Cucumaria frondosa and *Mya arenaria* Research

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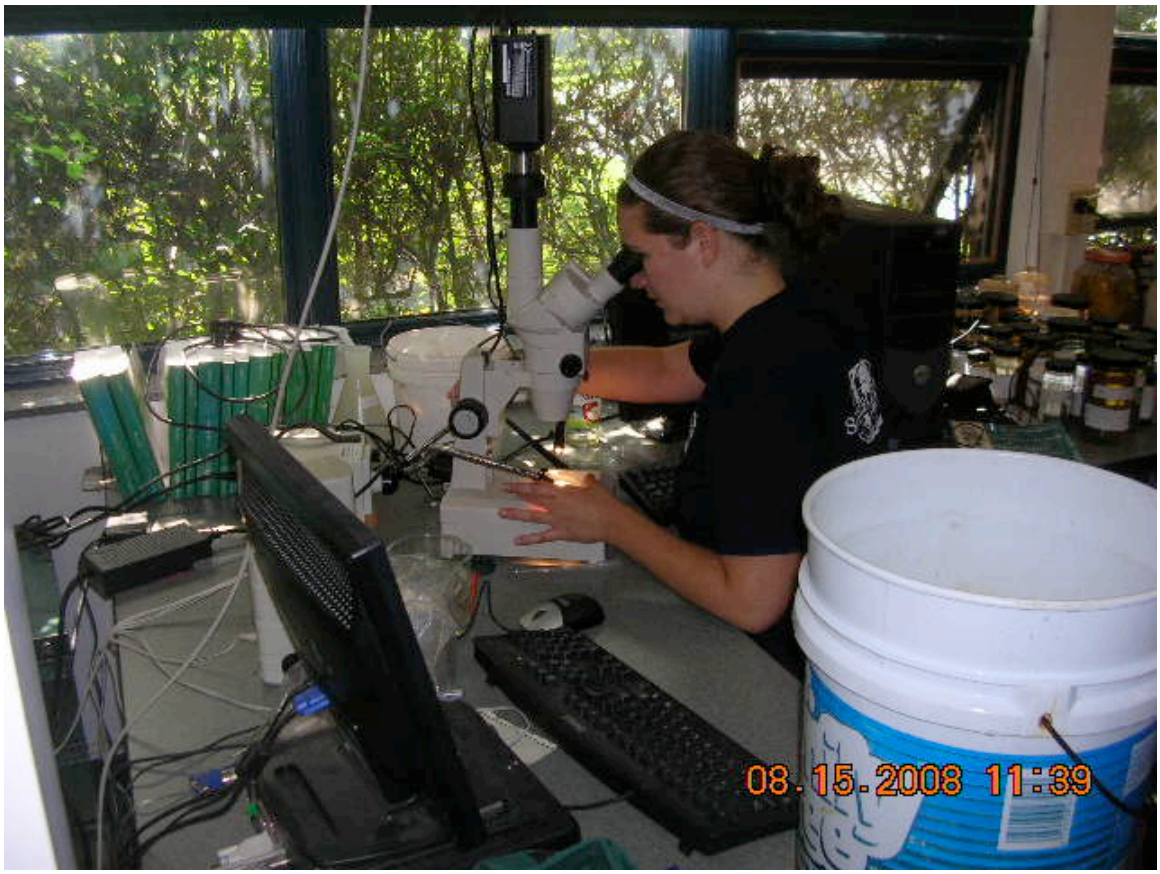
This document contains Chapter 1: Do current recruitment enhancement methods increase juvenile soft-shell clam (*Mya arenaria*) recruitment in an intertidal clam flat?



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Do current recruitment enhancement methods increase juvenile soft-shell clam (*Mya arenaria*) recruitment in an intertidal clam flat?

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Abstract

Increasing juvenile soft-shell clam (*Mya arenaria*) recruitment has been the focus of several shellfish committees along the New England coast in an effort to increase harvestable biomass. This study recreated three previously used enhancement techniques to determine if the treatments had any effect on juvenile soft-shell clam recruitment. Several replicates of brushing, transplanting seed, and raking treatments were laid out on a small grain mudflat located at Hadley Point in Bar Harbor, Maine. In all treatments and controls, high levels of juvenile clam recruitment were recorded. Although there was a significant effect of site, within a site none of the enhancement methods increased clam recruitment. Brushing and transplanting seed had no effect on juvenile clam recruitment and raking had a significant negative effect on recruitment. These results suggest that traditional clam recruitment techniques may not be as effective as believed. A review of the literature revealed that these techniques are seldom tested for their effects on clam recruitment, and although some studies find positive effects on recruitment, multiple studies have failed to find recruitment enhancement with these methods.

Introduction

The soft-shell clam, *Mya arenaria*, is an important town-managed fishery in the State of Maine. In 1963, towns were given the power to enact ordinances to protect their local clam resources (Newell 1983). The Maine Department of Marine Resources remains closely tied to shellfish management, providing area biologists to educate and assist towns on the management, biology, mariculture, and stock enhancement of shellfish resources (Mercer 2007). The Maine Department of Marine Resources is currently working on research projects on methods of enhancing soft-shell recruitment with towns that have enacted conservation ordinances (Mercer 2007).

Mya arenaria can be found in shallow sub-tidal and inter-tidal soft sediment habitats off the coast of Maine (Ellis 1998). North of Cape Cod, *M. arenaria* undergo an annual spawning event that takes place from late May through August (Ropes and Stickney 1965). The larval stage of *M. arenaria* lasts three to six weeks, with recruitment taking place from mid-summer into early fall. Larval supply and initial settlement densities are important factors in establishing population densities. Marcotti and Leavitt (1997) attribute the distribution of clam settlement to the chemical, biological, and physical components of the environment. Variables such as sediment grain size, salinity, light, temperature, chemical cues of conspecifics, and the amount of organic matter in substrate can have an impact on settling clam spat (Marcotti and Leavitt 1997).

The Maine State Clam Handbook (1998) briefly mentions experiments completed that support the idea that surface and current modification increases settlement of juvenile clams. To increase their local clam recruitment, every year towns along the New England coast purchase netting and other materials needed to implement treatments that attempt to manipulate the environment. Volunteers and paid workers, if funding is available, see clam enhancement projects to fruition (Phippsburg Shellfish Committee 2006 and Marcotti and Leavitt 1997). Three commonly used enhancement techniques include: brushing, transplanting seed clams, and raking. Brushing is a traditional method using pine and spruce boughs. The boughs are placed vertically into the sediment to slow tidal water flowing over the flat. The slowed current increases the amount of time in which clam larvae can sink and burrow into the sediment surrounding the pine boughs (Phippsburg Shellfish Committee 2006). Transplanting seed clams is another experimental treatment involving moving adult clams to a poorly populated flat to increase gregarious settlement. Gregarious settlement is the process of juvenile larvae settling in areas containing pre-existing adult populations (Phippsburg Shellfish Committee 2006), and is common in many clam species (Hay 2009, Phippsburg Shellfish Committee 2006, and U.S. Army Corps of Engineers 1987). Raking is a treatment using a clam rake to manipulate the surface of the sediment. Raking or using disks to change the structure of the sediment is thought to reduce predation, change the chemistry of the sediment, and increase sediment roughness on a short-term basis (Marcotti 1997).

While towns have used raking, transplanting seed, and brushing previously, data are rarely collected after implementation of the treatments. The lack of definitive data has led researchers (B. Beal pers comm., D. Marc-Nault pers comm.) to question the effectiveness of the treatments. In this study, all three methods were tested to determine if juvenile clam recruitment could actually be enhanced at a clamflat using typical town management practices.

Methods

Location

Data were collected on the effectiveness of brushing, raking, and seeding on increasing juvenile recruitment at Hadley Point in Bar Harbor, Maine (Latitude: 44.388815. Longitude: -68.210774). Hadley Point is a small-grained tidal mudflat located on the Western edge of Frenchman Bay in the Gulf of Maine.

Treatments

A total of three transects were laid out at Hadley Point East and West. At Hadley Point East, the single transect was laid out haphazardly 105 feet from the high tide mark and both transects at Hadley Point West were located 115 feet from the high tide mark. The site at Hadley Point East consisted of a 120-foot transect (Figure 1A). The straight transect had three replicate blocks that were made up of four 10 X 10 foot plots. Another transect with three replicate blocks was laid out at Hadley Point West and measured 110-feet (Figure 1B). A third, 60-foot transect, with only two replicated blocks was located at Hadley Point West (Figure 1C). The order of plots within each block was determined randomly, using a random number generator.

A. Hadley Point East 120-foot Transect

B	C	R	S	R	C	S	B	C	S	R	B

B. Hadley Point West 110-foot Transect

B	C	S	R	C	R	S	R	B	S	C

C. Hadley Point West 60-foot Transect

C	R	C	S	R	S

Figure 1: Order of experimental treatments in all three transects at Hadley Point from East to West. Types of treatment have the following abbreviations: B=Brushing, S=Seeding, R=Raking, C=Control.

One of the four plots in each block was raked using a five-tine clam rake in a crosshatch pattern with a depth of 2 - 5 cm (Image 1). The second plot in the block was seeded with transplanted clams from Bar Island, Maine. On May 5th, 2008, volunteers transplanted approximately 1,400 juvenile clams measuring 0.25 - 1.5 inches from Bar Island's sandy substrate to the muddy sediment of Hadley Point. Clams were wiped with dry cloths and marked along their outer edge using a Marks-A-Lot® permanent marker and seeded in the eight randomly selected ten-by-ten-foot study plots along the three transects. Seventy-five clams ranging in length between 0.25 to 1.5 inches were seeded within the 10 X 10 plot. The third plot was brushed using pine or spruce branches approximately two feet tall placed at a density of sixteen per one hundred square feet (Image 2). Brushing was put into place on July 6th, 2008. The fourth plot was a control and left unmanipulated throughout the duration of the experiment.

Image 1: Example of Raking in an Experimental Plot

Image 2: Example of Brushing in an Experimental Plot

Data Collection

Data on juvenile clam recruitment were collected during low tide at Hadley point East and West from October 14th, 2008 to October 18th, 2008. Core samples were taken in a straight line along the three transects at Hadley Point. Four core samples were taken in each plot. The cores were taken using circular PVC pipe with a four-inch diameter and a depth of four inches. A total of 68 cores were collected at Hadley Point East and 32 from Hadley Point West. Each core sample was strained of sediment and the number and length of each juvenile clam rounded down to the closest 0.25 of an inch was recorded.

An additional census on November 11, 2008 was taken on seeded plots to record adult clam populations and growth of previously marked clams. Two sample squares measuring one by one-feet were taken in each seeded plot along the three transects. Number, length, and clam growth from previously marked edge were noted. Statistical analysis of all data was preformed using SYSTAT 12.

Starting June 4th, 2008, plankton tows were collected from the Bar Harbor Town Dock once a week to monitor clam-spawning events. Surface plankton tows were taken using a 333μm net and samples were taken to the Zoology Lab at College of the Atlantic for analysis. Raking began on June 16th, 2008 after clam larvae were found in a weekly plankton tow and continued every other day at low tide until August 22nd, 2008, when clam larvae were no longer recorded in the water column.

Results:

There was a high level of juvenile recruitment in 2008 in all plots along all three study-sites at Hadley Point in Bar Harbor, Maine (Figure 2).

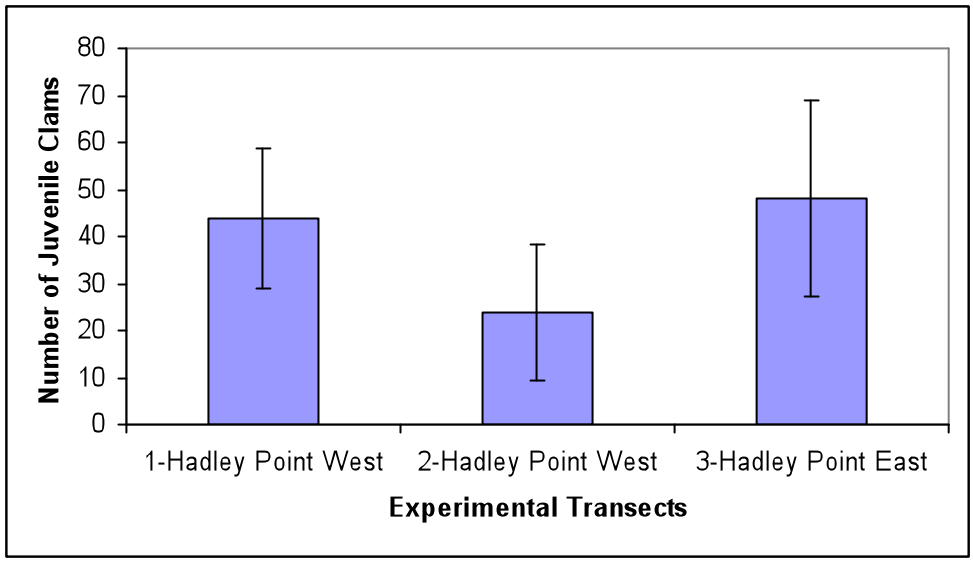

Figure 2: Juvenile recruitment for all plots in each of the three transects at Hadley Point in Bar Harbor, Maine. Error bars represent ± 1 standard deviation.

There was a significant effect of transect site on juvenile recruitment at Hadley Point. Within a site, none of the enhancement methods increased clam recruitment (Figure 3). Brushing ($p=0.870$) and transplanting seed ($p=0.975$) had no effect on juvenile clam recruitment and raking ($p=0.012$) had a significant negative effect on recruitment (all p-values from Tukey pairwise comparisons following an ANOVA).

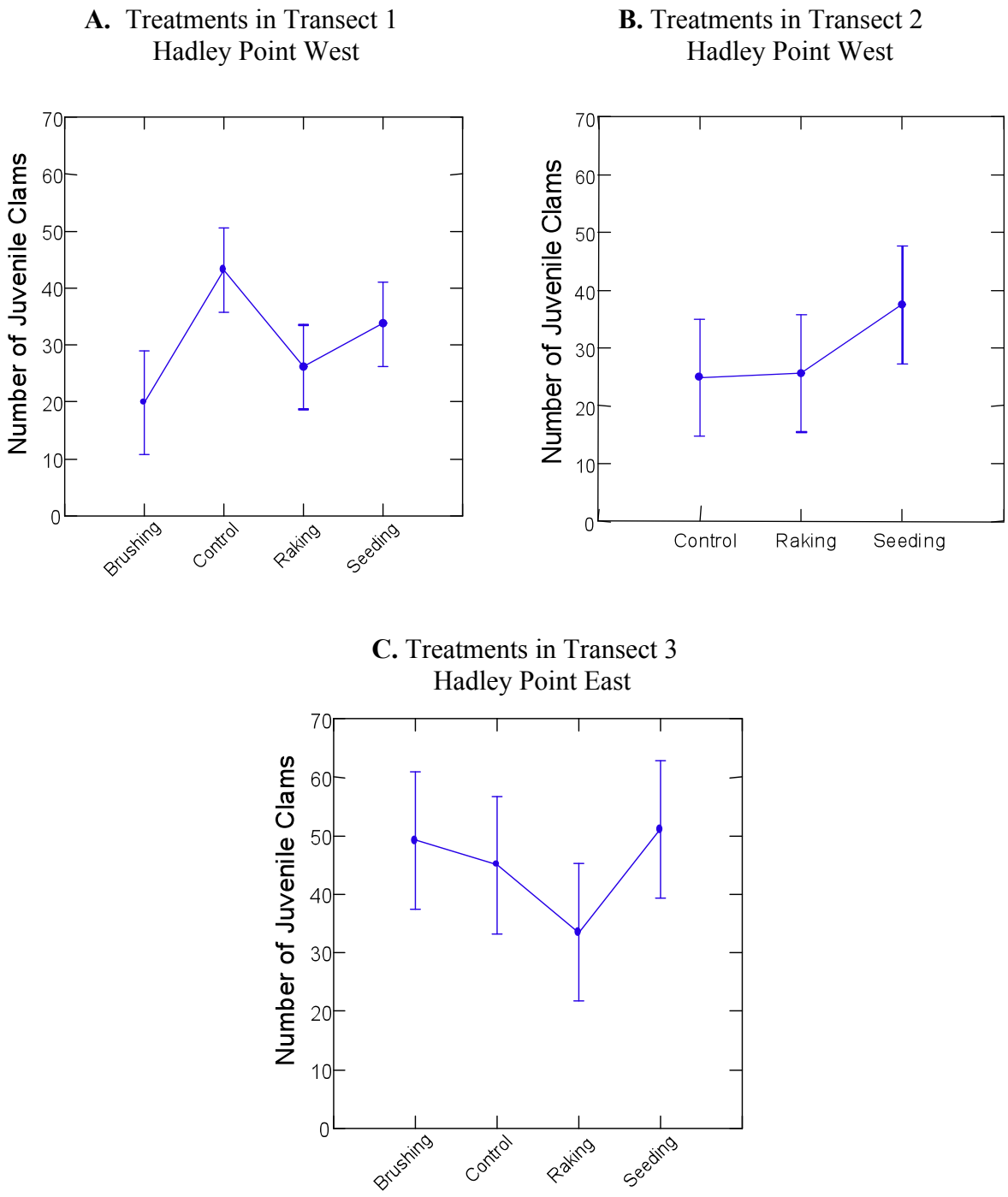

Figure 3: Number of juvenile clams recorded in each treatment. Error bars represent $\pm$ 1 standard deviation.

The November census at Hadley Point East and West showed that marking the outer edge of soft-shelled clams with a Marks-A-Lot permanent marker was an effective and inexpensive method of tagging clams for growth and seeding experiments. Seeded plots (2.00 $\pm$ 2.20) had over twice the non-recruit clam density of the control plots (0.86 $\pm$ 1.73), but due to the large natural variance this result was not statistically significant (p=0.375, paired sample t-test).

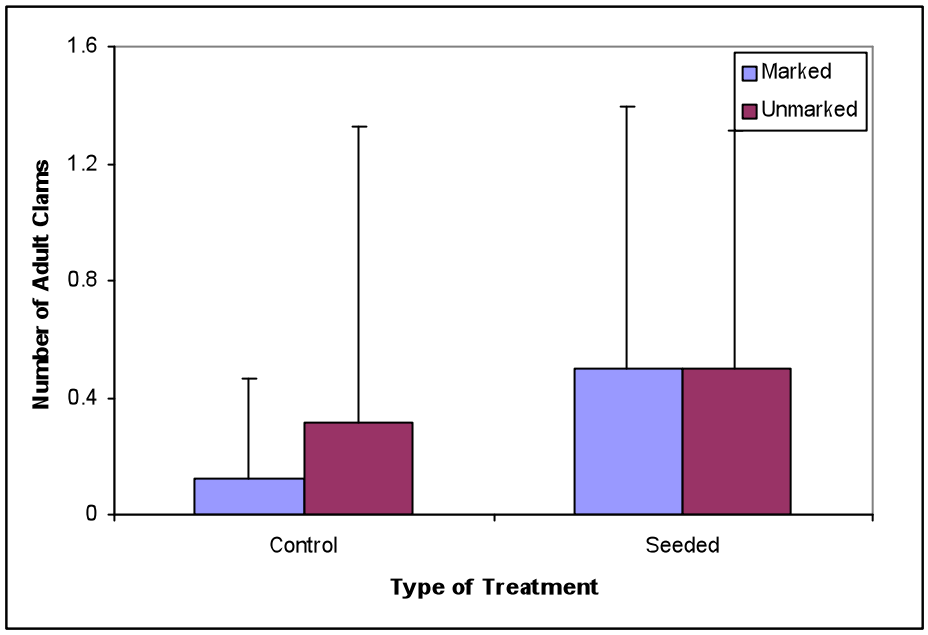

Figure 4: Number of adult clams in control and transplanted seed plots. Error bars represent 1 standard deviation.

On June 15th, 2008, juvenile clam larvae were first noted in the water column. Spawning lasted 38 days and by August 22, 2008, clam larvae were no longer present in the plankton tows. Based on the beginning date of the treatments, all clam recruitment occurred while clam enhancement methods were being actively maintained.

Discussion

Hadley Point in Bar Harbor, Maine is a productive clam-flat, yielding bushels of soft-shell clams when open to the public (Charlie Phippen pers. comm., Chris Petersen pers. obs.). Naturally occurring high levels of juvenile recruitment at Hadley Point replace adult clams lost from harvesting and mortality. Increasing juvenile recruitment

has been a focus of harvesters and shellfish management committees along the New England coast. To test current clam enhancement methods, raking, transplanting seed, and brushing were implemented and data were collected on the effects of the treatment. The results of this experimental study support the belief that the three clam enhancement treatments have no positive effect on juvenile clam recruitment (B. Beal pers. comm., D. Marc-Nault pers comm.).

The treatment of transplanting seeded clams may not have been effective due to the seeded clams not settling in a high enough density in research plots to allow for gregarious settlement. Seeded clams could have dispersed and recruited in other locations along the clam flat. Emigration of a high percentage of newly seeded clams has been documented to occur in the first two weeks after they were seeded (Beal and Vencile 2001). The treatment of brushing could have been ineffective due to low density. If a density greater than 16 per 100 square feed of pine and spruce is needed, the brush wouldn't have slowed the water enough to allow spat to drop from the water column.

Unlike brushing and transplanting seed clams, plots implemented with the raking treatment had a significant decrease in the number of recruited juveniles. The disturbance of the sediment caused by raking could impede juvenile clam recruitment by forcing newly recruited clams back into the water column. Low recruitment numbers could also have occurred due to death caused by the breaking of newly formed shell or exposure to predators by repeated raking. Previously thought to be an effective enhancement method (Clam Day, 2009 Fisherman's Forum), raking may be causing high mortality and displacement in juvenile clams.

The results of this study suggest that raking, brushing, and transplanting seed clams might not be effective clam enhancement methods in similar habitats. Two additional steps could help generalize these results. First the spatial scale and intensity of the manipulation differ from real attempts at enhancement. The 10 X 10 plots are small compared to the hundreds of feet of clamflats normally manipulated by towns in a typical clam enhancement treatment (Marcotti and Leavitt 1997, Frank Batson pers. comm., and Phippsburg Shellfish Committee 2006). Brushing with a higher density of boughs has previously been used (Frank Batson pers. comm.) and increasing the amount of transplanted seed clams could have a positive effect on gregarious settlement. The second

step in generalizing these results would be to repeat the experiment through time and space. The amount of natural clam spat varies each year (Hunt et. al 2003) and the location within and between clamflats is also highly variable.

Not only do variations in methodology need to occur, but data also need to be collected each time an enhancement method is put into place. Data are currently rarely collected on the effects of experimental treatments, even though every year shellfish committees, state workers, and numerous volunteers expend effort and purchase supplies in an attempt to increase their local clam harvest (Phippsburg Shellfish Committee 2006, Marcotti and Leavitt 1997). Data collected from this study showed raking, brushing, and transplanting seed clams to be ineffective clam enhancement treatments. Collecting data from future studies would determine if clam enhancement treatments are worthwhile for towns along the New England coast.

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