Findings from the Field

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The good, the bad and the muddy

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Abstract:
The purpose of this study was to find out if clams settle and survive on the mud flats on Islesboro. It was a comparison study using Beal Boxes designed by Dr. Brian Beal from the DownEast Institute. The town set out boxes in June 2018 at Ryder Cove, Sprague Cove, and Islesboro Harbor. The boxes were collected in December 2018 along with core samples of the mud beside the boxes. We counted and measured the clams found in the boxes and the core samples. We found that clam recruitment was significantly higher in the boxes. The study suggests that predation is a higher factor affecting clam recruitment, survival, and growth.

Question: Can clams survive in the Islesboro mudflats? If they can, which site is the best for recruiting and then planting new clams?

Introduction:
The people of Islesboro have been wondering why it's been harder to find soft shell clams on the island. Recent studies have suggested that water temperature, water pH, and predation all affect shellfish survivorship, but which is affecting the clams on Islesboro? The Islesboro Shellfish Committee asked to be part of Brian Beal's ongoing clam study. The Islesboro Shellfish Committee worked with Dr. Beal and island volunteers to set up Beal Boxes on three Islesboro coves last spring. The three coves were Islesboro Harbor, Ryder Cove, and Sprague Cove. The Shellfish Committee asked students from Islesboro Central School to helped collect, count, measure, and analyze the results from the study in an attempt to see how viable the mud here really is with the hope of finding out if it is possible to rebuild the clam fishery here, or are water conditions too unfavorable for clams?

In order to understand the factors affecting clam recruitment and survival, it's important to know that water temperature, water pH, and predation all could be a factor for Islesboro's clam flats.

Soft shell clams range in size up to three inches long. They have a surprisingly long life span, though they begin to reproduce at one year, they can live up to 10-12 years (Newell and Hidu, 1986). "Male and female clams reproduce by releasing their egg and sperm into the water column. Over the course of three weeks, the microscopic free-floating larvae develop shells and settle to the bottom" (Newell and Hidu, 1986). The first year of the soft shell clam is the most important because the clams are small and have lots of predators. The most common predator for the clams are the green crabs and the native milky ribbon worms which are increasing rapidly. "The typical female clam from 60-70 mm reproduce from one hundred twenty thousand to three million eggs a year depending on the location of the clam. The typical survival rate is point 1 percent which is one out of 1 thousand." (Newell,1986).

In 1998 the European green crabs were formally recognized as an Aquatic Nuisance Species by the Federal ANS Task Force ("Aquatic Nuisance Project Fact Sheet", n.d.). That same year Washington State made it illegal to possess or transport European green crabs. It is a prohibited species in Oregon and California. In Alaska there are no fish and game laws barring importing live green or mitten crab into the state for the live food market. The green crab is a invasive predator mainly feeding on shellfish such as Soft Shell Clams, Oysters,and Scallops. The female

crab grows an egg sack 1-2 months after fertilization. She carries the egg sack for several months and then the eggs hatch into free swimming larva. The larva will stay in the water callum for 17-80 days. An adult green crab can release up to 165,000 eggs! The green crab lives for 3-5 years, releasing hundreds of thousands of eggs (Beal, et al., n.d.).

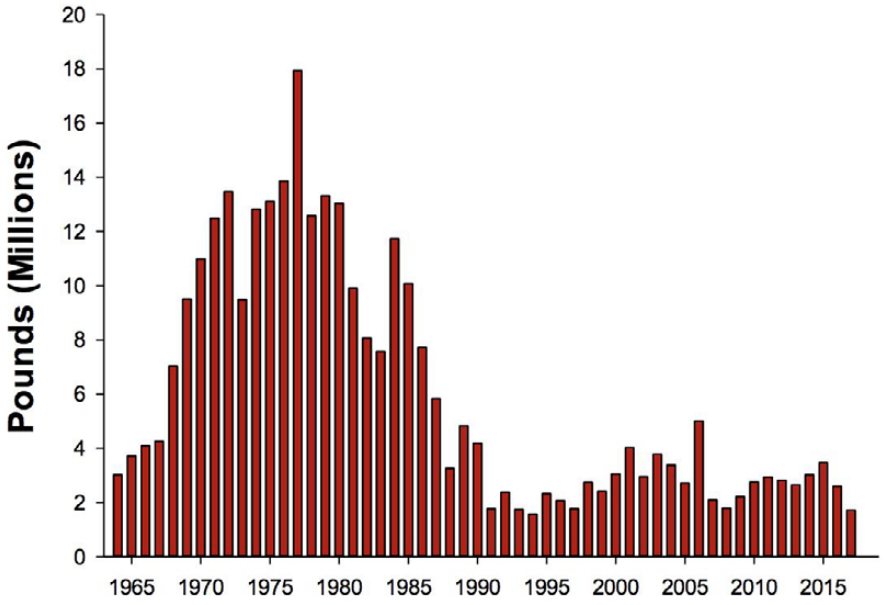


Plate 2. Soft-shell clam landings (1964-2017) from Washington County, Maine. Data from https://www.maine.gov/dmr/commercial-fishing/landings/historical-data.html.

Figure 1

The graph shows that landings were high in the 1970s and 80s, and then quickly dropped in the 1990s. It's stayed pretty much the same since then. Since the 1980s, sea water temperatures in the Gulf of Maine have increased faster (0.03 C/year) than the global average rate of 0.01 C/year (Beal, 2015). Green crabs have been following the waters up the East Coast and like the warm waters. They grow and reproduce faster in warmer water which may explain the reason why the clam landings have dropped since the 1980s - there are more crabs eating more clams.

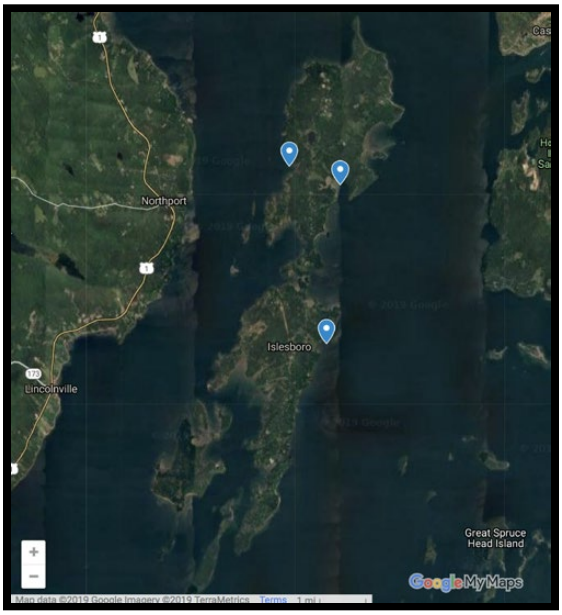
Water temperatures -
Warmer temperatures may not have a direct effect on clam growth and survival, but the warmer temperatures have an indirect effect. As previously stated, green crabs are adapted to warm waters which results in greater predation pressure on clams as the water around Islesboro gets warmer.

Ocean Acidification
Ocean Acidification is a decrease in the oceans pH. The ocean isn't actually acidic, it's less basic than it has been for the previous thousands of years. ("Ocean Acidification", 2019). It's caused by an increase of carbon dioxide. 30-40 percent of ocean acidification is caused by

human activity releasing carbon dioxide, primarily by burning fossil fuels (“Ocean Acidification”, 2019). As carbon dioxide levels in the atmosphere increase, more and more CO_2 is dissolved in the ocean. Carbon dioxide dissolved in water form carbonic acid, lowering the pH of the solution. Lowering pH has the effect of reducing the amount of calcium carbonate dissolved in the water. Shellfish like clams need this carbonate to build their shells. When there is less available calcium carbonate, they grow at a slower rate and have to put more energy into developing shells which also slows their development. Right now, ocean pH is about 8.1, an increase of over 30% acidity since the start of the Industrial Revolution. Clam recruitment and survival on Islesboro mudflats might be related to this changing pH.

Methods

Using the Beal Box design developed by Brian Beal at The DownEast Institute, The Shellfish Committee placed 5 boxes at 3 tide levels at Ryder Cove, Sprague Cove, and Iselsboro Harbor on May 20, 2018.



The dimensions of the boxes are 3 ½in tall, 2ft long, and 1 ft wide that has a screen on the top and bottom. The planktonic clams (baby clams) settle down from the water column and go through the screen into the box where they settle into the mud. That allowed a comparison of clams surviving in the mud to those protected in the boxes. Then, on December 20, 2018, we collected the boxes and core samples at the same locations. The core samples were taken by sticking a #9 coffee can into the mud, providing a plug of mud. The Beal Boxes and core samples were washed and screened to remove mud and debris. The clams for each sample were placed in a ziplock bag with a tyvek tag noting the location, tide level, and sample type (box or core). Students at ICS counted and measured the clams in each box and core sample from the three mud flats, also taking note of crabs and other species found. The results were entered onto a spreadsheet and uploaded to TuvaLabs for analysis. We needed to compute the number of clams per square foot (density) because there different number of boxes collected at the different

locations. Just finding the total number of clams wouldn't take into account the number of samples.

If water quality is the limiting factor for clam recruitment ands survival, we wouldn't expect to find clams in the protected Beal Boxes. However, if it were the predation pressure of the crabs causing a decline in clam numbers, we would expect to find more clams in the Beal Boxes than in the mud core samples beside the clam boxes.

Clam and crab counts, measurements, and sample location were recorded on data sheets and entered into a spreadsheet on Google Suites. We tabulated the data and uploaded that to our TuvaLabs account for making the graphs and charts included here.

Results

The Beal Boxes did not all survive the 9 months in the water. Only 5 boxes were retrieved from Islesboro Harbor. 15 boxes were collected from Ryder Cove, and only 2 boxes were retrieved from Sprague Cove. Several boxes were intact but with crabs inside the boxes, two of which were boxes with crabs larger than 15 mm.

Here are our graphs representing the data from the investigation.

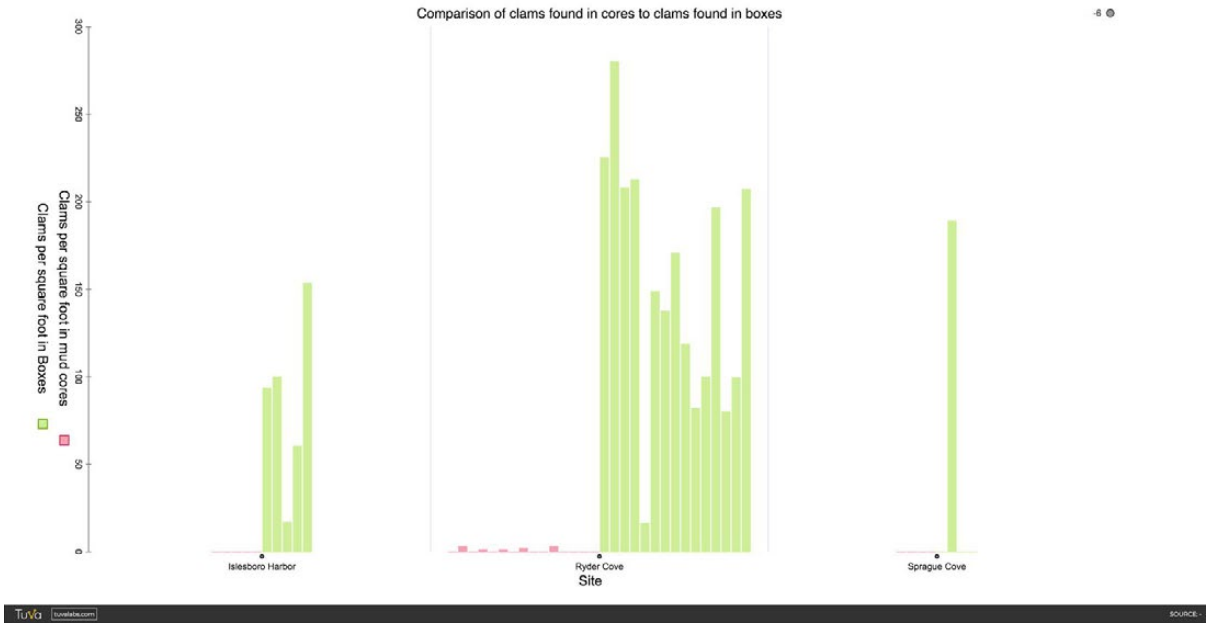


Figure 2

This chart shows the comparison between clams found in the mud and clams found in the Beal Boxes. Clams in the mud and boxes were all exposed to the same water conditions, but the clams in the mud had no protection from predation. The chart shows that very few clams were found in the mud core samples while hundreds of clams per square foot were found in the protected

boxes. It's interesting to note that the shortest bars in the "Clams per square foot in Boxes" category correspond to boxes that had crabs larger than 15mm in them.

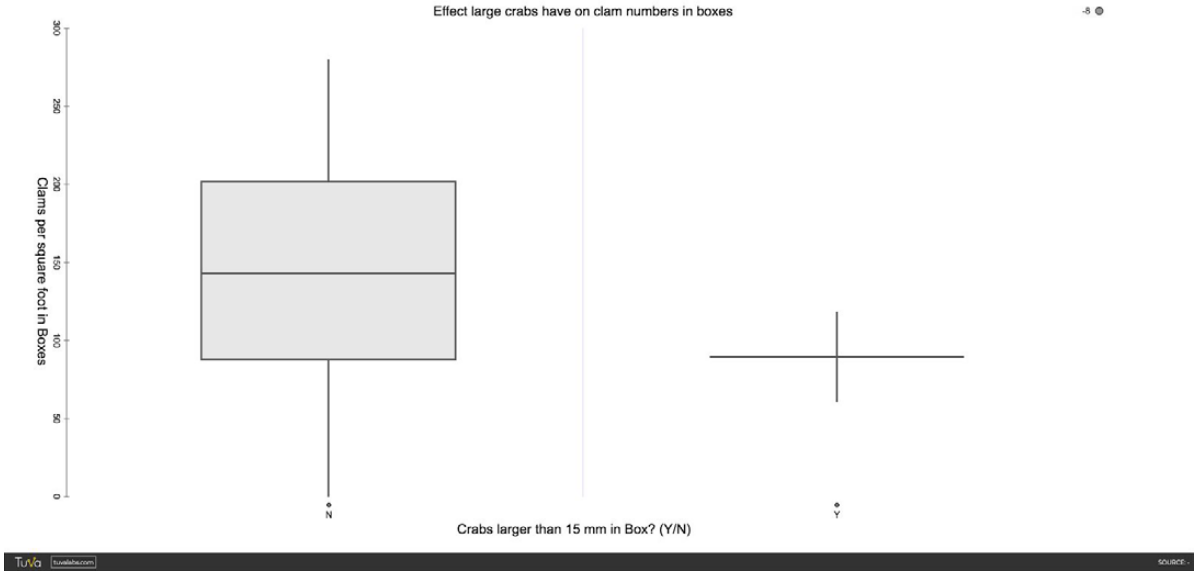


Figure 3

Figure 3 investigates the effect large crabs have on clam numbers in the boxes, explaining the short bars shown in Figure 2. The median number of clams in boxes without large crabs is 143 while there is no median for Sprague Cove because only one box was intact.

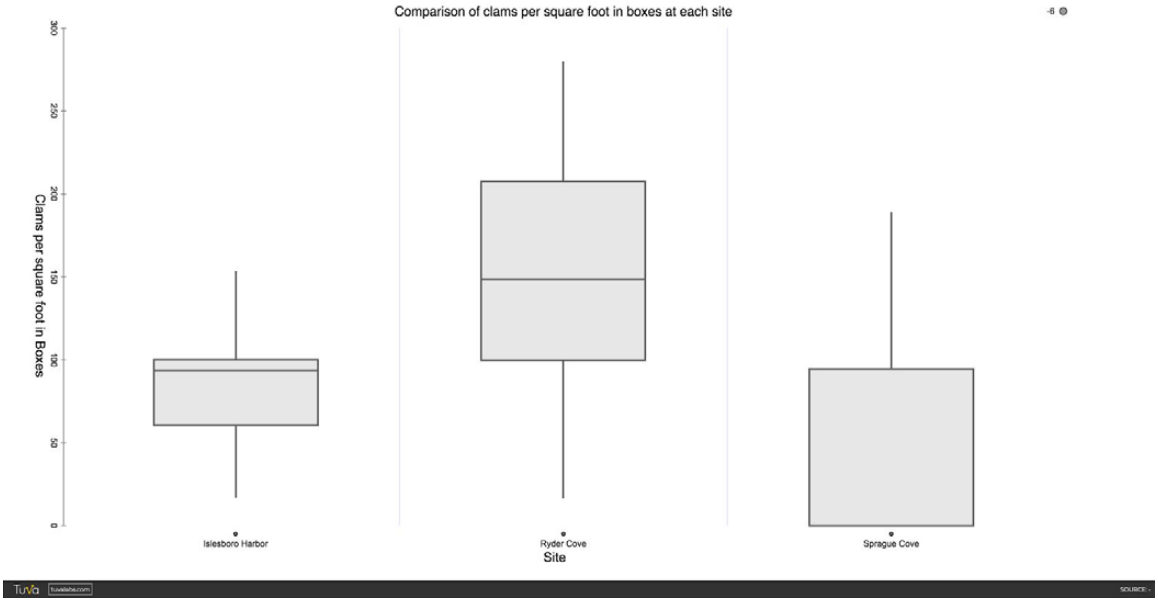


Figure 4

Figure 4 compares how many clams were found at the three sites. Ryder Cove has the most clams per square foot with a median of 148.5, Islesboro with a median of 93.5, and Sprague Cove with a median of 0. Results for Sprague Cove don't have a calculated median because only one boxes were found intact at the end of the study. There is more variation in the clam count in Ryder Cove than at Islesboro Harbor.

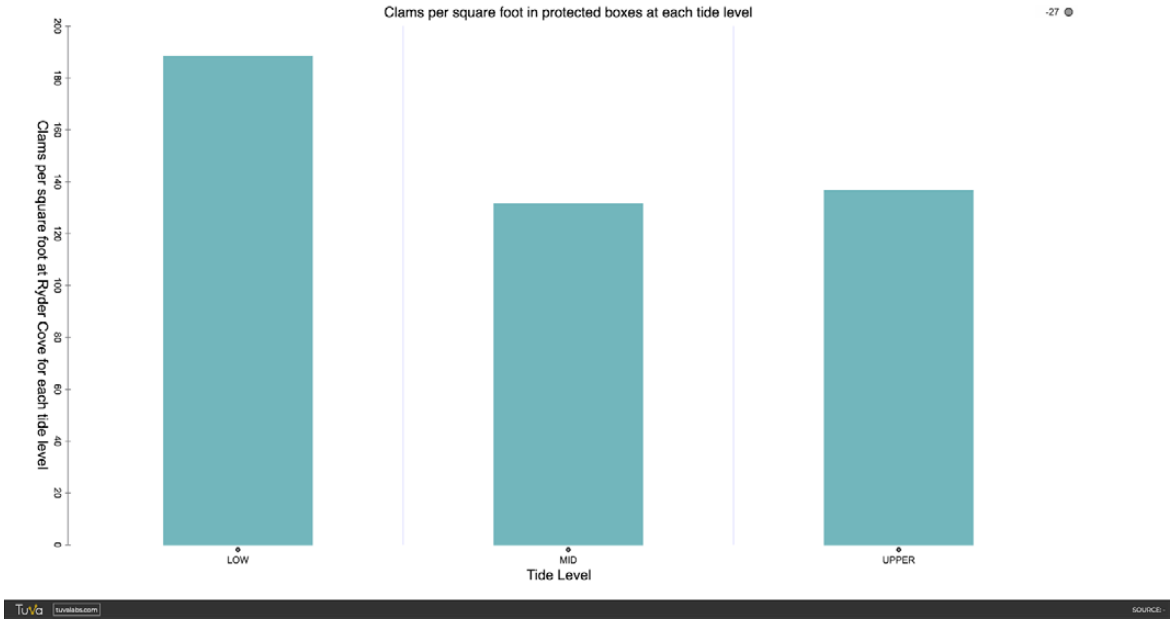


Figure 5

Figure 5 compares the number of clams per square foot at the different tide levels in Ryder Cove. Clearly low tide had the highest density of clams. This makes sense because clams are filter feeders and this section of the flats is underwater longer than the other levels. It's interesting that the high tide group has a slightly higher density than the middle tide level group. Perhaps the slope of the flats is low enough that the mid and high tide levels have similar time underwater.

Discussion

Analysis of the clam samples suggests that water temperature and quality are not limiting factors for clam recruitment and survivorship on Islesboro as there were clams found in every intact Beal Box. There was a measurable difference in survivorship when predation was controlled for with the protection provided by the Beal Boxes. Figure 1 shows the difference in clam counts between the unprotected core samples and the Beal Boxes for each Site. Some crabs settled into the boxes along with the clams and Figure 2 shows the effect of large crabs (> 15 mm) on clam counts. As shown in Figure 3, there was no significant difference in average clam size for the boxes on Ryder Cove and Islesboro Harbor, though there were much fewer clams found at Islesboro Harbor because several boxes had washed away. Finally, Figure 4 shows the effect tidal level has on clam counts, suggesting that the low tide line has more survivorship.

Next Steps

We will work with the Shellfish Committee this spring to put out 30 Beal Boxes out in Ryder Cove in june, then collect them in December. We will put ten Beal Boxes at each tide level as was

done in this study. Then we will keep them over winter and plant them back in the mud flats the following spring. This will help us see if the clams will grow when we put them back in the mud flats because as of right now all the clams we have collected are small. The Shellfish Committee plans on providing some sort of predation protection to prevent crabs from eating these juvenile clams. A concern is that at Ryder Cove there were also a lot of mussels,and razor clams. That could mean that there is a lot of competition there with the clams, mussels, and razor clams. Now our next step is to figure out a way to make the clams survive by predation control using techniques practiced in Freeport.

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