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: July 1, 2014 through December 31, 2014

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 water­fronts 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 soft­shell 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 soft­shell clams of all age­classes;

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 soft­shell clam juveniles and adults;

3) Examine whether sediment buffering, under the lowest sediment pore pH conditions, will result in enhanced numbers of soft­shell 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 2015 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.

This portion of the project was an outgrowth of activities that occurred in the town of Freeport in 2013 that were funded by their Town Council (see a compendium of activities in 2013 at: http://www.downeastinstitute.org/2013-field-trials.htm, and the Final Report on 2013 activities at: http://www.downeastinstitute.org/assets/files/manuals/1_24%20Final%20Report%20Freeport%20Shellfish%20Restoration%20Project%20-%20Beal.pdf). It was
decided that to be consistent both spatially and temporally, that one type of trap and one type of bait would be used in all locations and across time. Trap and bait type were similar to those used in 2013 (Figs. 1-2), allowing interannual comparisons.

**Figure 1.** Green crab trap (18-inch diameter x 36-inch long with a 4-inch diameter entrance on each end. The yellow object in the middle of the trap is a collapsed bait bag – see Fig. 2.)
A sampling design was developed to answer the following questions:

1) Do more crabs reside in the Upper vs. Lower Harraseeket River?
2) Do more crabs reside in the subtidal vs. intertidal?
3) When are more crabs caught? When traps are fished after 1-, 2-, or 4-days of soak time?
4) Is the sex ratio 1:1?
5) Does crab density remain constant through time?
6) Does size-frequency of male and female crabs remain constant through time?

Figure 2. Cracked, whole soft-shell clam adults were used as bait in all green crab traps.
A series of five green crab traps were deployed at five sites (three intertidal and two subtidal) in both the Upper and Lower Harraseeket River on 1 May 2014 (Figs. 3-4). Traps were approximately 100m apart and fished the same area through 1 October 2014. To determine effects of setting (soak) time on catch, traps were fished on a 1-, 2-, and 4-day basis. The contents of the five traps at a given site were pooled, and the mass of green crabs estimated using a digital scale (to the nearest 0.1 kg). A random subsample of green crabs (0.91 kg, or 2 lbs.) from each site on each trapping date was taken to estimate sex ratio and size-frequency (carapace width to the nearest 0.01 mm using digital calipers). In addition, ovigerous females were noted. If the pooled total mass from the five traps at a given site was less than 0.91 kg, all crabs were measured and sexed.

**Figure 3.** Schematic of location within the Harraseeket River where green crab traps were deployed. Five traps were fished at each location each Monday (4-day sets), Tuesdays (1-day sets), and Thursdays (2-day sets). Traps received fresh bait upon each haul. Upper and Lower Harraseeket: Blocks 1, 2, 5: Intertidal; Blocks 3, 4: Subtidal.
Preliminary Results

Data collected through 15 September 2014 indicates that catch rates were relatively low for the first 56 days (5 May to 30 June; Fig. 5). Catches tended to increase with soak time (1 day vs. 2 days vs. 4 days) in May, June, and July (Fig. 6); however section within the Harraseeket River (Upper vs. Lower), and location (intertidal vs. subtidal) within each section were also important in understanding catch data (Table 1; Fig. 7). For example, catches averaged less than 0.5
Figure 5. Results from green crab trapping studies in the Lower and Upper Harraseeket (5 May through 15 September 2014). Each point represents the pooled data from five groups of five traps in each section of the River (n = 5). Catch is based on 4-day soak time.

Pounds of green crabs per trap in both the Lower and Upper Harraseeket until mid-July at all locations (subtidal and intertidal), but after that date, numbers increased faster in the intertidal than subtidal in the Upper Harraseeket, and just the opposite in the Lower Harraseeket (Fig. 7). In addition, sex ratios varied in complex ways (Table 2; Fig. 8). In the Lower Harraseeket, mean ratios gradually changed from female- to male-biased in both intertidal and subtidal locations over the first seven weeks of trapping (5 May – 16 June), and remained male-biased through late August. In the Upper Harraseeket, mean ratios for intertidal locations were male-biased across all sampling dates, whereas ratios in the subtidal were similar to those observed in the Lower Harraseeket (Fig. 8). Differences in green crab size-frequency distribution was examined for females and males (Fig. 9) along with mean carapace width (Tables 3-4). Female and male green crab size distribution varied significantly through time, but in opposite directions. Female distribution shifted towards the smaller size classes from May to August (G = 791.9; P < 0.0001) while male sizes increased significantly (G = 675.3; P < 0.0001).
Figure 6. Relationship between amount of time traps were on the bottom (soak time) and catch (in pounds).
Table 1. Analysis of variance on the green crab catch data with time (weeks), section (Lower vs. Upper portion of the Harraseeket River), tidal position (intertidal vs. subtidal), and soak time as fixed factors. Data are preliminary - 5 May to 14 August plus one date at the end of August (28th) 2014. Probability values in red are statistically significant.

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Table 2. Analysis of variance on the arcsine-transformed sex ratio data with time (weeks), section (Lower vs. Upper portion of the Harraseeket River), and tidal position (intertidal vs. subtidal) as fixed actors. Data are preliminary – 5 May to 14 August plus one date at the end of August (28th) 2014. Probability values in red are statistically significant.

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Figure 7. Green crab trapping results in the Lower and Upper Harraseeket River, Freeport, Maine, for the weeks from 5 May to 25 August 2014. (n = 1 to 9).
Figure 8. Sex ratio of green crabs in the Upper and Lower Harraseeket River, Freeport, Maine, from traps fished in the intertidal and subtidal from 5 May to 25 August 2014. Means represent ratios from groups of five traps from each tidal position pooled over a weekly interval. (n = 1 to 9)
Figure 9. Size-frequency distribution of female and male green crabs by month pooled across section of the Harraseeket River (Upper; Lower) and tidal position (Intertidal; Subtidal). Means are presented with 95% confidence interval.
Table 3. Analysis of variance on mean carapace width of female green crabs with time (weeks), section (Lower vs. Upper portion of the Harraseeket River), and tidal position (intertidal vs. subtidal) as fixed actors. Data are preliminary – 5 May to 14 August plus one date at the end of August (28th) 2014. Probability values in red are statistically significant.

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Table 4. Analysis of variance on mean carapace width of male green crabs with time (weeks), section (Lower vs. Upper portion of the Harraseeket River), and tidal position (intertidal vs. subtidal) as fixed actors. Data are preliminary – 5 May to 14 August plus one date at the end of August (28th) 2014. Probability values in red are statistically significant.

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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;

Green crab fencing (Figs. 10-12) was used by the Federal Bureau of Commercial Fisheries and the Maine Department of Sea and Shore Fisheries during the early 1950’s when seawater temperatures increased dramatically (Fig. 13) compared to previous years and green crab populations exploded (Glude, 1955; Welch, 1968). Preliminary work to test the efficacy of fencing occurred in Freeport, Maine during the summer and fall of 2013 (see: http://www.downeastinstitute.org/2013-field-trials.htm).

Figure 10. Photo of green crab fencing in Plum Island Sound, Newburyport, MA around 1953. (NOAA photo library - http://www.photolib.noaa.gov/htmls/fizh2024.htm).
In 2014, a study was initiated in April in the lower intertidal at Staples Cove, Freeport (43°48’31.73” N; 70°06’43.98” W) to test the efficacy of fencing vs. protective netting on three dependent variables: survival/growth of cultured soft-shell clam juveniles, and densities of 0-year class individuals. In addition, the field trial examined whether fenced and netted plots performed better than control plots (no fences or netting) relative to the three dependent variables.

A 4 x 7 matrix was established near the mean low water mark at Staples Cove. Twenty-eight 30-ft x 30-ft plots (9.14 m x 9.14 m) were established within the matrix with approximately 50-ft 15.2 m) spaces between rows and columns. Fences (Fig. 14) and control plots were assigned randomly to positions within the matrix (Fig. 15). Fences were comprised of 12 ten-foot pieces. Each piece was constructed of two lengths of rough-cut spruce wood (2-inch stock x 10-ft long) approximately 2-ft apart nailed on each end to a 36-inch long 2- x 4-inch post (Fig. 16).
A heavy-duty plastic mesh that is extruded from rugged, UV stabilized polyethylene (6.4 mm VEXAR – XV1170, Industrial Netting, Minneapolis, MN; http://www.industrialnetting.com/xv1170.html) was used as the netting to deter crabs (Fig. 16). A piece of aluminum flashing (8-inches wide) was affixed to the top of each section to discourage green crabs from climbing up the extruded netting and entering the plot. The flashing provides a slippery surface that does not allow crabs to push off properly and restricts their movements to the outside of the plot. Each section of fencing was 26-inches tall was pushed or pounded into the mud approximately 10-15 cm. Once installed in the sediments, one section of fencing was connected to an adjacent section with short pieces of wood (Fig. 17). After installing all 12 sections of fencing, a 36-inch wide skirt of flexible, polypropylene netting (6.4 mm aperture – OV3018, Industrial Netting, Minneapolis, MN; http://www.industrialnetting.com/ov3018.html) was secured around the base of the periphery
**Figure 13.** Minimum monthly average seawater temperature (West Boothbay Harbor, ME) from 1940 to 2012. Green crab populations increased dramatically along the Maine coast from 1952-1954, and decreased to pre-1950’s levels by the late 1950’s when minimum monthly average seawater temperatures returned to near the 70-year minimum average of 2.1°C (see Welch, 1968). Data collected from daily sea surface temperatures, 1905-2012 ([http://www.maine.gov/dmr/rm/bbhenv/index.htm](http://www.maine.gov/dmr/rm/bbhenv/index.htm)).

of each fence to deter crabs from entering the fenced plot from below the surface of the sediments (Figs. 18-19).

To establish ambient densities at the study site, two benthic cores (A = 0.01824 m² x 15 cm deep) were taken haphazardly within each of the 28 plots. Each sample was washed through a 1.0 mm sieve and all live soft-shell clams, *Mya arenaria*, and hard clams, *Mercenaria mercenaria*, enumerated and the shell length (SL) of each measured to the nearest 0.01 mm using digital calipers.

To test the efficacy of fencing vs. netting on survival and growth of cultured clams, two 12-ft x 12-ft plots (13.4 m²) were established in each fenced plot (N = 14) and each control plot (N = 14). Cultured clams from the Downeast Institute (\( \bar{x}_{SL} = 12.4 \pm 0.68 \) mm, n = 92) were broadcast into each plot at a density of 20 ft² (215 m²). One plot was covered with a piece of flexible, plastic netting ( aperture = 4.2 mm; OV7100 – Industrial Netting, Minneapolis, MN; [http://www.industrialnetting.com/ov7100.html](http://www.industrialnetting.com/ov7100.html)). The other plot was left alone with only one
Figure 14. A 30-ft x 30-ft fence at Staples Cove, Freeport Maine.

Figure 15. Schematic of field trial at Staples Cove, Freeport, Maine. Blue boxes represent 30-ft x 30-ft fenced plots and open boxes represent 30-ft x 30-ft control plots.
Figure 16. Close-up of one 10-ft (3.05 m) section of fence used to deter green crabs at Staples Cove, Freeport, Maine. Extruded, plastic netting (6.4 mm VEXAR) was used between the top and bottom board, and a strip of aluminum flashing was affixed to the top of the fence to keep crabs from climbing over the top of the fence. A piece of 6.4 mm flexible netting was affixed to the bottom of each section and this was pushed using feet into the mud below the fence to deter crabs from burrowing under the fenced plot.

wooden stake marking each corner. Two more similar size plots were established within each 30-ft x 30-ft (83.6 m²) plot to examine effects of predators on recruitment of 0-year class individuals. One plot was covered with plastic netting (4.2 mm aperture, as described above), while the other plot was considered a control with wooden stakes marking the corners (Figs.
VEXAR (extruded netting) was the material used to deter crabs. This photo shows two sections of fencing prior to installing bottom netting (see Fig. 18).

20-21). Nets were cut into 14-ft x 14-ft pieces and five Styrofoam floats (4-inch diameter x 4-inches thick and arranged in a quincunx pattern) were affixed to the underside of each by placing a 4-inch wooden lath on top of the netting and pounding 3 trap nails through the lath through the netting and into the float). Sediments were soft enough in each 30-ft x 30-ft plot so that it was possible to secure nets around each 12-ft x 12-ft plot by walking around the periphery of each net. This forced the edge of the net into the sediments approximately 6-8 inches (15-20 cm). Floats were used so that the netting would not interfere with clam feeding during tidal inundation (see Beal and Kraus, 2002).

Because of a permit agreement with the Army Corps of Engineers, fenced plots were assessed once every 48 hours from 18 April to 31 December 2014 for the presence of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*). None was
Figure 18. Securing flexible netting (6.4 mm aperture) around the outside periphery of a fenced plot. The netting was used to prohibit green crabs from burrowing under the fence. The skirt of netting extended approximately 36 inches (0.91 m) away from the edge of the fence.

ever found. During inspections of the plots in mid-July 2014, many egg cases from the mud snail, *Ilyanassa obsoleta*, were noted on a majority of the nets both in control plots and fenced
plots (Figs. 22-23). The presence of the mud snail egg cases (Fig. 24) led to an increase in deposition of sediments on the nets which, in turn, led to the creation of an anoxic layer that had severe, negative effects on cultured clam survival and recruitment of 0-year class individuals. Attempts to remove the egg cases using brushes and squeegees were unsuccessful, and, although the majority of the nets were subsequently removed and replaced with clean nets, much of the juvenile clam mortality had already occurred.

Sampling of the 112 plots (twenty-eight 30-ft x 30-ft plots containing four 12-ft x 12-ft subplots) occurred from 11-15 November 2014. Two large benthic cores (15 cm diameter x 15 cm deep; \( A = 0.01824 \text{ m}^2 \)) and five small cores (4 cm diameter x 4 cm deep; \( A = 0.0081 \text{ m}^2 \)) were taken in each subplot. The larger cores were used to sample both 0-year class clams and 1+ year class clams whereas the smaller cores were used to increase sampling effort for the 0-year class individuals. A total of \( 28 \times 4 \times 2 = 224 \) large cores and \( 28 \times 4 \times 5 = 560 \) small cores were taken. Each sample was washed separately using a 1.0 mm mesh, and all live *Mya*, *Mercenaria*, *Ensis directus*, and *Carcinus maenas* were enumerated and the SL of bivalves and the carapace width
Figure 20. Schematic of experimental design used at Staples Cove, Freeport, Maine in 2014. A total of twenty-eight 30-ft x 30-ft plots were established in a 4 x 7 matrix with 50-ft spacing between rows and columns. Fourteen plots were surrounded by a wooden fence (Fig. 14) while no structures were used in the remaining fourteen plots (controls). The design is a completely randomized block design with one replicate of each of four treatments within each 12-ft x 12-ft plot: Treatment A: cultured clams at a density of 20 ft$^{-2}$ and covered with a piece of protective netting (4.2 mm aperture); Treatment B: cultured clams at a density of 20 ft$^{-2}$ with no netting; Treatment C: no clams with the plot protected with a piece of protective netting (4.2 mm aperture); Treatment D: no clams, no netting.

of the green crab measured to the nearest 0.01 mm using digital calipers.

Data has yet to be analyzed completely, and will be presented in the next Progress Report.
Figure 21. A fenced plot showing the two netted and two control plots.
Figure 22. Close-up of a netted plot within a larger control plot at Staples Cove, Freeport, Maine on 19 July 2014. Notice that the netting is weighed down by sediment, mud snails and their egg cases in all areas of the net except the area directly underneath the Styrofoam float.
Figure 23. Close-up of net on 19 July 2014 at Staples Cove where a layer of sediment has built up due to the presence of mud snails and their egg cases, which act as miniature sediment traps. Unfortunately, the excess sediment on top of this and other nets resulted in a layer of anoxia which had severe, negative effects on cultured clam survival as well as recruitment of wild soft-shell clam juveniles.
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 pH measurements appear in Table 5 and Fig. 25.

Table 5. Mean pH measurements (± 95% CI) from five intertidal sites in the Town of Freeport (6-8 May 2014). ANOVA on mean pH indicated a significant effect due to site (P < 0.0001). The lowest mean pH (Staples Cove) was significantly different than the highest mean pH (Recompence). n = 10

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Mean pH</th>
<th>95% CI</th>
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<tr>
<td>Recompence</td>
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<td>70° 04’ 15.0” W</td>
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<td>0.221</td>
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<td>Sandy Beach</td>
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<td>70° 05’ 49.0” W</td>
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<td>70° 06’ 33.0” W</td>
<td>7.09</td>
<td>0.193</td>
</tr>
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<td>70° 07’ 06.0” W</td>
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<td>0.240</td>
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</tbody>
</table>

Because lowest (most acidic) mean and median readings were observed at Staples Cove, the field trial was conducted at that site (Table 5).

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. 26). Pieces of flexible netting (2.3 m x 2.3 m) were used to cover one-half of the plots (Fig. 27). 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. 28). 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. 29). In addition, two large benthic cores ($A = 0.01824 \text{ m}^2$) and five small benthic cores ($A = 0.0081 \text{ m}^2$) 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. These data will be reported in the next Progress Report.
Figure 26. Spreading crushed soft-shell clams in a 2m x 2m plot at Staples Cove on 18 May 2014.

Figure 27. 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.
Figure 29. Boxplot of pH readings taken in each treatment at Staples Cove on 4 November 2014. ANOVA on the mean pH found no significant treatment effect (P = 0.1147). Overall mean pH ± 95% CI was 7.72 ± 0.07 (n = 30). This mean was significantly different (P < 0.001) from the mean pH from the same location taken on 8 May 2014 (7.09 ± 0.19; n = 10).

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 30). 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 30. 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.

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. 31) 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 (160-320 ind. m⁻²) within each plot. Nets were deployed in blocks of four nets (2 replicates of each planting density per block; Fig. 32) 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 =

Figure 31. 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.
Figure 32. A block of four nets at Collins Cove, South Freeport, Maine on 12 July 2014.

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 core samples were taken from three nets (at random) on 12 July 2014 at both sites (Figs. 33-34). 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. 34). Many of the core samples from Wolf Neck contained hundreds of wild, 0-year class individuals (Figs. 35-36). All of these “recruits” were counted; however, only 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. All data from this experiment has yet to be analyzed and will be presented in the next Progress Report.
Figure 34. 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.
Figure 35. Benthic core (15 cm diameter x 15 cm deep) on the surface of a plot at Wolf Neck flat (10 November 2014) that had been seeded with cultured clams in April 2014, then covered with protective, flexible netting. Most of the small holes are wild, 0-year class individuals of soft-shell clams, *Mya arenaria*. Some of the core samples contained > 1,000 soft-shell clam recruits (See Figs. 36-37).
Figure 36. 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 37. 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.

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. 38) 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. 39). Treatments were assigned randomly to positions within a 6 x 5 matrix (plots = 10-ft x 10-ft, or 9.3 m²) at both sites. Adult clams were purchased locally ($\overline{x}_{SL} = 67.2 \pm 2.7$ mm, n =
35), and pushed individually into each plot so that the ventral margin (siphonal area) was facing toward

![Figure 38. 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”).](image)

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 m²; five small – A = 0.00081 m²). 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. All data has been collected, but not fully analyzed. Results of this study will be presented in the next Progress Report.
Figure 39. 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 m²) plots. One bushel of clams = 50 lbs (22.7 kg); Number of clams per bushel varies from 650-820 (see Beal, 2002).

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. 40). 50,000 clams were added to each of twenty 55-gallon silos on 10 June 2014. Silos were initially cleaned on a weekly basis, but after mid-July, cleaning occurred
Figure 40. Bivalve nursery upweller, South Freeport, Maine. July 2014.
Figure 41. 2 mm cultured soft-shell clam seed from the Downeast Institute were added to 55-gallon silos at a density of 50,000/silo on 10 June 2014.

3-4 times per week. Clams grew rapidly during the first two months (Fig. 42), and had attained an average SL of nearly 20 mm by mid-September (Fig. 43). Fouling from solitary and colonial tunicates, blue mussels, and hydroids made cleaning the clams difficult by that time. In 2015, we will be placing the upweller in the water in early May and then transplanting clams to field plots in mid-July.

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.

A handout was created to give to the general public that encompassed all six aspects of the project (see Appendix III).
Figure 42. 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.
Figure 43. 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.
References


APPENDIX I (Army Corps Permit Application)
APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT
(33 CFR 325)

Public reporting burden for this collection of information is estimated to average 11 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters, Executive Services and Communications Directorate, Information Management Division and to the Office of Management and Budget, Paperwork Reduction Project (0710-0003). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. Please DO NOT RETURN your form to either of those addresses. Completed applications must be submitted to the District Engineer having jurisdiction over the location of the proposed activity.

PRIVACY ACT STATEMENT
Authorities: Rivers and Harbors Act, Section 10, 33 USC 403; Clean Water Act, Section 404, 33 USC 1344; Marine Protection, Research, and Sanctuaries Act, Section 103, 33 USC 1413; Regulatory Programs of the Corps of Engineers, Final Rule 33 CFR 320-332. Principal Purpose: Information provided on this form will be used in evaluating the application for a permit. Routine Uses: This Information may be shared with the Department of Justice and other federal, state, and local government agencies, and the public and may be made available as part of public notice as required by Federal law. Submission of requested information is voluntary, however, if information is not provided the permit application cannot be evaluated nor can a permit be issued. One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS

1. APPLICATION NO. 2. FIELD OFFICE CODE 3. DATE RECEIVED 4. DATE APPLICATION COMPLETE

ITEMS BELOW TO BE FILLED BY APPLICANT

5. APPLICANT'S NAME:
First - BRIAN Middle - F Last - BEAL
Company - DOWNEAST INSTITUTE FOR APPLIED MARINE RESEARCH & EDUCATION
E-mail Address - bbeal@maine.edu

8. AUTHORIZED AGENT'S NAME AND TITLE (an agent is not required)
First - Middle - Last -
Company -
E-mail Address -

6. APPLICANT'S ADDRESS:
Address - 116 O'Brien Avenue
City - Machias State - Maine Zip - 04654 Country - U.S.

9. AGENT'S ADDRESS
Address -
City - State - Zip - Country -

7. APPLICANT'S PHONE NO. & AREA CODE:
a. Residence b. Business c. Fax
207-255-1314 207-255-1314 207-255-1390

STATEMENT OF AUTHORIZATION
11. I hereby authorize, __________________________ to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

________________________________________
APPLICANT'S SIGNATURE

DATE

NAME, LOCATION, AND DESCRIPTION OF PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)
STAPLES COVE (FREEPORT, MAINE) GREEN CRAB FENCING PROJECT

13. NAME OF WATERBODY, IF KNOWN (if applicable)
CASCO BAY (LOWER HARRASEEKET RIVER; STAPLES COVE)

14. PROJECT STREET ADDRESS (if applicable)
Address

15. LOCATION OF PROJECT
Latitude: "N SEE ATTACHMENT A
Longitude: "W
City - State - Zip -

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions)
State Tax Parcel ID Municipality
Section - Township - Range -

17. DIRECTIONS TO THE SITE
ACCESS VIA CASCO BAY & HARRASEEKET RIVER TO COORDINATES SHOWN ON ATTACHMENT A
18. Nature of Activity (Description of project, include all features)

Construct fourteen 30-ft x 30-ft green crab fences in accordance to the workplan as described in Attachment B. Work to be completed entirely within the intertidal at Staples Cove, Freeport, Maine.

19. Project Purpose (Describe the reason or purpose of the project, see instructions)

The project is experimental in nature, and will test a set of hypotheses concerning the interaction of predators such as the green crab, Carcinus maenas, and their prey, the soft-shell clam, Mya arenaria. The efficacy of fencing to deter predation will be tested against treatments where no fencing occurs. Survival of cultured clams and recruitment of 0-year class clams will be the dependent variable.

USE BLOCKS 20-23 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. Reason(s) for Discharge

21. Type(s) of Material Being Discharged and the Amount of Each Type in Cubic Yards:

<table>
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<th>Type</th>
<th>Amount in Cubic Yards</th>
<th>Type</th>
<th>Amount in Cubic Yards</th>
<th>Type</th>
<th>Amount in Cubic Yards</th>
</tr>
</thead>
</table>

22. Surface Area in Acres of Wetlands or Other Waters Filled (see instructions)

Acres

Or

Liner Feet

23. Description of Avoidance, Minimization, and Compensation (see instructions)

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

25. Addresses of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (if more than can be entered here, please attach a supplemental list).

Address – See Attachment

City – State – Zip –

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

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<tr>
<th>AGENCY</th>
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<th>DATE APPLIED</th>
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<td>U.S. Coast Guard</td>
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* Would include but is not restricted to zoning, building, and flood plain permits

27. Application is hereby made for a permit or permits to authorize the work described in this application. I certify that the 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.

[Signature]

SIGNATURE OF APPLICANT DATE SIGNATURE OF AGENT DATE

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.
The proposed area of study is approximately 340,660 square feet (7.82 acres). The proposed study area is located at Staples Cove, Freeport, Maine.

The GPS Coordinates form a square within the cove.

NW Corner:  43° 48.554’N; 70° 06.841’W
SW Corner:   43° 48.458’N; 70° 06.841’W
NE Corner:  43° 48.554’N; 70° 06.750’W
SW Corner: 43° 48.458’N; 70° 06.750’W

The horizontal and vertical distances between corners is approximately 583.6 feet.
Attachment B

Staples Cove

A series of fourteen 30-ft x 30-ft fenced plots will be installed in the intertidal sediments at Staples Cove.

Plots will be square, and comprised on each side of three 10-ft sections (see Attachment C). Fences will be constructed of wood, and ¼-inch plastic, extruded netting (VEXAR) (see: http://www.industrialnetting.com/plastic_extruded.htm#search Product: XV 1170-48)

An additional fourteen 30-ft x 30-ft unfenced (control) plots will be marked off so that there are a total of twenty-eight

Arrangement of the fenced plots within the 7.82 acres will be using a completely randomized design in a 4 x 7 matrix, with 100-ft between adjacent rows and 50-ft between columns. Benthic cores will be taken within each fenced and control plot early in the spring 2014 at the time of installation, and again in November 2014. Number of juvenile soft-shell clams per core will be counted to determine if fenced plots provide better habitat than the control sites.

Schematic of the relative position of fenced and control plots within the 7.8 acre plot. Distance from the first to last plot within a row (A-G) is approximately 500 feet. Distance from the first plot in column A to the last plot in column A is approximately 500 feet.
Attachment C

FIG. A

GREEN CRAB FENCE
Attachment D

Who is responsible for the active maintenance and survey of the fenced areas?

Dr. Brian Beal, University of Maine at Machias, 116 O’Brien Avenue, Machias, ME 04654

How often will a designated individual(s) be frequenting the site?

At least once a week

Who will be those individuals?

Those individuals will be Dr. Brian Beal (not weekly); Mr. Chad Coffin (President, Maine Clammer’s Association), Mr. Clint Goodenow, Ms. Sara Randall, and others to be identified once the permit has been granted.

What is the protocol for maintenance?

Upon weekly (or sometimes sooner than a week) inspections of the fenced plots, the protocol will be to repair/replace any part/section of fence and/or netting as required. This includes adding VEXAR mesh to the bottommost portion of the fenced plot should erosion be an issue. Sections of the fenced plots will be inspected and should there be a need to re-position a section by pushing/pounding it further into the sediments, that will be done as well.

How will species that are not intended to be trapped in the fenced plots be released? Reported?

We will monitor the project area and fenced areas at Staples Cove and will notify the Corps (USACE), National Marine Fisheries Service (NMFS), and the Maine Department of Marine Resources (ME DMR) immediately in the event an Atlantic sturgeon (*Acipenser oxyrhincus oxyrhinus*) or Shortnose sturgeon (*Acipenser brevirostrum*) becomes entangled or stranded within the confines of the project area. We will contact LeeAnn Neal at the Corps (207-623-8367, ext. 2), Max Tritt at NMFS (207-866-3756), and Gail Wipplehauser at ME DMR (207-624-6349). We will follow guidelines for release of animals not intended to be trapped that are provided to us by the parties listed above.

Will you be compiling weekly reports?

If requested, yes.

What is the tidal range in the area?

The greatest tidal amplitude in this area is 12 feet.
**Complete drain at low tide?**

The area at Staples Cove where we are requesting a permit to work drains completely on any low tide. That is, fenced plots will be placed within the intertidal zone.

**How will the area and the plots be marked?**

The area and fenced plots will be marked in accordance with US Coast Guard Regulations. We will contact 1st Coast Guard District, Aids to Navigation Office (Attn: Stephen Pothier) at 617-223-8347 to ensure that marking meets all official requirements.

**What are the Past and current uses of the area, and what are the future uses of the area?**

Staples Cove used to be a commercially harvested clam flat. Currently, it has become non-productive so that it is no longer used for commercial clamming. It is the goal of this project to investigate methods that would encourage wild clams to settle and survive so that the flat will become a viable, commercial producer of soft-shell clams.

**If all permits are obtained, when would the installation occur?**

24-27 April 2014

**Who will install?**

Dr. Brian Beal, Mr. Chad Coffin, Mr. Clint Goodenow, Ms. Sara Randall, and others who are hired to assist us.

**How long will it take to install? (days?) Phased?**

It will take 2-4 days (tides) to install.

**When will the structures be removed, and how long will it take to remove the structures?**

The structures will be removed sometime after 15-16 November and before 31 December 2014. It will take 2-4 days (tides) to remove the structures.

**Beyond that associated with driving the posts into the substrate, will any soil disturbance occur? And, is any trenching necessary?**

No disturbance to marine sediments will occur other than the immediate area where posts are driven. No trenching will be necessary.
Attachment E

This is a section of Freeport Tax Map No. 25 that was obtained from http://www.freeportmaine.com/page.php?page_id=147&title=Maps that shows Staples Cove and the adjacent properties.
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, CORPS OF ENGINEERS
666 VIRGINIA ROAD
CONCORD, MASSACHUSETTS 01742-2751

MAINE GENERAL PERMIT (GP)
AUTHORIZATION LETTER AND SCREENING SUMMARY

BRIAN BEAL
UNIVERSITY OF MAINE AT MACHIAS
116 O'BRIEN AVENUE
MACHIAS, MAINE 04654

CORPS PERMIT # NAE-2014-00102
CORPS GP ID# 14-026, 14-052
STATE ID# EXEMPT

DESCRIPTION OF WORK:
To install and maintain up to 14 – 30’ x 30’ predator fencing plots within a 7.82 acre area below the mean high water line of Staples Cove at Freeport, Maine in conjunction with a green crab fencing project as shown on plans entitled “Brian Beal, Downeast Institute for Applied Marine Research & Education” on 5 sheets dated “02/07/2014”.

SPECIAL CONDITIONS: SEE ATTACHED SHEET

LAT/LONG COORDINATES: 43.8091208° N -70.1133956° W USGS QUAD: FREEPORT, MAINE

I. CORPS DETERMINATION:
Based on our review of the information you provided, we have determined that your project will have only minimal individual and cumulative impacts on waters and wetlands of the United States. Your work is therefore authorized by the U.S. Army Corps of Engineers under the enclosed Federal Permit, the Maine General Permit (GP). Accordingly, we do not plan to take any further action on this project.

You must perform the activity authorized herein in compliance with all the terms and conditions of the GP [including any attached Additional Conditions and any conditions placed on the State 401 Water Quality Certification including any required mitigation]. Please review the enclosed GP carefully, including the GP conditions beginning on page 5, to familiarize yourself with its contents. You are responsible for complying with all of the GP requirements; therefore you should be certain that whoever does the work fully understands all of the conditions. You may wish to discuss the conditions of this authorization with your contractor to ensure the contractor can accomplish the work in a manner that conforms to all requirements.

If you change the plans or construction methods for work within our jurisdiction, please contact us immediately to discuss modification of this authorization. This office must approve any changes before you undertake them.

Condition 41 of the GP (page 18) provides one year for completion of work that has commenced or is under contract to commence prior to the expiration of the GP on October 12, 2015. You will need to apply for reauthorization for any work within Corps jurisdiction that is not completed by October 12, 2016.

This authorization presumes the work shown on your plans noted above is in waters of the U.S. Should you desire to appeal our jurisdiction, please submit a request for an approved jurisdictional determination in writing to the undersigned.

No work may be started unless and until all other required local, State and Federal licenses and permits have been obtained. This includes but is not limited to a Flood Hazard Development Permit issued by the town if necessary.

II. STATE ACTIONS: PENDING [ ], ISSUED [ ], DENIED [ ] DATE__________________

APPLICATION TYPE: PBR:____ TIER 1:____ TIER 2:____ TIER 3:____ LURC:____ DMR LEASE:____ NA: X

III. FEDERAL ACTIONS:

JOINT PROCESSING MEETING: 1/16/14, 2/27/14 LEVEL OF REVIEW: CATEGORY 1:____ CATEGORY 2: X

AUTHORITY (Based on a review of plans and/or State/Federal applications): SEC 10 X 404 10/404 103

EXCLUSIONS: The exclusionary criteria identified in the general permit do not apply to this project.

FEDERAL RESOURCE AGENCY OBJECTIONS: EPA NO USFWS NO NMFS NO

If you have any questions on this matter, please contact my staff at 207-623-9367 at our Manchester, Maine Project Office. In order for us to better serve you, we would appreciate you completing our Customer Service Survey located at http://per2.nwp.usace.army.milsurvey.html

LEE ANN B. NEAL
SENIOR PROJECT MANAGER
MAINE PROJECT OFFICE

FRANK J. DEL GIULIDICE
CHIEF, PERMITS & ENFORCEMENT BRANCH
REGULATORY DIVISION

DATE 3/28/14
1.) The permittee shall assure that a copy of this permit is at the work site whenever work is being performed and that all personnel performing work at the site of the work authorized by this permit are fully aware of the terms and conditions of the permit. This permit, including its drawings and any appendices and other attachments, shall be made a part of any and all contracts and sub-contracts for work which affects areas of Corps of Engineers’ jurisdiction at the site of the work authorized by this permit. This shall be done by including the entire permit in the specifications for the work. If the permit is issued after construction specifications but before receipt of bids or quotes, the entire permit shall be included as an addendum to the specifications. The term "entire permit" includes permit amendments. Although the permittee may assign various aspects of the work to different contractors or sub-contractors, all contractors and sub-contractors shall be obligated by contract to comply with all environmental protection provisions of the entire permit, and no contract or sub-contract shall require or allow unauthorized work in areas of Corps of Engineers jurisdiction.

2.) The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

3.) This permit for the installation and maintenance of structures does not eliminate the need to obtain local harbormaster approval or conform to local harbor management plans. If, in the best interest of overall navigation and under harbormaster direction, it becomes necessary to relocate the structures, prior written authorization from the Corps is not required. No structures may be relocated into a Federal Navigation Project or in areas of submerged aquatic vegetation i.e. eelgrass. If relocation occurs, the permittee shall provide the Corps with a copy of the harbormaster approval and a plan and coordinates depicting the new location of the structures.

4.) Except in the surface areas physically occupied by the structures (green crab predator fencing), the permittee shall permit normal fishing and/or recreational and commercial boating activity to occur.

5.) The permittee is required to clearly mark the boundaries of the site in accordance with US Coast Guard Regulations, and to contact 1st Coast Guard District, Aids to Navigation Office, Attn: Steven Pothier, at 617-223-8347. In the event the USCG does not require specific marking of the site, the permittee shall mark the four corners of the site with mooring buoys marked “shellfish test site” indicating the outer boundaries of the site.

6.) The permittee shall ensure that monitoring of the sites shall occur at least once every 48 hours to ensure proper maintenance of the fence structures; the permittee shall submit a bi-weekly report to the Corps throughout the experimental window detailing the date, time, fencing condition, and level of interaction with the number and type of aquatic species should any be encountered within the fenced plots. Failure to submit reports in a timely manner will result in non-compliance with the permit conditions.

7.) The permittee shall monitor the project area(s) and notify the Corps (USACE), National Marine Fisheries Service (NMFS), and the Maine Department of Marine Resources (ME DMR) immediately in the event an Atlantic or Shortnose sturgeon becomes entangled or stranded within the confines of the project area(s). Point of contact at the Corps is LeeAnn Neal at (207) 623-8367 ext. 2; Point of contact at NMFS is Max Tritt at (207) 866-3756; and at ME DMR contact Gail Wipplehauser at (207) 624-6349.

8.) This Corps permit does not authorize a “take” of an endangered species, in particular the Atlantic or Shortnose sturgeon. “Take” of a species is defined as: harass, harm, pursue, hunt, shoot, trap, capture, or collect or attempt to engage in any such activity. In order to legally take a listed species, you must have separate authorization under the Endangered Species Act (e.g., an ESA Section 10 permit, or a Biological Opinion under ESA Section 7, with “incidental take” provisions with which you must comply). If a sturgeon is found dead within the fenced area, or if a sturgeon is found alive inside the fenced area and has to be evacuated, a take has occurred. Should a take occur, the research will cease, the fencing will immediately be removed, and a formal consultation under section 7 of the ESA will be required regardless of whether or not the research is to resume.

9.) This permit is valid for one season, March 2014 thru December 15, 2014. All gear, structures, staking, marking shall be removed and stored in an upland location by December 16, 2014. No gear or structure is to be stored on the substrate, marsh vegetation, or below the mean high water line outside of specified project season.

10.) The permittee must still obtain any other Federal, State, or local permits as required by law before beginning work. This includes but is not limited to a Flood Hazard Development Permit issued by the town if necessary.
11). This authorization requires you to 1) notify us before beginning work so we may inspect the project, and 2) submit a Compliance Certification Form. You must complete and return the enclosed Work Start Notification Form(s) to this office at least two weeks before the anticipated starting date. You must complete and return the enclosed Compliance Certification Form within one month following the completion of the authorized work and any required mitigation (but not mitigation monitoring, which requires separate submittals).
Attachment A

GPS Coordinates

The proposed area of study is approximately 340,660 square feet (7.82 acres). The proposed study area is located at Staples Cove, Freeport, Maine.

The GPS Coordinates form a square within the cove.

NW Corner: 43° 48.554'N; 70° 06.841'W
SW Corner: 43° 48.458'N; 70° 06.841'W
NE Corner: 43° 48.554'N; 70° 06.750'W
SW Corner: 43° 48.458'N; 70° 06.750'W

The horizontal and vertical distances between corners is approximately 583.6 feet.
Attachment B

Staples Cove

A series of fourteen 30-ft x 30-ft fenced plots will be installed in the intertidal sediments at Staples Cove.

Plots will be square, and comprised on each side of three 10-ft sections (see Attachment C). Fences will be constructed of wood, and ¼-inch plastic, extruded netting (VEXAR) (see: http://www.industrialnetting.com/plastic_extruded.htm#search Product: XV 1170-48)

An additional fourteen 30-ft x 30-ft unfenced (control) plots will be marked off so that there are a total of twenty-eight

Arrangement of the fenced plots within the 7.82 acres will be using a completely randomized design in a 4 x 7 matrix, with 100-ft between adjacent rows and 50-ft between columns. Benthic cores will be taken within each fenced and control plot early in the spring 2014 at the time of installation, and again in November 2014. Number of juvenile soft-shell clams per core will be counted to determine if fenced plots provide better habitat than the control sites.

Schematic of the relative position of fenced and control plots within the 7.8 acre plot. Distance from the first to last plot within a row (A-G) is approximately 500 feet. Distance from the first plot in column A to the last plot in column A is approximately 500 feet.
Attachment C

Fig. A

Green Crab Fence
AMENDMENT TO DEPARTMENT OF THE ARMY
GENERAL PERMIT
STATE OF MAINE

1. Due to a Distinct Population Segment (DPS) of Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus) being listed as a threatened species in the Gulf of Maine, the New England District of the U.S. Army Corps of Engineers has modified the following General Permit Conditions (GC) for the general permit for the State of Maine (MEGP), issued on October 12, 2010.

**GC 3.** The following is to be added: (d) Direct impacts in tidal waters from contiguous bank stabilization projects in excess of 200 linear feet (Applicant or Applicant + Abutters combined) must undergo Cat 2 review.

**GC 10.** The following is to be read as: (b) Work in Inland Waters and Wetlands\(^1\) and the non-tidal portions of Navigable Waters\(^2\) (e.g., the Penobscot River, Kennebec River) is not eligible for Category 1 if:

i. The project action area occurs within a watershed occupied by listed Atlantic salmon, Atlantic sturgeon, or shortnose sturgeon. Project proponents must check the site in Footnote 3 below.

ii. In areas outside these watersheds contact the USFWS and NMFS (see Appendix D, Page 1 for contact information) to check for the presence of other listed species.

(c) Work in the tidal portions of Navigable Waters may be eligible for Category 1. Reference Appendix A, II. Navigable Waters, Pages 4 – 9, and the other terms and general conditions (GC 11 is particularly relevant) of this GP to determine Category 1 eligibility. Project proponents must contact the USFWS and NMFS (see Appendix D, Page 1 for contact information) to ensure that work in all tidal portions of Navigable Waters\(^2\) is not in critical habitat or areas occupied by listed species other than Atlantic salmon, Atlantic sturgeon, or shortnose sturgeon.

**GC 20.** The following is to read as: (d) Direct impacts in tidal waters from contiguous bank stabilization projects in excess of 200 linear feet (Applicant or Applicant + Abutters combined) must undergo Cat 2 review. Additional information for Navigable Water bank stabilization activities are provided at Appendix A, Page 4.

**GC 22.** The following is to be read as: (b) In-stream work in a watershed occupied by listed Atlantic salmon, Atlantic sturgeon, or shortnose sturgeon.

2. This amendment will become effective on June 1, 2012 and will remain in effect until October 12, 2015 unless further modified or revoked by the New England District.

3. For further information, contact Jay Clement or Shawn Mahaney at the Manchester, Maine Project Office at 207-623-8367

[Signature]

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

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\(^1\) For areas considered occupied by listed Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon in Inland Waters and Wetlands, see Footnote 16 below.

\(^2\) For areas occupied by listed Atlantic salmon or shortnose sturgeon, described in these waters from the Moosehead River to the Piscataquis River, plus the Penobscot River, the Piscataquis River, the Kennebec River, the Sheepscot River, the Midcoast area of the State of Maine, the Piscataquis River, and the Penobscot River.
COMPLIANCE CERTIFICATION FORM

USACE Project Number: NAE-2014-00102

Name of Permittee: Brian Beal, University of Maine at Machias
                  Downeast Institute for Applied Marine Research & Education

Permit Issuance Date: _________________

Please sign this certification and return it to the following address upon completion of the activity and any mitigation required by the permit. You must submit this after the mitigation is complete, but not the mitigation monitoring, which requires separate submittals.

*****************************************************************************
* MAIL TO: U.S. Army Corps of Engineers, New England District
  * Policy Analysis/Technical Support Branch
  * Regulatory Division
  * 696 Virginia Road
  * Concord, Massachusetts 01742-2751
*****************************************************************************

Please note that your permitted activity is subject to a compliance inspection by an U.S. Army Corps of Engineers representative. If you fail to comply with this permit you are subject to permit suspension, modification, or revocation.

I hereby certify that the work authorized by the above referenced permit was completed in accordance with the terms and conditions of the above referenced permit, and any required mitigation was completed in accordance with the permit conditions.

Signature of Permittee

Date

Printed Name

Date of Work Completion

(_______)

Telephone Number

(_______)

Telephone Number
GP WORK START NOTIFICATION FORM
(Minimum Advance Notice: Two Weeks)

MAIL TO: U.S. Army Corps of Engineers, New England District
Regulatory Branch
Policy Analysis/Technical Support Section
696 Virginia Road
Concord, Massachusetts 01742-2751

A Corps of Engineers Permit (NAE-2014-00102) was issued to Brian Beal. The permit authorized the permittee(s) to install and maintain up to 14 – 30’ x 30’ predator fencing plots within a 7.82 acre area below the mean high water line of Staples Cove at Freeport, Maine. Structures will remain in place from March 2014 thru December 2014.

The people (e.g., contractor) listed below will do the work, and they understand the permit's conditions and limitations.

PLEASE PRINT OR TYPE

Name of Person/Firm: __________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Business Address: __________________________________________________________

________________________________________________________________________

________________________________________________________________________

Telephone: ( ) ____________________________ ( ) ____________________________

Proposed Work Dates: Start: ______________________________________

Finish: ______________________________________

PERMITTEE'S SIGNATURE: ______________________ DATE: _______________

PRINTED NAME: ______________________ TITLE: ______________________

FOR USE BY THE CORPS OF ENGINEERS

PM NEAL ___________ Submittals Required: ________________________________

Inspection Recommendation: ____________________________________________
APPENDIX III (Handout for General Public)
Hatchery-reared soft-shell clam juveniles (one-half inch in shell length) have been planted at Collin’s Cove and Wolfe’s Neck in the Harraseeket River and protected using flexible plastic netting with 1/6th aperture. Forty 14-ft x 22-ft plots occur at each location. One-half of the plots were seeded at 15 clams per square foot while the other half were seeded at 30 clams per square foot. Predator exclusion netting is being used to deter green crabs and other predators from feeding on the clams.

Clammers and volunteers will be operating a floating bivalve upweller located at the Harraseeket Lunch and Lobster in South Freeport through the summer and fall of 2014. The upweller is designed to grow up to 1 million seed clams (initially 1/10th of an inch) to transplantable sizes (ca. 1/2-inch). Clams will be overwintered and seeded into protected plots in Freeport in 2015.

Throughout 2014 and 2015, an historic, large-scale study is taking place in Freeport town waters to examine the effectiveness of different methods designed to protect shellfish from green crabs and other predators, and how to restore soft-shell clam populations.

The study is being conducted by Stewards of the Sea LLC, the University of Maine at Machias, and the non-profit Downeast Institute for Applied Marine Research & Education. It is funded through the University of Maine System, Sea Pact, and the Saltonstall-Kennedy program of NOAA/NMFS.
Study #1
Green Crab Predator Exclusion Fencing

This experiment in Staples Cove tests the ability of specially constructed fencing to deter predation by green crabs on wild and cultured soft-shell clams. Fourteen 30-ft. x 30-ft. fences (18 inches tall with ¼-inch mesh) and comparably-sized control plots (without fences) are arrayed near the middle of the cove. Samples taken in early November within each of the 28 plots will help us determine the efficacy of fencing.

Study #2
Green Crab Trapping

Trapping is being conducted in the upper and lower Harraseeket River from May to October in both 2014 & 2015 to gauge if it is possible to reduce crab populations locally. This study also measures important aspects of spatial and temporal trends in crab abundance, size-frequency, sex ratio, percentage of egg-bearing females, and diet.

Study #3: Adult Clams Used to Enhance Wild Clam Recruitment

A field experiment at Spar Cove and Recompence Flat is examining the combined effects of the presence of adult clams and predator deterrent netting on numbers of wild clam spat. The experiment is designed to determine if wild clam spat settle and recruit to the flats in a gregarious fashion.

Study #4: Sediment Buffering for Coastal Acidification

This study in Staples Cove tests whether crushed and weathered clam shells can buffer acidic sediments enough to allow soft-shell clam spat (early juveniles) to settle and grow without their shells dissolving due to low pH conditions. This is important because ocean and coastal acidification is an increasing concern worldwide as more carbon dioxide is released into the atmosphere, and more nutrient run-off occurs from the land.