St. George River / Weskeag River Field Trials (2017)

Soft-shell clam recruitment study
Life cycle of the Soft-shell clam, *Mya arenaria*
Greg’s
Neil’s
Vivian’s
# CORE SAMPLES

<table>
<thead>
<tr>
<th>Site</th>
<th>Tidal Height</th>
<th>16 June 2017 (n = 5)</th>
<th>13 Oct 2017 (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greg’s</td>
<td>Upper</td>
<td>0.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Neil’s</td>
<td>Upper</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>GRLT</td>
<td>Upper</td>
<td>4.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Mid</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>GRLT</td>
<td>Low</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Vivian’s</td>
<td>Upper</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
80% of clams in the cores are less than ¼-inch

June 2017
100% of clams in the cores are less than ¼-inch

October 2017

1/4-inch
1/2-inch
GRLT - Upper
Greg’s - Upper
Greg’s Box #4
Greg’s Box #4 = 12 clams
1,608 clams
1,655 clams
<table>
<thead>
<tr>
<th></th>
<th>Greg - Upper</th>
<th>Neil - Upper</th>
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<th>GRLT - Mid</th>
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<th>Vivan’s - Upper</th>
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<tbody>
<tr>
<td>BOX 1</td>
<td>42</td>
<td>1655</td>
<td>0</td>
<td>0</td>
<td>861</td>
<td>6</td>
</tr>
<tr>
<td>BOX 2</td>
<td>20</td>
<td>6</td>
<td>0</td>
<td>0</td>
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<tr>
<td>BOX 3</td>
<td>35</td>
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<td>10</td>
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<tr>
<td>BOX 5</td>
<td>58</td>
<td>7</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Avg/Box</td>
<td>33.4</td>
<td>450.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1400.0</td>
<td>6.8</td>
</tr>
<tr>
<td>Avg/ft²</td>
<td>20.7</td>
<td>278.7</td>
<td>0.0</td>
<td>0.0</td>
<td>867.1</td>
<td>4.2</td>
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Log (Clam Abundance per Box) + 95% CI

- Greg's: 33.4
- Neil's: 450.0
- GRLT - Low: 1400.0
- Vivian's: 4.2
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<tr>
<th>Site</th>
<th>Tidal Height</th>
<th>CORES AVG # clams/ft²</th>
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Shell Length (mm)

- **Greg’s**
  - ¼-inch: 14
  - ½-inch: 12
  - n = 92

- **Neil’s**
  - n = 53

- **GRLT - Low**
  - n = 100

- **Vivian’s**
  - n = 34

- **Vivian’s**
  - n = 34

- **GRLT - Low**
  - n = 100

- **General**
  - n = 34

### Frequency
- **Percent Frequency**
  - n = 34
  - n = 100
  - n = 53
  - n = 92
Average Shell Length (mm) (+ 95% CI)

- Greg's
- Neil's
- GRLT - Low
- Vivian's

1/2-inch

1/4-inch
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What can explain the high variability in wild clam abundance from box-to-box at Neil’s, Greg’s, and GRLT-Low?
<table>
<thead>
<tr>
<th>Event</th>
<th>Details</th>
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<tbody>
<tr>
<td>Copulation</td>
<td>Peaks in August</td>
</tr>
<tr>
<td>Egg masses appear</td>
<td>July to November</td>
</tr>
<tr>
<td>Eggs released</td>
<td>May to June</td>
</tr>
<tr>
<td>Larvae in plankton</td>
<td>50-82 days</td>
</tr>
<tr>
<td>Larvae settle</td>
<td>Peaks in Aug-Oct.</td>
</tr>
<tr>
<td>Size (first winter)</td>
<td>1-10 mm CW</td>
</tr>
<tr>
<td>Size (second winter)</td>
<td>13-30 mm CW</td>
</tr>
<tr>
<td>Maximum size</td>
<td>86 mm ♂; 80 mm ♀</td>
</tr>
<tr>
<td>Size at first mating</td>
<td>35-45 mm CW</td>
</tr>
<tr>
<td>Age at first mating</td>
<td>2-3 yrs</td>
</tr>
<tr>
<td>Life span</td>
<td>5-6 yrs</td>
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Berrill 1982
Klassen and Locke 2007
http://www.arkive.org
Zoeal Stages I - IV

Zoea Stage II
CL = 0.67 mm

Zoea Stage III
CL = 0.82 mm

Zoea Stage IV
CL = 1.06 mm

Rice & Ingle 1975
Crab Biomass in a Clam Recruitment Box

<table>
<thead>
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<th>Low</th>
<th>High</th>
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<td></td>
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Crab Biomass in a Clam Recruitment Box

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Crab Biomass in a Clam Recruitment Box

Number of Clams Per Recruitment Box

Low  High

Low

High

Crab Biomass in a Clam Recruitment Box
Crab Biomass in a Clam Recruitment Box

Number of Clams Per Recruitment Box

Low | High
---|---
Low | Few clams at high crab biomass
High | Many clams at low crab biomass
Neil’s Site

Graph 1: Relationship between Crab Biomass and Clam Abundance
- Crab Biomass on the x-axis
- Clam Abundance on the y-axis
- Data points showing a negative correlation

Graph 2: Distribution of Crab Size (mm)
- Crab Size (mm) on the x-axis
- Percent Frequency on the y-axis
- Bar graph with percent frequency for different crab size intervals
- n = 21

Legend:
- Crab Biomass
- Clam Abundance
- Crab Size (mm)
- Percent Frequency
GRLT – Low tide site

**Graph 1:**
- **X-axis:** Crab Biomass
- **Y-axis:** Clam Abundance
- Data points show a negative correlation between crab biomass and clam abundance.

**Graph 2:**
- **X-axis:** Crab Size (mm)
- **Y-axis:** Percent Frequency
- Bar chart indicates the distribution of crab sizes with a frequency peak at 15 mm.
- *n = 48*
Vivian’s Site

![Graphs showing relationships between crab biomass and clam abundance, and crab size distribution.]

- **Graph 1:** Scatter plot showing crab biomass on the x-axis and clam abundance on the y-axis. The data points are plotted with a trend line.
- **Graph 2:** Bar graph showing the percent frequency of crab sizes ranging from 0 to 35 mm. The data has a mode at 10 mm, with a frequency of 60%.

- **Note:** The sample size (n) for both graphs is 25.
Median Green Crab Sizes Across All Sites

Size of Green Crabs (mm)

- Greg's
- Neil's
- GRLT Upper
- GRLT Mid
- GRLT Low
- Vivian's

Median green crab sizes across all sites.
CONCLUSIONS

• In the upper part of the St. George River, soft-shell clam populations are not limited by the lack of clam post-larvae that settle onto intertidal flats. There’s plenty of clam larvae in the water column over a mudflat at high tide;

• At sites where average clam abundance was relatively high (Neil’s & GRLT - low), variability in juvenile clam numbers between boxes was quite high;
CONCLUSIONS

• As many as 2,296 clams occurred in one box (GRLT – Low). This is 1,422 clams/ft$^2$;

• No clam juveniles were found in boxes at two sites (GRLT – Upper & Mid). For sites with clams, the GRLT – Low site had the highest average # (867/ft$^2$), and Vivian’s the lowest (3/ft$^2$);

• Clams in boxes ranged from 1.9 mm to 21.3 mm ($\approx 1/12^{th}$ to $3/4^{th}$ inches);
CONCLUSIONS

• For sites where average clam abundance was greater than zero, there was, in most cases, a negative relationship between the number of clams and the biomass of green crabs in a box;

• Green crabs settled into boxes at every site, and ranged in size from 3.3 mm to 37.3 mm; and,

• Green crabs are likely responsible for a large percentage of clam mortality in the Upper St. George River.
How unique were results from the Upper St. George River?

19 May to 12 October (146 days)
19 May to 12 October (146 days)
Nearly 2-3x more clams recruited to boxes at the Stockton Springs site than the other two sites.
SUMMARY

• The data we’ve been collecting over the past 5-6 years points to predation as the number ONE cause of clam declines along the Maine coast;

• The declines are not due to too few clam larvae in the water column, pollution, over-fishing, ocean acidification, green slime, wormers, or disease;

• Clam recruitment boxes placed in the intertidal zone in Freeport, St. George River, Searsport, Bagaduce River, and Machiasport show similar results – Clams are generally abundant in boxes that deter predators, but are uncommon in adjacent mudflats;
WHAT'S NEXT?
May 25, 2017
Thank You!

Thanks to those who participated in the work:

Neil Krane
Vivian Newman
Greg Hamlin
Annette Naegel
Anita Siegenthaler
Ben Ellis

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University of Maine at Machias