Downeast Institute

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Technical Report #2

2020 CLAM RECRUITMENT MONITORING RESULTS

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2020 Soft-Shell Clam Recruitment Monitoring Network Results

Technical Report #2

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Brunswick Marine Resources Committee
Wiscasset Shellfish Conservation Committee
Bremen Shellfish Conservation Committee
Islesboro Shellfish Conservation Committee
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TABLE OF CONTENTS

Overview, Objectives & Goals.....ii
Introduction and Methodology.....1
Southern Maine Results
- Wells.....5
- Scarborough.....9
- Brunswick.....13

Midcoast Results
- Wiscasset.....17
- Bremen.....21
- Islesboro.....25

Downeast Results
- Frenchman's Bay.....29
- Beals.....33
- Sipayik.....36

Overall Results
- Temperature.....41
- Recruitment Levels.....41
- Recruit Growth.....42
- Numbers of Green Crabs.....44
- Average Green Crab Growth.....44
- Relationship between Crab Size and Clams Per Box.....45

Further Acknowledgment & References.....46
Appendix A: Seawater Temperatures.....48
Appendix B: 2020 Clam Recruitment.....51
Appendix C: Recruit Growth Rates.....60
Appendix D: Size Range of Fall Survey Clams.....66
Appendix E: Green Crab Density.....67
Appendix F: Green Crab Size Distribution.....70
Appendix G: Green Crab Box Presence Totals.....75

OVERVIEW

The **Soft-shell Clam Recruitment Monitoring Network** partners with nine community shellfish programs spanning the coast of Maine to measure densities of young-of-the-year soft-shell clams and quahogs recruiting to their mudflats, conduct shellfish surveys of the monitoring sites in the spring and fall, record seawater temperatures, determine growth rates, and estimate recruit survival rates.

This report details the 2020 results of this effort.

OBJECTIVES & GOALS

We are building a long-term database to better understand local, regional, and coastwide trends in clam production. Our goal is that this information will be used to sustain the fishery for current and future generations of clammers and coastal communities.

This information is crucial to understanding the impacts of a warming marine environment on clam populations, and equips managers for the challenges of sustaining and enhancing clam populations under these warming conditions.

INTRODUCTION and METHODOLOGY

What is Clam Recruitment?

Clams have two major life history stages- a planktonic larval stage that has three major developmental components: trochophore, veliger, and pediveliger where they swim in the water column, and then settle to the bottom where they become a juvenile and then adult clam. When clams settle out of the water column they are ⅛ of a mm.

Clam recruitment occurs when: 1) clams settle from the water column to the flats; and, 2) some period of time has elapsed during which the clam survives and then it is sampled. Therefore, the size of a clam recruit could be anywhere from a microscopic speck to a half-inch or larger animal depending on the length of time between clam settlement and when someone samples the flat. Recruits are also referred to as "0-year class individuals" because they are not yet 1-year old. They are also called "young of the year."

Why is the Fate of Clam Recruits Important?

The recruit is a critical stage in the early life-history of the clam. Robust commercial harvests rely on strong recruitment followed by relatively high survival.

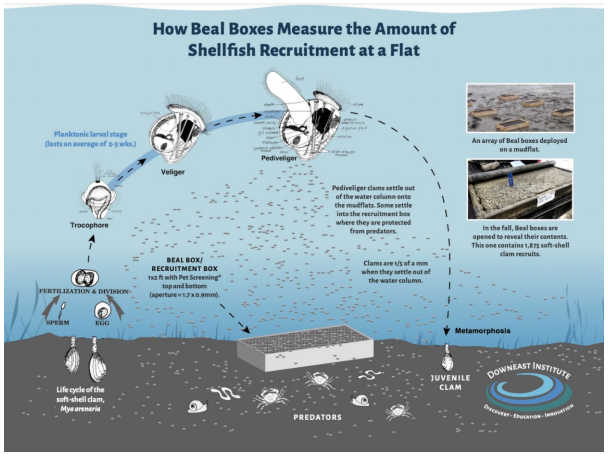
Because of their size, recruits are extremely vulnerable to mortality. Previous independent field research conducted in three southern Maine towns (Wells, Portland, and Freeport) found that less than 1% of clam recruits survive to reach 1-year-old (Beal et al. 2018). Repeated field research through the years has found that predation is the most important factor causing clam mortality on flats along the entire coast of Maine (Beal et al. 2001, Beal & Kraus 2002, Beal 2006a,b, Beal et al. 2016, Beal et al. 2018, Beal et al. 2020a,b).

The Gulf of Maine has been warming for the last 40 years (Pershing et al. 2015), and the warming is changing Maine's marine environment. Intertidal ecology is being altered due to the proliferation of predators such as the invasive green crab, *Carcinus maenas*, that thrives in warmer waters. In addition, warming has the effect of increasing the metabolism of native and non-native shellfish predators, resulting in higher predation rates. Adding to that problem, as summertime and fall seawater temperatures continue to warm, invertebrate predators especially will respond by increasing their foraging rates on clams and other infaunal organisms. This means it is even more important than ever to monitor annual clam recruitment abundance and distribution (i.e. how many and where), as well as the number of clams that survive their first year of life.

Using Beal Boxes to Monitor Clam Recruitment

In 2015 DEI invented a simple, low-tech method to measure clam recruitment and estimate survival. Recruitment boxes, also called Beal boxes, are affixed to the mudflats and passively collect clams that happen to settle into them. The clams that settle into them are protected from most predators, and therefore are able to survive and grow.

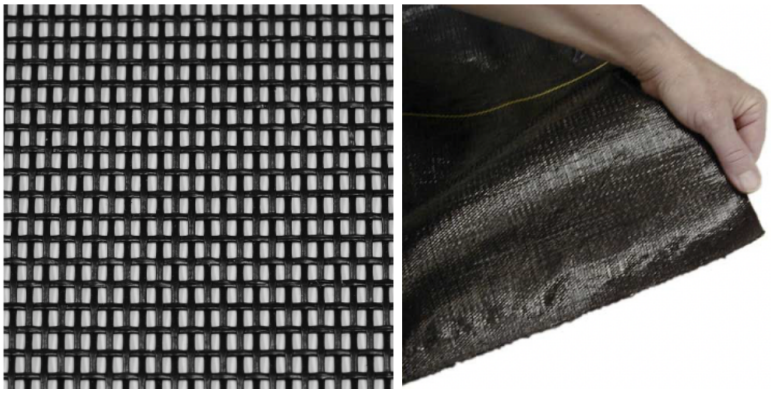
Boxes are 1-ft x 2-ft x 3-inches deep wooden frames with mesh on the top and bottom. All the boxes (16 at each site) in the Soft-shell Clam Recruitment Monitoring Network had **PetScreen® mesh** tops. PetScreen® has an aperture size of 1.7 x 0.9 mm, or 0.067-inches x 0.035-inches (0.002 in^2). This size is large enough so that approximately 50 settling soft-shell clams could all fit through one of the thousands of apertures in the screening.



Juvenile clams settle into recruitment boxes where they are protected from predators and are able to survive the growing season.

2020 Beal Box Bottom Types

In 2020 the boxes used in the Clam Recruitment Monitoring Network had two different types of bottoms. At each site, ½ of the boxes had **PetScreen® mesh** on the bottom. The other half had a bottom constructed of a woven, polypropylene fabric that is used as a weed barrier in gardens (**ground cover**). Its use in our study was to determine if erosion under the boxes were to occur, whether settling clams would be retained more effectively than in boxes with the PetScreen® mesh.



PetScreen® (left) and ground cover (right). Petscreen® is a mesh, ground cover is a fabric.

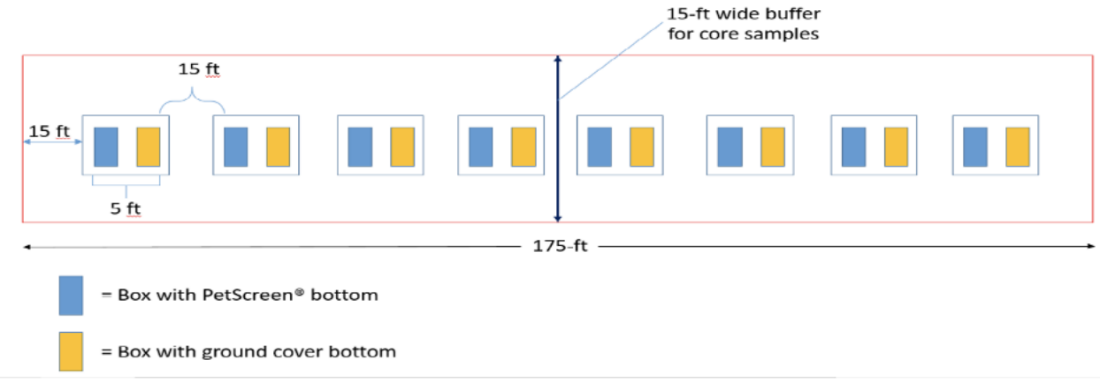
This methodology enabled us to answer three questions:

1) Is there a difference in recruitment rate at each site between boxes that had mesh vs. fabric bottoms?
2) What is the density and size of recruits in the boxes at each site?
3) What is the density of green crabs and their size in the boxes at each site?

2020 Deployment

Monitoring sites were established in the lower mid-intertidal of each of two intertidal flats in each of nine communities. The mid-intertidal is the area of the mudflat that is exposed 1-2 hours before low tide.

At each of the 18 monitoring sites, 16 recruitment boxes were deployed in a line parallel to the incoming tide. They were affixed onto the mudflats by wooden laths.



Field layout at each flat

In 2020, boxes were deployed in the early spring (at the beginning of May) before clams started spawning.

We know the timing of clam spawning because DEI conducted a concurrent pilot-scale study to learn more about clam fecundity. That study found that clams in southern Maine began to spawn by May 27, and clams in downeast Maine started by June 2. Spawning in southern Maine occurred in a burst over four consecutive weeks, ending by June 17. Spawning in eastern Maine occurred over ten consecutive weeks, ending by August 3. In both locations peak spawning occurred at 55 ° (for more information see: https://downeastinstitute.org/research/soft-shell-clams/how-many-eggs-does-a-clam-produce/).

Spring Shellfish Site Surveys

On the same day that the Beal boxes were deployed, 16 core samples were taken at each of the sites (coring device had a surface area of 0.1963 ft^2) to establish density (# clams/ft^2) and the range of sizes of clams that existed at each site. Cores extend to a depth of 8-inches or to a hardpan layer, whichever comes first, with each sample weighing about 10 lbs.

Samples were tagged with location information and transported off the mudflat to a secure location where each was washed with seawater through a sieve with 1mm size mesh to remove the mud. Commercially important shellfish 1mm or bigger were identified, counted, and measured and the information recorded. More detail about those results are reported in the *Clam Recruitment Monitoring Network Technical Report: 2020 Baseline Clam Survey Results* (DEI 2020).

Site Temperatures

Temperature loggers (HOBOs) were also deployed at each site to determine the site-specific seawater temperatures throughout the tidal cycle for the duration of the monitoring. The loggers recorded air (low tide) and seawater (high tide) temperatures every 30 minutes.

Appendix A of this report contains plotted graphs showing the temperature change throughout the deployment period. It depicts the average temperature one hour before and one hour after high tide on each day (May-November). Each point represents an average of five recordings taken thirty minutes apart – one at high tide, two prior to, and two following each high tide.

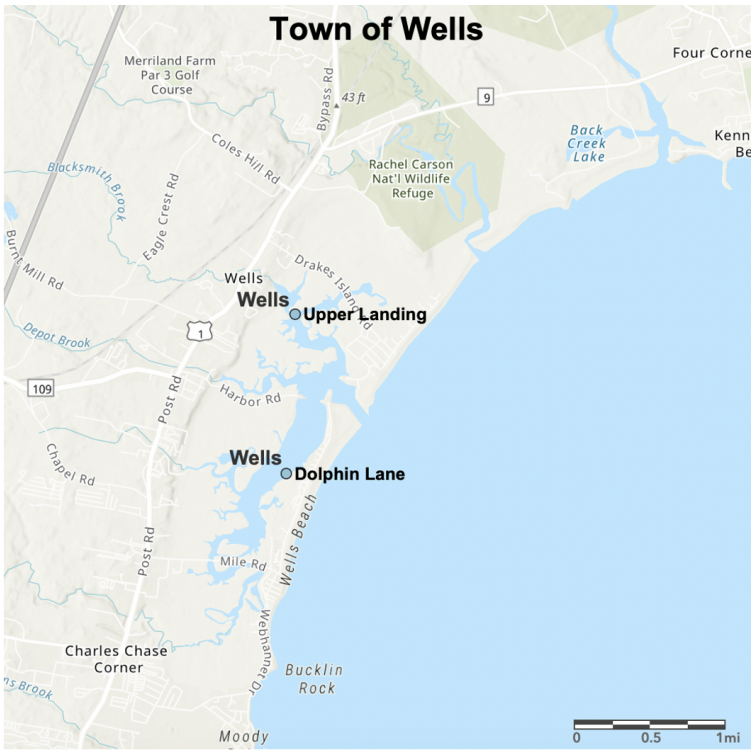
Average temperatures presented in this report are composed of all the temperature data (i.e. every 30 minutes from May-November) from the loggers over the entire deployment.

End of the Year Sampling: Recruitment Boxes and Fall Shellfish Survey

At the end of the clam growing season, in late October/ early November, the 16 recruitment boxes were retrieved from the sites and 16 benthic core samples (same size and technique as the spring survey) were randomly taken from mud adjacent to the boxes at each site.

The contents of all 16 recruitment boxes and 16 core samples were individually processed by washing samples through a 1mm mesh sieve (as described above) so that any commercial shellfish and green crabs larger than 1mm would be retained on the screen, identified, counted, and measured. On occasions where an abundance of recruits were found, a subsample was measured. This report details the results from this process.

SOUTHERN MAINE
WELLS



Site locations: Upper Landing and Dolphin Lane

CLAMMING PROFILE:

- 511.2 intertidal acres (DMR Acreage by Town, 2016).
- Wells does not have a commercial clamming program, but has a strong recreational program, with 101 recreational licenses sold in 2020.

Beginning (Deployment) Date: May 2, 2020
Ending (Fall Sampling) Date: November 14th (196 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site* temperature (May 2 to November 14, 2020)
Upper Landing	15.8°C (60.4°F)

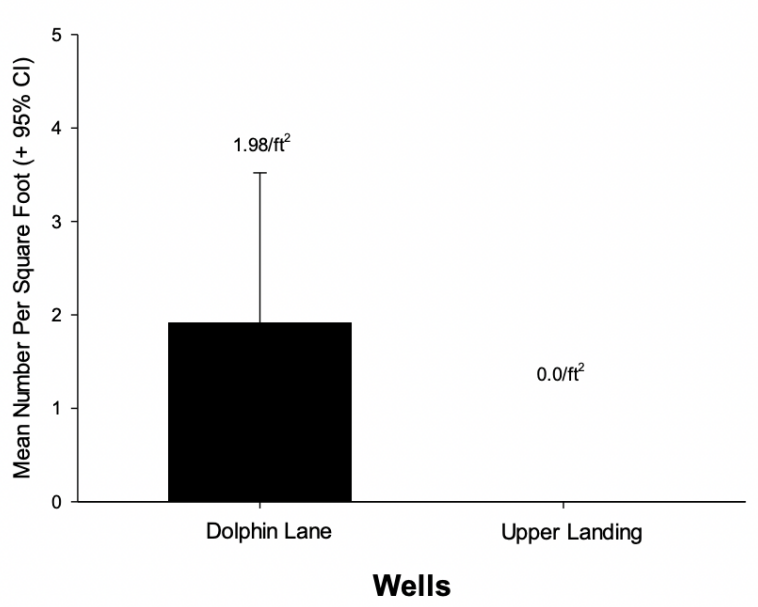
Dolphin Lane	15.5°C (59.9°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

The chart below shows the results from the fall site surveys conducted on Nov. 14, 2020 in Wells. It depicts the number of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").



The survey recorded that between the spring and fall surveys there was an average loss of 2.4 clams/ft^2. Size range of the fall survey clams shown by size-frequency distribution graphs can be found in Appendix D.

2020 SITE SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results for Wells. Sample size from the core samples is n = 16. Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Dolphin Lane	3.2 ft^2 (±2.2)	1.98 ft^2 (±1.7)	Average loss of 2.4 clams/ft^2	4.5mm [0.177 in]	3.5 (±1.1) mm [0.14 in]
Upper Landing	3.5 ft^2 (±2.2)	0		4.6mm [0.181 in]	n/a

*Confidence intervals are used by statisticians to understand where the boundaries are that capture the true mean. It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±). Using the Dolphin Lane spring survey clam density as an example, CI can be understood this way: the best estimate of the true mean is the sample mean (3.2), and we have 95% confidence that the true mean lies between 3.2 **+** 2.2 = 5.4, **and** 3.2 **-** 2.2 = 1.0. This means that the true mean would, with 95% confidence, fall somewhere between 1.0 and 5.4 clams per square foot.

2020 CLAM RECRUITMENT BOX RESULTS

In addition to *Mya* clams, Atlantic surf clams, *Spisula solidissima*, were found in some of the boxes.

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Dolphin Lane	Mesh	7.8 (±7.9)	Approximately 2.5x more clam recruits at Dolphin Lane than at Upper Landing.
	Fabric	0.8 (±1.1)★	
Upper Landing	Mesh	1.7 (±2.4)	
	Fabric	1.5 (±2.5)	

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

Even though there were more clams, on average, between boxes with the two different bottom types, a statistical test indicated that there was no significant difference in the averages of the two bottom treatments. This tells us the area was not prone to erosion.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site Between Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number:

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Dolphin Lane	Mesh	75	16.2 mm [0.64 in]	33.1mm [1.3 in]	90	27.2 (± 0.83) mm [1.07 (± 0.03) in]
	Fabric	15	16.5 mm [0.65 in]	34.9 mm [1.37 in]		
Upper Landing	Mesh	22	5.9 mm [0.23 in]	21.8 mm [0.86 in]	42	14.6 (± 1.68)mm [0.56 (± 0.065)in]
	Fabric	20	7.6 mm [0.3 in]	29.2 mm [1.15 in]		

*Graphs showing recruit size frequency distributions by flat and recruitment box type can be found in Appendix C.

Clams were generally able to achieve a larger size at Dolphin Lane than Upper Landing.

At Dolphin Lane, the size recruits grew similarly between the two different types of boxes, but the distribution of sizes was different. Both types of boxes contained no clams less than ~ 15 mm (slightly larger than a half-inch), and the largest clams were in the 33-35 mm size range (~ 1 ¼-inches). While many more clams were found in the boxes with the mesh bottoms, about 50% were between 1-inch and 1 ⅛-inches, whereas in the boxes with fabric bottoms less than 20% of the recruits were in this size category.

At Upper Landing, the size range and distribution of sizes of the clams in the recruitment boxes was very similar between the two different types of boxes.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8) and fabric bottoms (n=8), and size information.

Site	Total # of Crabs	Density in Mesh	Density in Fabric	Min. size	Max. size	Avg. size

Dolphin Lane	152	7.7 (±2.1)mm	3.9 (±3.4) mm	2.1 mm [0.08 in]	32.9 mm [1. 30 in]	14.5 mm (±1.1) [0.57 in]
Upper Landing	41	2.2 (±0.7) mm	1.0 (±0.5) mm	3.9 mm [0.15 in]	24.2 mm [0.95 in]	13.9 mm (±1.7) [0.55 in]

* An analysis of green crab density by flat and box type can be found in Appendix E.

** An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*** Charts showing the number of green crabs found per individual recruitment box can be found in Appendix G.

Similar to the Wells clam recruits, crabs were slightly larger at Dolphin Lane (~ 10% had carapace widths [CW] greater than 1-inch) than at Upper Landing where none were greater than 1-inch CW.

The size distribution of crabs did not vary significantly between the two different box bottom treatments at either flat.

SCARBOROUGH

Site locations: Winnock Neck and Jones Creek

CLAMMING PROFILE:

- 1,008.7 intertidal acres (DMR Acreage by Town, 2016).

- 48 commercial clammers and 374 recreational licenses sold in 2020 (DMR General Town Shellfish Information, 2020).
- 8th in the state for soft-shell clam landings in 2020 with 329,624 live pounds (ex-vessel value of $737,597) (DMR Landings, 2020).

Beginning (Deployment) Date: May 5, 2020
Ending (Fall Sampling) Date: November 13th (192 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site★ temperature (May 5 to November 13, 2020)
Jones Creek	14.9°C (58.8°F)
Winnock Neck	17.1°C (62.8°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Nov. 13, 2020 in Scarborough. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they are not protected from predators (aka "clam survival rate").

At Jones Creek, no soft-shell clams were observed in any core (0/ft²). One quahog (hard clam) was sampled from a core. Its length was 39.4 mm. At Winnock Neck 30 clams, an average of 9.6 ± 4.4 clams/ft² , were observed from the 16 core samples..

The size-frequency distribution showed very few recruits in 2020, with most (>75%) clams larger than 2 inches (50 mm) in length. An analysis of the size range of fall survey clams and corresponding size-frequency distribution graphs can be found in Appendix D.

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided in the average number of clams per square foot (ft²) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Jones Creek	1.9ft^2 (±1.7)*	0	Loss of 1.9 clams/ft^2	8.6mm [0.339 in]	N/A
Winnock Neck	29.6ft^2 (±9.4)	9.6ft^2 (±4.4)	Loss of 20.0 clams/ft^2	40.8mm [1.606 in]	53.9 (±6.32) mm [>2 in]

*Confidence intervals are used by statisticians to get as close as possible to the true mean. It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT BOX RESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Jones Creek	Mesh	1.3 (±2.7)	There was a significant difference in average clam density between the two locations, but not between box types.
	Fabric	0.4 (± 0.7)	
Winnock Neck	Mesh	105.5 (±128.5)	
	Fabric	72.0 (±91.0)	

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

A statistical test determined that the two averages at each flat were not significantly different from each other, suggesting that at these sites using either bottom treatments will yield similar results.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits	Min. size of recruit	Max. size of recruit	Total # of recruits	Overall Avg. size (both bottom

		measured			measured	types)
Jones Creek	Mesh	17	2.1 mm [0.08 in]	14.3 mm [0.56 in]	22	8.2 (± 1.33) mm [0.32 (± 0.05) in]
	Fabric	5	4.6 mm [0.18 in]	9.1 mm [0.36 in]		
Winnock Neck	Mesh	72	1.5 mm [0.06 in]	16.2 mm [0.64 in]	162	8.6 (± 0.57) mm [0.34 (± 0.02) in]
	Fabric	90	2.5 mm [0.1 in]	20.9 mm [0.82 in]		

*Graphs showing recruit size frequency distributions by flat and recruitment box type can be found in Appendix C.

At Jones Creek, clam size range was narrower in recruitment boxes with fabric vs. mesh bottoms. Clams were slightly larger in the boxes with mesh bottoms. For example, ~ 30% of clams in boxes with mesh bottoms were larger than 10 mm, whereas all clams were less than 10 mm in boxes with fabric bottoms.

The size range and distribution of clams observed at Winnock Neck was similar between the two different types of boxes. No significant difference was observed between the two size-frequency distributions.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8)and fabric bottoms (n=8), and size information.

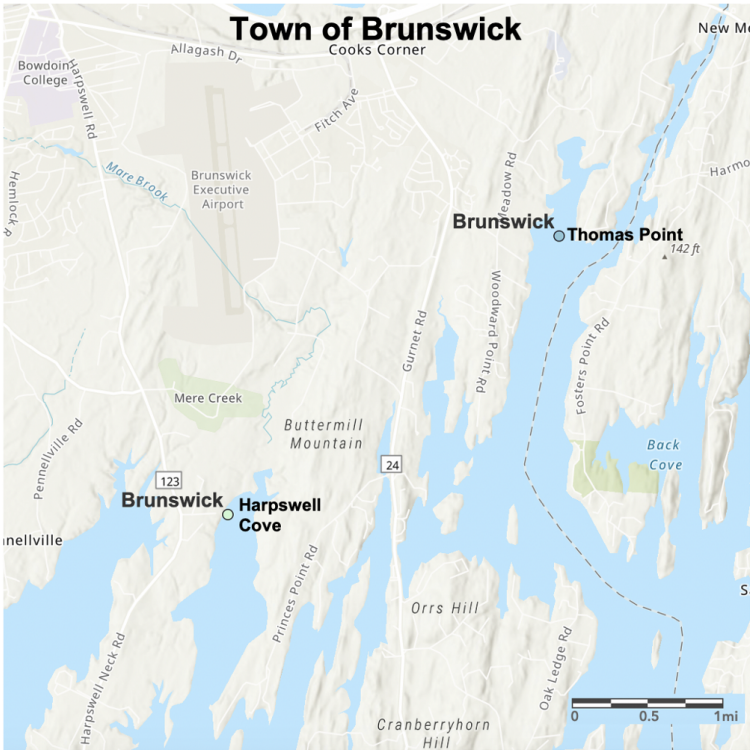
Site	Total # of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Jones Creek	2	1.3 (± 2.7) mm	0.4 (± 0.7) mm	5.8 mm [0.23 in]	27.8 mm [1.09 in]	16.8 mm (±139) [0.66 in]
Winnock Neck	115	105.5 (± 128.5) mm	72.0 (± 91.0) mm	2.6 mm [0.10 in]	37.3 mm [1.47 in]	9.6 mm (±5.53) [0.38 in]

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix C.

*An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.
*An analysis of green crab density by flat and box type can be found in Appendix E.

The range of clam recruit sizes between box types at Jones Creek and Winnock Neck was similar. No significant difference in size-frequency distribution was observed between the two box types.

BRUNSWICK



Site locations: Thomas Point and Harpswell Cove

CLAMMING PROFILE:

- 2,254.53 intertidal acres (DMR Acreage by Town, 2016).
- 80 commercial clammers in 2020. No limit on the amount of recreational licenses sold to residents, and a 10% limit on recreational licenses sold to nonresidents.
- #1 in landings for soft-shell clams out of all Maine towns in 2020, with 617,463 lbs. live pounds (ex-vessel value of $1,522,211) (DMR Landings, 2020).
- Landed the most quahogs in 2020 out of all towns at 640,450 lbs. (quahogs are sold by the piece) (DMR Landings, 2020), though a substantial amount of these are from the subtidal New Meadows Salt Pond.

Beginning (Deployment) Date: May 3, 2020

Ending (Fall Sampling) Date: November 12th (193 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site★ temperature (May 3 to November. 12, 2020)
Harpswell Cove	17.0°C (62.6°F)
Thomas Point	17.3°C (63.1°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Nov. 12, 2020 in Brunswick. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").

Only one soft-shell clam was found in the fall surveys (at Harpswell Cove). The fact that no clams were found at Thomas Point was surprising given the commercial clam populations located higher up (closer to shore) in the cove. The average density for clams at Harpswell Cove was 0.3 ± 0.7 clams/ft².

Quahogs (hard clams) were found in both coves at similar densities: Harpswell Cove: 1.3 ± 1.6 clams/ft²; Thomas Point Beach: 1.3 ± 1.2 clams/ft².

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16) Clam densities are provided in the average number of clams per square foot (ft²) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Harpswell Cove	0 clams	0.3 (± 0.7) clams ft²	Gain of 0.3 clams/ft²	N/A	7.9 mm [0.31 in]

		1.3 (±1.6) quahogs/ft^2			
Thomas Point	1.3 (±1.2) clams ft^{2**}	0 clams 1.3 (±1.2) quahogs/ft^2		5.8 mm [0.228 in]	N/A

*Confidence intervals are used by statisticians to get as close as possible to the true mean. It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

**These clams were likely recruits from the previous fall that overwintered.

2020 CLAM RECRUITMENT BOXRESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Harpswell Cove	Mesh	5.1 (±5.1)	There was no significant difference in clam density between boxes with mesh or fabric bottoms at either Harpswell Cove or Thomas Point.
	Fabric	2.6 (±1.8)	
Thomas Point	Mesh	1.2 (±1.6)	
	Fabric	1.5 (±1.9)	

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Harpswell Cove	Mesh	58	3.7 mm [0.15 in]	28.1 mm [1.11 in]	92	14.4 (±1.47) mm [0.57 (±0.06) in]
	Fabric	34	2.7 mm [0.11 in]	28.4 mm [1.12 in]		

Thomas Point	Mesh	15	4.7 mm [0.19 in]	33.1 mm [1.30 in]	34	19.9 (± 3.5) mm [0.78 (± 0.13) in]
	Fabric	19	2.1 mm [0.08 in]	34.8 mm [1.37 in]		

*Graphs of recruit growth by flat and recruitment box type can be found in Appendix C.

The size range was similar between the two different types of boxes , but the distributions were dissimilar. Clams in boxes with mesh bottoms were generally smaller than those in boxes with the fabric bottoms. For example, ~ 70% of clams were smaller than 15 mm in the recruitment boxes with mesh bottoms compared to ~ 30% in boxes with fabric bottoms.

The size range of *Mercenaria* was much smaller than that of *Mya* since *Mercenaria* spawn at least two months after *Mya*. Minimum and maximum size of quahog (hard clam) recruits in boxes with mesh bottoms was 2.9 mm and 8.2 mm, respectively, compared to 2.7 mm and 4.5 mm in boxes with fabric bottoms.

The range and distribution of soft-shell clam sizes observed at Thomas Point was similar between the two different types of boxes. Clams generally were smaller in boxes with mesh bottoms. For example, ~ 60% of clams were less than 15 mm in boxes with mesh bottoms, compared to 16% in boxes with the fabric bottoms. Nearly half of the clams in boxes with fabric bottoms were > 25 mm, compared to 33% of those in boxes with mesh bottoms.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8)and fabric bottoms (n=8), and size information.

Site	# of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Harpswell Cove	37	1.7 (± 0.9) mm	1.2 (± 1.3) mm	6.5 mm [0.26 in]	40.8 mm [1.61 in]	14.2 mm [0.56 in]
Thomas Point	0	N/A	N/A	N/A	N/A	N/A

*An analysis of green crab density by flat and box type can be found in Appendix E.

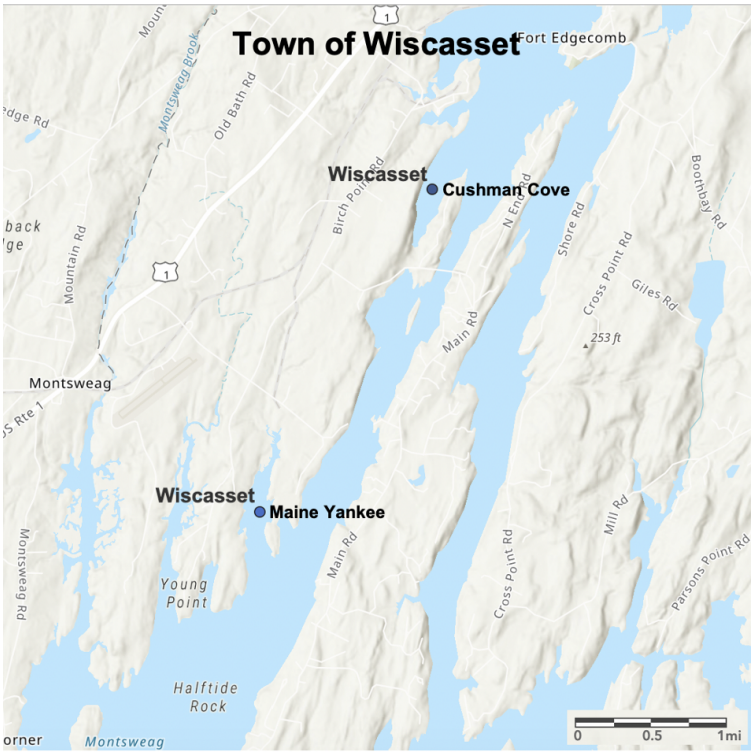
*An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix G.

Green crab size ranges at Harpswell Cove were similar between the two different types of recruitment boxes. No significant difference in size-frequency distribution was observed between the two box types.

MIDCOAST

WISCASSET



Site locations: Cushman Cove and Maine Yankee

CLAMMING PROFILE:

- 901.29 intertidal acres (DMR Acreage by Town, 2016).
- 14 commercial clammers and 33 recreational licenses sold in 2020.
- Landed 50,831 live pounds of soft-shell clams in 2020, valued at $131,543 (DMR Landings, 2020). Wiscasset ranked 31st out of 67 towns with shellfish programs in terms of landings.

Beginning (Deployment) Date: May 6, 2020
Ending (Fall Sampling) Date: November 8th, 2020 (186 days total duration)

TEMPERATURE

Average Site Temperature

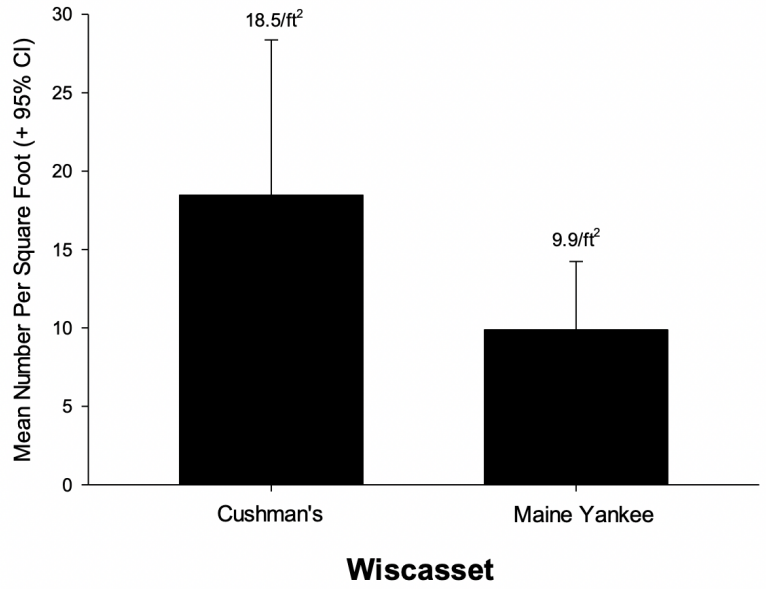
Cove	Average site★ temperature (May 6 to November 8, 2020)
Maine Yankee	17.6°C (63.7°F)
Cushman Cove	15.3°C (59.5°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

This chart shows the Wiscasset Fall 2020 site survey that was conducted on Nov. 8, 2020. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").



Core sampling recorded an average loss of 6.4 clams/ft² between the spring and fall surveys.An analysis of the size range of fall survey clams and corresponding size-frequency distribution graphs can be found in Appendix D.

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided in the average number of clams per square foot (ft²) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Cushman Cove	23.9ft^2 (± 9.1)*	18.5ft^2 (± 9.9)	Average loss of 6.4 clams/ft^2	23.4 mm [0.921 in]	21.6 (± 8.1) mm [0.85 in]
Maine Yankee	17.2ft^2 (± 5.3)	9.9ft^2 (± 4.4)		18.1 mm [0.713 in]	25.0 (± 7.5) mm [~1 in]

* Confidence intervals are used by statisticians to get as close as possible to the true mean. It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT BOX RESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Cushman Cove	Mesh	43.8(± 21.6)	There were approximately 7x fewer clam recruits at the Maine Yankee site than at Cushman Cove.
	Fabric	22.4 (±24.5)	
Maine Yankee	Mesh	3.8 (± 1.9)	
	Fabric	6.1 (± 5.5)	

*A detailed analysis of fall clam recruitment density by flat can be found in Appendix B.

A statistical test indicates that there was no significant difference in the average number between boxes with the two bottom treatments. This tells us the area was not prone to erosion, and further deployments at this site should be carried out with Petscreen bottoms.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Cushman Cove	Mesh	161	2.01 mm [0.08 in]	17.1 mm [0.67 in]	239	6.5 (± 0.39) mm [0.26 (±0.02) in]
	Fabric	78	2.59 mm [0.10 in]	18.2 mm [0.72 in]		
Maine Yankee	Mesh	50	2.35 mm [0.09 in]	17.9 mm [0.70 in]	115	5.8 (± 0.68) mm [0.23 (± 0.03) in]
	Fabric	65	2.35 mm [0.09 in]	17.9 mm [0.70 in]		

*Graphs of recruit growth by flat and recruitment box type can be found in Appendix C.

The size range and distribution of the clams in the recruitment boxes at Cushman Cove was very similar between the two different types of boxes.

The size range and distribution of the clams in the recruitment boxes at Maine Yankee was very similar between the two different types of boxes. Most (80%) of clams in boxes with mesh bottoms were less than ½-inch, and 100% of clams in boxes with fabric bottoms were less than ½-inch.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8) and fabric bottoms (n=8), and size information.

Site	# of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Cushman Cove	18	0.8 (±1.1) mm	0.5 (±0.2) mm	3.9 mm [0.15 in]	29.3 mm [1.15 in]	10.5 mm [0.41 in]
Maine Yankee	6	0.4 (±0.4) mm	0.1 (± 0.2) mm	4.7 mm [0.18 in]	14.6 mm [0.57 in]	9.5 mm [0.37 in]

*An analysis of green crab density by flat and box type can be found in Appendix E.

*An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix C.

At Cushman Cove, all crabs in the mesh bottom boxes were less than 15 mm. At Maine Yankee, crabs were fewer and smaller.

BREMEN

Site locations: Broad Cove and Sam's Cove

CLAMMING PROFILE:

- 1,078.76 intertidal acres (DMR Acreage by Town, 2016).
- 46 commercial clammers and 55 recreational licenses were sold in 2020.
- Landed 28,126 live pounds of soft-shell clams (ex-vessel value of $62,619) (DMR Landings, 2020). Bremen ranked 39th in terms of landings in 2020.

Beginning (Deployment) Date: May 14, 2020
Ending (Fall Sampling) Date: November 19th, 2020 (189 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site★ temperature (May 14 to November 19, 2020)
Sam's Cove	16.3°C (61.3°F)
Broad Cove	16.6°C (61.9°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Nov. 19, 2020 in Bremen. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").

We found no live soft-shell clams in any core taken at Sam's Cove in the Fall, and a single clam was found in two cores at Broad Cove (0.6 ± 0.9 clams/ft^2). The two Broad Cove soft-shell clams measured 7.2 mm and 9.0 mm.

No quahogs (hard clams) occurred in samples at Broad Cove, but three were observed from the cores at Sam's Cove (0.9 ± 1.1 clams/ft^2). The three Sam's Cove hard clams measured 3.1 mm, 3.65 mm, and 27.7 mm.

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	**Densities of clams found in surveys**		**Difference between Spring and Fall densities**	**Average size of clams found**	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Sam's Cove	0	0	On average, no change in clams/ft^2	N/A	N/A
Broad Cove	0.6ft^2 (±2.6)	0.6ft^2 (±0.9) 0.9 ± 1.1 quahogs/ft^2		11.3 mm [0.445 in]	8.1 (± 11.4) mm [0.32 in]

*Confidence intervals are used by statisticians to get as close as possible to the true mean. It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT BOX RESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Sam's Cove	Mesh	6.8 (± 1.9)	Clam densities were similar in both box bottom types at Sam's Cove and Broad Cove.
	Fabric	4.4 (± 3.1)	
Broad Cove	Mesh	13.7 (± 15.5)	
	Fabric	12.2 (± 19.3)	

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

A statistical test indicated that the averages were not significantly different from each other, suggesting that at this site using either bottom type will yield similar results.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Sam's Cove	Mesh	88	1.9 mm [0.07 in]	41.5 mm [1.63 in]	145	17.7 (± 1.74) mm [0.70 (± 0.07) in]
	Fabric	57	1.9 mm [0.07 in]	41.5 mm [1.63 in]		
Broad Cove	Mesh	68	3.2 mm [0.13 in]	21.4 mm [0.84 in]	115	13.3 (± 1.24) mm [0.52 (± 0.05) in]
	Fabric	47	1.8 mm [0.07 in]	29.5 mm [1.16 in]		

*Graphs of recruit growth by flat and recruitment box type can be found in Appendix C.

The size range of clams at Sam's Cove was similar between the two different types of boxes ; but, once again, clams were significantly smaller in boxes with mesh bottoms than fabric bottoms. We observed ~ 65% of clams in boxes with fabric bottoms to be greater than 20 mm (¾ths of an inch) vs. ~

25% of clams in boxes with mesh bottoms. Conversely, more clams smaller than 15 mm were observed in boxes with mesh bottoms (~ 55%) compared to fabric bottoms (~ 33%).

The size range was slightly greater in boxes with fabric vs. mesh bottoms. The size-frequency distributions were dissimilar, where ~ 45% of clams were larger than 20 mm (about ¾ths of an inch) in boxes with fabric bottoms vs. ~ 5% in boxes with mesh bottoms. Conversely, about 70% of clams in the boxes with mesh bottoms were less than 15 mm (about ½-inch) vs. ~ 40% in boxes with fabric bottoms.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8) and fabric bottoms (n=8), and size information.

Site	Total # of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Sam's Cove	16	0.8 (± 0.9) mm	0.4 (± 0.5) mm	3.7 mm [0.15 in]	31.5 mm [1.24 in]	14.9 mm [0.58 in]
Broad Cove	13	0.5 (± 0.2) mm	0.5 (± 0.3) mm	6.0 mm [0.24 in]	41.0 mm [1.62 in]	26.2 mm [1.03 in]

*An analysis of green crab density by flat and box type can be found in Appendix E.

*An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix G.

Crab size distribution did not differ between types of recruitment boxes at either site, so the data from all boxes at Broad Cove and Sam's Cove was combined and we compared the two size-frequency distributions. A statistical test indicated no significant difference between the two distributions.

ISLESBORO

Site locations: Ryder Cove and Little Broad Cove

CLAMMING PROFILE:

- 4,380.15 intertidal acres (DMR Acreage by Town, 2016).
- In 2020 Islesboro had an unlimited number of commercial and recreational clamming licenses available for residents.
- In 2015 (the most recent available data), Islesboro landed 5,350 live pounds of soft-shell clams, valued at $13,586 (DMR Landings, 2020).

Beginning (Deployment) Date: May 12, 2020
Ending (Fall Sampling) Date: October 22nd, 2020 (163 days total duration)

TEMPERATURE

Average Site Temperature

Cove	Average Site★ Temperature (May 12 to October 22, 2020)
Little Broad Cove	14.7°C (58.5°F)
Ryder Cove	15.3°C (59.5°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Oct. 22, 2020 in Islesboro. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").

Core sampling recorded no live clams in any of the 32 core samples.

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Little Broad Cove	0.9ft^2 (±1.1)*	0	Loss of 0.9 clams/ft^2	4.5 mm [0.177 in]	N/A
Ryder Cove	3.2ft^2 (±1.9)	0	Loss of 3.2 clams/ft^2	7.2 mm [0.283 in]	N/A

* Confidence intervals are used by statisticians to get as close as possible to the true mean.It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT RESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Little Broad Cove	Mesh	0.5 (±0.5)	There was a significant difference in clam densities between box types at Little Broad Cove and Ryder Cove, but not between the two locations. Densities were greater in boxes with fabric bottoms at both locations.
	Fabric	**64.7 (±44.9)★**	
Ryder Cove	Mesh	4.8 (±5.9)	
	Fabric	**47.5 (±24.8)★**	

★ Significantly more clams were found in this type of bottom.

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

A statistical test indicated that there was s ignificant difference in the average between the two bottom types. Most boxes with mesh bottoms had a gap of 1-2 inches between the mudflat surface and bottom of the box, indicating that erosion occured at this site. Future deployments will be carried out with groundcover bottoms.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Little Broad Cove	Mesh	6	3.4 mm [0.13 in]	13.2 mm [0.52 in]	126	15.9 (± 0.82) mm [0.63 (± 0.04) in]
	Fabric	120	4.0 mm [0.16 in]	25.0 mm [0.98 in]		
Ryder Cove	Mesh	50	2.3 mm [0.09 in]	25.8 [1.02 in]	191	20.1(± 0.9) mm [0.79 (± 0.03) in]
	Fabric	141	2.3 mm [0.09 in]	33.9 mm [1.33 in]		

*Graphs of clam recruit growth by flat and recruitment box type can be found in Appendix C.

The size range was dissimilar between the two different types of boxes, likely due to clams being lost from the boxes with mesh bottoms.

The size range and distribution of clams observed at Ryder Cove was dissimilar between the two different types of boxes.. Clams generally were smaller in boxes with mesh bottoms, likely due to the erosion observed under those boxes. More clams greater than 1-inch (25.4 mm) were observed in boxes from Ryder Cove than Little Broad Cove. Approximately 25% of clams were larger than an inch at Ryder Cove, whereas less than 1% of clams were larger than an inch at Little Broad Cove.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8) and fabric bottoms (n=8), and size information.

Site	Total # of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Little Broad Cove	33	0.0 mm	2.5 (±3.9) mm	5.1 mm [0.20 in]	20.0 mm (0.79 in)	10.0 mm [0.39 in]
Ryder Cove	31	0.2 (±0.2) mm	2.2 (±1.1) mm	4.8 mm [0.19 in]	28.7 mm [1.13 in]	11.3 mm [0.45 in]

*An analysis of green crab density by flat and box type can be found in Appendix E.

*An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix G.

Due to the paucity of green crabs in boxes with mesh bottoms, comparison of size distributions between treatments at both sites is not appropriate. When data from the two treatments was combined, the size-frequency distribution of crab carapace widths was not significantly different between the two flats.

DOWNEAST
FRENCHMAN'S BAY

Site Locations: Hog Bay and Raccoon Cove

CLAMMING PROFILE:

- Frenchman's Bay is a regional clamming program, composed of the seven towns in Hancock County: Ellsworth, Franklin, Hancock, Lamoine, Sorrento, Sullivan, and Trenton .
- Frenchman's Bay Regional Shellfish Program is composed of 8,054.81 intertidal acres (DMR Acreage by Town, 2016). Franklin (the location of Hog Bay) has 1,725.09 intertidal acres and Lamoine (the location of Raccoon Cove) has 1,907.55 intertidal acres (IA). Ellsworth has 280.72 IA, Hancock has 1,589.71 IA, Sorrento has 770.92 IA, Sullivan has 306.65 IA, and Trenton has 1,473.80 IA.
- There were no limits on the number of residential commercial or recreational licenses sold in 2020.
- In 2020, Franklin landed 270,688 live pounds of soft-shell clams (valued at $668,998) and Lamoine landed 94,800 pounds (valued at $213,946). Hancock landed 32,293 pounds (valued at $71,539). Sullivan landed 105,651 pounds (valued at $283,177). Trenton landed 10,640 pounds (valued at $28,629). In 2019, Sorrento landed 21,871 pounds (valued at $46,150) (DMR Landings, 2020).

Beginning (Deployment) Date: May 13, 2020
Ending (Fall Sampling) Date: October 23rd, 2020 (163 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site★ temperature (May 13 to October 23, 2020)
Raccoon Cove, Franklin	14.4°C (57.9°F)
Hog Bay, Lamoine	19.2°C (66.6°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Oct. 23, 2020 in Frenchman's Bay. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they are not protected from predators (aka "clam survival rate").

We found no live soft-shell clams in any core taken at Hog Bay, and eight clams (1.6 ± 1.3 clams/ft^2) in cores taken at Raccoon Cove. These Raccoon Coves clams ranged in length from 2.5-30.2mm (<1/8 -inch to 1 1/4 -inch).

An analysis of the size range of fall survey clams and corresponding size-frequency distribution graphs can be found in Appendix D.

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Raccoon Cove	28.0ft^2 (±26.4)*	1.6ft^2 (±1.3)	Loss of 26.4 clams/ft^2	39.3 mm [1.547 in]	15.4 (±15.6) mm [0.61 in]
Hog Bay	2.2ft^2 (±1.9)	0	Loss of 2.2 clams/ft^2	10.4 mm [0.409 in]	N/A

*Confidence intervals are used by statisticians to get as close as possible to the true mean.It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT BOX RESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Raccoon Cove	**Mesh**	**32.3 (±18.9)★**	At Raccoon Cove, average clam density in boxes with mesh bottoms was 6x greater than the density in boxes with fabric bottoms. Average densities were also significantly different between box types at Hog Bay, although there, density was greater in boxes with fabric bottoms.
	Fabric	4.9 (± 3.6)	
Hog Bay	Mesh	0.0	
	Fabric	**4.2 (±3.4)★**	

★ Significantly more clams were found in this type of bottom.

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

No erosion occurred under any of the boxes at Raccoon Cove where the average number of recruits varied significantly between box types. Deployment in 2021 will proceed with mesh tops and bottoms.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Raccoon Cove	Mesh	126	2.2 mm [0.09 in]	11.0 mm [0.43 in]	190	5.8 (±0.32)mm [0.23 (± 0.01) in]
	Fabric	64	2.2 mm [0.09 in]	11.0 mm [0.43 in]		
Hog Bay	Mesh	0	0.0 mm	0.0 mm	54	9.1 (± 0.79)mm [0.36 (± 0.03) in]
	Fabric	54	3 mm [0.12 in]	16 mm [0.63 in]		

*Graphs of recruit growth by flat and recruitment box type can be found in Appendix C.

The size range of clams at Raccoon Cove was similar between the two different types of boxes; however, the size distributions varied by box type. Soft-shell clam recruits were significantly smaller in boxes with mesh vs. fabric bottoms. We observed ~ 50% of clams in boxes with mesh bottoms to be smaller than 5 mm, compared to ~ 20% in that category associated with fabric bottoms. Conversely, more clams larger than 9 mm were observed in boxes with fabric bottoms (~ 15%) compared to mesh bottoms (~ 6%).

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8) and fabric bottoms (n=8), and size information.

Site	Total # of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Raccoon Cove	0	N/A	N/A	N/A	N/A	N/A
Hog Bay	4	0.2 (±0.2) mm	0.2 (±0.2) mm	29.3 mm [1.15 in]	33.5 mm [1.32 in]	30.7 mm [1.21 in]

*An analysis of green crab density by flat and box type can be found in Appendix E.

* An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

* Charts of the number of green crabs found per individual recruitment box can be found in Appendix G.

The carapace widths of the four crabs observed at Hog Bay were as follows: 29.3 mm, 29.4 mm, 30.6 mm, 33.5 mm.

BEALS

Site Locations: Perio Point and Dobbin's Island

CLAMMING PROFILE:

- Beals has 1,741.22 intertidal acres (DMR Acreage by Town, 2016).
- Beals had no limit on the sale of commercial and recreational licenses for residents in 2020.
- In 2018 (the most recent available data), Beals landed 41,711 live pounds of soft-shell clams, valued at $69,767 (DMR Landings, 2020).

Beginning (Deployment) Date: May 11, 2020
Ending (Fall Sampling) Date: October 20th, 2020 (162 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site★ temperature (May 11 to October 20, 2020)
Dobbin's Island	14.5°C (58.1°F)
Perio Point	12.7°C (54.9°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Oct. 20, 2020 in Beals. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").

We found no live clams in any core at either site.

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	**Densities of clams found in surveys**		**Difference between Spring and Fall densities**	**Average size of clams found**	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Dobbins Island	2.2ft^2 (±1.7)	0	Loss of 2.2 clams/ft^2	3.5 mm [0.138 in]	N/A
Perio Point	8.3ft^2 (±3.6)	0	Loss of 8.3 clams/ft^2	7.0 mm [0.276 in]	N/A

*Confidence intervals are used by statisticians to get as close as possible to the true mean.It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT BOX RESULTS

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided as the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Dobbin's Island	Mesh	137.0 (±108.5)	At Perio Point, boxes with fabric bottoms yielded nearly 5x the number of recruits as boxes with mesh bottoms. At Dobbin's Island, there was no significant difference in average clam density between box types.
	Fabric	75.9 (±41.9)	
Perio Point	Mesh	4.4 (± 3.2)	
	Fabric	**21.3 (± 9.1)★**	

★Significantly more clams were found in this type of bottom.

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Dobbin's Island	Mesh	135	3.5 mm [0.14 in]	21.5 mm [0.85 in]	256	11.9 (± 0.58) mm [0.47 (± 0.02) in]
	Fabric	121	2.9 mm [0.11 in]	20.5 mm [0.81 in]		
Perio Point	Mesh	57	1.8 mm [0.07 in]	10.6 mm [0.42 in]	202	6.5 (± 0.5) mm [0.26 (± 0.02) in]
	Fabric	145	1.3 mm [0.05 in]	16.9 mm [0.67 in]		

*Graphs of recruit growth by flat and recruitment box type can be found in Appendix C.

The size range of clams at Dobbin's Island was similar between the two types of recruitment boxes ; however, the size-frequency distributions were dissimilar. ~ 40% of clams were larger than 15 mm (about ¾ths of an inch) in boxes with fabric bottoms, compared to 18% in boxes with mesh bottoms. Conversely, about 60% of clams in boxes with mesh bottoms were less than 10 mm (about ½-inch), compared to 21% in boxes with fabric bottoms.

The size range of clams at Perio Point was similar between the two different types of boxes ; but, once again, clams were significantly smaller in boxes with mesh vs. fabric bottoms. We observed ~ 95% of clams in boxes with mesh bottoms to be less than 10 mm, whereas 85% of clams in boxes with fabric bottoms were less than 10 mm.

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8)and fabric bottoms (n=8), and size information.

Site	Total # of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Dobbin's Island	105	5.9 (±2.7) mm	2.2 (±1.7) mm	2.3 mm [0.09 in]	27.5 mm [1.08 in]	6.4 mm [0.25 in]
Perio Point	0	N/A	N/A	N/A	N/A	N/A

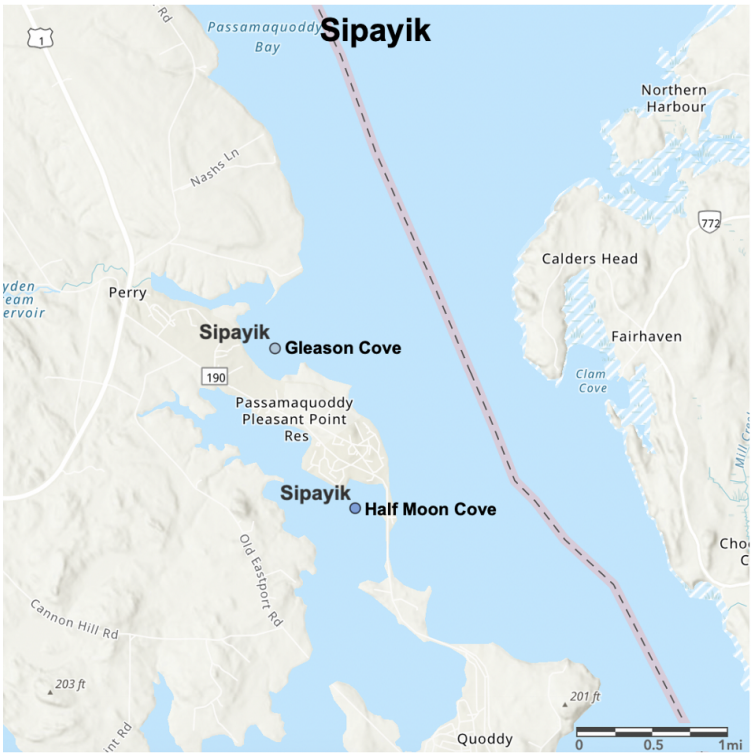
* An analysis of green crab density by flat and box type can be found in Appendix E.

* An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix G.

No significant difference in size-frequency distribution was observed between the two box types.

SIPAYIK



Site Locations: Gleason Cove and Half Moon Cove

Beginning (Deployment) Date: May 15, 2020
Ending (Fall Sampling) Date: November 11th, 2020 (180 days total duration)

TEMPERATURE

Average Site Temperature:

Cove	Average site★ temperature (May 15 to November 11, 2020)
Half Moon Cove	13.0°C (55.4°F)
Gleason Cove	13.5°C (56.3°F)

★ This average was derived from all temperature data (high tide and low tide) at the site.

Seawater Temperatures: Analysis of how seawater temperatures changed through the season can be found in Appendix A.

FINAL (FALL) 2020 SITE SURVEY RESULTS

Fall site surveys were conducted on Nov. 11, 2020 in Sipayik. Results show the number of recruits (and adults) of commercially important shellfish present in the mid-intertidal area of the monitoring site at the end of the clam growing season. This provides an estimate about how many clams were able to survive when they were not protected from predators (aka "clam survival rate").

We found live soft-shell clams in cores from both sites, but at very low densities. Samples showed 1.3 ± 1.2 clams/ft² at Gleason Cove and 1.6 ± 1.6 clams/ft² at Half Moon Cove. The five clams at Gleason Cove ranged in length from 3.5-24.6 mm, whereas the four clams at Half Moon Cove were all less than 6 mm (¼-inch).

2020 SITE CLAM SURVEY SUMMARY: Fall and Spring

Below is a summary of the spring vs. fall site survey results. Sample size from core samples (n = 16). Clam densities are provided in the average number of clams per square foot (ft²) and accompanied by the 95% confidence interval (CI) number in the parenthesis.

Site	Densities of clams found in surveys		Difference between Spring and Fall densities	Average size of clams found	
	Spring Survey	Fall Survey		Spring Survey	Fall Survey
Gleason Cove	1.9ft^2 (±1.4)*	1.3ft^2 (±1.2)	Loss of 0.6 clams/ft^2	4.7 mm (0.185 in)	13.3 (±17.0) mm [~½-in]
Half Moon Cove	4.8ft^2 (±2.5)	1.6ft^2 (±1.6)	Loss of 3.2 clams/ft^2	5.1 mm (0.201 in)	4.65 (±1.7) mm [0.18 in]

*Confidence intervals are used by statisticians to get as close as possible to the true mean. It is used because the actual ("true") average of the number of clams cannot be known unless every inch of mud on the flat is processed through a 1mm sieve. The most common type of CI is 95% and they are usually listed with the plus/minus symbol (±).

2020 CLAM RECRUITMENT BOX RESULTS

Gleason Cove had the highest number of clams recruiting out of all the sites. In fact, Gleason Cove had the second highest number of recruits in a single box in the history of using Beal boxes along the coast - 4,331. The only other time we found more recruits in a box was on the west side of the Harraseeket River in Freeport in 2015, when we found 6,009 recruits in a box. The overall density of clam recruits at Gleason Cove was 1,148 per ft^2.

Summary of Average Soft-shell Clam Recruit Density

Clam densities are provided in the average number of clams per square foot (ft^2) and accompanied by the 95% confidence interval (CI)* number in the parenthesis.

Site	Bottom Type	Avg. # per ft^2	Conclusion
Gleason Cove	Mesh	1,187.5 (± 264.7)	The most clams observed anywhere along the coast in the 18 sites occurred in Sipayik at Gleason Cove.
	Fabric	1,109.6 (± 861.6)	
Half Moon Cove	**Mesh**	**34.9 (± 12.7)★**	
	Fabric	22.1 (±6.1)	

★ Significantly more clams were found in this type of bottom.

*A detailed analysis of fall clam recruitment by flat can be found in Appendix B.

RECRUIT GROWTH

Summary of Clam Recruit Growth at Each Site in Each Bottom Type

Size summary of recruits depicted in both mm and inches. Average size accompanied by the 95% confidence interval (CI)* number.

Site	Bottom Type	# of recruits measured	Min. size of recruit	Max. size of recruit	Total # of recruits measured	Overall Avg. size (both bottom types)
Gleason Cove	Mesh	162	1.8 mm [0.07 in]	15.4 mm [0.61 in]	291	5.6 (± 0.35) mm [0.22 (± 0.01) in]
	Fabric	129	1.5 mm [0.06 in]	13.3 mm [0.52 in]		
Half Moon Cove	Mesh	160	2.5 mm [0.10 in]	14.6 mm [0.57 in]	324	8.3 (± 0.33) mm [0.33 (± 0.02) in]
	Fabric	164	3.0 mm [0.12 in]	15.7 mm [0.62 in]		

*Graphs of recruit growth by flat and recruitment box type can be found in Appendix C.

The size range of clams at Gleason Cove was similar between the two different types of recruitment boxes . The two size distributions were not significantly different, indicating that clams grew similarly in both types of recruitment boxes.

The size range of clams at Half Moon Cove was similar between the two types of boxes; however, size distributions varied by box type. Soft-shell clam recruits were significantly smaller in boxes with mesh vs. fabric bottoms. We observed ~ 33% of clams in boxes with mesh bottoms to be smaller than 6 mm (¼-inch) vs. ~ 20% in that category associated with fabric bottoms. Conversely, more clams larger than 10 mm were observed in boxes with fabric bottoms (~ 40%) compared to mesh bottoms (~ 20%).

GREEN CRAB RESULTS

Green Crab Density and Size Summary

Number of green crabs along with average number of green crabs per square foot ± 95% CI in mesh (n=8)and fabric bottoms (n=8), and size information.

Site	Total # of green crabs	Mesh	Fabric	Min. size	Max. size	Avg. size
Gleason Cove	54	2.5 (±2.2) mm	1.7 (±1.9) mm	2.2 mm [0.09 in]	24.6 mm [0.97 in]	5.9 mm [0.23 in]
Half Moon Cove	2	0	0.2 (±0.2) mm	2.8 mm [0.11 in]	8.2 mm [0.32 in]	5.5 mm [0.22 in]

* An analysis of green crab density by flat and box type can be found in Appendix E.

* An analysis of green crab size-frequency distribution by flat and box type can be found in Appendix F.

*Charts of the number of green crabs found per individual recruitment box can be found in Appendix G.

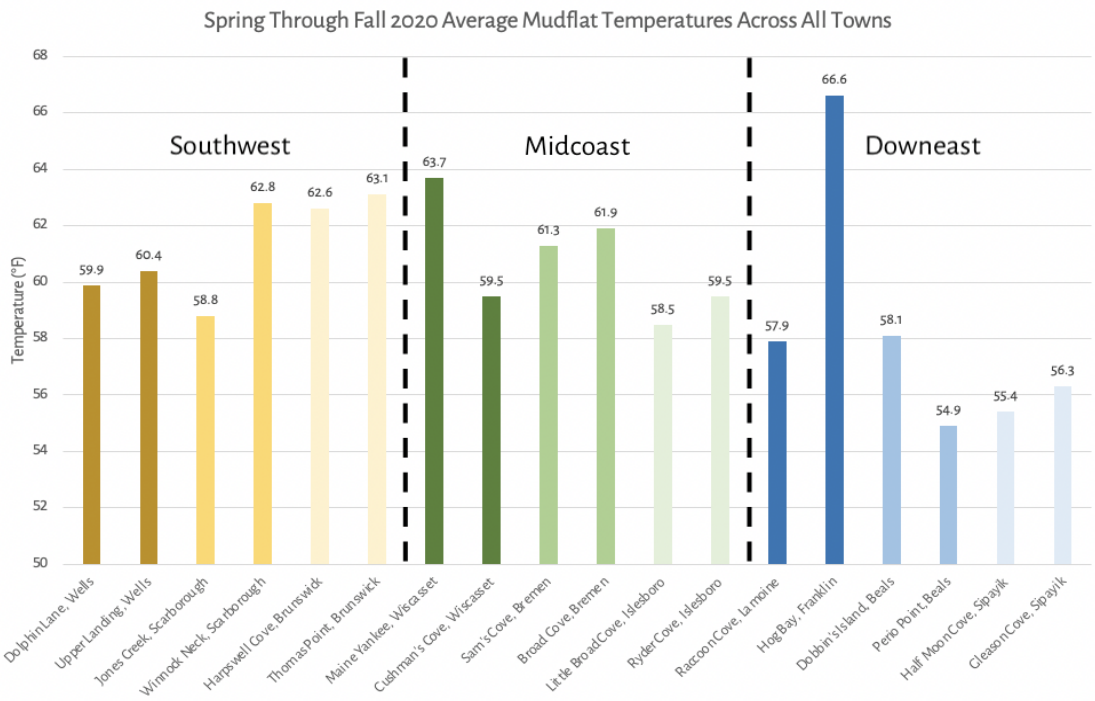
At Half Moon Cove, 53 soft-shell clam recruits were found in the box with the 2.8 mm carapace width (CW) crab and 50 recruits were found in the box with the 8.2 mm CW crab. The size distribution of the 54 green crabs at Gleason Cove did not differ significantly between the two different box types. However, ~ 20% of crabs had CW greater than 16 mm in boxes with fabric bottoms, whereas all crabs in the mesh boxes had CW less than 11 mm.

OVERALL RESULTS

Temperature

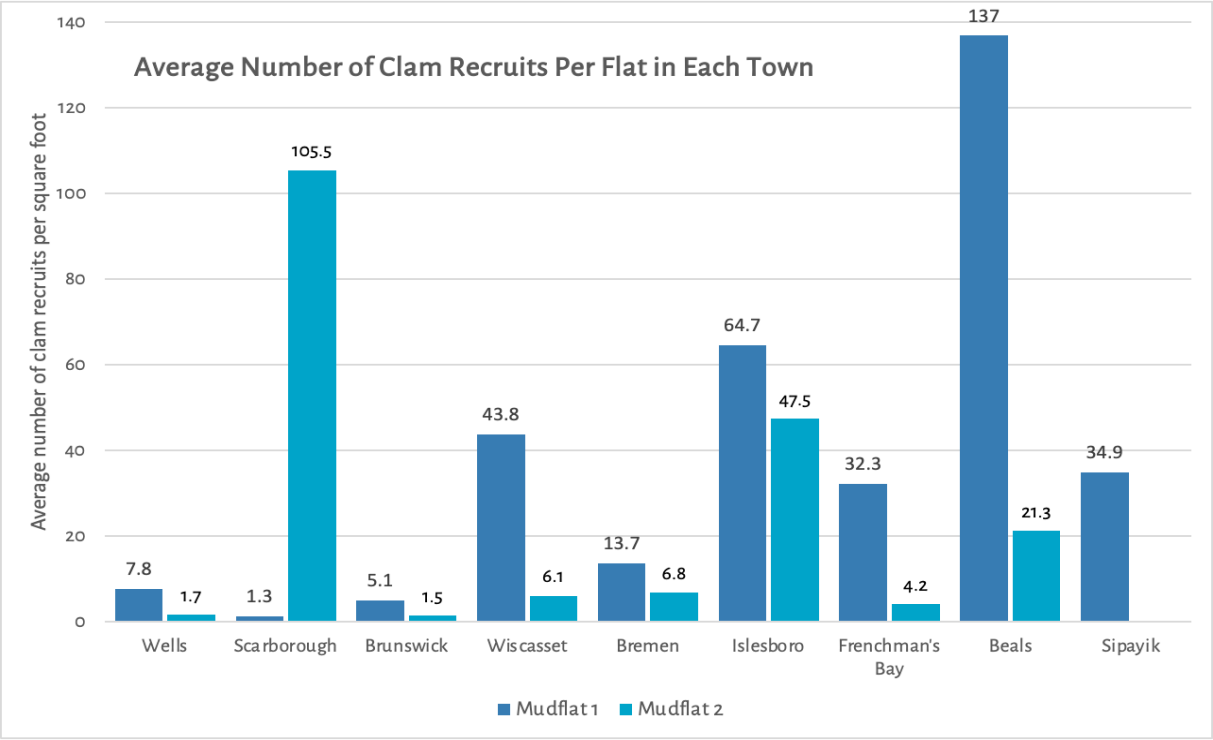
Temperatures are the most important driver influencing the biological and ecological processes that govern the health of the clam fishery. Temperature is the key prompt for spawning to commence, and may drive the duration of the spawning season (How Many Eggs Does a Clam Produce? 2020). It also impacts how fast clams grow and predation rates. Increased temperatures allow certain predators to proliferate, such as invasive green crabs, and also increases predation intensity by speeding up the metabolism of clam predators. In addition, increased temperatures extend the time period that predators feed at a high intensity.

The graph below shows the average temperature at each cove over ther 2020 Clam Recruitment Monitoring season. For information about seawater temperatures, see Appendix A.



Recruitment Levels

Overall, the average densities of clams we found in recruitment boxes in 2020 were surprisingly low compared to data from previous years. When looking at the average recruits per square foot in the bottom box type that retained the most clams, eight of the 18 sites (44%) had densities of less than 10 recruits/ft^2. Twelve of the sites were under 35 recruits/ft^2. Only three sites, Sipayik's Gleason Cove, Beals' Dobbins Island, and Scarborough's Winnock Neck averaged more than 100 recruits/ft^2.



Curiously, we did record the second highest number of recruits ever found in a Beal box at Gleason Cove. Gleason Cove averaged by far the highest clam recruit density this year at 1,148 recruits/ft^2.

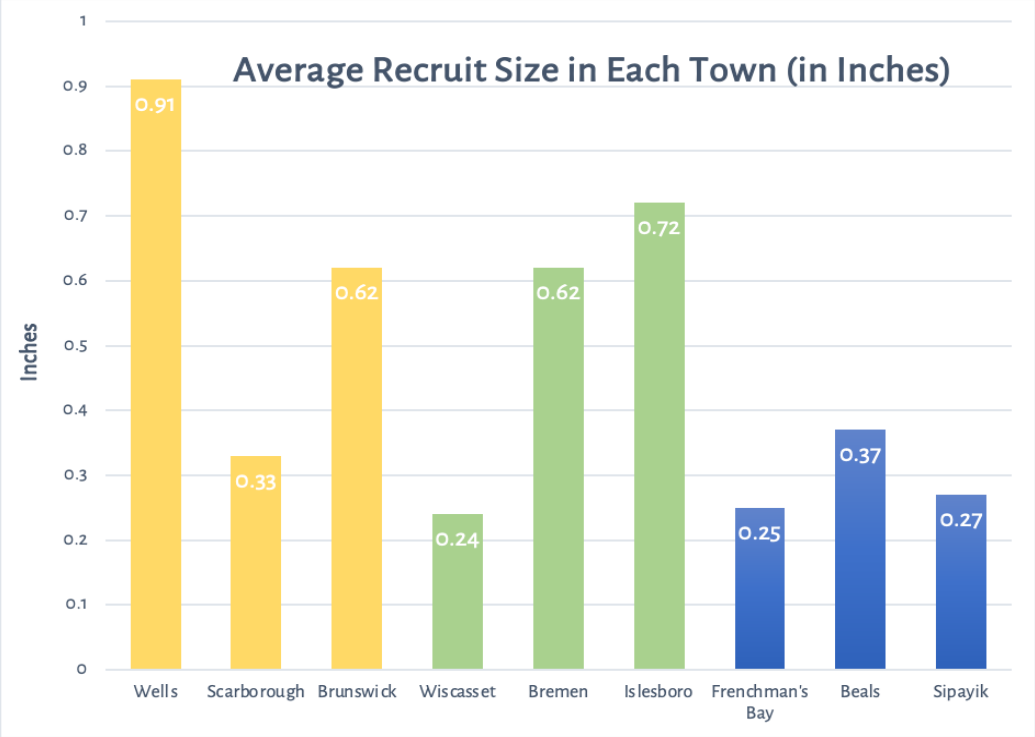
Overall, densities of clam recruits were highest downeast with an average of 227 recruits/ft^2. This was true even when the results for Gleason Cove were omitted from the calculations (which resulted in an average of 46 recruits/ft^2). The six midcoast region sites had on average 30 recruits/ft^2 occuring at the sites. While the southern region had, on average, 21 recruits/ft^2 recruiting to their six flats. More information about the recruitment levels can be found in Appendix B.

Recruit Growth

Clams settle out of the water column at about ⅛ of a mm. Growth of recruits is driven by seawater temperatures, food availability, how long the juvenile clam has been settled out, and genetics. Because Beal boxes are on the mudflats during the entirety of the clam recruiting and growing season, a variety of recruit sizes are found in the boxes.

Knowing how fast clams grow is crucial to understand when a clam will reach harvestable size. In places where clams are not protected from predators, it is the clams that recruit later in the year, when summer predation is settling down, that have the best chance of surviving their first year of life and making it to harvestable size in the following years (Beal et al. 2018). That means the bulk of clams that settle to flats during June and July become food for predators ranging from green crabs and hermit crabs to killifish, milky ribbon worms, and moon snails.

The chart below shows the average size of recruits found in the Beal boxes in each town in 2020.



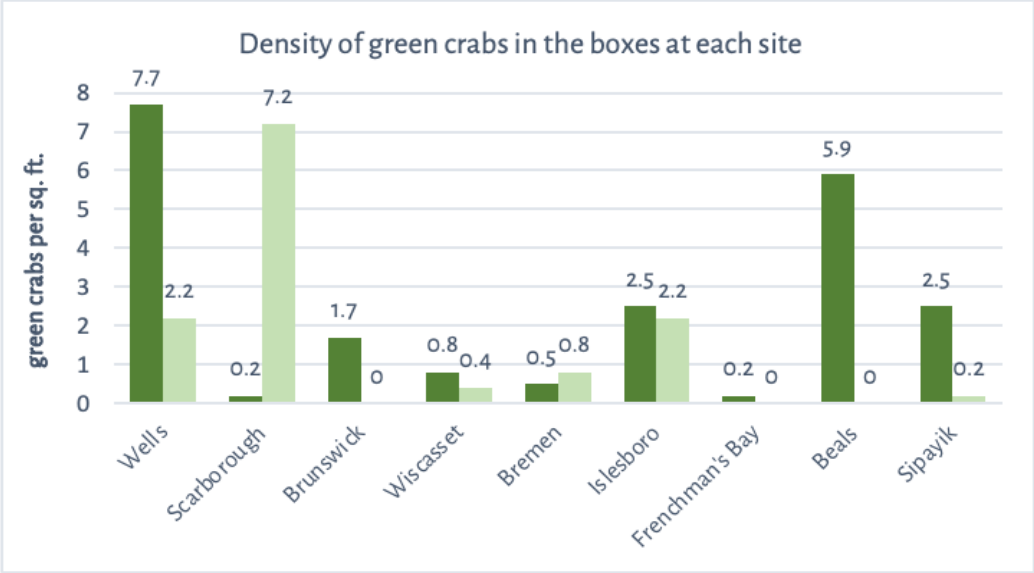
The chart below shows the size of the LARGEST recruit found in each town. This chart is helpful for understanding what is possible in each town for clam growth.

For more information about the growth rate of the recruits see Appendix C.

Numbers of Green Crabs

A total of 141 out of 288 recruitment boxes (49%) contained green crabs in 2020.
There are at least two ways, and times, for crabs to enter the boxes. Crabs may settle into a recruitment box from the plankton (as do clams and other species with planktotrophic larvae). Or, those with CW as large as 2.02 mm that either settled during the experimental period or those that overwintered at small sizes could presumably crawl into the box through the aperture of the screening.

The number and size of green crabs in the boxes is important to understanding their biomass level. For more information about green crab densities, see Appendix E.



Average Green Crab Growth

Green crabs settle out of the water column at 1 mm, giving them a distinct size advantage over their prey of soft-shell clams (at 1 mm, green crabs are about 5x larger than settling soft-shell clams). Crab settlement occurs during the summer (Berrill 1982), typically after soft-shell clams settle. How fast green crabs grow is controlled by the same factors that control clam growth.

It is not possible to discern the length of time a particular crab was in a box, but based on its size, one may assume that a crab greater than 15 mm CW resided in boxes longer and consumed more clam recruits than those less than 10 mm CW.

The smallest green crab found was 2mm (Dolphin Lane, Wells), and the largest was 41mm (in Broad Cove, Bremen). There were many small green crabs found at the Wells sites

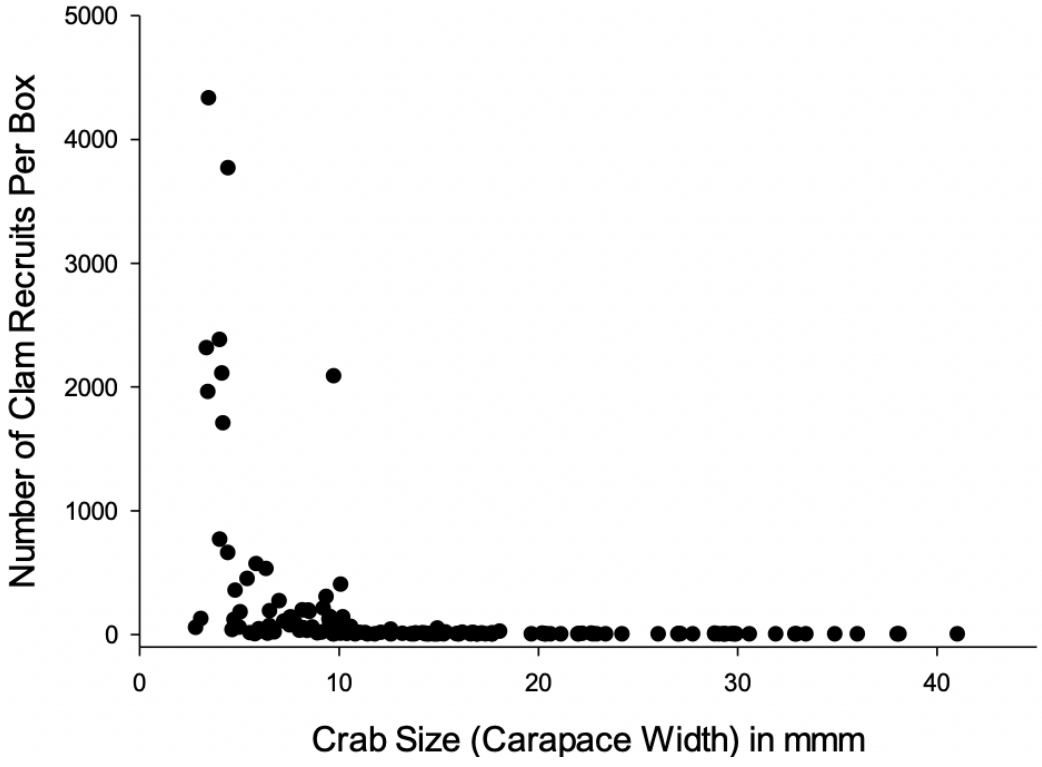
The table below shows the size of the smallest and largest green crabs found at each site. For more information about the sizes of green crabs found at the study sites, see Appendix F.

Site, size of smallest green crab found, and size of largest green crab found (in mm)

Dolphin Lane	2	34	Cushman's Cove	3.9	29.3	Raccoon Cove	0	0
Upper Landing	4	24	Maine Yankee	6.4	14.6	Hog Bay	29.3	33.5
Jones Creek	5	27.8	Sam's Cove	3.7	31.5	Dobbins Island	2.3	27.5
Winnock Neck	5.8	27.8	Broad Cove	6	41	Perio Point	0	0
Harpswell Cove	5.8	40.8	Little Broad Cove	5	20	Half Moon Cove	2.8	8.2
Thomas Point	0	0	Ryder Cove	4	28	Gleason Cove	3	25

Relationship Between Crab Size and Clams Per Box

Our analysis of results from all 18 monitoring sites determined a relationship between the number of clam recruits per box and crab size. The relationship shows that when crabs exceed 10 mm (~ ½-inch) in carapace width, few soft-shell clam juveniles occur in recruitment boxes.



In addition to the community partners listed on the first page, thank you to the following community volunteers for their assistance in this project:

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Scarbrough: Terry Twomey
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Wiscasset: Dick Forrest, Mike Ashby
Bremen: Jaime Farrar, Scott Hutchinson, Bobby Kaler, Dale Witham, Dana Morse
Islesboro: James Cowen, Travis Sterns
Frenchman's Bay: Jeff Normant

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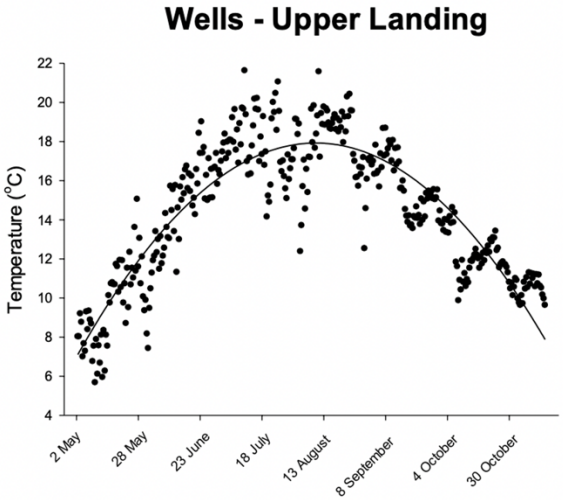
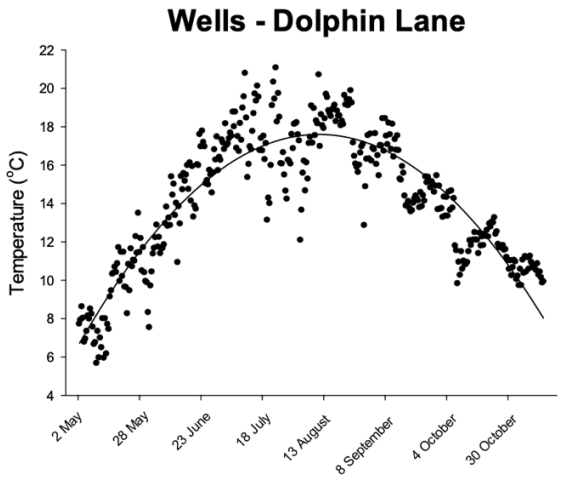
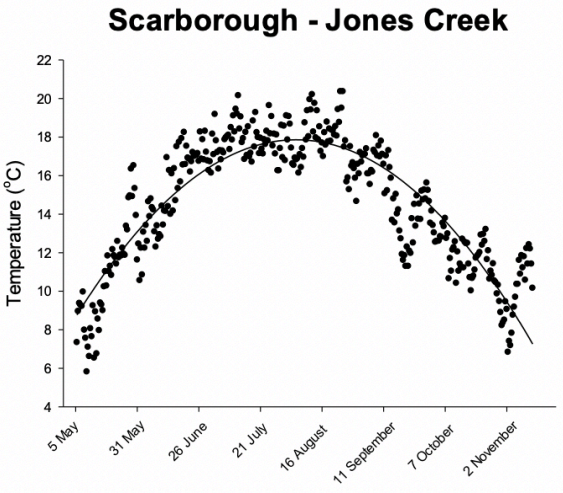
Appendix A: Seawater* Temperatures
Southwest Region

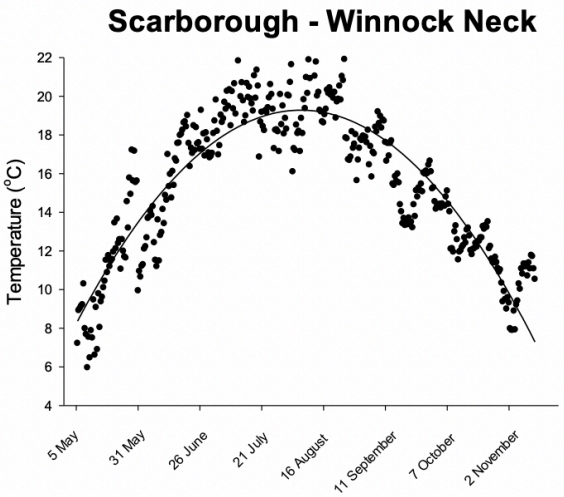




Seawater temperature from May 2 to November 14, 2020.

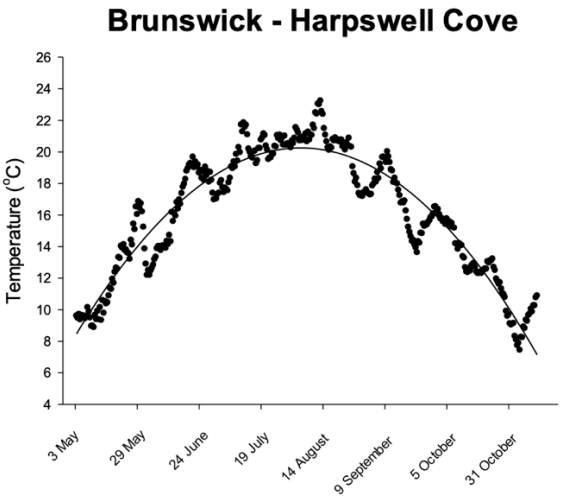
Summer temperatures were similar between the two sites.

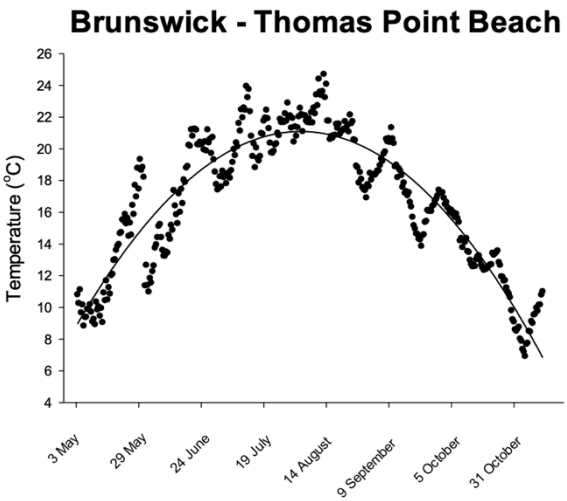




Seawater temperature from May 5 to November 13, 2020.

Summer temperatures were cooler at Jones Creek than Winnock Neck.



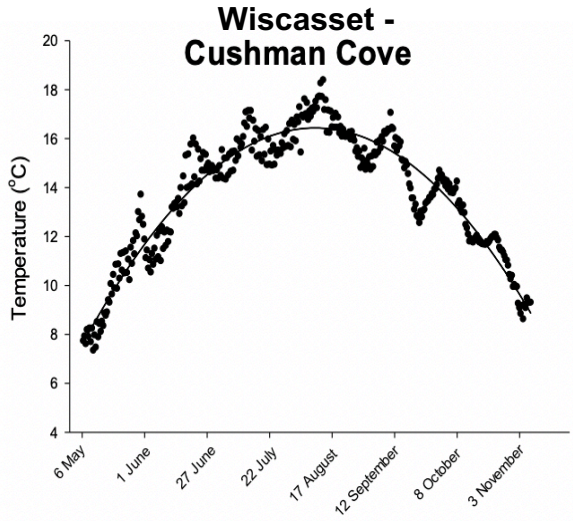


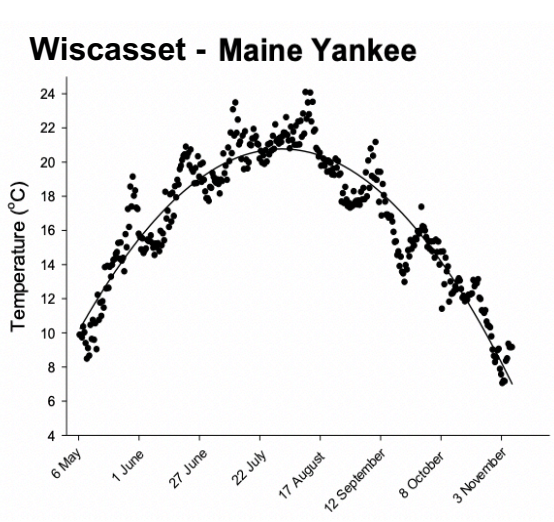
Seawater temperature from May 3 to November 12, 2020.

Summer temperatures were similar between the two sites.

* Each point represents an average of five recordings taken thirty minutes apart – one at high tide, two prior to, and two following each high tide.

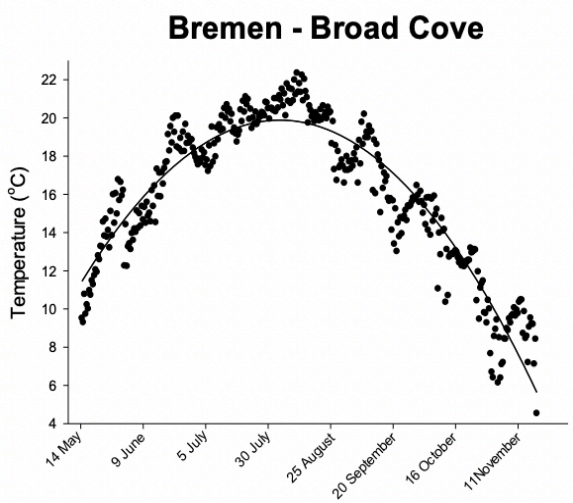
Appendix A: **Seawater*** Temperature
Midcoast Region

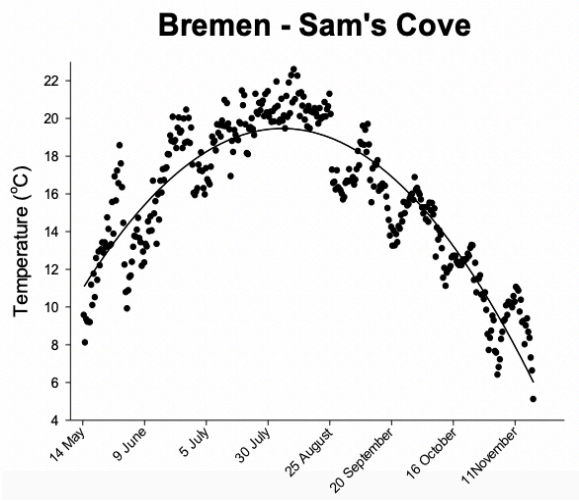




Seawater temperature from May 6 to November 8, 2020.

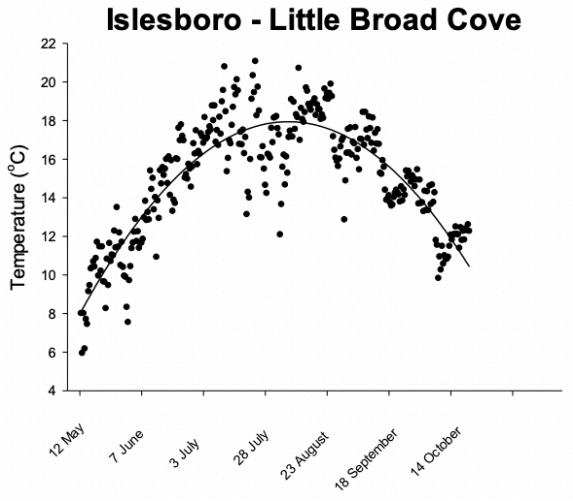
Summer temperatures were higher at Maine Yankee than at Cushman Cove.

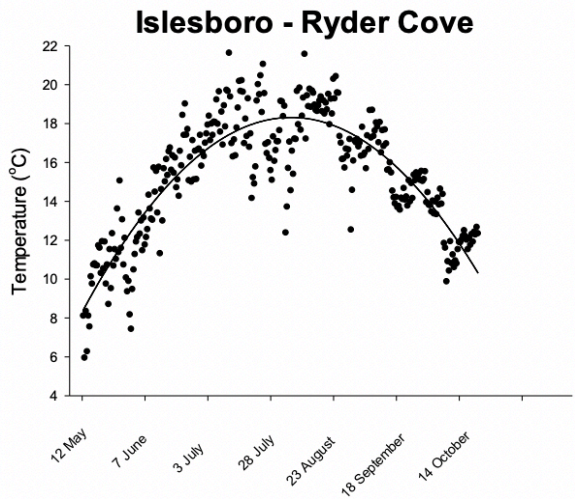




Seawater temperature from May 14 to November 19, 2020.

Temperatures were similar at both sites over the study period.



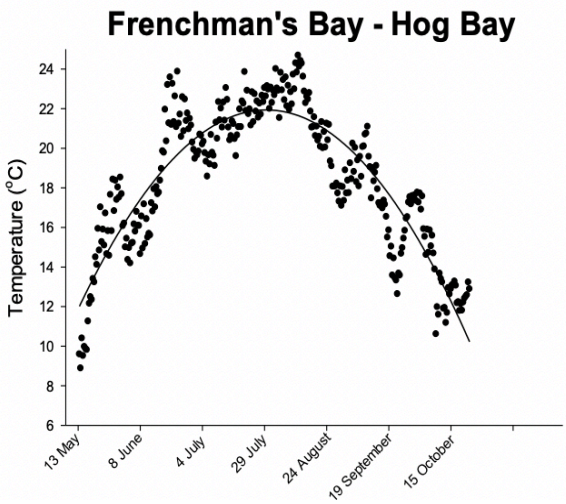


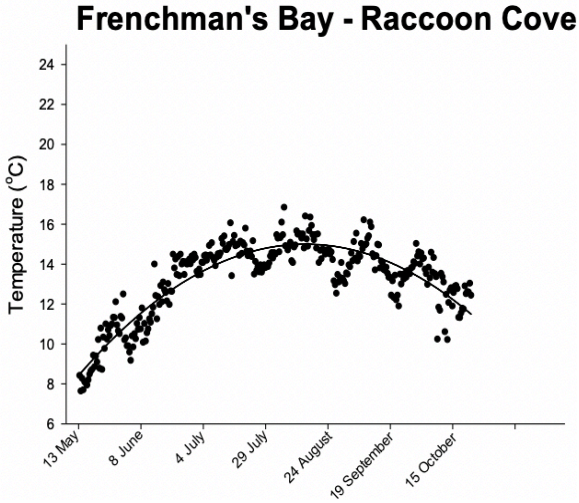
Seawater temperature from May 12 to October 22, 2020.

Summer temperatures were similar between the two sites.

* Each point represents an average of five recordings taken thirty minutes apart – one at high tide, two prior to, and two following each high tide.

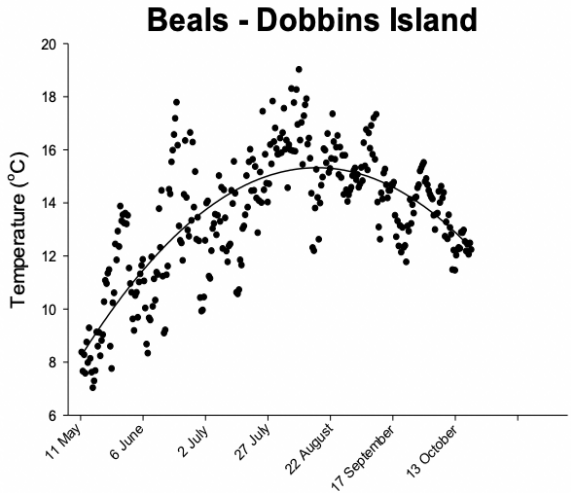
Appendix A: **Seawater*** Temperature
Downeast Region

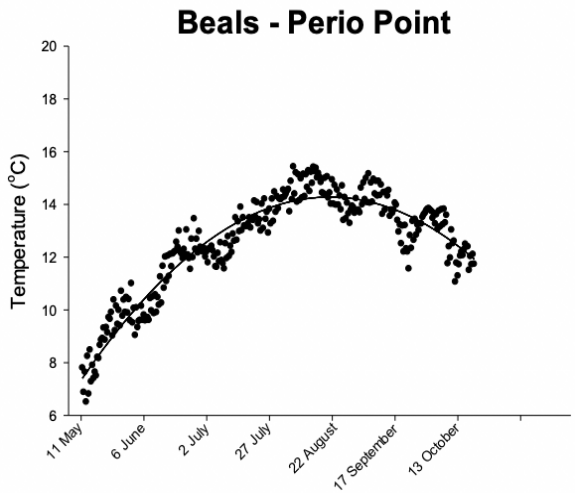




Seawater temperature from May 13 to October 23, 2020.

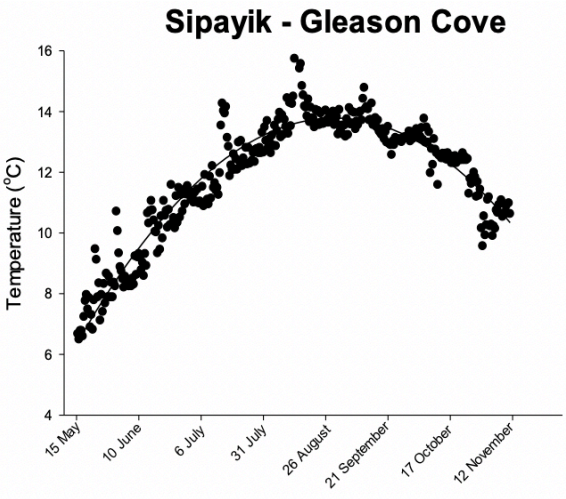
Temperatures were quite warmer at Hog Bay, especially during summer.

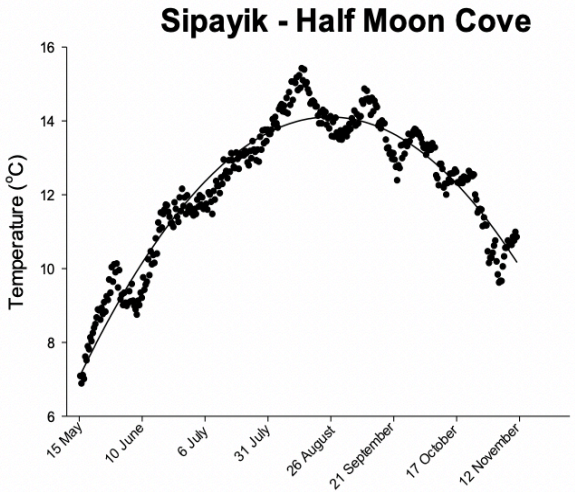




Seawater temperature from May 11 to October 20, 2020.

Summer temperatures were cooler at Perio Point than Dobbin's Island.





Seawater temperature from May 15 to November 11, 2020.

Summer temperatures were similar between the two sites.

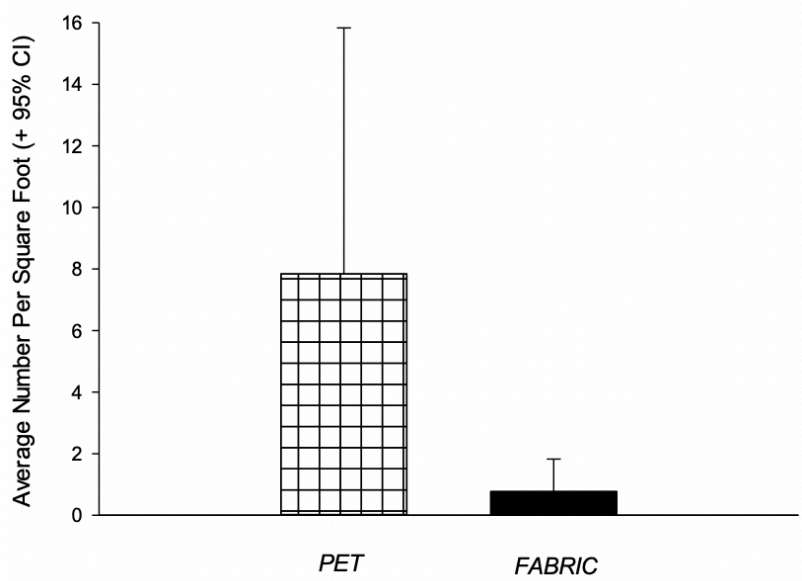
* Each point represents an average of five recordings taken thirty minutes apart – one at high tide, two prior to, and two following each high tide.

Appendix B: 2020 Clam Recruitment Results

Southwest Region

WELLS

Recruitment at Dolphin Lane

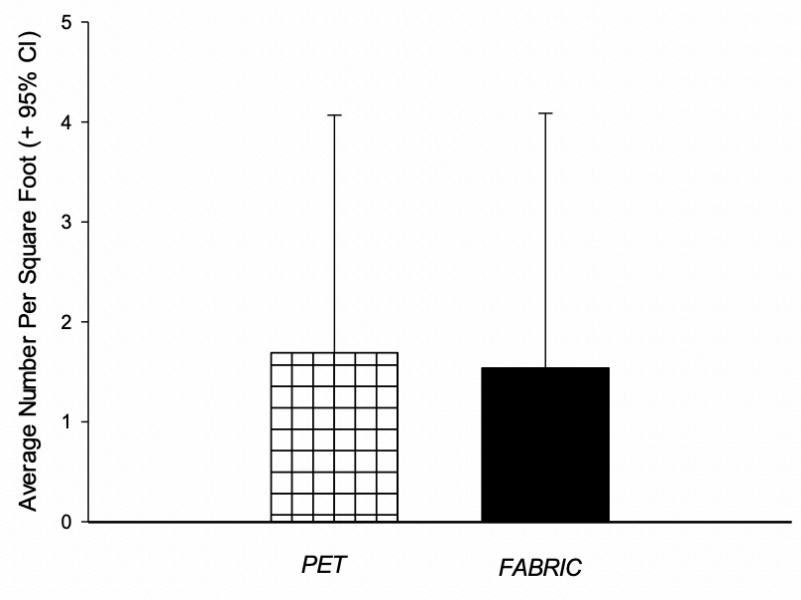


The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 8 per square foot, while the average density in the eight boxes with fabric bottoms was ~ 0.75 per square foot.

Even though there were more clams, on average, between boxes with the two different bottom types, a statistical test indicated that there was no significant difference in average number between bottom treatments.

*The line extending above each bar represents a measure of the variation in number of clams per box.

Recruitment at Upper Landing

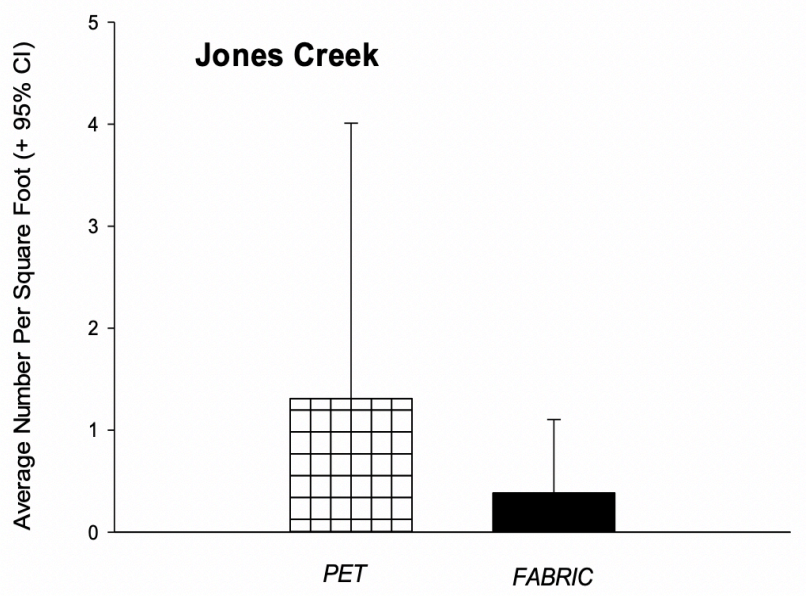


There were approximately 2.5x fewer clam recruits at the Upper Landing site than at Dolphin Lane. The average density of clams in the eight Upper Landing recruitment boxes with mesh bottoms was ~ 1.7 per square foot, while the average density in boxes with fabric bottoms was ~ 1.5 per square foot.

There was no significant difference in the average number of recruits between boxes with the two bottom treatments (P = 0.9125). This tells us that the area was not prone to erosion, and that future deployments at this site should be carried out using recruitment boxes with mesh bottoms.

SCARBOROUGH

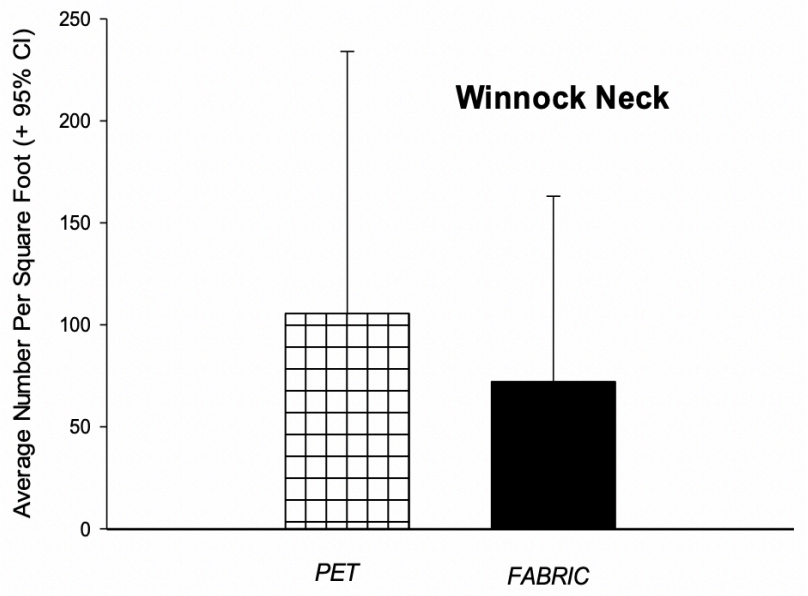
Recruitment at Jones Creek



The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 1.3 per square foot, while the average density in the boxes with fabric bottoms was ~ 0.4 per square foot.

A statistical test indicated that these two averages were not significantly different from each other (P = 0.4328), suggesting that at this site using either boxes with mesh bottoms or fabric bottoms will yield similar results.

Recruitment at Winnock Neck



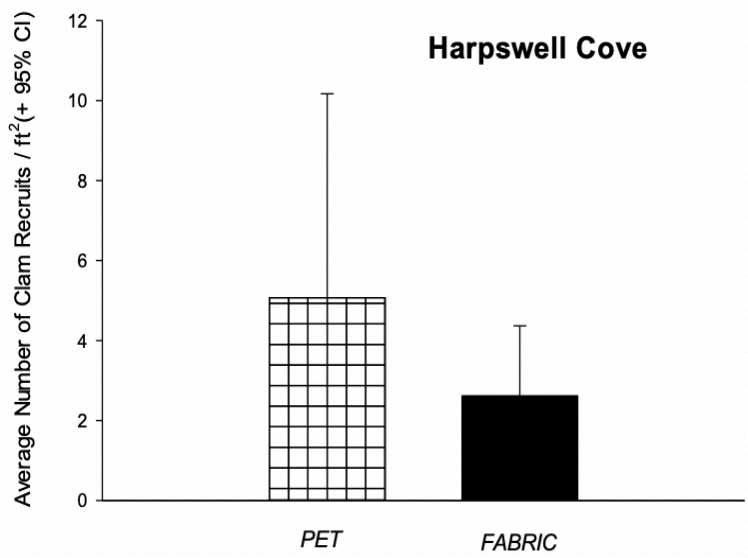
Average clam density in the eight recruitment boxes with mesh bottoms was ~ 105 per square foot, while the average density in boxes with fabric bottoms was 72 per square foot.

These two averages were not significantly different (P = 0.6258). However, there was a significant difference in average density of clams per box between Jones Creek and Winnock Neck.

No serious erosion occurred at either site; therefore, deployment of boxes in 2021 will proceed with 100% use of boxes with mesh on both top and bottom.

BRUNSWICK

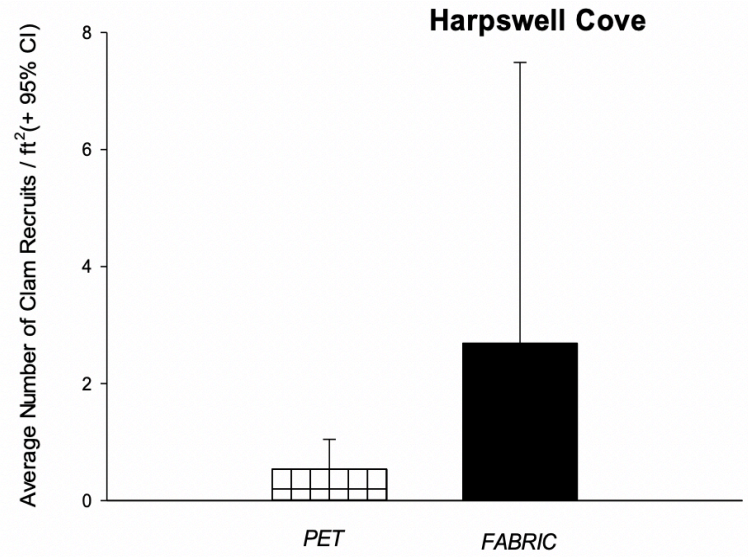
Soft-Shell Recruitment at Harpswell Cove



The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 5 per square foot, while the average density in boxes with fabric bottoms was ~ 2.6 per square foot.

A statistical test indicated that these two averages were not significantly different from each other (P = 0.2234), suggesting that at this site, using either boxes with mesh bottoms or fabric bottoms will yield similar results.

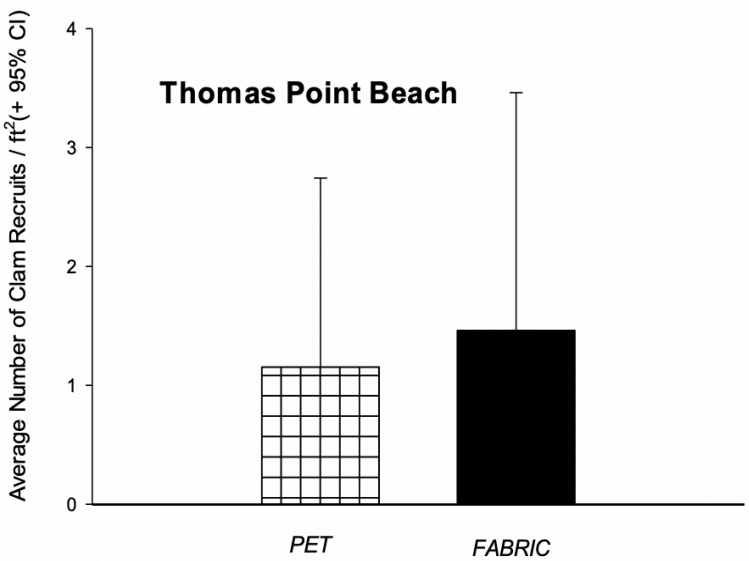
Hard-Shell Recruitment at Harpswell Cove



35 recruits of *Mercenaria mercenaria*, the northern quahog or hard clam, were observed in boxes at Harpswell Cove (a single hard clam recruit – 2.7 mm – was observed in one of the sixteen boxes at Thomas Point Beach).

28 hard clams occurred in boxes with fabric bottoms and 7 occurred in boxes with mesh bottoms. The variability was so great that the two averages were not statistically significant.

Soft-Shell Recruitment at Thomas Point



Average clam density in the eight recruitment boxes with mesh bottoms was ~ 1.2 per square foot, while the average density in boxes with fabric bottoms was ~ 1.5 per square foot.

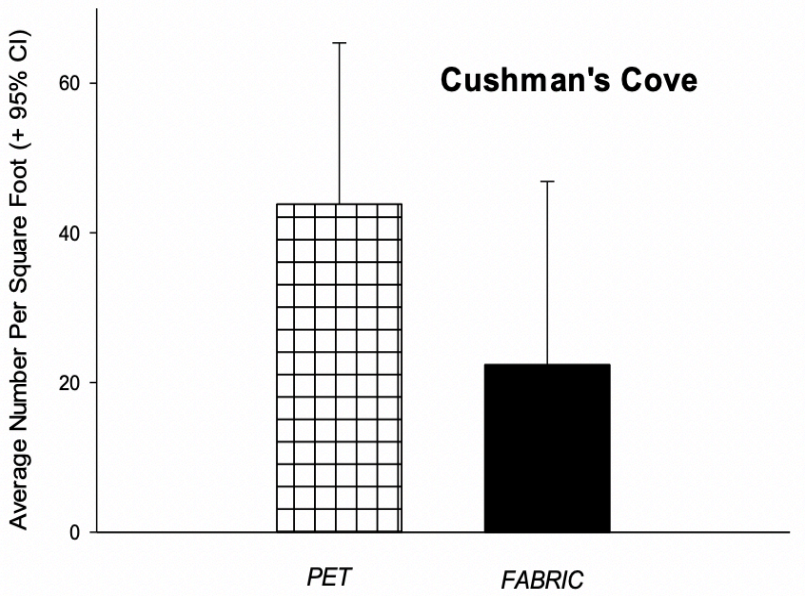
There was no significant difference in clam density in either type of box between Harpswell Cove and Thomas Point (P = 0.4700). No serious erosion occurred at either site in Brunswick; therefore, deployment of boxes in 2021 will proceed with 100% use of boxes with mesh on both top and bottom.

Appendix B- 2020 Clam Recruitment Results

Midcoast Region

WISCASSET

Recruitment at Cushman Cove

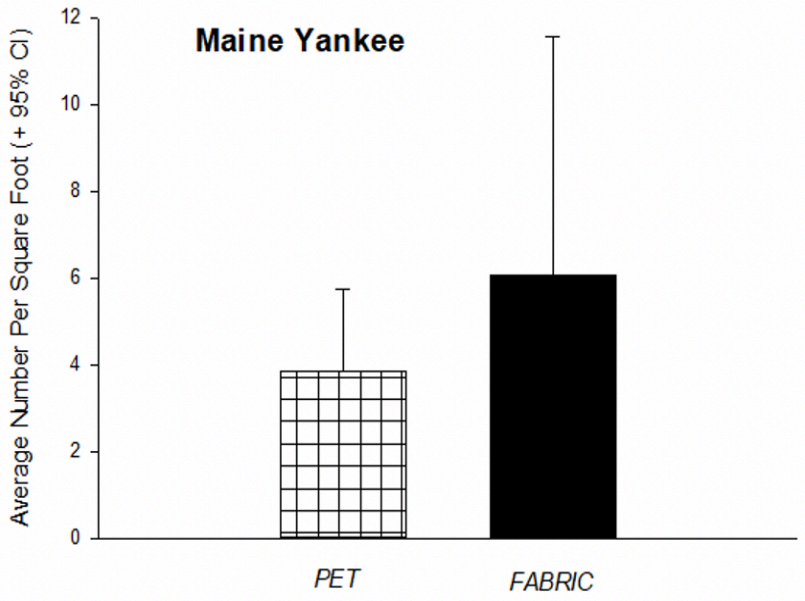


The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 44 per square foot, while the average density in the boxes with fabric bottoms was ~ 22 per square foot.

A statistical test indicated that there was no significant difference in the average number between boxes with the two bottom treatments (P = 0.1904).

Neither site was prone to erosion; therefore, future deployments should be carried out using recruitment boxes with mesh bottoms.

Recruitment at Maine Yankee

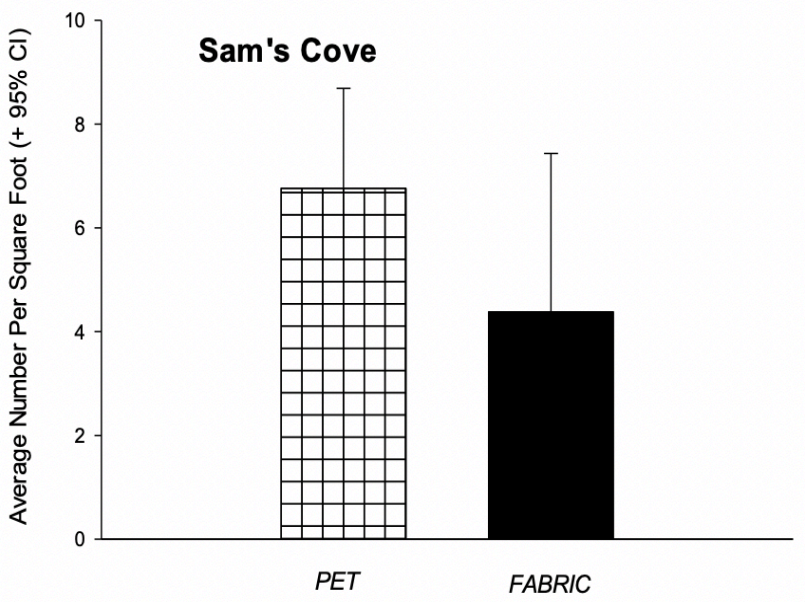


The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 4 per square foot, while the average density in the boxes with fabric bottoms was ~ 6 per square foot. There were approximately 7x fewer clam recruits at the Maine Yankee site than at Cushman Cove.

There was no significant difference in the average number of recruits between boxes with the two bottom treatments (P = 1.000).

BREMEN

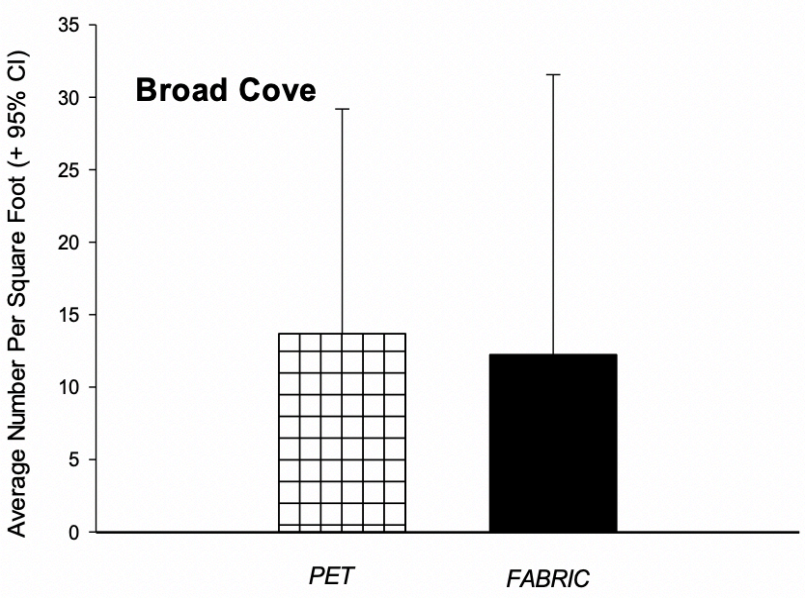
Recruitment at Sam's Cove



The average number of recruits at Sam's Cove was similar between boxes with the two bottom types (6.8 ± 1.9 clams/ft² in boxes with mesh bottoms vs. 4.4 ± 3.0 clams/ft² in boxes with fabric bottoms; P = 0.2353).

No obvious erosion occurred under any of the boxes at Sam's Cove. Deployment of boxes in 2021 will proceed with 100% having mesh on both top and bottom.

Recruitment at Broad Cove

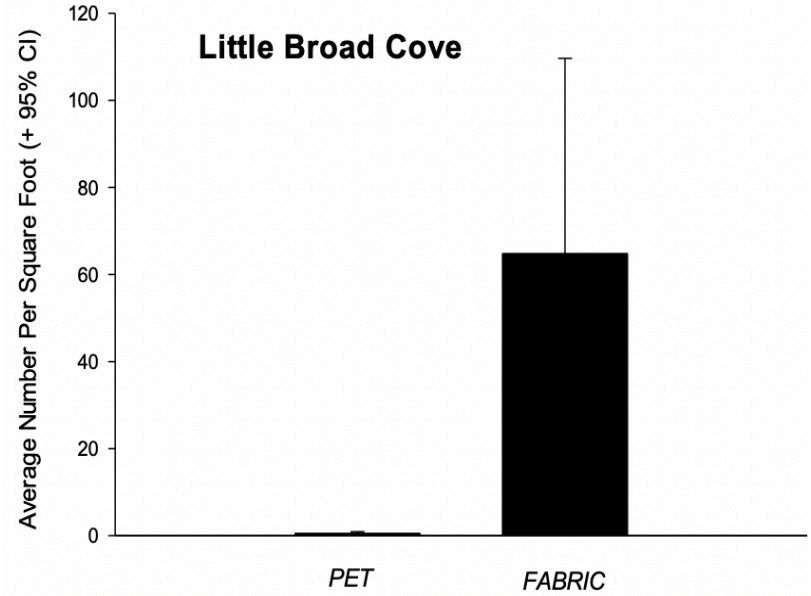


The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 14 per square foot, while the average density in boxes with fabric bottoms was ~ 12 per square foot.

A statistical test indicated that these two averages were not significantly different from each other (P = 0.8900. We observed no substantial erosion under any of the boxes. Deployment in 2021 will proceed using all traditional boxes with mesh on the top and bottom of each.

ISLESBORO

Recruitment at Little Broad Cove

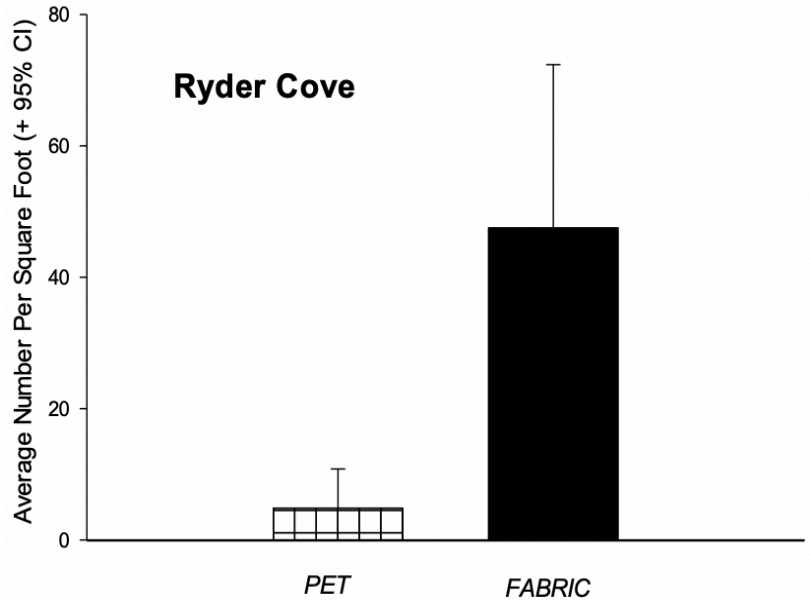


The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 0.5 per square foot, while the average density in boxes with fabric bottoms was ~ 65 per square foot.

A statistical test indicated that there was a significant difference in the average number between boxes with the two bottom types (P = 0.0120).

Most boxes at both locations with mesh bottoms had a gap of 1-2 inches between the mudflat surface and the bottom of the box, indicating that the area was prone to erosion. Future deployments at this site will be carried out using recruitment boxes with fabric bottoms.

Recruitment at Ryder Cove



Average clam density in the eight recruitment boxes with mesh bottoms was ~ 4.8 per square foot, while the average density in boxes with fabric bottoms was ~ 47.5 per square foot.

A statistical test indicated that there was a significant difference in the average number between boxes with the two bottom types (P = 0.0072).

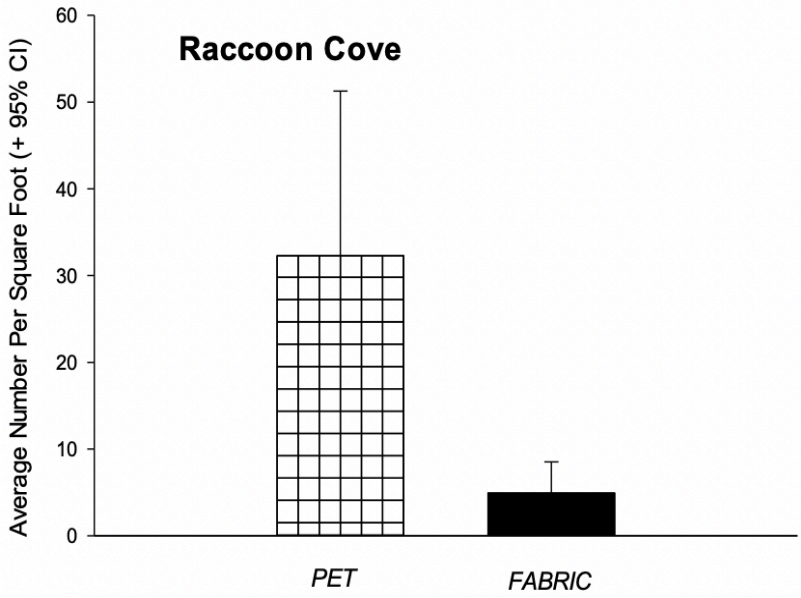
There was no significant difference in clam density in either type of box between Ryder Cove and Little Broad Cove.

Appendix B- 2020 Clam Recruitment Results

Downeast Region

FRENCHMAN'S BAY

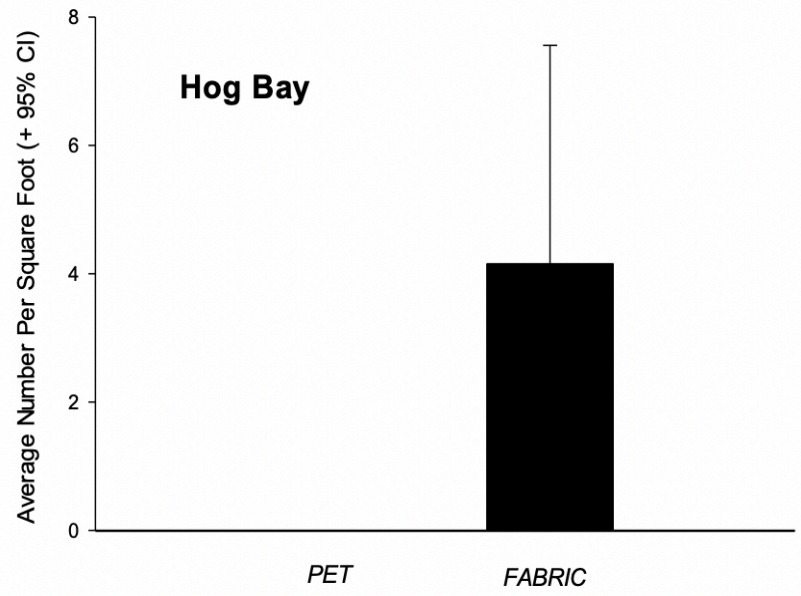
Recruitment at Raccoon Cove, Lamoine



The average density of recruits in boxes with mesh bottoms was ~ 32 clams/ft^2. That was about 6x greater than the density observed in boxes with fabric bottoms (4.9 ± 3.6 clams/ft^2).

The average number of recruits varied significantly between box types (P = 0.0108). No obvious erosion occurred under any of the boxes at Raccoon Cove. Deployment of boxes in 2021 will proceed with 100% having mesh on both top and bottom.

Recruitment at Hog Bay, Franklin

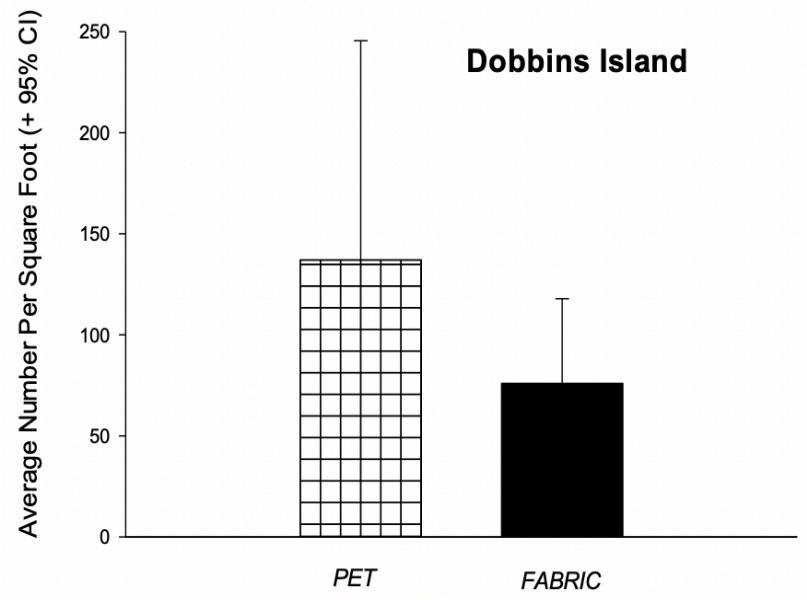


No clams were observed in the eight boxes with mesh bottoms. The average density of clams in the eight recruitment boxes with fabric bottoms was ~ 4 per square foot.

A statistical test indicated that these two averages were significantly different from each other (P = 0.0236). In addition, we observed no substantial erosion under any of the boxes. Due to the observed densities, deployment in 2021 will proceed using the same number of both types of recruitment boxes.

BEALS

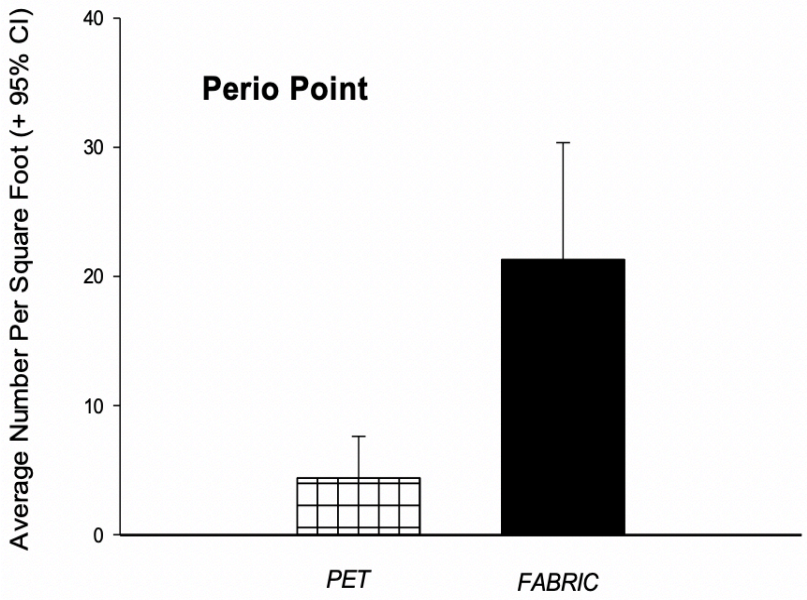
Recruitment at Dobbin's Island



The average density of clams in the eight recruitment boxes with mesh bottoms was ~ 137 per square foot, while the average density in boxes with fabric bottoms was ~ 76 per square foot.

A statistical test indicated that these two averages were not significantly different from each other (P = 0.2360). In addition, we observed no substantial erosion under any of the boxes. Deployment in 2021 will proceed using all traditional boxes with mesh on the top and bottom of each.

Recruitment at Perio Point

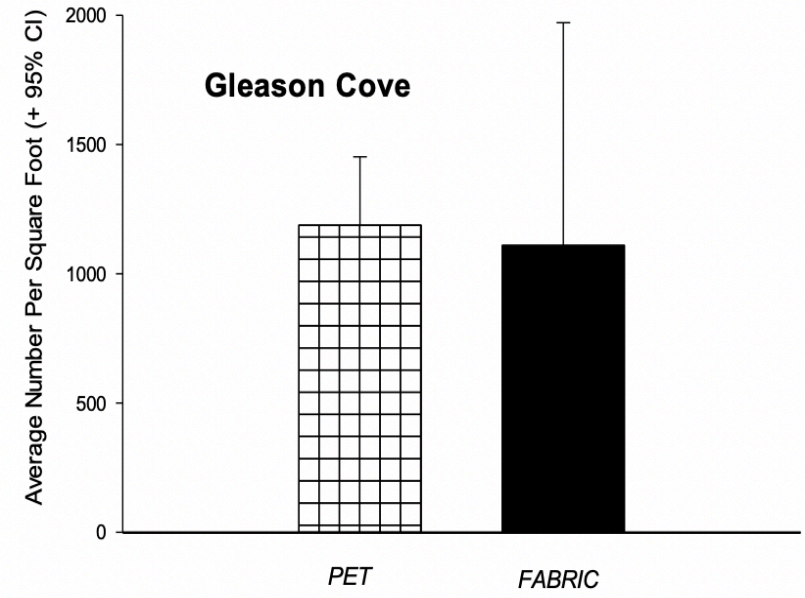


While no obvious erosion occurred under any of the boxes at Perio Point, boxes with fabric bottoms yielded nearly 5x the number of recruits as boxes with mesh bottoms (21.3 ± 9.1 vs. 4.4 ± 3.2 recruits per square foot; P = 0.0027).

Deployment of boxes in 2021 will proceed with 50% having mesh on both top and bottom, and 50% with fabric bottoms.

SIPAYIK

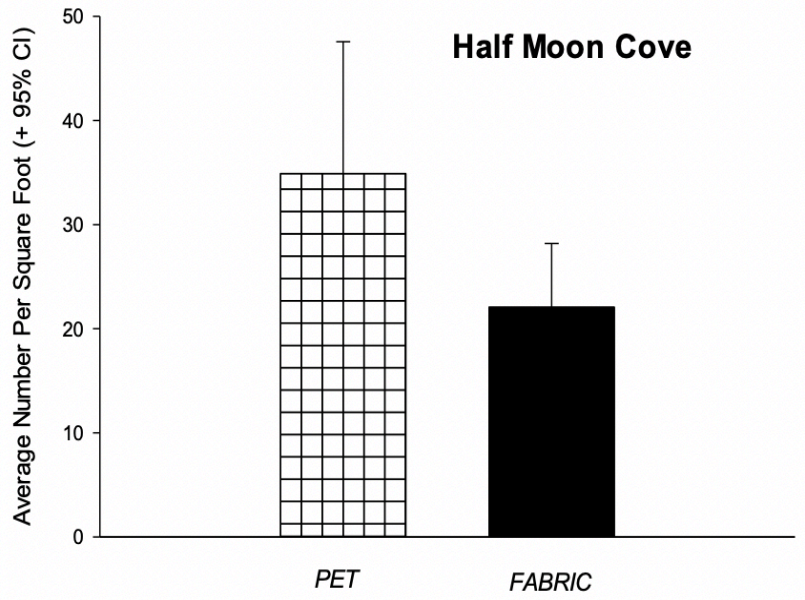
Recruitment at Gleason Cove



The most clams observed anywhere along the coast in the 18 sites occurred in Sipayik at Gleason Cove. Clam recruit densities were 1,187.5 ± 265 clams/ft² in boxes with mesh bottoms and 1,109 ± 861.5 clams/ft² in boxes with fabric bottoms.

A statistical test indicated that there was no significant difference in the average number of clam recruits between boxes with the two bottom types (P = 0.8226).

Recruitment at Half Moon Cove



Clam recruit densities were 34.9 (± 12.7) clams/ft² in mesh boxes and 22.1 (±6.1)clams/ft² in fabric bottoms.

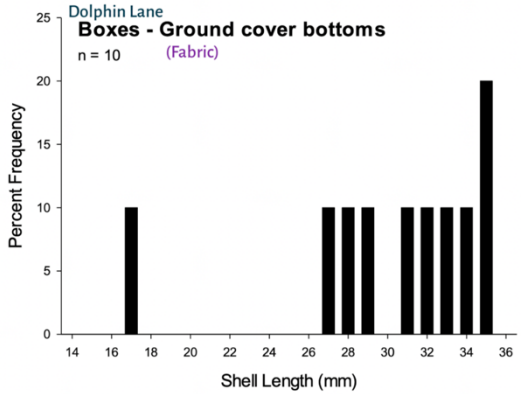
A statistical test indicated that there were significantly more clams in mesh boxes than fabric bottoms (P = 0.0502) at Half Moon Cove.

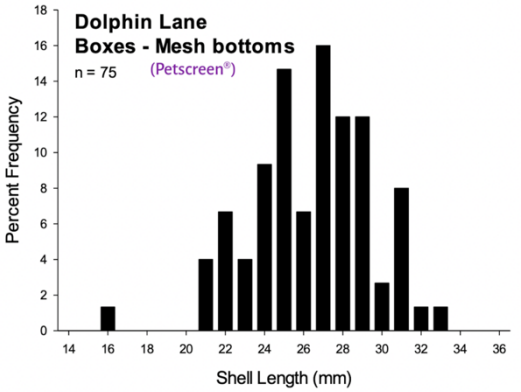
Appendix C: Recruit Growth Rates

Southwest Region

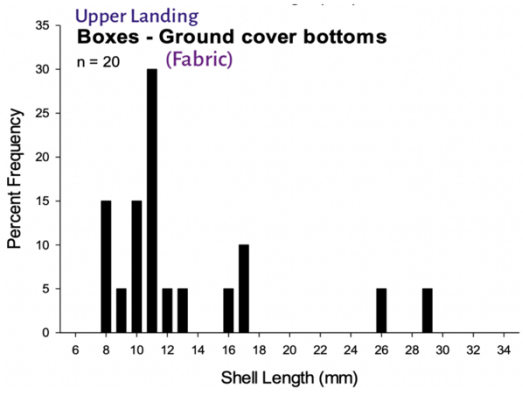
WELLS

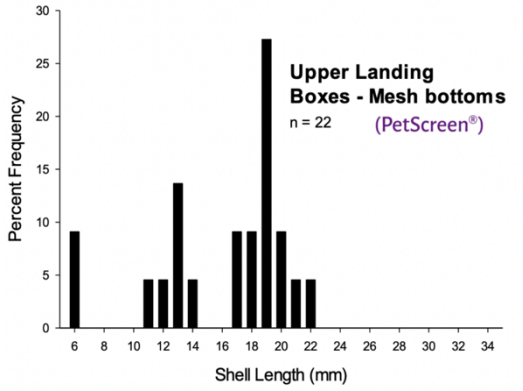
Dolphin Lane





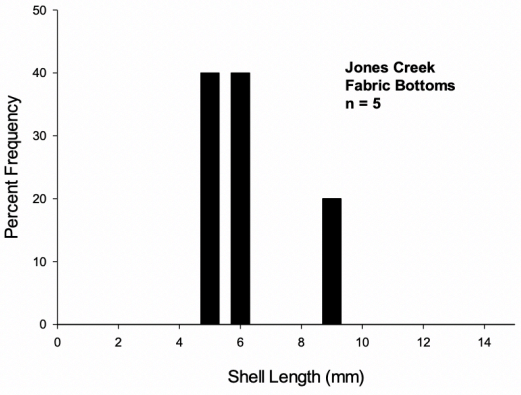
Upper Landing

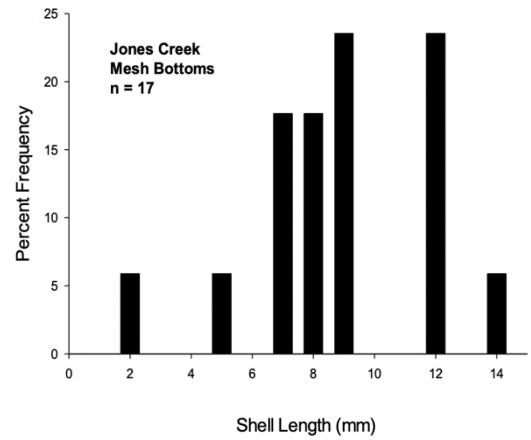




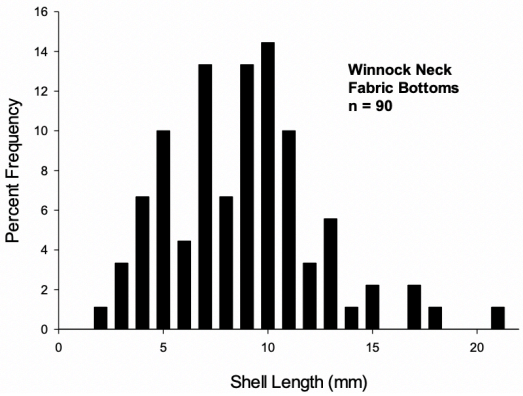
SCARBOROUGH

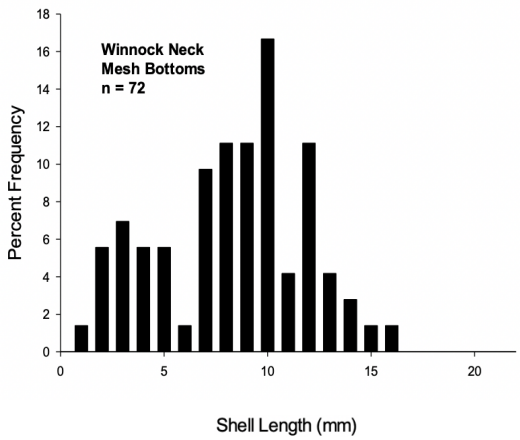
Jones Creek





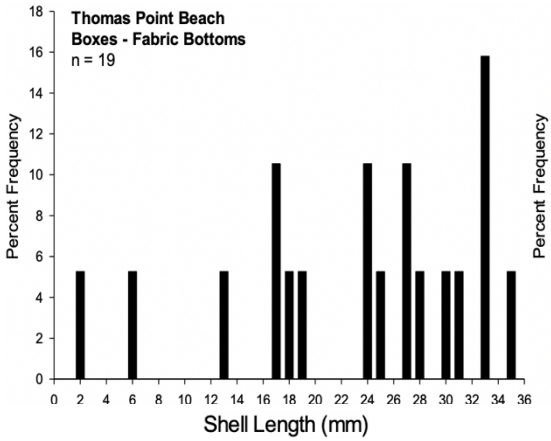
Winnock Neck

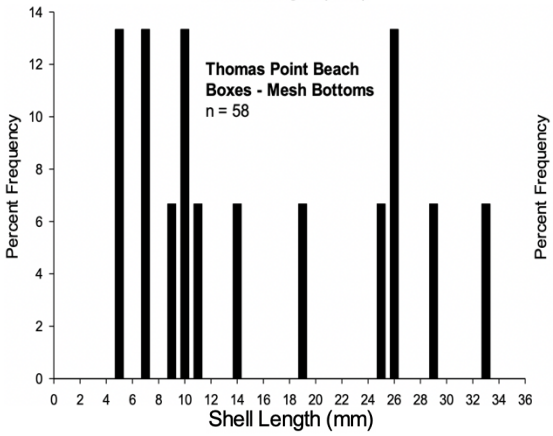




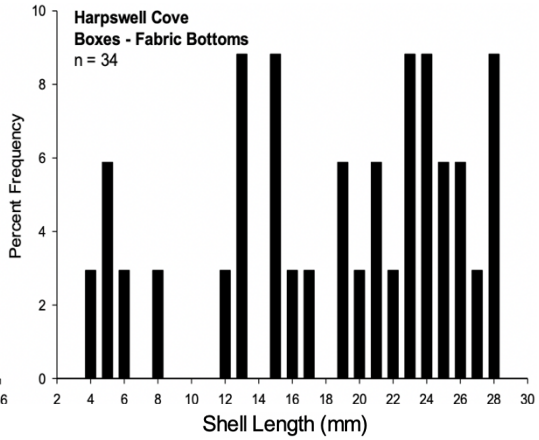
BRUNSWICK: Soft-shell

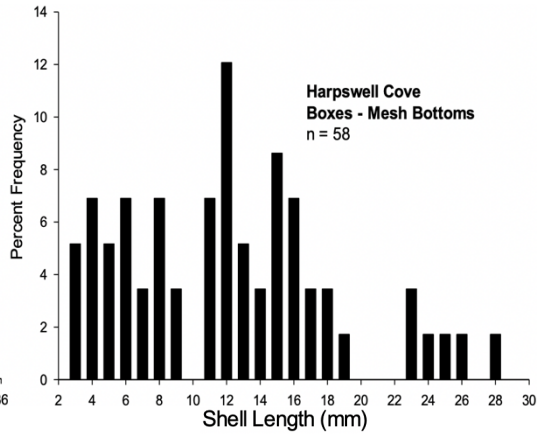
Thomas Point



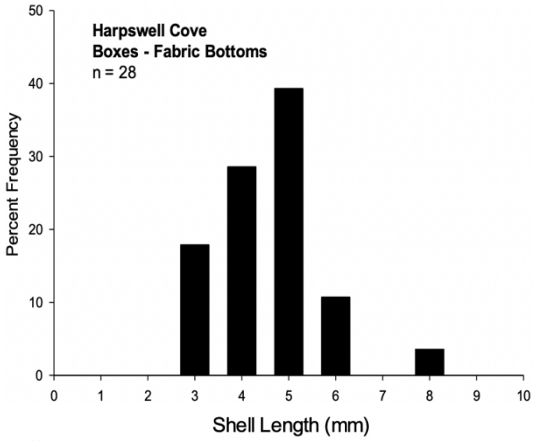


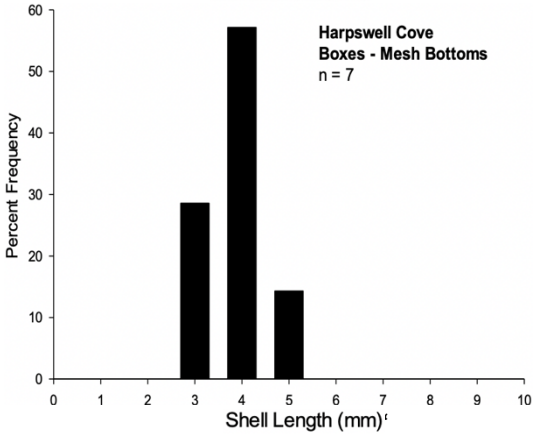
Harpswell Cove





BRUNSWICK: Hard-shell



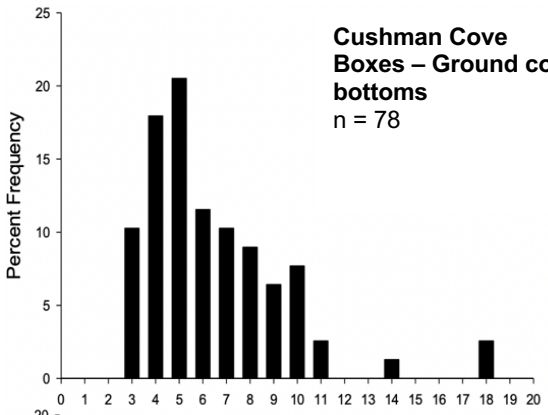


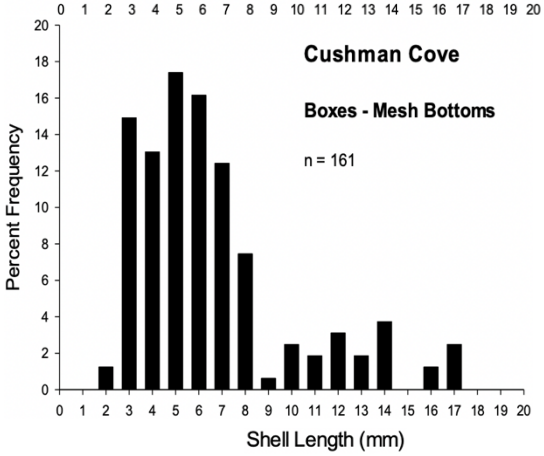
Appendix C: Recruit Growth Rates

Midcoast Region

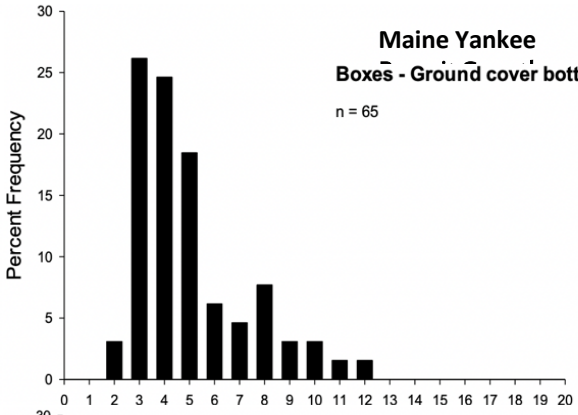
WISCASSET

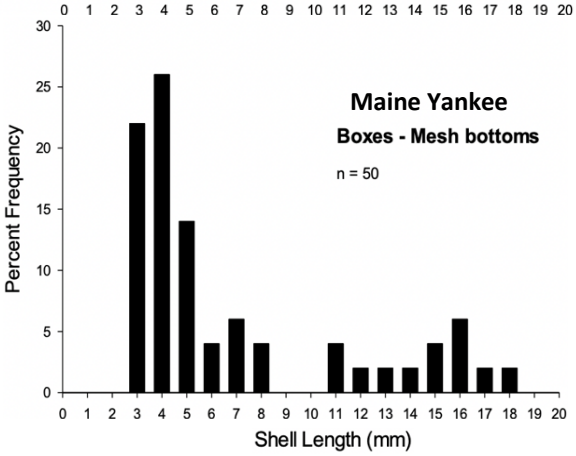
Cushman Cove





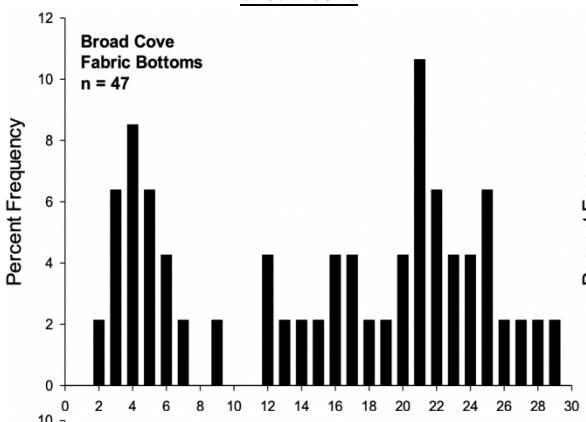
Maine Yankee

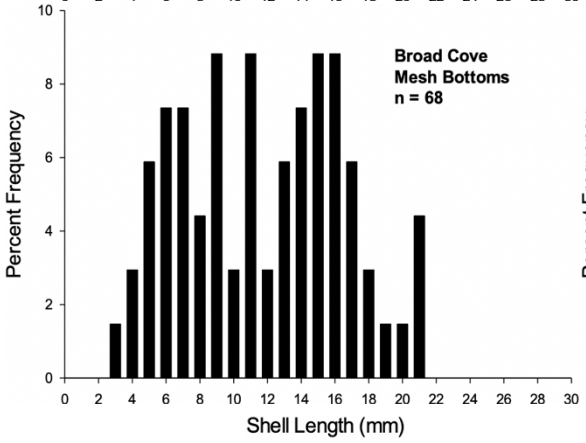




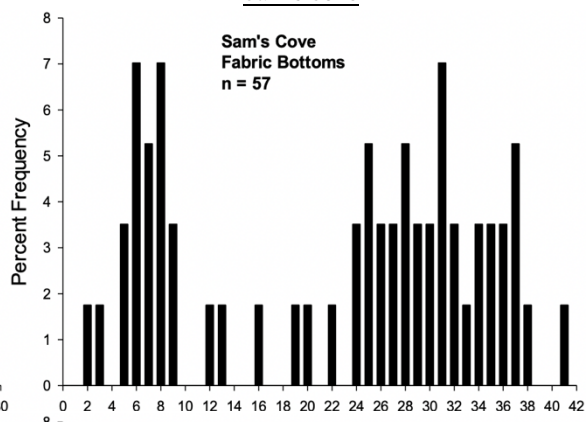
BREMEN

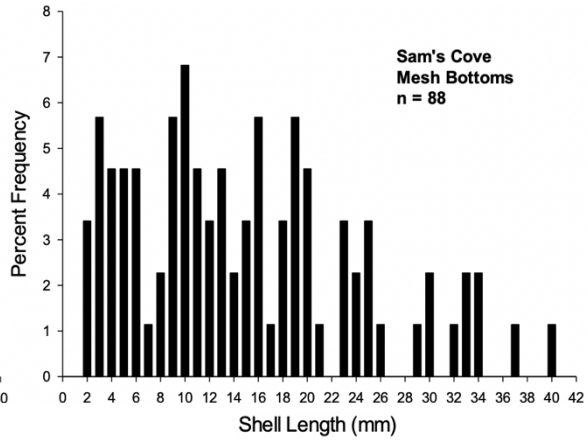
Broad Cove





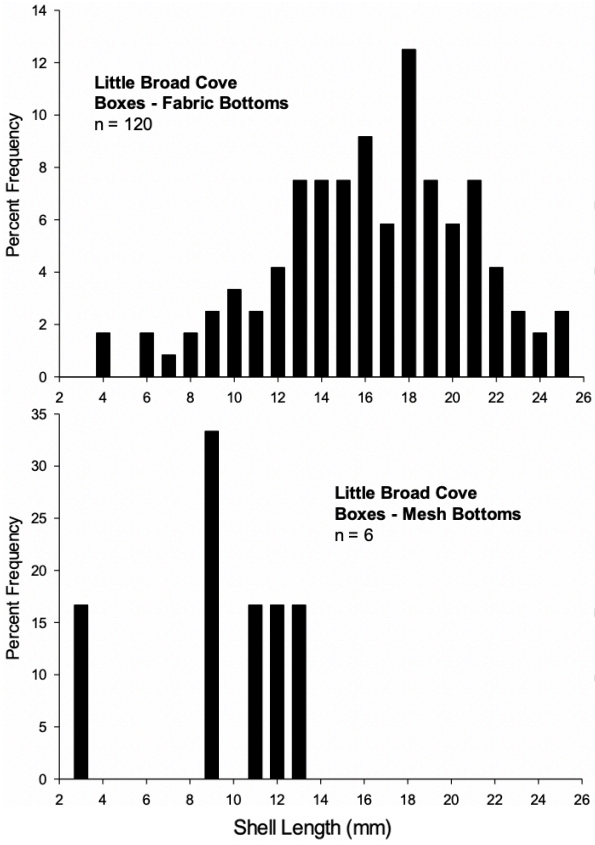
Sam's Cove



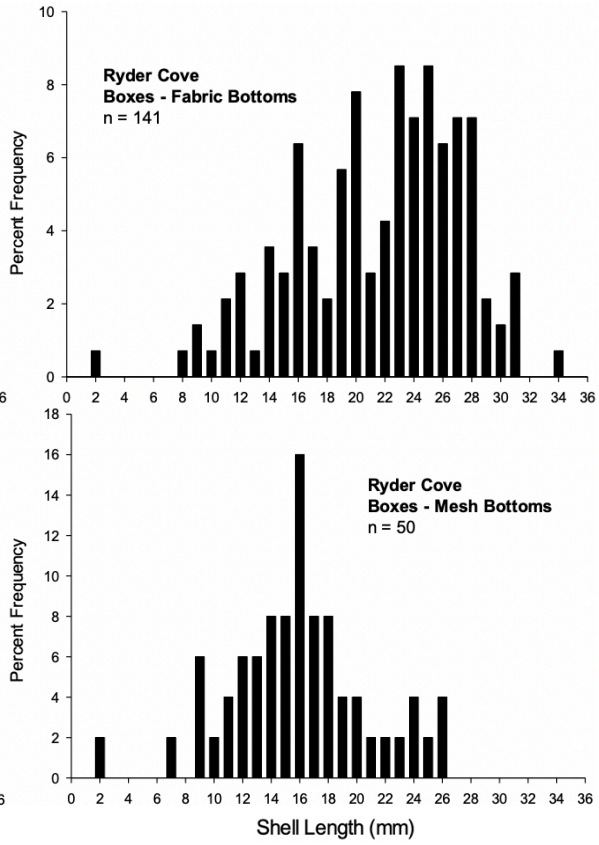


ISLESBORO

Little Broad Cove



Ryder Cove

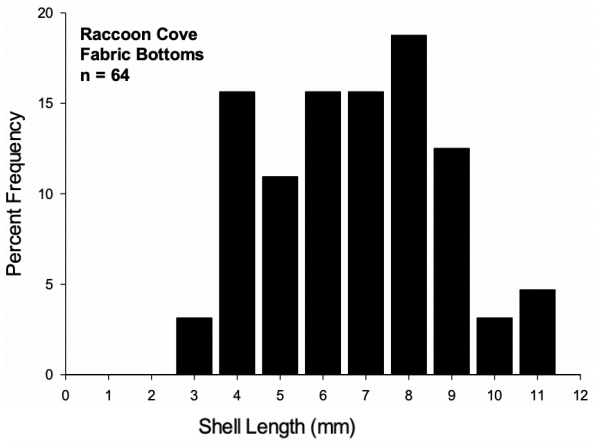


Appendix C: Recruit Growth Rates

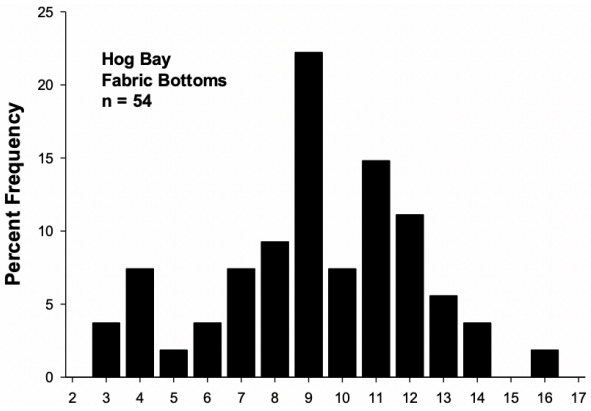
Downeast Region

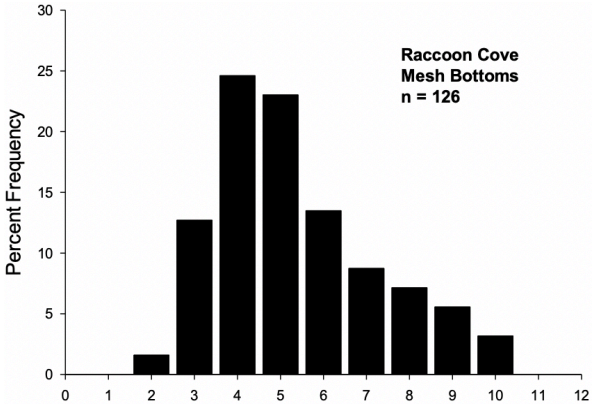
FRENCHMAN'S BAY

Raccoon Cove



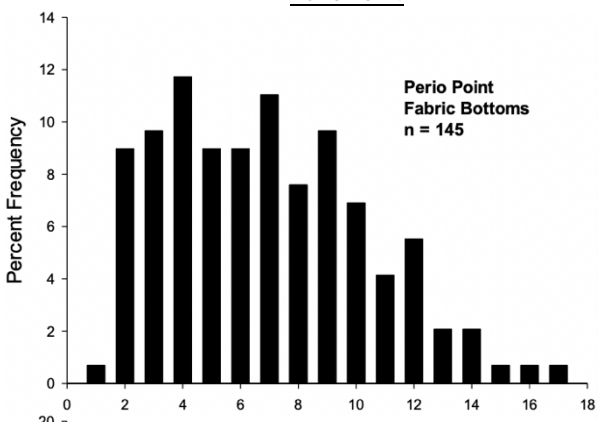
Hog Bay

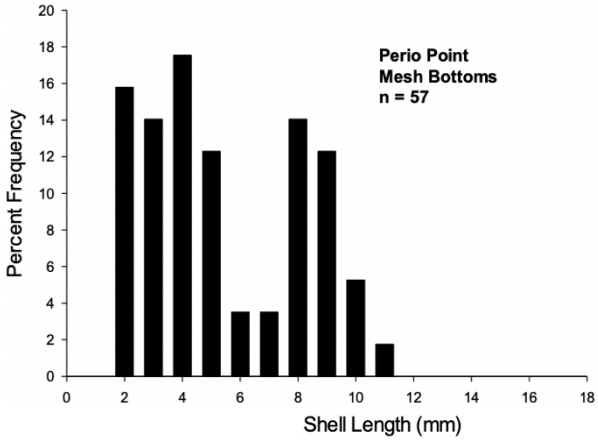




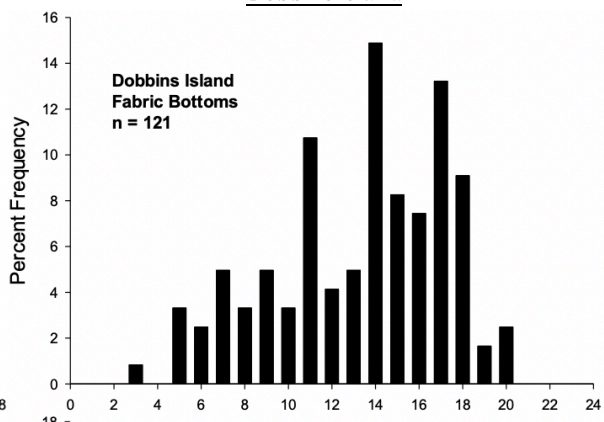
BEALS

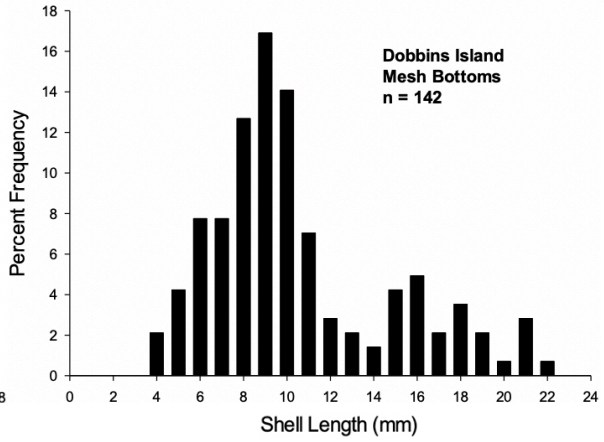
Perio Point





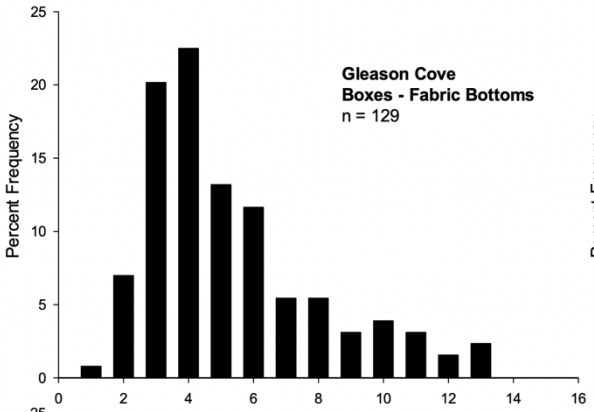
Dobbins Island

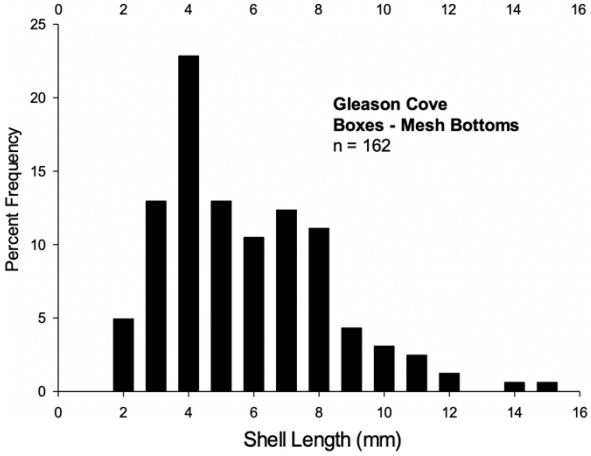




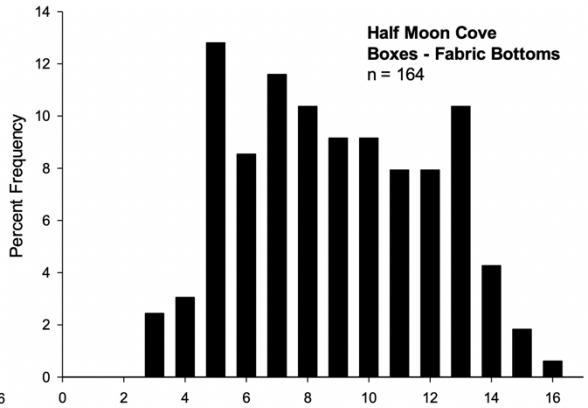
SIPAYIK

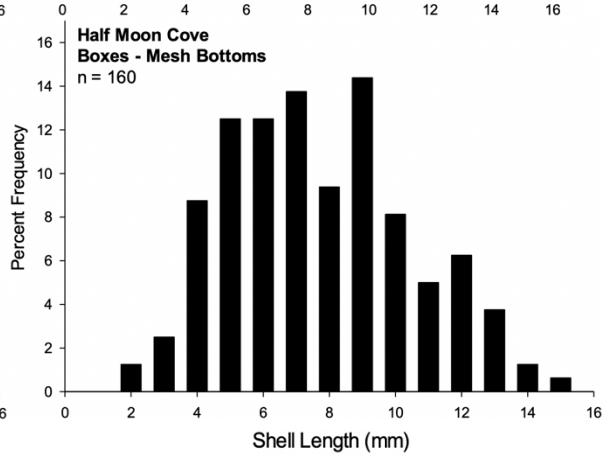
Gleason Cove





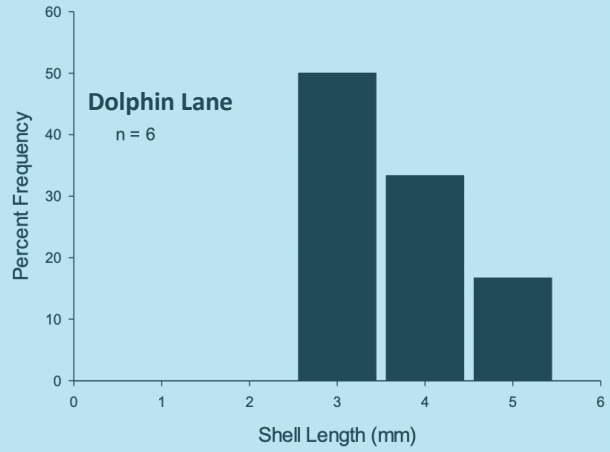
Half Moon Cove





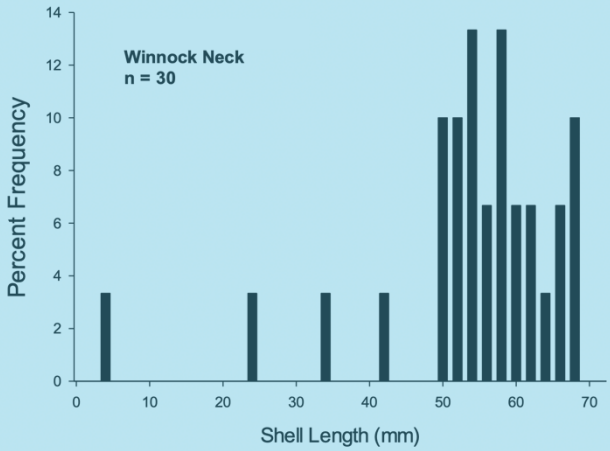
Appendix D: Size Range of Fall Survey Clams (Size-Frequency Distribution Graphs)

WELLS



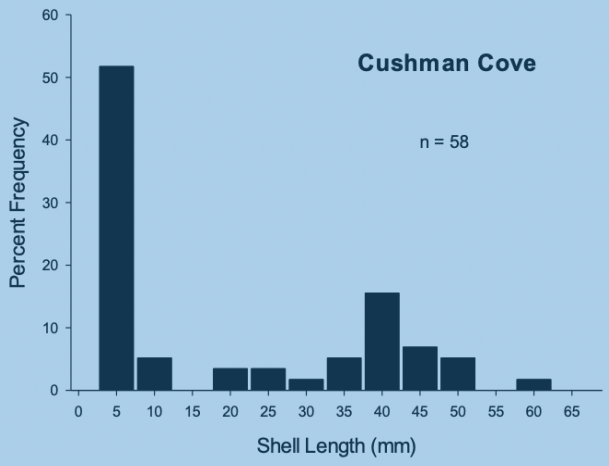
Clams were only found in the cores at Dolphin Lane. The graph shows their size-frequency distribution.

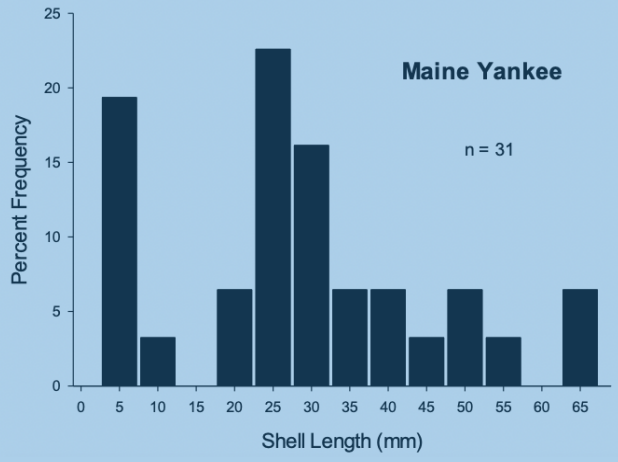
SCARBOROUGH



Clams were only found in the cores at Winnock Neck. Few recruits surviving from 2020, with most (> 75%) clams larger than the harvestable size of 2-inches (50 mm) in length.

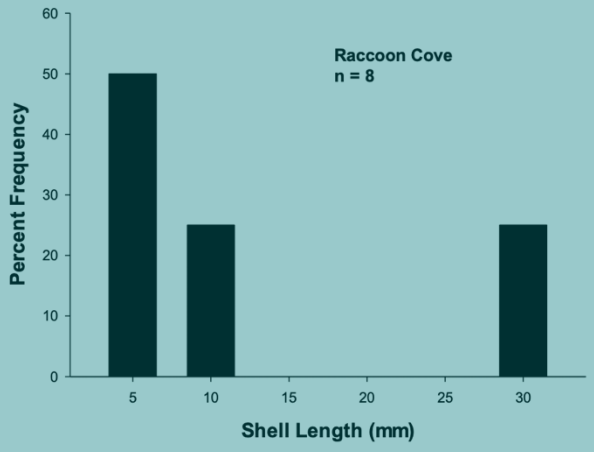
WISCASSET





The size range of clams from the fall core samples was similar to that in the spring. The majority (~ 65%) of clams at Cushman Cove were less than 1-inch (25.4 mm in shell length), suggesting a successful settlement event. Approximately 50% of clams sampled from cores at Maine Yankee were less than 1-inch.

FRENCHMAN'S BAY

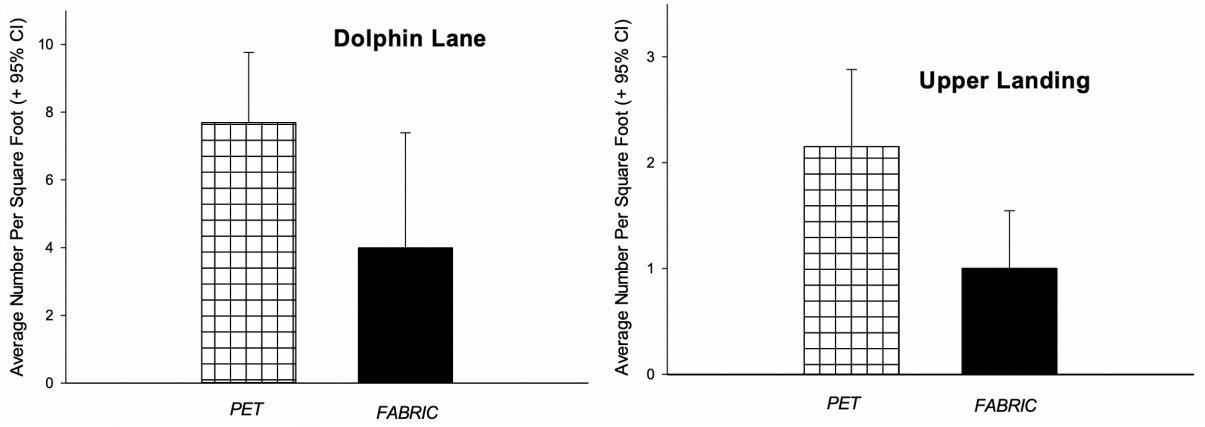


Clams were only found in the cores at Raccoon Cove. Clams ranged in length from 2.5-30.2 mm (< ⅛-inch to 1¼-inch).

Appendix E: Green Crab Density

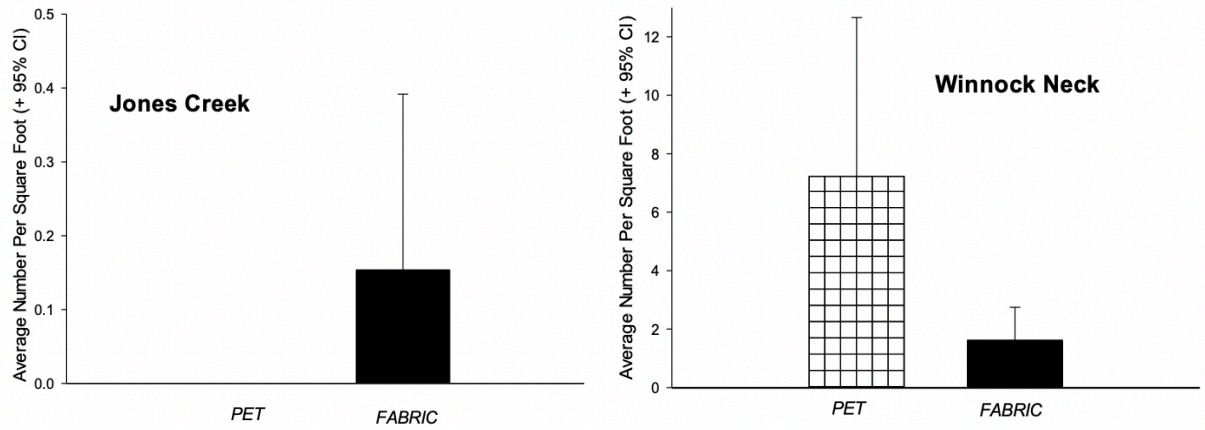
Southwest Region

WELLS



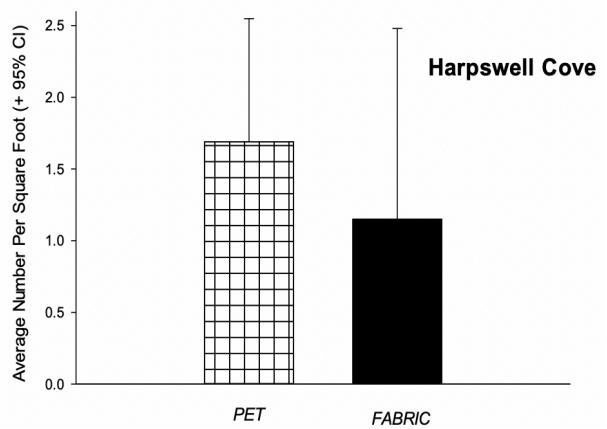
Significantly more green crabs were found in boxes with mesh bottoms at both locations.

SCARBOROUGH



Although it may appear so, green crab density did not vary significantly between the types of boxes at either location. However, significantly more green crabs were discovered at Winnock Neck than Jones Creek.

BRUNSWICK



Green crab density did not vary significantly between the types of boxes at Harpswell Cove. Density pooled across treatments was 1.4 individuals/ft^2.

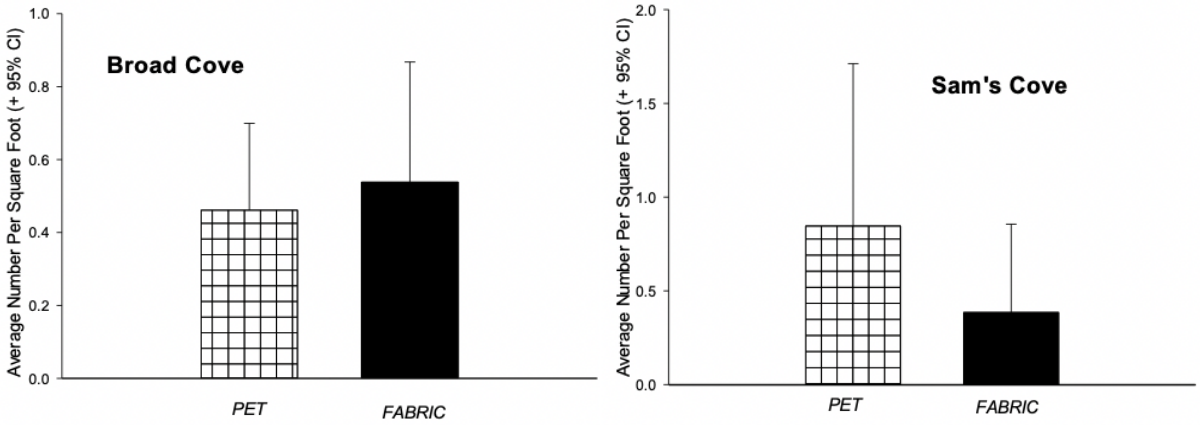
No green crabs were found in any boxes at Thomas Point.

Appendix E: Green Crab Density

Midcoast Region

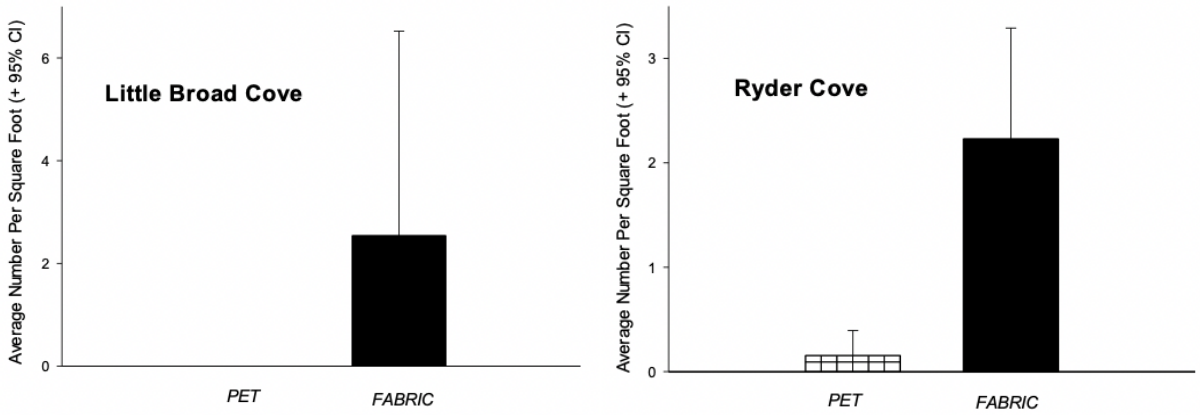
WISCASSET- No graph available

BREMEN



Average green crab density did not differ significantly between the two types of recruitment boxes at either site.

ISLESBORO



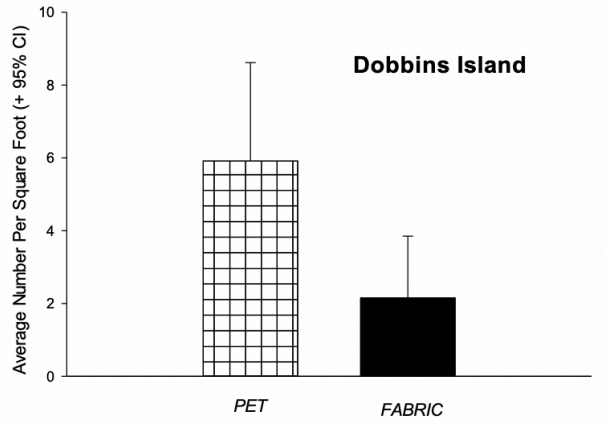
Similar to patterns observed with clams, more crabs were found in the fabric boxes. At Little Broad Cove all crabs were found in fabric bottom boxes, and about 94% of the crabs at Ryder Cove were found in the fabric boxes.

Appendix E: Green Crab Density

Downeast Region

FRENCHMAN'S BAY- No graph available. Crabs (n=4) only found at one site (Hog Bay).

BEALS



Approximately 2.75x more green crabs occurred in boxes with mesh vs. fabric bottoms. The two averages are significantly different.

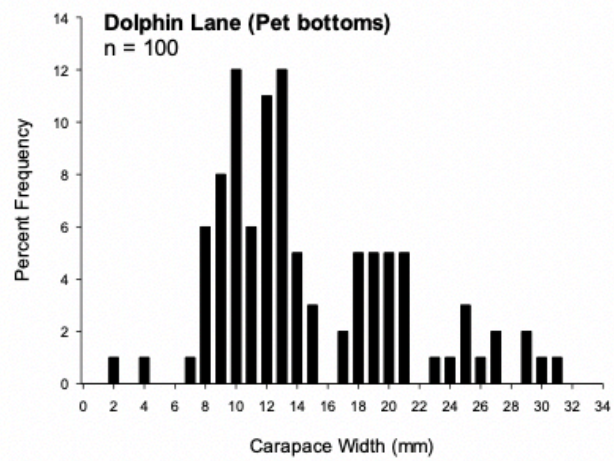
No green crabs were found in any boxes at Perio Point.

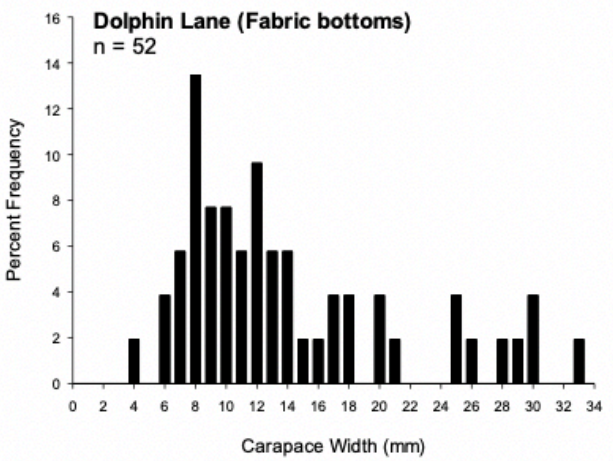
SIPAYIK- No graph available. Only 2 crabs found in boxes at Half Moon Cove, and 54 were found in Gleason Cove.

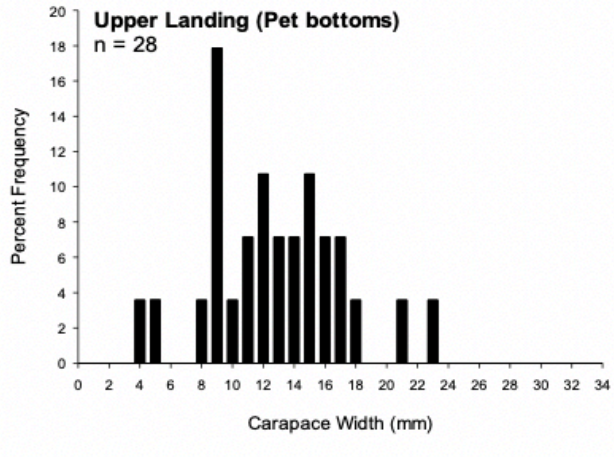
Appendix F: Green Crab Size Distribution Graphs

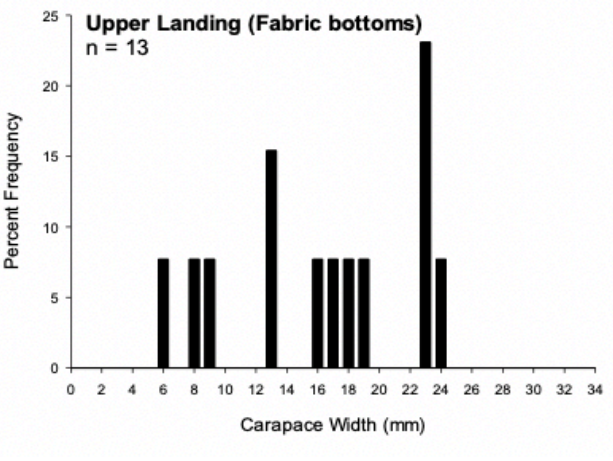
Southwest Region

WELLS

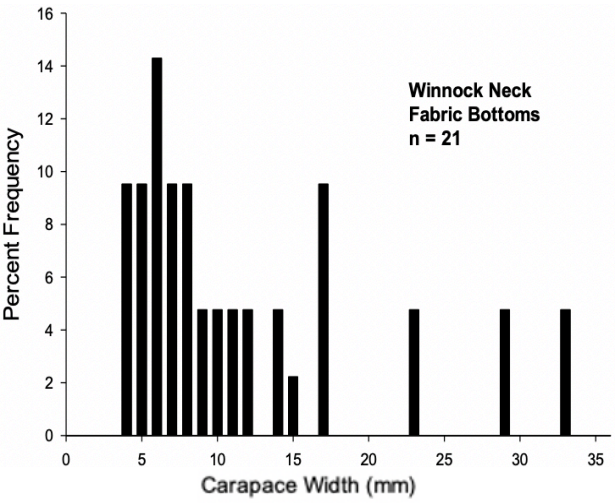


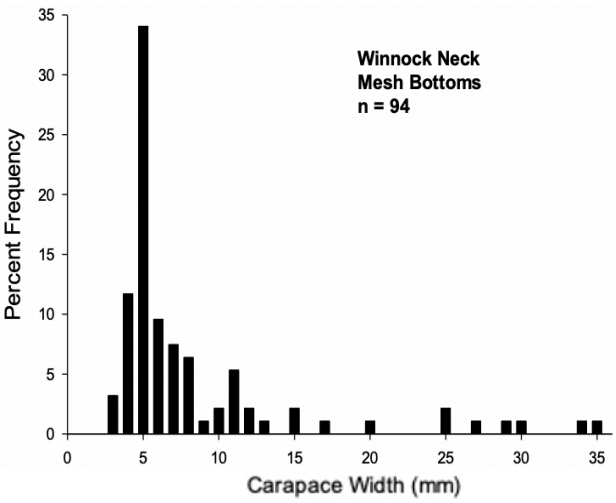






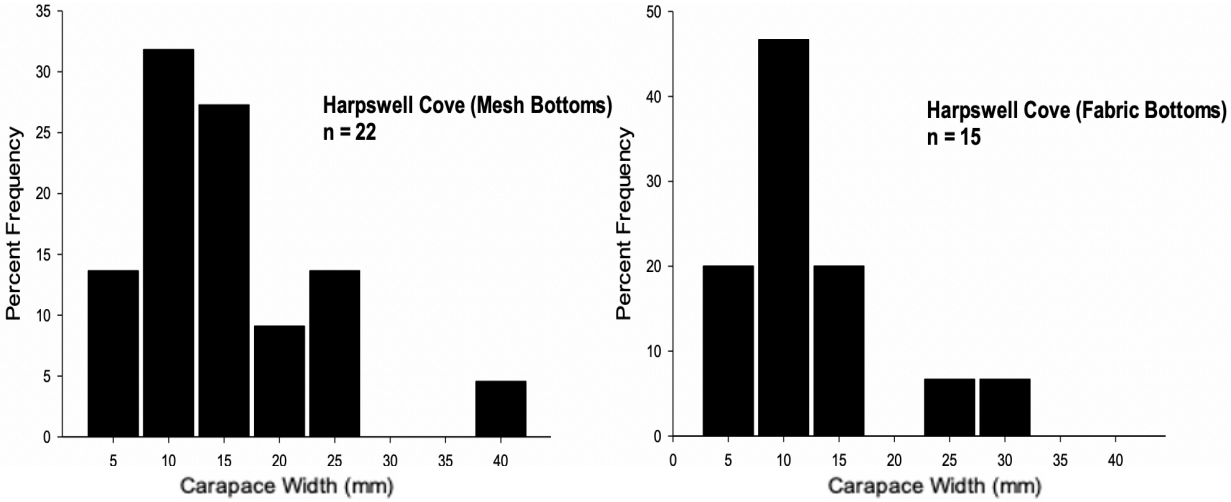
SCARBOROUGH





No crabs found at Jones Creek.

BRUNSWICK

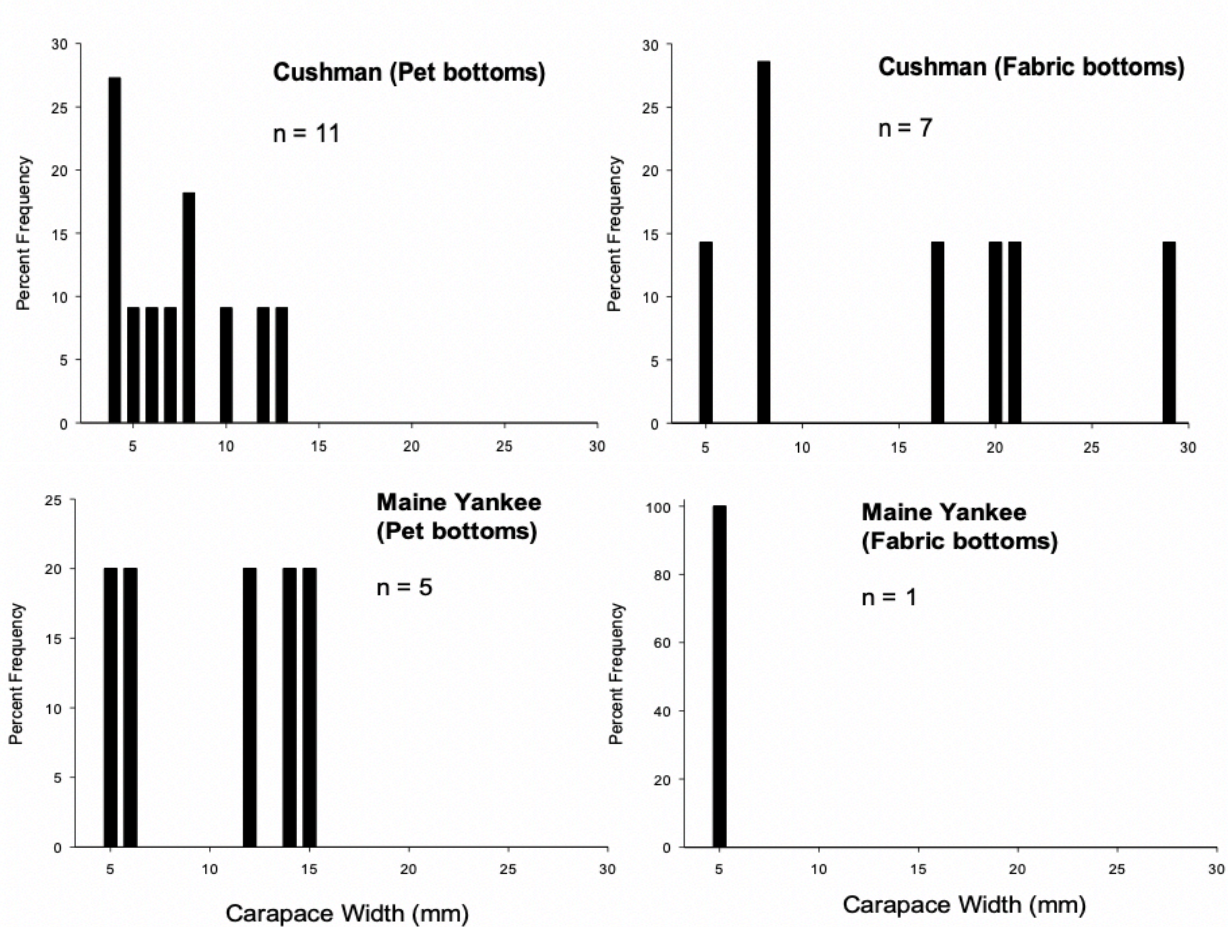


No crabs found at Thomas Point Beach.

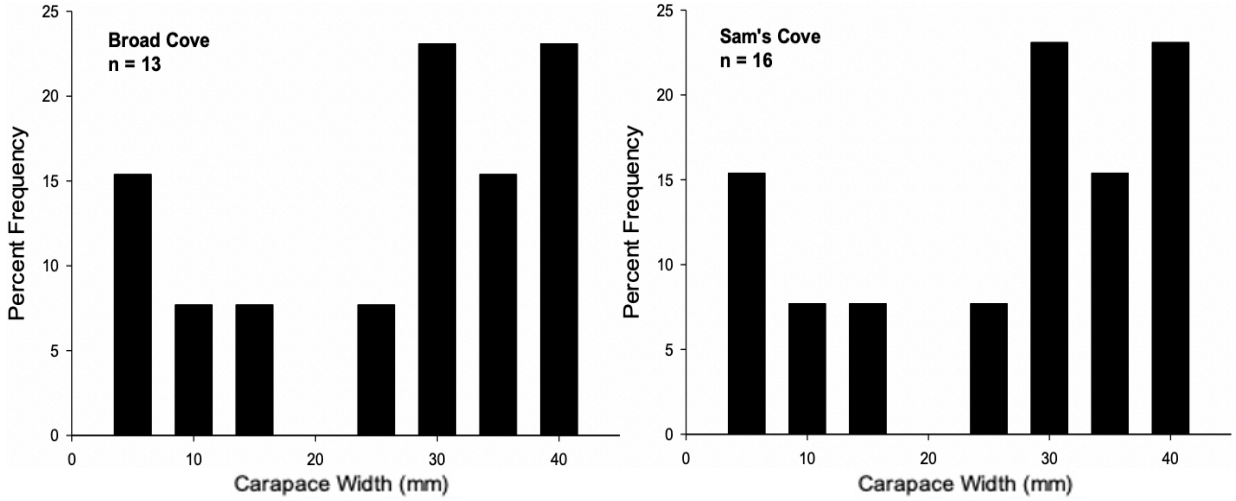
Appendix F: Green Crab Size Distribution Graphs

Midcoast Region

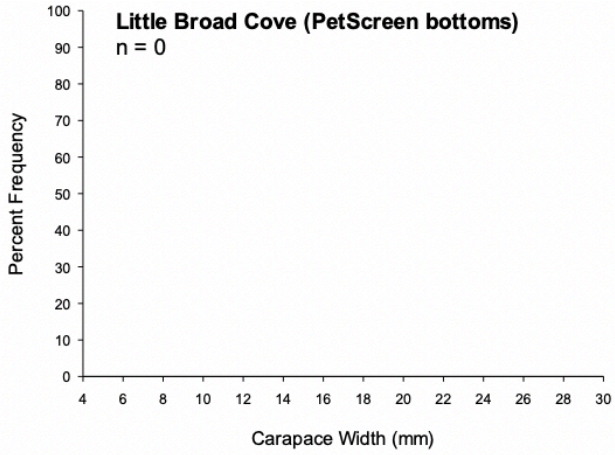
WISCASSET

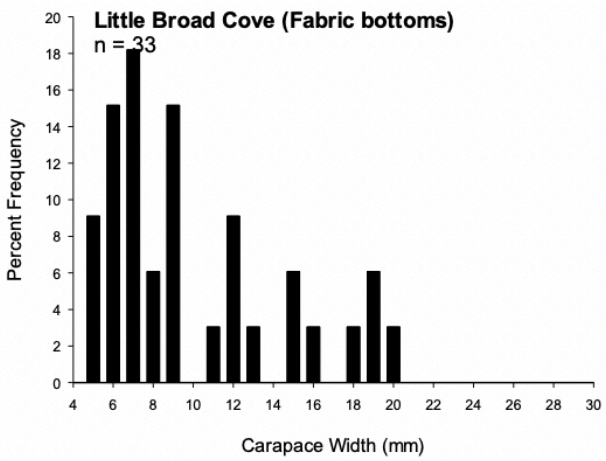


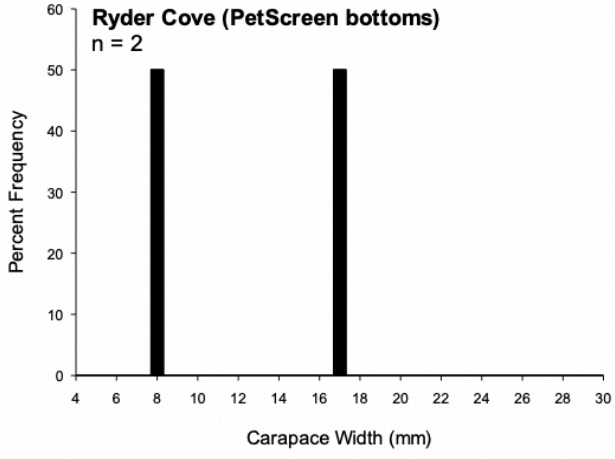
BREMEN

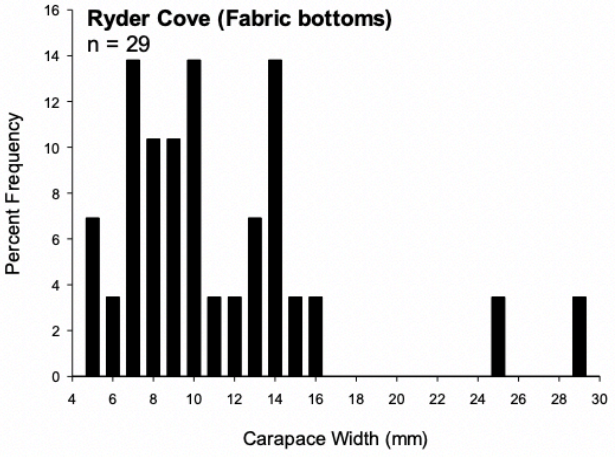


ISLESBORO


Little Broad Cove (PetScreen bottoms)
n = 0
Percent Frequency
Carapace Width (mm)


Little Broad Cove (Fabric bottoms)
n = 33
Percent Frequency
Carapace Width (mm)


Ryder Cove (PetScreen bottoms)
n = 2
Percent Frequency
Carapace Width (mm)

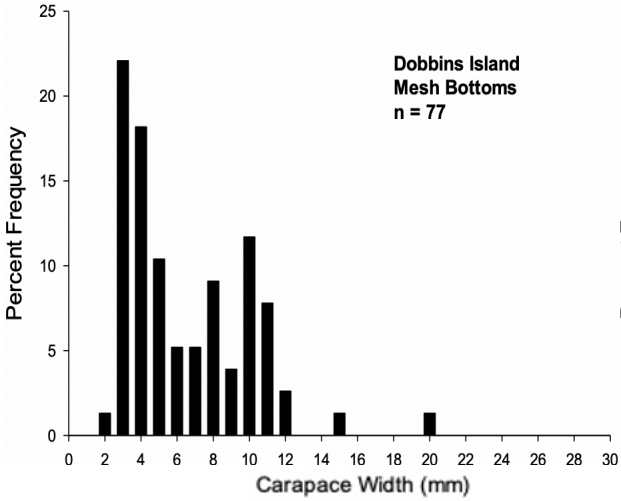

Ryder Cove (Fabric bottoms)
n = 29
Percent Frequency
Carapace Width (mm)

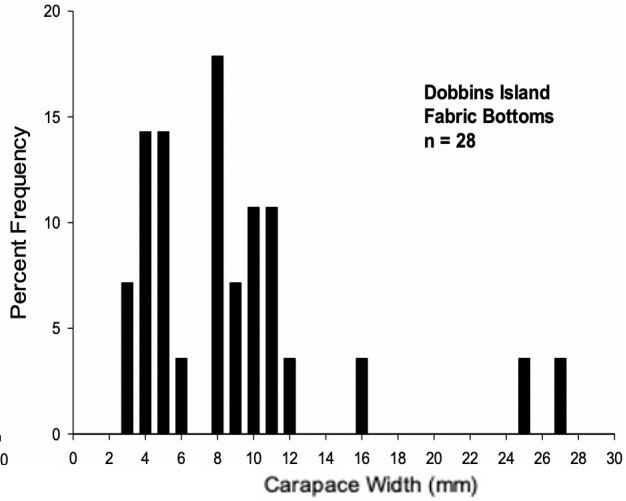
Appendix F: Green Crab Size Distribution Graphs

Downeast Region

FRENCHMAN'S BAY- No graphs available. Only 4 crabs were found at Hog Bay, and none at Raccoon Cove.

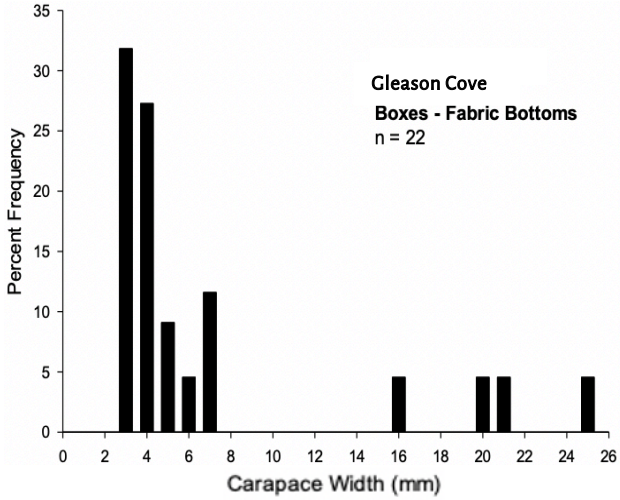
BEALS

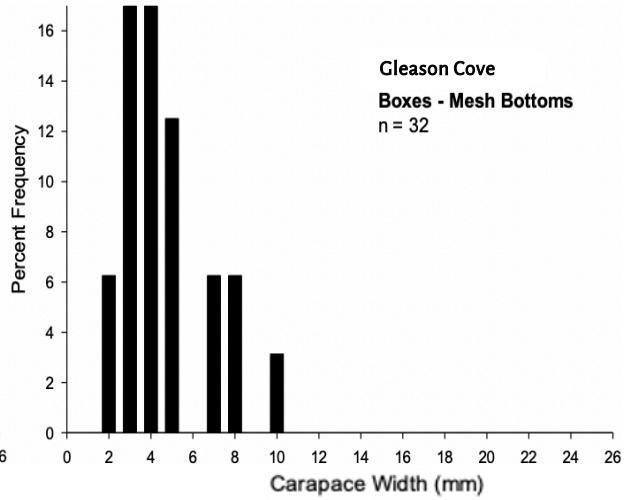




No crabs were found at Perio Point.

SIPAYIK





Appendix G: Green Crab Box Presence Charts
Southwest Region

WELLS

Dolphin Lane Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	14	9	6	18	1	1	1	2	**52**
Mesh	10	14	13	19	5	14	11	14	**100**
Totals	**24**	**23**	**19**	**37**	**6**	**15**	**12**	**16**	**152**

A total of 152 green crabs were discovered in boxes at Dolphin Lane. All 16 boxes contained green crabs: 100 within boxes with mesh bottoms and 52 in boxes with fabric bottoms.

Upper Landing Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	3	3	1	2	1	2	1	0	**13**
Mesh	4	3	4	1	3	3	4	6	**28**
Totals	**7**	**6**	**5**	**3**	**4**	**5**	**5**	**6**	**41**

A total of 41 crabs were discovered in boxes at Upper Landing. Most, 15 of the 16 boxes, contained green crabs: 28 occurred within boxes with mesh bottoms and 13 in boxes with fabric bottoms.

SCARBOROUGH

Jones Creek Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	1	0	0	0	0	1	0	0	**2**
Mesh	0	0	0	0	0	0	0	0	**0**
Totals	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**

A single green crab was discovered in two boxes with fabric bottoms at Jones Creek. No green crabs were found in boxes with mesh bottoms.

Winnock Neck Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	2	4	4	0	1	4	6	0	**21**
Mesh	3	2	28	24	13	2	4	18	**94**
Totals	**5**	**6**	**32**	**24**	**14**	**6**	**10**	**18**	**115**

A total of 115 green crabs were discovered in boxes at Winnock Neck. Most, 14 of the 16 boxes, contained green crabs: 21 within boxes with fabric bottoms and 94 in boxes with mesh bottoms. Four of the boxes with mesh bottoms contained more than a dozen green crabs each, and two of those had at least two dozen green crabs.

BRUNSWICK

Harpswell Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	0	1	1	6	0	6	0	1	**15**
Mesh	3	5	4	1	2	3	0	4	**22**
Totals	**3**	**6**	**5**	**7**	**2**	**9**	**0**	**5**	**37**

A total of 37 green crabs were discovered in boxes at Harpswell Cove. 12 of the 16 boxes contained green crabs: 15 within boxes with fabric bottoms and 22 in boxes with mesh bottoms.

Thomas Point: No green crabs were discovered in the 16 boxes at Thomas Point.

Appendix H- Green Crab Block Charts
Midcoast Region

WISCASSET: A total of 18 green crabs were discovered in boxes at Cushman Cove. 11 of the 16 boxes contained green crabs: four within boxes with mesh bottoms and seven in boxes with fabric bottoms. A total of 6 green crabs were discovered in boxes at Maine Yankee. Less than half, 5 of the 16 boxes, contained green crabs: one within a fabric bottom box and five in boxes with mesh bottoms.

BREMEN

Sam's Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	0	2	0	0	1	0	2	0	5
Mesh	0	0	3	0	0	1	4	3	11
Totals	0	2	3	0	1	1	6	3	16

A total of 16 green crabs were discovered in boxes at Sam's Cove. Roughly half, 7 of the 16 boxes, contained green crabs: five within boxes with fabric bottoms and 11 in boxes with mesh bottoms.

Broad Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	1	0	1	1	1	1	0	2	7
Mesh	1	1	1	1	1	1	0	0	6
Totals	2	1	2	2	2	2	0	2	13

A total of 13 green crabs were discovered in boxes at Broad Cove. 12 of the 16 boxes contained green crabs: seven within boxes with fabric bottoms and six in boxes with mesh bottoms.

ISLESBORO

Little Broad Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	2	0	0	2	23	0	3	3	33
Mesh	0	0	0	0	0	0	0	0	0
Totals	2	0	0	2	23	0	3	3	33

A total of 33 green crabs were discovered in boxes at Little Broad Cove. Less than half, 5 of the 16 boxes, contained green crabs. All boxes with green crabs had fabric bottoms.

Ryder Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	2	3	2	2	5	7	2	6	29
Mesh	0	1	0	0	0	0	1	0	2
Totals	2	4	2	2	5	7	3	6	31

A total of 31 green crabs were discovered in boxes at Ryder Cove. All eight boxes with fabric bottoms contained crabs, whereas only two crabs were discovered in boxes with mesh bottoms.

Appendix H- Green Crab Block Charts
Downeast Region

FRENCHMAN'S BAY

Raccoon Cove: No green crabs were discovered in the 16 boxes at Raccoon Cove.

Hog Bay Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	0	1	0	0	0	0	0	1	**2**
Mesh	0	0	0	1	1	0	0	0	**2**
Totals	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**4**

Green crabs were observed only at Hog Bay, and only in 4 of the 16 recruitment boxes: two within boxes with mesh bottoms and two in boxes with fabric bottoms.

BEALS

Dobbin's Island Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	1	2	10	4	0	2	7	2	**28**
Mesh	5	12	17	9	10	16	2	6	**77**
Totals	**6**	**14**	**27**	**13**	**10**	**18**	**9**	**8**	**105**

A total of 105 green crabs were discovered in boxes at Dobbin's Island. Green crabs were found in all but one box: 28 within boxes with fabric bottoms and 77 in boxes with mesh bottoms.

Perio Point: No green crabs were observed in the 16 boxes at Perio Point.

SIPAYIK

Gleason Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	0	0	2	3	11	3	3	0	**22**
Mesh	6	13	2	2	0	1	6	2	**32**
Totals	**6**	**13**	**4**	**5**	**11**	**4**	**9**	**2**	**54**

A total of 54 green crabs were observed in boxes at Gleason Cove. 12 of the 16 boxes contained green crabs: 22 within boxes with fabric bottoms and 32 in boxes with mesh bottoms.

Half Moon Cove Block

Treatment	I	II	III	IV	V	VI	VII	VIII	Total
Fabric	1	1	0	0	0	0	0	0	**2**
Mesh	0	0	0	0	0	0	0	0	**0**
Totals	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**

Only two crabs were observed in boxes at Half Moon Cove. Both were in boxes with fabric bottoms.