of adult clams did not result in an enhancement of wild recruits, but this may have been a result of the poor survival of the adult clams. Size-frequency distribution of the recruits (Fig. 36) is similar to that observed at Spar Cove (Fig. 33) with the majority less than 6 mm.
Table 14. Analysis of variance on the mean number of wild, juvenile soft-shell clams in large benthic core within plots at Recompence Flat in Freeport, Maine on 4 November 2014. Commercial size adult clams were added to 9.3 m$^2$ plots at a density of 0, 1, or 2 bushels (1 bu = 22.7 kg), then one-half of the plots were covered with a flexible, plastic netting (4.2 mm aperture) to deter predators. Two core samples (0.01824 m$^2$) were taken in each of the 30 plots.

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Figure 36. Size-frequency distribution of juveniles of Mya arenaria from large benthic core samples taken at Recompence Flat, Freeport, Maine on 4 November 2014. No significant differences in mean shell length were detected across the two fixed factors (adult clams and predator exclusion netting).
Mercenaria mercenaria recruits

Recruits of *Mercenaria mercenaria* averaged 50.1 ± 23.9 ind. m$^{-2}$ (n = 30), but the interactive effects of the presence of adult clams and predator netting was statistically significant (Table 14), making interpretation of these factors difficult. For example, no live recruits were found in benthic cores from plots without netting that were stocked with zero or one bushel of adult clams; however, 38.0 ± 30.2 and 135.9 ± 86.1 ind. m$^{-2}$ (n = 5) were sampled from cores associated with netted plots stocked with the same adult clam treatments, respectively. On the other hand, 18.1 ± 34.7 ind. m$^{-2}$ (n = 5) were sampled from unnetted plots stocked with 2 bushels of adult clams vs. 108.7 ± 58.3 ind. m$^{-2}$ (n = 5) in the netted plots with the same number of adult clams. The ANOVA table suggests that the more important factor in understanding this scenario is predator netting given the percent of variation in mean numbers explained by this source (31.6%; Table 14). Size-frequency distribution of *Mercenaria* recruits (Fig. 37) indicated that no individuals greater than 8 mm were found, and most were less than 5 mm. No significant differences in mean shell were detected across the two fixed factors (adult clams and predator exclusion).

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<th>Source of Variation</th>
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*Table 14.* Analysis of variance on the mean number of wild, juvenile hard clams in large benthic core within plots at Recompence Flat in Freeport, Maine on 4 November 2014. Commercial size adult clams were added to 9.3 m$^2$ plots at a density of 0, 1, or 2 bushels (1 bu = 22.7 kg), then one-half of the plots were covered with a flexible, plastic netting (4.2 mm aperture) to deter predators. Two core samples (0.01824 m$^2$) were taken in each of the 30 plots.
VI. Train clammers and other interested fishers in the use of aquacultural techniques to improve local clam harvests.

All of the green crab sampling and field experiments referred to above involved clammers (Stewards of the Sea, LLC), and were intended to provide hands-on experience in aquacultural and other techniques to improve local clam harvests. One additional project was carried out during the spring and summer of 2014 that engaged clammers and interested fishers more than any other project discussed in this Progress Report. The project focused on using a bivalve nursery upweller to grow cultured seed (2 mm SL) from the Downeast Institute at a commercial dock in South Freeport. A slip was rented from 1 June through 30 October 2014. A nursery upweller was built locally using a schematic provided by Joseph Porada (Acadia Bay Clam and Oyster, Trenton, ME; Fig. 38). 50,000 clams (Fig. 39) were added to each of twenty 55-gallon...
Figure 38. Bivalve nursery upweller, South Freeport, Maine. July 2014.
Silos on 10 June 2014. Silos were initially cleaned on a weekly basis, but after mid-July, cleaning occurred 3-4 times per week. Clams grew rapidly during the first two months (Fig. 40), and had attained an average SL of nearly 20 mm by mid-September (Fig. 41). Fouling from solitary and colonial tunicates, blue mussels, and hydroids made cleaning the clams difficult by that time.

Due to the success of this portion of the project, during the spring of 2015, we built and deployed an additional upweller (Figs. 42-43), and seeded it with soft-shell clam juveniles in mid-July 2015.

Overall, this particular portion of the project generated the most positive attention to the project than any other aspect. The upweller was visible on the waterfront, easily accessible to clammers and the general public, and created a lot of good publicity for the project by the print and radio media.
Figure 40. Clams from the upweller on 19 July 2014. Mean SL = 13.4 ± 0.61 mm (n = 29). This represents a mean growth of ca. 11 mm in 39 days.

2015 Activities

In 2015, the project grew from one that was composed entirely of projects generated by the PI to projects generated by the PI and clammers.

To determine if the stark differences between Collins Cove and Wolfe Neck (see section IV) are anything but a random chance occurrence, we have established ten study sites on both sides of the Harraseeket River. Each site is approximately 200 m apart. At each site, we have placed four nets (22.3m², as in 2014) with two receiving soft-shell clam seed grown in the upweller from 2014 and overwintered in Freeport using techniques outlined in Beal et al. (1995) at 15 individuals per square foot (161 ind. m⁻²) and two at 30 individuals per square foot (322 ind. m⁻²; Fig. 41). Results from this portion of the 2015 studies will illuminate, perhaps, the nature of the large spatial variation both in cultured clam survival and in wild clam recruitment from one side of the Harraseeket River to the next.
Clams from the upweller on 25 September 2014. Most clams had attained shell lengths > 20 mm; however, fouling organisms (tunicates – both colonial and solitary; mussels; and hydroids) attached to the shells making cleaning difficult and time-consuming. Most of the clams in the upweller were transplanted to the field shortly after this photo was taken.

Beginning in early April 2015, nets were deployed at each of the 20 stations along the Harraseeket River (Figs. 44-47). In addition, at each station a series of six wooden boxes (1-ft x 2-ft x 3-inches deep (Fig. 48) were deployed in a 2 x 3 matrix. Each box was covered on both the top and bottom with a piece of netting. Four boxes received Pet screening (http://www.newegg.com/Product/Product.aspx?Item=9SIA5D52R50502&nm_mc=KNC-GoogleMKP-PC&cm_mmc=KNC-GoogleMKP-PC-pla-Raw+Materials-9SIA5D52R50502&gclid=CIf6q_nZ-MYCFQ2QHwod6ncGzA&gclsrc=aw.ds) while two received an extruded, polyethylene mesh (6.4 mm aperture). Boxes were placed on top of the sediments in April at the same time that nets were deployed. Approximately 1000 ml of play sand was added to two of the boxes with Pet screening, while the other four received no extra sediment. The idea is that the boxes will increase information about natural recruitment at each of the 20 stations. Each box will receive natural sediments during the period between April and November 2015. In addition, wild recruits of soft-shell clams and hard clams likely will occur in
the boxes. The Pet screening has small enough apertures to keep out most large predators such as crabs and milky ribbon worms while the other mesh will allow small individuals of these predators access (Fig. 49).

Figure 42. The second upweller was built during the spring of 2015 and deployed at the South Freeport dock adjacent to the upweller that was built and deployed in 2014 (See Fig. 38).

Another aspect of the project in 2015 has been the interest by clammers to examine other clam growout scenarios. To this end, we have set out several experiments to examine effects of stocking density and various types of predator deterrent netting on the growth and survival of juvenile clams that were collected from plots at the Wolfe Neck site during 2014 (see section IV), and overwintered successfully using techniques described in Beal et al. (1995). For the overwintering, clams and sediments were scraped from the surface of some of the seeded plots from the Wolfe Neck site and placed into onion bags. The bags were shaken in seawater to remove the sediments leaving behind thousands of wild juvenile clams. These juveniles were placed in 18-inch x 18-inch bags constructed of Pet screening (Fig. 50) at a density of ca. 10,000, and then one bag was placed into a heavy-duty mesh (VEXAR) bag to protect it from green crabs (Fig. 51). Next, a series of 5-6 bags of clams were added to a cage with shelves (Fig. 52) and the cage was attached to a floating dock in South Freeport, Maine. Cages and bags of clams remained submerged throughout the winter (December 2014 to April 2015). In April 2015, clams in all bags were assessed for survival and 98.2% were found to have survived (Fig. 53), which is consistent with results that are obtained annually at the Downeast Institute.
Figure 43. The 2014 upweller (rightmost) and the 2015 unit in South Freeport – July 2015.

Figure 44 Deploying predator exclusion netting near Collins Cove, South Freeport Maine in April 2015.
Field experiments using overwintered wild juveniles of soft-shell clams were initiated at five intertidal sites in Freeport in April 2014 (Fig. 54-55). Variables assessed in the experiments are: stocking density, type of exclusion netting used on top and bottom of the boxes, and intertidal location.

The sediment buffering experiment initiated in 2014 (see section III) was replicated at two intertidal locations outside the Harraseeket River (Little River and Winslow Park) but within the town limits of Freeport in late April 2015. The same experimental design that was used in 2014 (see First Progress Report and section III in this Progress Report) was used in 2015 (Figs. 56-57). In addition to the large-scale experiments located at the two study sites in 2015, a small-scale experiment (similar to that deployed in 2014) was initiated at the same time at both sites. This portion of the study also is designed to examine the relative effects of predation vs. sediment buffering on wild clam recruitment, but it includes two additional treatments that are not included in the large-scale study. Those two treatments include the use of marble chips (hard limestone) and small granite rocks. The two treatments are designed to examine potential effects of spatial heterogeneity on clam recruitment in both buffered and non-buffered experimental treatments (Fig. 58-59).
Figure 46. The periphery of each net is pushed into the soft sediments by walking on it, then filling in the furrow with the surrounding sediments. This secures the net in place.
Figure 47. A secured net that is protecting seed clams (12-20 mm SL). The Styrofoam floats are affixed to the underside of the net and act to lift the netting 8-10 inches (20-25 cm) off the mudflat surface during tidal inundation so that the netting does not interfere with clam feeding.

Finally, we are continuing to collect data on green crab population dynamics within the Harraseeket River. We began the first week of May and will continue through October 2015. Traps are deployed in pairs of five each (see section I of the First Progress Report) at five sites in the Lower and Upper Harasseeket River. The traps are fished every four days and the bait is rotated during each 4-day period from crushed soft-shell clams (used 100% in 2013 and 2014) to herring (bait that is used by lobster fishers).
Figure 48. Wooden boxes (1-ft x 2-ft) either with Pet Screening on the top and bottom or VEXAR – an extruded, heavy plastic with 6.4 mm apertures. Boxes are designed to increase information about wild recruits of soft-shell clams.

Figure 49. Clam recruitment boxes that are deployed at 10 stations along both sides of the Harraseeket River, Freeport, Maine. The box on the left is protected with Pet screening on both the top and bottom while the box on the right is protected with an extruded, polyethylene mesh (6.4 mm aperture).
Figure 50. An overwintering bag containing approximately 10,000 wild juvenile soft-shell clams.
Figure 51. Each Pet screening bag of wild clam juveniles is placed within a larger, heavy-duty mesh bag made from VEXAR screening (6.4 mm aperture) that is designed to reduce any threat of green crab predation.
Figure 52. A cage that is used to hold bags of soft-shell clam juveniles over the winter.
Figure 53. Overwintered wild juvenile clams from a bag that was sampled in April 2015. Clams had been placed into this bag in December 2014. Survival was nearly 100%.
Figure 54. A wooden box (ca 2-ft x 4-ft) that has mesh on the bottom and is filled with ambient sediments. Wild juvenile clams that had been overwintered are seeded in the box.
**Figure 55.** Clammers affixing predator-exclusion netting to the top of a growout box.

**Figure 56.** A plot at Winslow Park with 13 lbs. of crushed soft-shell clam shell in an attempt to buffer sediments to create attractive settlement zones for wild soft-shell clam recruits.
Figure 57. This plot contains 26 lbs of crushed soft-shell clam shells and is protected with a piece of predator netting (flexible, polypropylene, 4.2 mm aperture). The experiment is designed to test the relative importance of predation vs. sediment buffering on the densities of wild soft-shell clam juveniles.
Figure 58. Four of the eight treatments associated with the small-scale sediment buffering experiment. These are 6-inch plastic plant pots filled with ambient sediments (see Fig. 6). a) marble chips added to the sediment surface; b) crushed shell; c) granite rocks; d) marble chips plus predator netting. Photo was taken on 30 April 2015 at Winslow Park, Freeport, Maine.
Figure 59. Clint Goodenow, one of the Freeport clammers who is participating in the demonstration project, is working to place a 6-inch plant pot into the sediments as part of the small-scale sediment buffering experiments. This photo was taken on 30 April 2015 Winslow Park, Freeport, Maine.
References


APPENDIX I (Army Corps Permit Application)
### Predator-exclusion studies in the soft-bottom intertidal along the Maine coast

See Appendix A

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see Instructions)

State Tax Parcel ID: See Appendix A

Municipality:

Section - Township - Range -
Appendix A is included that provides GPS coordinates of each of the study sites.

These studies (defined in Appendix A) are designed as field experiments to investigate the use of and arrangements of various predator-deterrent netting with respect to cultured bivalve growth and survival as well as wild recruitment of various bivalve species (e.g., Mya arenaria and Mercenaria mercenaria).

The purpose of this project is to create information that can be used by clammers and other entrepreneurs who are interested in enhancing local stocks of commercially important shellfish to create new economic opportunities for themselves and/or their community’s.

No discharge is occurring as a result of these projects.

Impacts to waters are being avoided or minimized at each site because the netting used is plastic and is not a hazard to navigation as propellers tear the netting and do not get entangled in it, the nets are secured in the mud-flat down to a depth of 10-inches, and the nets are routinely inspected to ensure that they are secure.
The completed work is described in detail in Appendix A

The work is spread out along the Harraseeket River (Freeport), the St. George River (South Thomaston and St. George), Boothbay, the Chandler River (Jonesboro), Machias Bay (Machiasport), and Holmes Bay (Cutler). All work is conducted within the intertidal on mudflats that are open to the public harvesting of shellfish according to the Maine Department of Marine Resources.

24. Is Any Portion of the Work Already Complete? ☑ Yes ☐ No
   IF YES, DESCRIBE THE COMPLETED WORK

25. Addressees of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (If more than can be entered here, please attach a supplemental list).
   a. Address-
      City - State - Zip -
   b. Address-
      City - State - Zip -
   c. Address-
      City - State - Zip -
   d. Address-
      City - State - Zip -
   e. Address-
      City - State - Zip -

26. List of Other Certificates or Approvals/Denials received from other Federal, State, or Local Agencies for Work Described in This Application.

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* Would include but is not restricted to zoning, building, and flood plain permits

27. Application is hereby made for permit or permits to authorize the work described in this application. I certify that this information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

Brian F. Beal
10 June 2015

The Application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.
Instructions for Preparing a
Department of the Army Permit Application

Blocks 1 through 4. To be completed by Corps of Engineers.

Block 5. Applicant's Name. Enter the name and the E-mail address of the responsible party or parties. If the responsible party is an agency, company, corporation, or other organization, indicate the name of the organization and responsible officer and title. If more than one party is associated with the application, please attach a sheet with the necessary information marked Block 5.

Block 6. Address of Applicant. Please provide the full address of the party or parties responsible for the application. If more space is needed, attach an extra sheet of paper marked Block 6.

Block 7. Applicant Telephone Number(s). Please provide the number where you can usually be reached during normal business hours.

Blocks 8 through 11. To be completed, if you choose to have an agent.

Block 8. Authorized Agent's Name and Title. Indicate name of individual or agency, designated by you, to represent you in this process. An agent can be an attorney, builder, contractor, engineer, or any other person or organization. Note: An agent is not required.

Blocks 9 and 10. Agent's Address and Telephone Number. Please provide the complete mailing address of the agent, along with the telephone number where he / she can be reached during normal business hours.

Block 11. Statement of Authorization. To be completed by applicant, if an agent is to be employed.

Block 12. Proposed Project Name or Title. Please provide name identifying the proposed project, e.g., Landmark Plaza, Burned Hills Subdivision, or Edsall Commercial Center.

Block 13. Name of Waterbody. Please provide the name of any stream, lake, marsh, or other waterway to be directly impacted by the activity. If it is a minor (no name) stream, identify the waterbody the minor stream enters.

Block 14. Proposed Project Street Address. If the proposed project is located at a site having a street address (not a box number), please enter it here.

Block 15. Location of Proposed Project. Enter the latitude and longitude of where the proposed project is located. If more space is required, please attach a sheet with the necessary information marked Block 15.

Block 16. Other Location Descriptions. If available, provide the Tax Parcel Identification number of the site, Section, Township, and Range of the site (if known), and / or local Municipality that the site is located in.

Block 17. Directions to the Site. Provide directions to the site from a known location or landmark. Include highway and street numbers as well as names. Also provide distances from known locations and any other information that would assist in locating the site. You may also provide description of the proposed project location, such as lot numbers, tract numbers, or you may choose to locate the proposed project site from a known point (such as the right descending bank of Smith Creek, one mile downstream from the Highway 14 bridge). If a large river or stream, include the river mile of the proposed project site if known.

Block 18. Nature of Activity. Describe the overall activity or project. Give appropriate dimensions of structures such as wing walls, dikes (identify the materials to be used in construction, as well as the methods by which the work is to be done), or excavations (length, width, and height). Indicate whether discharge of dredged or fill material is involved. Also, identify any structure to be constructed on a fill, piles, or float-supported platforms.

The written descriptions and illustrations are an important part of the application. Please describe, in detail, what you wish to do. If more space is needed, attach an extra sheet of paper marked Block 18.

Block 19. Proposed Project Purpose. Describe the purpose and need for the proposed project. What will it be used for and why? Also include a brief description of any related activities to be developed as the result of the proposed project. Give the approximate dates you plan to both begin and complete all work.
Block 20. Reasons for Discharge. If the activity involves the discharge of dredged and/or fill material into a wetland or other waterbody, including the temporary placement of material, explain the specific purpose of the placement of the material (such as erosion control).

Block 21. Types of Material Being Discharged and the Amount of Each Type in Cubic Yards. Describe the material to be discharged and amount of each material to be discharged within Corps jurisdiction. Please be sure this description will agree with your illustrations. Discharge material includes: rock, sand, clay, concrete, etc.

Block 22. Surface Areas of Wetlands or Other Waters Filled. Describe the area to be filled at each location. Specifically identify the surface areas, or part thereof, to be filled. Also include the means by which the discharge is to be done (backhoe, dragline, etc.). If dredged material is to be discharged on an upland site, identify the site and the steps to be taken (if necessary) to prevent runoff from the dredged material back into a waterbody. If more space is needed, attach an extra sheet of paper marked Block 22.

Block 23. Description of Avoidance, Minimization, and Compensation. Provide a brief explanation describing how impacts to waters of the United States are being avoided and minimized on the project site. Also provide a brief description of how impacts to waters of the United States will be compensated for, or a brief statement explaining why compensatory mitigation should not be required for those impacts.

Block 24. Is Any Portion of the Work Already Complete? Provide any background on any part of the proposed project already completed. Describe the area already developed, structures completed, any dredged or fill material already discharged, the type of material, volume in cubic yards, acres filled, if a wetland or other waterbody (in acres or square feet). If the work was done under an existing Corps permit, identify the authorization, if possible.

Block 25. Names and Addresses of Adjoining Property Owners, Lessees, etc., Whose Property Adjoins the Project Site. List complete names and full mailing addresses of the adjacent property owners (public and private) lessees, etc., whose property adjoins the waterbody or aquatic site where the work is being proposed so that they may be notified of the proposed activity (usually by public notice). If more space is needed, attach an extra sheet of paper marked Block 24.

Information regarding adjacent landowners is usually available through the office of the tax assessor in the county or counties where the project is to be developed.

Block 26. Information about Approvals or Denials by Other Agencies. You may need the approval of other federal, state, or local agencies for your project. Identify any applications you have submitted and the status, if any (approved or denied) of each application. You need not have obtained all other permits before applying for a Corps permit.

Block 27. Signature of Applicant or Agent. The application must be signed by the owner or other authorized party (agent). This signature shall be an affirmation that the party applying for the permit possesses the requisite property rights to undertake the activity applied for (including compliance with special conditions, mitigation, etc.).

DRAWINGS AND ILLUSTRATIONS

General Information.

Three types of illustrations are needed to properly depict the work to be undertaken. These illustrations or drawings are identified as a Vicinity Map, a Plan View or a Typical Cross-Section Map. Identify each illustration with a figure or attachment number.

Please submit one original, or good quality copy, of all drawings on 8½ x11 inch plain white paper (electronic media may be substituted). Use the fewest number of sheets necessary for your drawings or illustrations.

Each illustration should identify the project, the applicant, and the type of illustration (vicinity map, plan view, or cross-section). While illustrations need not be professional (many small, private project illustrations are prepared by hand), they should be clear, accurate, and contain all necessary information.
A. Experiment I (Freeport). (Initiated 11-17 April 2015)

Experiment I is located at 20 intertidal sites along both sides of the Harraseeket River. The same configuration of plastic netting (biaxially oriented polypropylene net – see Industrial Netting web site @ http://www.industrialnetting.com/plastic-mesh/oriented-netting.html; Product OV 7100 – see: http://www.industrialnetting.com/ov7100.html) occurs at each of the 20 sites.

Each of the twenty sites has four nets (Fig. 1) that are 22-ft x 14-ft that are arrayed in a straight line with ca. 10-feet spacing between each net. Each net has a total of nine (9) Stryofoam floats affixed (using a piece of wood and stainless steel screws; Fig. 1a) to the underside. This lifts the net off the flat approximately 10-inches during tidal inundation. The edge of the netting is secured in the flat by pushing a 225-lb to 260-lb force on the net perimeter (8-inches on each side) that drives the net into the mud. The photo below (Fig. 1) shows a neatly secured net at Collins Cove on 11 April 2015. Cultured clam seed (ca. ½-inch shell length) were planted in each plot – two plots received a density of 15 clams/ft² and the other two received 30/ft².

Figure 1. A 22-ft x 14-ft polypropylene net secured in the muddy sediments at Collins Cove, Freeport, Maine on 11 April 2015. All nets (N = 80) will be removed from each site by 31 December 2015.
Beside the linear array of four nets (ca. 10-ft away) I have added a 2 x 3 (two rows and three columns) array of wooden boxes that are 1-ft x 2-ft x 0.25-ft deep (Fig. 2). The top and bottom of each box is covered with one or two types of mesh. There are three treatments:


II. Boxes with Pet Screening on top and bottom with a 1-inch layer of Play Sand.

III. Boxes with Black Polyethylene Diamond Mesh (see: Industrial Netting web site for Product XB1131 (http://www.industrialnetting.com/xb1131.html).

This design examines how mesh size and natural vs. play sand substrates affects natural recruitment of soft-shell clams.
Figure 2. Wild clam recruitment boxes. a) refers to Treatment I; b) refers to Treatment II; c) refers to Treatment III (see above). Each box is secured in the sediments by two 18-inch wooden, slotted laths. The slot of each lath fits into a piece of polypropylene heading (lobster) twine that is attached to the short end of each box. All boxes will be removed from each site by 31 December 2015.
Site I.    Lat. 43° 49.356’ N; Long. 70° 06.290’W  (Fig. 3)
Site II.   Lat. 43° 49.418’ N; Long. 70° 06.211’W  (Fig. 3)
Site III.  Lat. 43° 49.472’ N; Long. 70° 06.145’W  (Fig. 3)
Site IV.   Lat. 43° 49.552’ N; Long. 70° 06.055’W  (Fig. 3)
Site VI.   Lat. 43° 49.632’ N; Long. 70° 05.980’W  (Fig. 3)
Site VII.  Lat. 43° 49.980’ N; Long. 70° 05.770’W  (Fig. 3)
Site VIII. Lat. 43° 50.121’ N; Long. 70° 05.761’W  (Fig. 4)
Site IX.   Lat. 43° 50.363’ N; Long. 70° 05.791’W  (Fig. 4)
Site X.    Lat. 43° 50.556’ N; Long. 70° 05.747’W  (Fig. 4)
Site XI.   Lat. 43° 50.648’ N; Long. 70° 04.896’W  (Fig. 4)
Site XII.  Lat. 43° 50.251’ N; Long. 70° 05.186’W  (Fig. 4)
Site XIII. Lat. 43° 50.164’ N; Long. 70° 05.155’W  (Fig. 4)
Site XIV.  Lat. 43° 49.401’ N; Long. 70° 05.724’W  (Fig. 5)
Site XV.   Lat. 43° 49.478’ N; Long. 70° 05.663’W  (Fig. 5)
Site XVI.  Lat. 43° 50.109’ N; Long. 70° 05.223’W  (Fig. 5)
Site XVII. Lat. 43° 49.224’ N; Long. 70° 05.879’W  (Fig. 5)
Site XVIII. Lat. 43° 49.173’ N; Long. 70° 05.956’W  (Fig. 5)
Site XIX.  Lat. 43° 49.069’ N; Long. 70° 06.049’W  (Fig. 5)
Site XX.  Lat. 43° 49.016’ N; Long. 70° 06.088’W  (Fig. 5)

Figure 3. Sites 1-6 in the Harraseeket River (intertidal flats) associated with Experiment I.
Figure 4. Sites 7-13 in the Harraseeket River (intertidal flats) associated with Experiment I.

Figure 5. Sites 14-20 in the Harraseeket River (intertidal flats) associated with Experiment I.
B. Experiment II (Freeport). (Initiated 11-17 April 2015)

Experiment II is located at two intertidal sites – Little River and Winslow Park in Freeport, Maine (Fig. 6). The same configuration of plots with plastic netting (biaxially oriented polypropylene net – see Industrial Netting web site @ [http://www.industrialnetting.com/plastic-mesh/oriented-netting.html](http://www.industrialnetting.com/plastic-mesh/oriented-netting.html); Product OV 7100 – see: [http://www.industrialnetting.com/ov7100.html](http://www.industrialnetting.com/ov7100.html)) and plots without netting occur at each site. This experiment is designed to determine the relative effects of coastal acidification and predation on wild clam recruitment.

Each site has thirty 10-ft x 10-ft plots (a 6 x 5 matrix with ca. 10-ft between rows and columns). Fifteen of the plots are netted, and the rest of the 15 plots represent controls (i.e., unnetted). One-third of all plots contain crushed soft-shell clam shells (buffering agents) at 26 lbs, one-third of all plots contain 13 lbs of crushed soft-shell clam shells, and one-third of all plots contain no clam shells. Shells used in these trials were obtained from A.C. Inc. (Beals, ME), and had been processed one year prior to their use in these field trials.

In addition, an array of wooden boxes (1-ft x 2-ft x 0.25-ft deep – as described above) was deployed at both sites. Nets used in Experiment II were secured in the intertidal sediments as described above.

![Figure 6. Location of intertidal sites where Experiment II is being conducted.](image-url)
Winslow Park.  Lat. 43° 48.001’ N; Long. 70° 07.177’ W
Little River.  Lat. 43° 49.571’ N; Long. 70° 04.598’ W

The field layout at each site is as shown in Figure 7.

**Figure 7.** Schematic for Experiment II in Freeport, Maine (Winslow Park and Little River). The intertidal plots are 10-ft x 10-ft with 10-ft spacing between rows and columns.
**C. Experiment III (Freeport). (Initiated 20-25 April 2015)**

Experiment III is located at three intertidal sites in Freeport, Maine – Calls Cove (Flying Point), Staples Cove, and Winslow Park in Freeport, Maine (Fig. 8). In this trial, thirty wooden boxes (35-inches x 18-inches x 4-inches deep) were arrayed in a 6 x 5 matrix with ca. 5-feet spacing between rows and columns (Fig. 8). Boxes were placed on top of the mudflat and then filled with adjacent sediments by using clam hoes to dig mud. The amount of sediment in each box was sufficient to secure each box to the sediments. The volume of sediment used to fill the boxes was not sufficient to cause large, excavated areas of the flat. Quite the opposite – when the boxes were filled, it was difficult to see where the sediments had come from. Clams were seeded within each box at a density of 30 or 60 per square foot. The top of each box was covered with a piece of **plastic netting** (biaxially oriented **polypropylene** net – see Industrial Netting web site @ [http://www.industrialnetting.com/plastic-mesh/oriented-netting.html](http://www.industrialnetting.com/plastic-mesh/oriented-netting.html)) that was either 1/6\(^{th}\)-inch aperture (F-4.2 in Fig. 8; Product OV 7100 – see: [http://www.industrialnetting.com/ov7100.html](http://www.industrialnetting.com/ov7100.html)), or 1/4-inch aperture (F-6.4 in Fig. 8; Product OV 3018 – see: [http://www.industrialnetting.com/ov3018.html](http://www.industrialnetting.com/ov3018.html)), or 1/4-inch aperture extruded netting (Product OV 7100 – see: [http://www.industrialnetting.com/ov7100.html](http://www.industrialnetting.com/ov7100.html)). This experiment is designed to determine the interactive effects of stocking density and type of predator-deterrent netting on clam growth and survival. This experiment will be sampled during November 2015. The boxes are only 4-inches off the bottom and do not affect navigation. The predator-deterrent netting tops from each box will be removed upon the November 2015 sampling.

![TOWARDS SHORE](image)

**Figure 8.** The array of wooden boxes (35-inches x 18-inches x 4-inches deep) in the intertidal zone at three mudflats in Freeport, Maine (Winslow Park, Calls Cove, and Staples Cove).
Figure 9 shows where the sites are located on a topographic map.

![Map showing locations of sites](image)

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calls Cove</td>
<td>43° 49.020’ N</td>
<td>70° 03.896’ W</td>
</tr>
<tr>
<td>Staples Cove</td>
<td>43° 48.399’ N</td>
<td>70° 06.711’ W</td>
</tr>
<tr>
<td>Winslow Park</td>
<td>43° 48.028’ N</td>
<td>70° 07.137’ W</td>
</tr>
</tbody>
</table>

**D. Experiment IV (Freeport). (Initiated 18 & 22 April 2015)**

This field trial was similar in scope to that of Experiment III in that it tested the interactive effects of predator deterrent netting (1/4-inch vs. 1/6-inch flexible [oriented] netting – as described above) and stocking density of cultured soft-shell clams (30, 45, or 60 cultured clams per square foot). The experiment was deployed at two sites on the Wolf Neck side of the Harraseeket River: Celia’s and Across-the-River. The field layout (Fig. 10) is in a 6 x 5 matrix with ca. 5-ft spacing between rows and columns. Boxes were 48-inches x 15.5-inches x 4-inches deep (surface area = 5.2 ft²) and were arrayed on top of the sediments and filled with adjacent sediments similar to that described (above) for Experiment III. All boxes will be sampled in November 2015, and the top (predator deterrent netting) of each will be removed from the flat by 31 December 2015.
Figure 10. Field schematic associated with Experiment IV that was deployed at two intertidal locations in the Harraseeket River: Celia’s and Across-the-River – see Fig.11). Five foot spacing occurred between each row and column.
Figure 11. Location of study sites associated with Experiment IV in the Harraseeket River. Thirty wooden boxes (5.2 ft²) were deployed at each site in a 6 x 5 array with ca. 5 ft spacing between each row and column.

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
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<tr>
<td>Celia’s</td>
<td>Lat. 43° 50.056’ N; Long. 70° 05.254’ W</td>
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<tr>
<td>Across-the-River</td>
<td>Lat. 43° 49.033’ N; Long. 70° 06.064’ W</td>
<td></td>
</tr>
</tbody>
</table>

E. Experiment V (Freeport). (Initiated 2-27 May 2015)

Experiment V is a series of five independent studies located across three different intertidal sites and at several different tidal heights. Wild clam seed (60/ft²) that was collected from field trials in the Harraseeket River from Fall 2014 were used in each experiment.

In Experiment A, a total of 50 wooden boxes (4-inches deep) were deployed at the low intertidal at Staples Cove in the Lower Harraseeket River (Fig. 12). Specifically, the 10 x 5 array included seventeen 35-inch x 18-inch boxes (surface area = 2.1 ft²), sixteen 48-inch x 14-inch boxes (surface area = 4.7 ft²), five 48-inch x 31-inch boxes (surface area = 10.3 ft²), three 38-inch x 38-inch boxes (surface area = 10.0 ft²), three 42-inch x 38.5-inch boxes (surface area = 11.2 ft²), five 48-inch x 30-inch boxes (10.0 ft²), and one 69-inch x 21-inch box (surface area = 10.1 ft²). Boxes were filled with ambient sediments (as described above). One-half of the boxes were covered with 1/4-inch flexible netting and the other half with 1/6-inch flexible netting.
In Experiment B, a total of ten flexible nets (4.2 mm aperture; oriented polypropylene netting as described above) were deployed in the lower intertidal at Staples Cove (Fig. 12). Five nets measured 22-ft x 14-ft and the other five measured 14-ft x 14-ft. All nets had a series of Styrofoam floats (see Fig. 1a) to help elevate them ca. 10-inches into the water column during tidal inundation (as described above). Wild clams seed (< 12 mm shell length) were planted at a density of 100/ft² under each net. Benthic cores will be taken from each netted plot during November 2015 and all nets will be removed from the flat prior to 31 December 2015. Nets were arrayed in a 5 x 2 matrix with 10-ft spacing between rows and columns.

In Experiment C, twenty-one boxes (36-inches x 21-inches x 4-inches deep = 5.25 ft²) were arrayed in a 3 x 7 matrix (5-ft spacing between rows and columns) at the mid intertidal at Staples Cove (Fig. 12). Boxes were filled with ambient sediments (as described above). Wild clam seed (60/ft²) were added to each box and a piece of flexible netting (4.2 mm) used to cover the top. The bottom of each box was comprised of either Pet Screen, 4.2 mm netting, or trap wire (1/2-inch aperture). All boxes will be sampled in November 2015 and the tops of each (predator deterrent netting) removed by 31 December 2015.

In Experiment D, forty-four boxes were deployed on Powers Bar (mid intertidal outside the pilings near Spar Cove, Lower Harraseeket River – Fig. 12). All boxes were 4-inches deep. Nine boxes were 38-inch x 38-inch (surface area = 10.0 ft²), three boxes were 48-inch x 31-inch (surface area = 10.3 ft²), eleven boxes were 35-inch x 20-inch (surface area = 4.9 ft²), eighteen boxes were 35-inch x 14-inch (surface area = 3.4 ft²), one box was 48-inches x 15-inches (surface area = 5 ft²), one box was 48-inches x 15-inches (surface area = 5 ft²), and one box was 40-inches x 18-inches (surface area = 5 ft²). All boxes were filled with ambient sediments (as described above), and were seeded with wild clams at a density of 60/ft². All boxes will be sampled in November 2015 and the tops of each (predator deterrent netting) removed by 31 December 2015.

In Experiment E, twenty-three nets (4.2 mm aperture – oriented polypropylene – as described above) were deployed over two tides in mid-May 2015 at the upper intertidal at Little River (above the bridge; Fig. 12). No clams were planted under any of the nets, as the trial was initiated in an attempt to capture wild soft-shell clam seed for eventual planting in Spring 2016. Three nets were 12-ft x 20-ft, seventeen nets were 12-ft x 12-ft, one net each had the following dimensions: 6-ft x 12-ft, 8-ft x 12-ft, and 12-ft x 22-ft. All nets will be removed from the intertidal site by 31 December 2015.
F. Experiment VI (Collaboration with Maine Department of Marine Resources). (Initiated 7, 14 and 15 May 2015)

This field experiment was initiated at two intertidal sites within three coastal communities - Jonesboro, St. George, and Boothbay (Fig. 13a, b, c) as part of a collaborative field experiment with the Maine Department of Marine Resources. At both sites within each community, a series of eight 14-ft x 14-ft plots were initiated. Each plot was netted and included a series of seven Styrofoam floats (Fig. 14). Nets were secured in the sediments as described above. One-half of the nets were 1/4-inch aperture while the others were 1/6-inch aperture (Fig. 15). The design tests for the growth and survival of cultured clams under two types of predator deterrent netting as well as the effect of the different netting types on wild clam recruitment. Netted plots will be sampled in late October or early November 2015, and all nets will be removed at the time of the sampling.
Figure 13a. Study sites in Jonesboro, Maine. A series of eight nets (14-ft x 14-ft) were deployed in the mid intertidal at each site on 7 May 2015. See Fig. 15 for field schematic.
**Figure 13b.** Study sites in the St. George River, Maine. A series of eight nets (14-ft x 14-ft) were deployed near the mid intertidal at each site on 14 May 2015. See Fig. 15 for field schematic.

**Figure 13c.** Study sites in Boothbay, Maine. A series of eight nets (14-ft x 14-ft) were deployed near the mid intertidal at each site on 14 May 2015. See Fig. 15 for field schematic.
Figure 14. Net deployed at an intertidal site in St. George (Barney’s Cove) on 14 May 2015. Cultured seed clams were planted under the net at a density of 30 per square feet.
Figure 15. Field schematic used at six intertidal locations in a collaborative effort with the Maine Department of Marine Resources during May 2015.

<table>
<thead>
<tr>
<th>Community</th>
<th>County</th>
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<th>Longitude</th>
<th>Flat Name</th>
<th>Date (2015)</th>
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<td>Jonesboro</td>
<td>Washington</td>
<td>44.64184</td>
<td>-67.54922</td>
<td>Arthur Hill</td>
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</tr>
<tr>
<td>Jonesboro</td>
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<td>-67.55582</td>
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<td>South Thomaston</td>
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<td>St. George</td>
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<td>44.02724</td>
<td>-69.20219</td>
<td>Barney’s Cove</td>
<td>14 May</td>
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<td>Boothbay</td>
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<td>Boothbay</td>
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<td>43.92356</td>
<td>-69.62274</td>
<td>Cross River</td>
<td>15 May</td>
</tr>
</tbody>
</table>

CLAMS = 4,320 per 144 ft² plot
G. Experiment VII. (Initiated 5-6 June 2015)

The field experiment used a series of 6-ft x 10-ft flexible nets (oriented, polypropylene – as described above; 5 @ 4.2 mm aperture 5 @ 6.4 mm aperture) at two low intertidal locations in eastern Maine – Duck Brook Flat (Cutler) and Larrabee Cove (Machiasport). The field trial was designed to examine growth and survival of cultured Arctic surfclams juveniles. The field schematic (Fig. 16) shows a series of 6-inch plant pots that are underneath a single piece of netting. All nets and plant pots will be removed from both sites by 31 Dec. 2015.

Figure 16. Schematic for Experiment G. This is a 7-ft x 10-ft net with a total of twelve 6-inch plastic plant pots under it that are level with the sediment and filled with ambient sediments. The S, M, and L refer to different sizes of cultured Arctic surfclam individuals. A total of ten nets were deployed at each site (see Figure 17). Five nets were a 1/4-inch aperture and the other five nets were 1/2-inch aperture (flexible, oriented, polypropylene material). Each net contained two Styrofoam floats and the perimeter of each net was forced into the sediments and secured as described above.
Figure 17. The study sites where a total of ten 7-ft x 10-ft plastic nets were deployed on 5-6 June 2015 to protect cultured Arctic surfclam individuals.

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude/Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larabee Cove, Machiasport, Maine</td>
<td>Lat. 44° 40’ 22.3062” N; 67° 22’ 33.2004” W</td>
</tr>
<tr>
<td>Duck Brook Flat, Cutler, Maine</td>
<td>Lat. 44° 41’ 18.8880” N; 67° 18’ 39.4302” W</td>
</tr>
</tbody>
</table>

**H. Experiment VIII. (Initiated 7-8 June 2015)**

The experiment was initiated at the same two lower intertidal locations as Experiment VIII (Fig. 17), and was designed to examine growth and survival of cultured Arctic surfclams in large-scale plantings. Surfclams were seeded at a density of 50/ft² under four 14-ft x 14-ft nets (4.2 mm aperture; oriented, polypropylene as described above) at Larabee Cove and five nets at Duck Brook Flat. Each net had a series of five Styrofoam floats. Nets were secured in the sediments as described above. All nets will be removed from sediments by 31 December 2015.
More specific details on areas in Freeport, Maine associated with Experiments I-V.

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Articles Deployed</th>
<th>GPS coordinates</th>
</tr>
</thead>
</table>
| **EXPERIMENT II.**  
Ocean Acidification | A series of nets (14’ x 14’) laid out in a square of 5 nets x 5 nets (25 nets total). The entire site is approximately 110’ wide by 110’ across. | 1) see Winslow Park Study Area section  
2) Little River:  
Front Left: N43°49.571’ W070°04.598’  
Front Right: N43°50.578’ W070°04.630’  
Back Right Side: N43°49.602’ W070°04.631’  
Left Back Side: N43°49.595’ W070°04.595’ |
| Sites:  
1) Winslow Park Cove (South Freeport)  
2) Little River Cove (Wolfe’s Neck) | | |
| **EXPERIMENT III.**  
Clam Density x Barrier (3 types) Field Experiments | Boxes are 35” long by 18” wide, by 4”. Boxes are arranged in a grid that is 6 boxes across and 5 boxes deep (approx. 40’ x 40’). | 1) Calls Cove:  
Front Left: N43°49.020’ W070°03.896’  
Front Right: N43°49.024’ W070°03.889’  
Back Right Side: N43°49.021’ W070°03.885’  
Left Back Side: N43°49.014’ W070°03.888’  
2) Staples Cove  
Front Left: N43°48.399’ W070°06.711’  
Front Right: N43°48.410’ W070°06.697’  
Back Right Side: N43°48.393’ W070°06.693’  
Left Back Side: N43°48.390’ W070°06.696’  
3) Winslow Park: see Winslow Park Study Area section. |
| 1) Calls Cove (Flying point)  
2) Staples Cove (South Freeport)  
3) Winslow Park Cove (South Freeport) | | |
| **EXPERIMENT IV**  
Clam Density x Barrier (2 types) Field Experiments | -30 48” long by 15.5” wide and 4” tall boxes. Boxes are arranged in a grid 6 across by 5 wide. Site is approximately 43’ wide by 48’ long. | 1) Across the River (Wolfe’s Neck side of River)  
Front Left: N43°49.033’ W070°06.064’  
Front Right: N43°49.040’ W070°05.240’  
Back Right Side: N43°49.036’ W070°06.047’  
Left Back Side: N43°49.036’ W070°06.047’  
2) Celia’s (Wolfe’s Neck side of Harraseeket River)  
Front Left: N43°50.056’ W070°05.254’  
Front Right: N43°50.059’ W070°05.245’  
Back Right Side: N43°50.052’ W070°05.240’  
Left Back Side: N43°50.049’ W070°05.242’ |
| 1) Across the River Cove (Wolfe’s Neck)  
2) Celia’s Cove (Wolfe’s Neck) | | |
| **Harraseeket River EXPERIMENT I**  
Field Experiments (20 sites total)  
1) South Freeport to Porters Landing  
2) Wolfe Neck | - 6 24” long x 13.5” wide x 4” boxes tall at each site. Boxes are deployed in a small grid that is 3 x 2 deep. There are 4 nets at each site that are each 14’ wide by 20’ long. The entire site is 90’ long x 95’ wide. | 1) South Freeport side of river  
I  
Boxes: N43°49.356’ W070°06.290’  
Left Side: N43°49.366’ W070°06.275’  
Right side (closest to Harbor): N43°49.355’ W070°06.290’  
II  
Boxes: N43°49.418’ W070°06.211’  
Left Side: N43°49.434’ W070°06.193’  
Right Side: N43°49.424’ W070°06.207’ |
III
Boxes: N43°49.472’ W070°06.145’
Left Side: N43°49.486’ W070°06.131’
Right side: N43°49.473’ W070°06.143’

IV
Boxes: N43°49.552’ W070°06.055’
Left Side: N43°49.561’ W070°06.040’
Right side: N43°49.554’ W070°06.053’

V
Boxes: N43°49.632’ W070°05.980’
Left side of nets at Collins V: N43°49.647’
Right side of nets @ Collins V: N43°49.641’ W070°05.963’

VI
Boxes VI: N43°49.701’ W070°05.900’
Left Side: N43°49.715’ W070°05.880’
Right side: N43°49.708’ W070°05.893’

VIII
Boxes VI: N43°50.121’ W070°05.761’
Left Side: N43°50.144’ W070°05.755’
Right side: N43°49.125’ W070°05.752’

IX
Boxes: N43°50.363’ W070°05.791’
Left Side: N43°50.371’ W070°05.783’
Right Side (D): N43°50.371’ W070°05.788’

X
Boxes: N43°50.556’ W070°05.747’
Left Side: N43°50.555’ W070°05.744’
Right Side (D): N43°50.562’ W070°05.756’

2) Wolfe Neck side
XI
Boxes: N43°49.016’ W070°06.088’
Left Side: N43°49.034’ W070°06.076’
Right Side: N43°49.034’ W070°06.076’

XII
Boxes: N43°49.069’ W070°06.049’
Left Side: N43°49.071’ W070°06.048’
Right Side: N43°49.083’ W070°06.031’

XIII
Boxes: N43°49.173’ W070°05.956’
Left Side: N43°49.176’ W070°05.955’
Right Side: N43°49.188’ W070°05.945’

XIV
Boxes: N43°49.224’ W070°05.879’
EXPERIMENT V

Field Experiments
1) Low Staples Cove Box Experiment
2) Low Staples Cove Net Experiment
3) Mid Staples Box Experiment
4) Powers Bar Box Experiment
5) Little River Net Experiment

The Low Staples Cove Box Experiment is composed of:
- 17 35” x 18” boxes
- 16 48” x 14” boxes
- 5 48” x 31” boxes “double” boxes
- 3 38” x 38” boxes
- 3 42” x 38.5” “large square” boxes
- 5 30” x 48 “ double boxes
- 1 21” x 69” long box
All boxes are 4” high. These boxes are deployed in a shape that is 95’ across the forward facing side and 119” long.

The Low Staples Cove Net Experiment is composed of:
- 5 22” x 14’ nets

Low Staples Cove Box Experiment
Front Left side: N43°49.229’ W070°05.879’
Right Side: N43°49.240’ W070°05.866’

XV
Boxes: N43°50.109’ W070°05.223’
Left: N43°50.110’ W070°05.224’
Right: N43°50.122’ W070°05.212’

XVI
Boxes: N43°49.478’ W070°05.663’
Right: N43°49.495’ W070°05.646’

XVII
Boxes: N43°49.401’ W070°05.724’
Left: N43°49.404’ W070°05.726’
Right: N43°49.414’ W070°05.712’

XVIII
Boxes: N43°50.164’ W070°05.155’
Left Side: N43°50.183’ W070°05.372’
Right side: N43°50.164’ W070°05.387’

XIX
Boxes: N43°50.251’ W070°05.168’
Left Side: N43°50.257’ W070°05.171’
Right side (facing channel): N43°50.262’ W070°05.155’

XX
Boxes: N43°50.648’ W070°04.896’
Left Side: N43°50.669’ W070°04.869’
Right side (facing channel): N43°50.122’ W070°05.212’

Low Staples Cove Net Experiment
Front Left side: N43°48.405 W070°06.706
Front Right side: N43°48.406’ W070°06.700
Back Right Side: N43°48.406’ W070°06.699’
Left Back Side: N43°48.401’ W070°06.713’

Low Staples Cove Net Experiment
Front Left side: N43°48.420 W070°06.682
Front Right side: N43°48.436’ W070°06.667
Back Right Side: N43°48.419’ W070°06.660’
Left Back Side: N43°48.413’ W070°06.676’

Mid Staples Cove Box Experiment
Front Left side: N43°48.364 W070°06.841
Front Right side: N43°48.370’ W070°06.831
Back Right Side: N43°48.359’ W070°06.831’
Left Back Side: N43°48.359’ W070°06.831’

Powers Bar Box Experiment
### The Mid Staples Box Experiment
- 21 36”x21” boxes deployed in 3 rows of 7.

### The Powers Bar Box Experiment
- 9 38”x38” boxes
- 3 48”x 31” “double” boxes
- 11 20” x 35” boxes
- 18 14” x 35” boxes
- 1 15” x 48” box
- 1 28” x 28” box
- 1 18” x 40” box

### The Little River Net Experiment
- 3 12’x 20’ nets
- 17 12’ x 12’ nets
- 1 6’ x 12’ net
- 1 8’ x 12’ net
- 1 12’ x 22’ net

### Winslow Park Study Area
1) **Ocean Acidification study**
2) **Clam Density x Barrier (3 types)**

#### 1) Ocean Acidification & Plant pot study
- 25 14’ x 14’ nets laid out in a square of 5 nets long x 5 nets wide.
  - The entire site is approximately 110’ wide by 110’ across.
  - Also, small (6”) plant pots, not standing above the mud, are also deployed in an 8 pot x 10 pot grid that is approximately 50’ wide and 40’ across.

#### 2) Clam Density x Barrier (3 types)
- 30 Boxes that are 35” long by 18” wide, by 4” tall. The boxes are arranged in a grid that is 6 boxes across and 5 boxes deep (approx. 40’ x 40’ site)

### Entire Winslow Park Experiment
- Front Left side: N43°48.553 W070°06.652
- Front Right side: N43°48.547 W070°06.640
- Back Right Side: N43°48.549 W070°06.650
- Left Back Side: N43°48.549 W070°06.644

- Front Left side: N43°49.723 W070°04.514
- Front Right side: N43°49.765 W070°04.501
- Back Right Side: N43°49.771 W070°04.496
- Left Back Side: N43°49.724 W070°04.514
APPENDIX B
CERTIFIED MAIL, RETURN RECEIPT REQUESTED

June 4, 2015

Regulatory Division  
CENAE-R-55  
File Number: NAE-2015-01027

Brian Beal,  
Professor of Marine Ecology  
Director of UMM’s Marine Field Station  
University of Maine at Machias  
116 O’Brien Avenue  
Machias, Maine 04654

NOTICE OF VIOLATION

Dear Mr. Beal:

This letter is reference to work that you conducted in several locations below the mean high water line of the Harraseeket River at Freeport, Maine. The work involved the installation of 14’ x 20’ sheets of netting in addition to 1’ x 2’ wooden boxes below mean high water without a Department of the Army permit.

These aquatic resources are regulated by the Corps of Engineers pursuant to Section 10 of the Rivers and Harbors Act of 1899. The Rivers and Harbors Act prohibits the installation of structures or performing work in navigable waters of the United States, without the proper authorization. Violations of Section 10 can result in civil fines of up to $37,500 per day for each violation. Injunctive relief, including restoration, is also available.

Some or all of the work undertaken at the locations identified above appears to be within Corps of Engineers jurisdiction and we have no record that you have obtained a Corps of Engineers permit. Although you are well aware of Corps jurisdiction and permit requirements from numerous discussions with LeeAnn Neal and Jay Clement of our Maine Project Office, a fact sheet that includes a summary of our authority, jurisdiction, definitions and permit requirements is attached to this letter.

Please note that no additional regulated work within our jurisdiction may be started or allowed to continue until you receive a permit signed by the District Engineer or his authorized representative. Any such future work without a permit may be considered willful, repeated, or flagrant per 33 C.F.R Part 326.5(a) warranting legal action. This includes work in Freeport or any other location in Maine you’re considering similar deployments.
I have determined that initial corrective measures are required in order to address the violation described above. Therefore, in accordance with Title 33 Code of Federal Regulations, Part 326.3(d) as published in the November 13, 1986 Federal Register, you are hereby directed to undertake the following initial corrective measure(s).

1. Forward a completed Corps Maine General Permit application form ENG 4345 Dec. 2014 inclusive of project plans and locations maps to our Maine Project Office, Attn: LeeAnn Neal at 675 Western Avenue #3, Manchester, Maine 04351.
2. Forward a copy of all local, state and federal permit authorizations obtained to conduct the described work.
3. Indicate how local concerns for poorly secured nets and their potential impact to the environment and navigation will be addressed.
4. Indicate how local noise concerns will be addressed.
5. Submit a description of the work that you have undertaken (installation of structures, gear, and or work conducted) in areas subject to Federal jurisdiction (waters below mean high water).
6. Identify the footprint (area in square feet or acres) of impact to each water and/or wetland. This should include those areas receiving netting materials and those areas receiving wooden boxes.
7. Identify the timeframe (e.g. days, months, years) that the work was undertaken. Be as specific as possible, giving the starting and ending dates for each area or type of activity under Corps jurisdiction.
8. Identify the types of equipment used to access and/or install the above described materials. State the names and addresses of those individuals assisting in the installation of the materials.
9. Identify, where feasible, pre-construction characteristics and habitat type of wetlands and waters altered and/or provide any environmental or ecological assessment reports or survey of the resources already completed on the parcel(s).
10. As an alternative to the submission of an After-the-Fact application and supporting documentation, immediately remove all netting, wooden structures, and associated gear from the waterway and store in an upland location above the mean high water line not on marsh vegetation.

Federal Regulation requires that we investigate any unauthorized work that has occurred in areas subject to our jurisdiction. To assist us in this investigation we request that you respond, in writing, to the following questions:

1. Explain how you believe the work was authorized by Corps of Engineers pursuant Section 10 of the Rivers and Harbors Act of 1899.
2. Explain why a Corps of Engineers permit was not obtained prior to the installation of the described materials.

Please respond to our request for information within fifteen (15) days of the date of this letter. If you fail to respond to this notification or to provide the requested information within the
specified time frame we may seek immediate legal action to halt any ongoing activity, conduct our investigation with the information available to us, and take enforcement action as allowed by federal law. Our action may include referral to the U.S. Attorney’s Office or the Environment and Natural Resources Division of the U.S. Department of Justice.

If you have any questions or wish to arrange a meeting to discuss this matter, please contact LeeAnn Neal of my staff at (207) 623-8367 extension 2.

Sincerely,

[Signature]

Frank J. Del Giudice  
Chief, Permits & Enforcement Branch  
Regulatory Division

Enclosure: JD Fact Sheet  
Form ENG 4345 Dec. 2014

Copies Furnished:

William.Otto, Dept.of Environmental & Biological Sciences, UMM William.otto@maine.edu  
Max Tritt, National Marine Fisheries max.tritt@noaa.gov  
Jay Pinkham, Harbormaster, Town of Freeport frprthmstr@gmail.com  
Bill Rixon, Freeport Town Council brixon@freeportamine.com  
Denis-Marc Nault, Maine Department of Marine Resources denis-marc.nault@maine.gov
Answers to specific questions posed in the 4 June 2015 letter from the Army Corps of Engineers (File number: NAE-2015-01027)

1) A copy of the completed Permit application has been e-mailed to LeeAnn Neal, with copies to representatives of the Maine Department of Marine Resources who are also engaged in part of the field activities described here for which a permit is sought.

2) A copy of Special License Number ME 2015-39-01 is included in Appendix C.

3) Several citizens in Freeport have indicated their concerns for “poorly secured nets” and how these nets will impact the environment and navigation. First, the assertion that nets are poorly secured is not an accurate one. Nets are secured using force of 200-250 pounds over a 12-14 inch surface of the edge of a net over the entire perimeter of a net. This force drives the net into the sediments to an 8-10 inch depth. Netting has been and will continue to be routinely monitored by volunteers and contracted workers on a weekly basis. This monitoring program has resulted in the collection of one net (of ca. 150) during 2015. Citizens who have encountered any floating nets in 2015 may be confused that those nets are a result of activity conducted in 2015 or that the nets may be associated with my research. These citizens may have encountered netting that was deployed from projects co-occurring in 2014 in Brunswick and/or Harpswell. To date (10 June 2015) a single net from Experiment I (see Appendix A) became loose and was recovered within 12 hours. Due to a routine inspection schedule, the net was placed back in the place where it had been originally deployed. In terms of impact on navigation, these are not nets constructed of fiber or twine or other material that can wrapped around a propeller. On the contrary, a propeller quickly cuts the net and does not interfere with navigation. The material is a flexible plastic (polypropylene), and a close inspection of this material will show clearly how it would not become entangled in a propeller. In terms of minimizing impacts on the environment, routine monitoring of the nets has resulted, to date, in a recovery rate of 100% and a secure-rate of 149/150 = 99.3%.

4) Several citizens in Freeport have indicated concerns for “local noise” emanating from an airboat that is used to routinely inspect the nets. While I am aware of the state law concerning noise in the marine environment (M.R.S.A., Title 12: Conservation, Part 13: Inland Fisheries and Wildlife, Subpart 6: Recreational Vehicles Heading, Chapter 935: Watercraft and Airmobiles Heading, Section 13068 - http://legislature.maine.gov/statutes/12/title12sec13068-A.html), I understand that an airboat similar to that used in my research that is operated daily by the Town of Brunswick for enforcement of its shellfish ordinance (i.e., operation within the intertidal zone as is the airboat use for this project) has been tested by a noise expert and that it was found that operating the boat below 4000 rpms kept the noise levels below the legal limits on noise. Also, there is a commercial fishing exemption on noise levels that marine wormers and clammers fall under. I have instructed the operator of the air boat used in Freeport to inspect nets routinely to operate the boat between the hours of 7:30 am and 7:00 pm Monday through Saturday and under 4000 rpms. This should allay the concerns of local citizens.
5) A description of the work that has been undertaken is contained in Appendix A. All of the work occurs in the intertidal zone.

6) The area of the footprint is given using the GPS coordinates as well as an extension table contained in Appendix A for those sites in Freeport. For the collaborative activity with the Maine Department of Marine Resources that is taking place in Boothbay (2 intertidal sites), St. Georges River (2 intertidal sites), and Jonesboro (see Appendix A, Experiment VI), the square footage of the area occupied by the eight nets per site is approximately 2,128 square feet (0.05 acres). For the activities occurring in Washington County (Machiasport and Cutler), the area occupied by the nets at each site is approximately 1,670 square feet (0.04 acres).

7) The starting dates for each study are given in Appendix A. Each study will be finished prior to 31 December 2015, and all nets will be removed from the intertidal flats at that time.

8) No equipment was used to install any nets or wooden boxes. All were forced into the sediments using hands and feet.

9) There was no construction that occurred at any site; however, the characteristics and habitat type of each site were soft-bottom intertidal mud with a soft-shell clam and/or hard clam (both commercially important marine shellfish) of less than 20 animals per square foot, and for the majority of areas, less than 1 animal per square foot. In addition, except the St. George River, no other activity besides clamming occurs in the area occupied by the site where the experiment has been set up. In the St. George River, commercial marine worming co-occurs in the area where the experiment is set up (in addition to commercial clamming).

Additional questions:

1) I did not believe that the work conducted to date at any of the sites (Freeport, St. George, Boothbay, Jonesboro, Machiasport, or Cutler) required authorization by Corps of Engineers because none of the work can be considered a hazard to navigation. In addition, I believed that the Maine Department of Marine Resources (a collaborator defined in Experiment VI) was the authority to whom I needed to correspond about the work, and, by obtaining a Special License from them that the scope and level of activity (non-commercial and research only), I was under the impression that my work was vetted (and approved) by the responsible agency.

2) A Corps of Engineers permit was not obtained prior to the installation of the netting and wooden boxes because, once again, none of these materials cause a hazard to navigation and these are materials that I have used extensively over a 30-year career in which I have never been asked to submit such a permit application. A permit application was submitted in a timely fashion to the Corps of Engineers by me in 2014 when structures (actual structures that could interfere with navigation) were proposed for Staples Cove in Freeport. Those structures were wooden fences measuring 30-ft x 30-ft x 18-inches tall.
that were installed in the lower soft-bottom intertidal at Staples Cove and could have been a navigation hazard. I followed all requirements that the Corps of Engineers required to carry out that project, including a 48-hr inspection of the fences for two species of endangered sturgeon (none being observed over a 6-month period from June to December 2014), as well as marking the fences with appropriately labeled buoys/floats that provided warning to the general public about the presence of the wooden structures. No such structures have been deployed or installed at any of the study sites in 2015 that are described in this application. Wooden boxes that are raised above the mudflat surface 4-inches cannot possibly be considered a hazard to navigation as these provide less vertical structure than some rocks and cobbles that occur on the same mudflats. In addition, the plastic netting that is used to deter predators from cultured and wild clam juveniles cannot be considered a navigational hazard as the material rips too easily to become entangled in a propeller blade.

I have applied for, and received, a Special License from the Maine Department of Marine Resources since the application process was first instituted in the mid-1990’s. The Department has been aware of, and has approved (i.e., given permission), my License that has allowed me to conduct my work since that time. This work has been similar in scope and volume to the work that is described in Appendix A. Therefore, I did not think about obtaining a permit for these research activities because I believed that I had already communicated to the agency with the authority to grant me permission to carry out the work.
APPENDIX C
January 28, 2015

SPECIAL LICENSE NUMBER ME 2015-39-01

Acting under the authority vested in the Commissioner of Marine Resources by virtue of 12 M.R.S. §6074(8)(D), I hereby renew a Special License to BRIAN F. BEAL, Professor of Marine Ecology, University of Maine at Machias (UMM), 9 O'Brian Avenue, Machias, Maine 04654 and the Downeast Institute for Applied Marine Research & Education (DEI). This Special License exempts BRIAN F. BEAL in his academic activities conducting applied marine research using a variety of marine organisms, plus educating students (K-16+) about marine resources (identification, life-history, etc.) from the following portions of the Department of Marine Resources (DMR) laws and regulations pertaining to the taking, possession, legal size limits of marine organisms. See Table 1 for additional exemptions. This Special License is issued subject to the following conditions:

1. **Who:** All projects: Brian F. Beal (UMM & DEI), Dr. Jeremy Nettleton (UMM), George Protopopescu (DEI staff), Dr. Philip Yund (DEI staff), Cody Jourdet (DEI staff), Kyle Peperman (DEI staff), Colleen Haskell (DEI staff), Scott Morello (DEI staff) Dr. Robert Steneck, Dr. M. Gayle Kraus, Dr. Robert Bayer University of Maine, and UMM or DEI students under their direct supervision; plus divers Chris Bartlett and Paul Cox; and DMR employees Jon Lewis, Marcy Nelson, Robert Russell. Project 2 Freeport Clam Study only: Chad Randall Cofin, Sarah Faith Randall, Garrett N. Simmons, Clint Goodenow and Connor Watson O’Neil. Collection of egg-bearing lobster via trap as allowed in Table 1: Brian Cates of Cutler. Project 3 Soft-Shelled Claim Bait Research Project: Chad Randall Cofin, Clint Goodenow, Brian Beal (UMM), Kohl Kanwitt (DMR) NOTE: Notification to Marine Patrol mandatory before lobster collection as per conditions below.

2. **What:** Overall: Activities include collecting marine organisms, including green crabs, for class identification, conducting applied research (both subtidal and intertidal) with marine organisms, and culturing marine organisms at the DEI hatchery for research purposes.

Additional Projects:

**Project 1:** Cultured lobsters (stage IV-IX) are being grown in aquariums in classrooms for educational purposes or to demonstrate (in the case of Camden National Bank in Jonesport) the kind of work that is done at the Downeast Institute. Cultured soft-shell clams are also part of the educational project in some schools. These are animals that are 12-20 mm that are placed into aquaria with sand and are then fed cultured algae that is grown in the schools. The lobster and clam projects are designed to incorporate information about the marine environment into the K-12 curriculum. See Table 2 for list of schools and points of contacts.

**Project 2:** This project is to examine growth and survival of cultured soft-shell clam seed that is planted on several flats in Freeport. Clams will be protected with 4.2 mm flexible netting to deter green crabs. In addition, we will be fishing for green crabs in the Harraseeket River from 1 May to 1 October to collect data on green crab population dynamics. DEI will use the same green crab traps that were used for similar collections in 2014.

**Project 3:** Project will consist of harvest of legal size soft-shelled clams from prohibited and/or restricted areas in Freeport, ME. These clams will be used for bait only in a research project designed to evaluate predator controls and their effectiveness. The project will use trapping (bait required) and fencing to remove and deter green crabs from study plots where soft-shelled clams will be established/planted. It will evaluate various methods for control of green crabs and how to best mitigate their predatory impact on soft-shelled clams. The harvest will be limited to 1000 pounds and product will be crushed, bagged, and tagged “BAIT ONLY NOT FOR HUMAN CONSUMPTION” at the landing point before transportation. Tags MAY NOT be removed until the bait is put into traps and the traps are immediately set. Crushing/bagging and tagging activities will be conducted at the point of landing and under the supervision of the local shellfish warden. The crushed, tagged bags of clams will then be stored in a freezer at 26 Litchfield Rd. Freeport, ME. Catch data will be recorded and sent to the DMR weekly until the catch cap (1000 lbs) is reached.

3. **Where:** Collecting activities: Coastwide mostly located in Washington County. Many species will be held at the Downeast Institute (Beals) where there is an approved quarantine system if needed or required. Any
organisms to be released would be relocated near the site of collection. The green crab study is to be conducted in Freeport. The soft-shelled clam bait study will take place in the restricted and/or prohibited areas in Freeport (Cousins River or near the WWTP outfall). Harvest in Restricted areas is preferred. Crushed tagged clams will be stored at 26 Litchfield Rd Freeport, Maine.

4. **When:** Date of issuance—December 31, 2015.

5. **How:** Hand collection using coring device, clam hoe, bull rake, fyke net, seine net or by hand. Traps for invertebrates may include lobsters, crabs, and fish may be set by hand from a float at the DEI facility. Gear requiring vessel operations are contingent upon vessels being amended to this special license that hold a current USCG CFVE inspection.

6. **Conditions:**

- **Marine Patrol Division II,** east of Port Clyde, tel. (207) 667-3373 or Marine Patrol Division I office, west of Port Clyde, tel. (207) 633-9595 shall be contacted at least 24 hours prior to the start of activities for the year and for collection of egg-bearing lobsters. Arrangements with Marine Patrol must be made as to the frequency when persons listed on this SL must contact Marine Patrol to provide information they require, i.e., SL number, activity date(s), location(s) of activities, name(s) of person(s) participating in the activity, and names of those person(s) transporting soft-shell clams, etc. Arrangements shall be made in advance with Marine Patrol as to what contacts/procedures must be made and followed prior to the transport of seed lobsters. The local shellfish warden (Tom Kay, Freeport) shall be contacted at least 24 hours prior to any harvest of restricted or prohibited area clams. The local shellfish warden will determine the landing location and shall supervise the product being brought to shore, crushed, bagged and tagged before transportation from the point of landing.

- **USCG CFVE:** Special Licenses are contingent upon all vessels holding current USCG commercial fishing safety Collection of egg-bearing lobsters via methods not using the facility’s hand-set trap and use of other commercial fishing gear is contingent upon vessels. These activities are not authorized without vessels with current CFVE inspections amended to this license. Please forward completed CFVS inspection updates to DMR.

- **Reporting requirement (general):** Provide report(s) on education, research, hatchery efforts, and shellfish cultivation work to be filed with the DMR annually and prior to renewal. Research and Marine Patrol personnel of the Department of Marine Resources shall have access to all biological data, records, and research aspects of the operation or facilities. Please forward all reports to dmr.speciallicensing@maine.gov.

- **Reporting requirements - lobster:** A report at the end of each season and prior to renewal that includes data/results of lobster hatchery work; report each year the number of egg-bearing females collected and location of their collection; the stage, number, location of release, survival rate plus the following:
  1. A discussion of hatchery techniques, and steps taken to increase survival in 2013
  2. The number, date, and size of egg bearing lobsters received by the hatchery from cooperating fishermen*
  3. The fate of each lobster relative to larval hatch, and release back to the wild
  4. The estimated survival rate of larval production
  5. The date, location, and number of post larval stage lobsters released during the hatchery season

- **No:** Marine organism authorized under this SL shall be used for human consumption.

- Any infraction of these conditions or any violation of any Marine Resources laws shall be grounds for the immediate revocation of this Special License. Pursuant to 12 M.R.S. §6074(9) an individual who fails to comply with the conditions or limitations on the licensed activity under this section commits a civil violation for which a fine of not less than $100 nor more than $500 may be adjudged.

- Additional conditions may be added at the discretion of the Commissioner

This Special License expires **December 31, 2015** and has three renewals.

_Signed_

**Administrative Officer, as AUTHORIZED BY 12 M.R.S. §6023**

For Commissioner Patrick C. Kelther

**cc:** Marine Patrol Divisions I & II
Carl Wilson
Maggie Hunter
Marcy Nelson
<table>
<thead>
<tr>
<th>Ex species:</th>
<th>Number allowed per year</th>
<th>12 M.R.S. Sections and DMR Regulation Chapters, exemptions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common inverts/fish</td>
<td>Up to 20 each or see (qty)</td>
<td>§6501, Commercial fishing license to fish for, take, possess or transport marine organisms; for invertebrate and fish species without specific laws or regulations; and Chapter 8 Landings Program</td>
</tr>
<tr>
<td>Alewives</td>
<td>10</td>
<td>§6131(2A)&amp;(3) alewife fishing closed periods, (72-hr closure/areas not under lease agreement)</td>
</tr>
<tr>
<td>Atlantic Salmon</td>
<td>5</td>
<td>§6140-B(4)(C) - allowance for possession of Atlantic Salmon raised by means of aquaculture</td>
</tr>
<tr>
<td>Jonah / rock crab</td>
<td>50</td>
<td>§6421 lobster, crab license – section (4) exemption for hand take = no license required.</td>
</tr>
<tr>
<td>Lobster (size)</td>
<td>5/day</td>
<td>§6431 possession of a lobster less than the minimum size; §6436 egg-bearing lobsters. <strong>No restriction on limit of seed specimens under hatchery conditions.</strong></td>
</tr>
<tr>
<td>American eel, elvers</td>
<td>160</td>
<td>§6505-A, §6505-C, §6575-E Method of eel fishing (must use eel pot or hoop net); Chapter 32.03 method of fishing; and Chapter 8 reporting</td>
</tr>
<tr>
<td>soft-shelled clam, quahog, Arctic surf clams</td>
<td>1000</td>
<td>§6601 and Chapter 9 license, take and possession of shellstock; §6681(3) Minimum size of clams; §6621 closed areas, Chapters 95, 96 areas closed for pollution and toxins. <strong>No restriction on limit of seed specimens under hatchery conditions.</strong></td>
</tr>
<tr>
<td>Sea scallop</td>
<td>1000 Whole scallops, 100 max broodstock scallops</td>
<td>§6701 Scallop license, for take and possession, §6721 shell size minimum, §6722 closed season, §6725 and Chapter 11 Possession of illegal scallops; pertaining to take legal size, method of take, season; Chapter 96 Area <strong>No restriction on limit of seed specimens under hatchery conditions.</strong></td>
</tr>
<tr>
<td>Mahogany</td>
<td>1000</td>
<td>Quahogs: §6731(3) see exemption for three bushels per day for personal use <strong>No restriction on limit of seed specimens under hatchery conditions</strong></td>
</tr>
<tr>
<td>Blue/ribbed mussels</td>
<td>1000</td>
<td>§6745(4) blue mussel take and possession; exemption for two bushels per day for personal use; Chapter 12. <strong>No restriction on limit of seed specimens under hatchery conditions.</strong></td>
</tr>
<tr>
<td>urchins</td>
<td>2400</td>
<td>§6748 license, §6749 season and Chapter 26 size, method of take, possession of urchins; for gonad research. 15-20 urchins per month from 8-10 sampling stations coast wide. No sublegal size for this purpose. Maximum number 20 x 10 x 12 = 2400 / year. Hatchery reared urchins (sublegal size) would be used in field studies.</td>
</tr>
<tr>
<td>marine worms</td>
<td>500</td>
<td>§6752 marine worms allows personal take for &lt;125/day, Chapter 28</td>
</tr>
<tr>
<td>sea cucumber</td>
<td>50</td>
<td>§6801-A, §6811, Chapter 27 season, harvest method, drag size, and commercial license and permit</td>
</tr>
<tr>
<td>green crab</td>
<td>No limit</td>
<td>§6808 green crab and Chapter 25.40, permit, method of take; 25.40(B)(5)(a) exemption for personal use of take by method other than by</td>
</tr>
</tbody>
</table>

**OFFICES AT 2 BEECH ST., BAKER BUILDING, HALLOWELL, MAINE**

PHONE: (207) 624-6550  http://www.Maine.gov/dmr  FAX: (207) 624-6024
<table>
<thead>
<tr>
<th>Category</th>
<th>Limit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knotted wrack, bladder wrack, seaweed spp.</td>
<td>400 lbs.</td>
<td>§6803 – Seaweed license (2)(C) personal take exemption for &lt;two bushels per day and Chapter 29 seaweed; holdfasts of Ascophyllum nodosum will be left attached to portable rocks, if cut it must be cut no lower than 16 inches above the holdfast in compliance with Chapter 29 regulations.</td>
</tr>
<tr>
<td>Whelks and periwinkles</td>
<td>500</td>
<td>§6501 Commercial license endorsement; and Chapter 13 license(s), method of take, see personal exemption for periwinkles (two quarts per day) size, method of take</td>
</tr>
<tr>
<td>Oyster</td>
<td>500</td>
<td>§6621 – closed areas, Chapters 95 and 96; Chapter 14 Oysters, season, size, possession. <strong>No restriction on limit of seed specimens under hatchery conditions.</strong></td>
</tr>
<tr>
<td>Horseshoe crab</td>
<td>4</td>
<td>Chapter 31.10(C) exempt from take and possession during closed period for a maximum of four crabs; to be returned alive to collection site</td>
</tr>
<tr>
<td>Groundfish</td>
<td>5</td>
<td>Chapter 34.10(1)(C)(3), i.e., no cod may be taken in the months of April, May and June; see Chapter 34 for species listed; <strong>NO exemption or take allowed for window pane flounder, wolfish or oceanpout. Halibut maximum take is five per year.</strong></td>
</tr>
<tr>
<td>Herring</td>
<td>50</td>
<td>Chapter 36</td>
</tr>
<tr>
<td>Smelt</td>
<td>50</td>
<td>Chapter 40 closed areas and method of take</td>
</tr>
<tr>
<td>Am. Shad</td>
<td>50</td>
<td>Chapter 44 limits</td>
</tr>
<tr>
<td>N. Shrimp</td>
<td>500</td>
<td>Chapter 45, season, possession</td>
</tr>
<tr>
<td>Dogfish/Shark</td>
<td>10</td>
<td>Chapter 50 No exemption from reporting pursuant to ASMFC compliance, see conditions on page two.</td>
</tr>
<tr>
<td>Mackerel</td>
<td>50</td>
<td>Chapter 80 license</td>
</tr>
<tr>
<td>Other</td>
<td>50</td>
<td>Non-indigenous species require a permit pursuant to Chapter 24 – Contact DMR Dir. of Public Health</td>
</tr>
<tr>
<td>School/Business</td>
<td>Lobster</td>
<td>Clam</td>
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<tr>
<td>Beals Elementary School</td>
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<tr>
<td>Calais High School</td>
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<tr>
<td>Washington Academy</td>
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<td>X</td>
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<tr>
<td>Camden National Bank (Jonesport)</td>
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</table>