Clams in Crisis:

Field Research Tells Us Why and Shows Us How to Adapt

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Food History of Clams

- Food history changes with abundance.
- Major source of food for Native Americans.
- Important for colonists: 1641 Massachusetts Bay Colony Ordinance gave rights of fishing, fowling and navigation in the intertidal to all residents.
- When Maine became a state one of the first laws established the rights of Maine citizens to harvest in the intertidal.
- Developed a stigma as "poor farm" fishery, but clams emerged as a common source of food by mid 1850s.
- Commercial fishery developed in 1850, and clams were salted for bait for Grand Banks cod fishermen (indicating many clams).
- After 1875, offshore cod fishermen switched to fresh bait, and the salt clam market dried up. Over time demand for clams as a staple protein emerged- steamed clams in the shell and summer clambakes became popular.
- Demand for canned clams- Cannery Era: 1900 to 1940 canneries processed most of the clams caught in Maine (high abundance, found neew ways to process to keep market going)

Photo credit: Scarborough Historical Society

1950s= decline in clams due to warm period.
Food history changes with availability.
1960s- on: Fried Clam & Tourist Market.
Demand is highest during summer season.
Less and less Mainers can afford to eat clams because the price is so high.
Now a rich man's food!

Soft-Shell Clams are an important and iconic Maine Food

- Local food source
- Clambakes, Clam Shacks
- Lean source of protein
- Rich in minerals & vitamins:

  iron, vitamin C, B12, omega 3 fatty acids

- One of last wild foods

Socio- Economic importance of the clam fishery

- Suited to social & ecological context of ME as in most ME communities labor & resources are abundant relative to capital. Hand harvesting rules make it Equitable and allows more people to be employed.
- Hunter gatherers have a higher quality of life (as long as they have animals to hunt).
- Equity of Access because of low capital investment, which is important because more and more wealth is concentrated into fewer and fewer hands, and less of us have access to capital.
- Increased community prosperity from small businesses:
  - More money into stays in circulation locally (residency requirement)

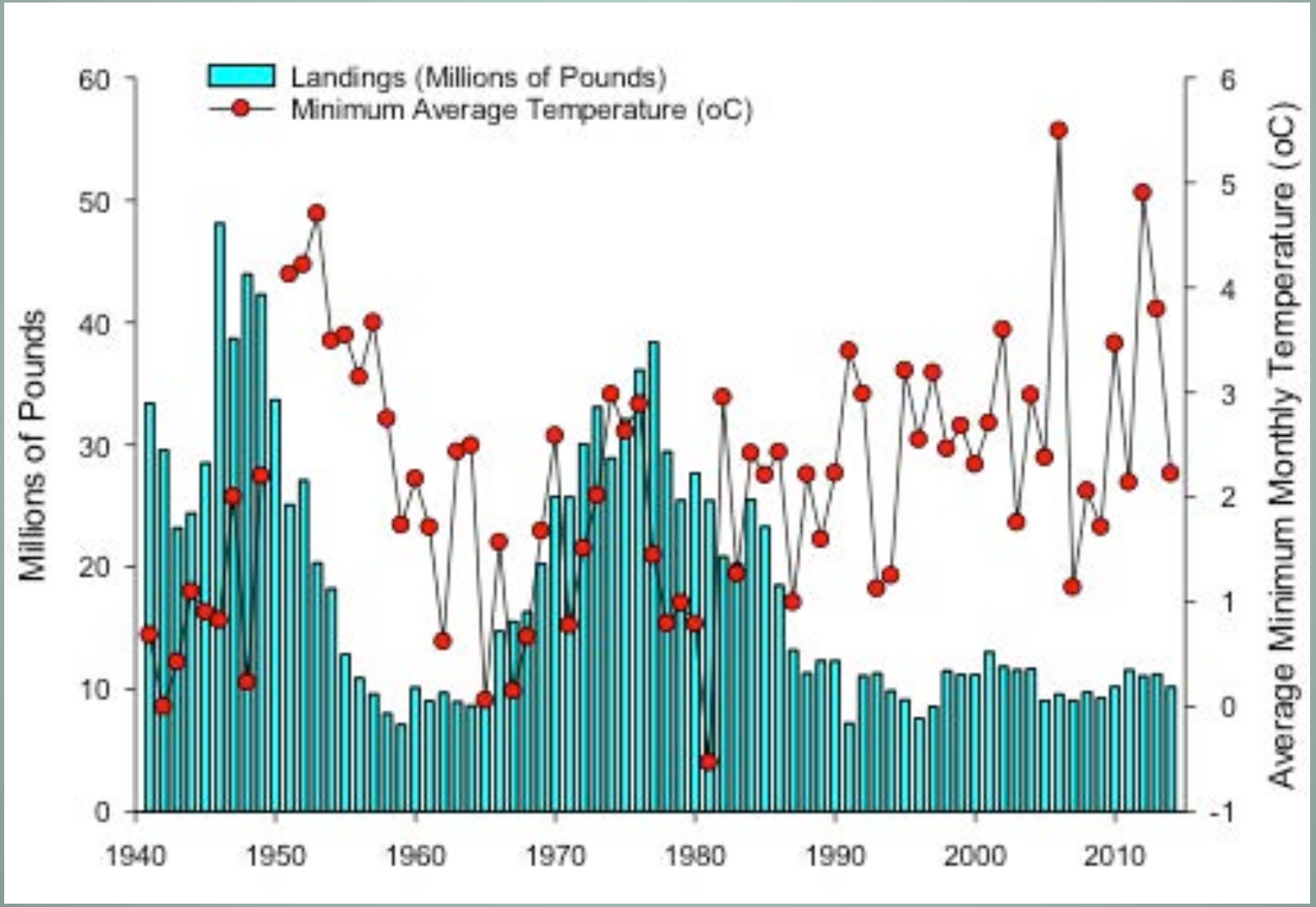
Climate Change is driving changes in availability of shellfish

- Clams are in crisis due to rising water temperatures and associated increased predation.

Invasive Green Crabs

- 1950's Biologists noticed proliferation of green crabs and lessened populations of clams.
- Early 2010's Maine Clammers Association sounded the alarm about rising crab populations.
- Clams now found primarily in high intertidal areas (areas with reduced predation)

Rising Ocean Temperatures are leading to increased predation



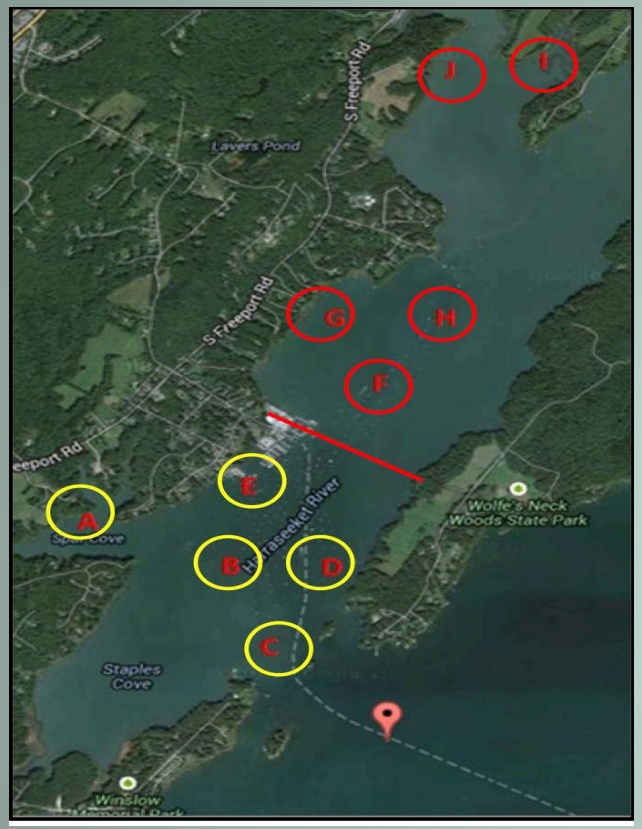
Finding solutions: Purpose of Freeport Clam Field Experiments

- Identify causes of steep declines in shellfish populations.
- To examine the effectiveness of different methods to protect shellfish from green crabs and other predators, that can be used by fishermen to reverse the decline.
- <u>APPLIED</u>: focused on ways to improve and sustain the commercial fishery.
- Large-scale! Often times bigger then most aquaculture farms.

Field Experiments

	2014	2015	2016
1	Green Crab Trapping -10 sites in Harraseeket, subtidal & intertidal	Green Crab Trapping- same sites as previous year	Bioremediation for MR Worms-1 site, 80 4-ft x 2.5-ft x 6-inch deep boxes
2	Predator Deterrent Fencing- 1 site, 28 plots, 14 fenced in.	Harraseeket Predator Deterrent Netting & Recruitment Boxes- 20 sites, 6 boxes, 4 nets @ each.	Harraseeket Recruitment Boxes- 20 sites, 14 boxes @ each tidal height.
3	Clam Enhancement w/ Cultured Seed & Netting- 2 coves, 40 14-ft x 22-ft nets.	Protective Boxes- 30 boxes @ 5 different coves	Protective Boxes- 3 coves, 45 boxes each
4	Sediment Buffering for OA 1 site, 30 plots w/different amount of buffering, ½ netted. Small-scale: 80 plant pots.	Sediment Buffering for OA- 2 sites, large and small-scale experiments, 30 plots, 80 plant pots @ each.	Sediment Buffering for OA- 2 coves, 120 plant pots @each. 12 different treatments.
5	Adult Clams (under nets) to enhance recruitment- 2 sites, each w/ 30 10ft x 10ft plots.	Protection of planted wild seed- 1 cove, 2 tidal heights 71 boxes of different sizes	Clam Impoundments- 2 coves, 30 clam cages @ each
6	Growing clams in an upweller-1 million clams.	Growing clams in 2 upwellers- 2 million clams.	Reducing mud snail eggs laid on predator deterrent netting -2 coves, 40 14 ft x 14ft nets

2014 & 2015: Systematic Green Crab Trapping



- 10 intertidal & subtidal sites
- 50-60 traps fished per trip
- weighed and measured crabs
- Looked at: crab abundance, sex ratio, diet, size- frequency, % of egg-bearing females

Findings:

- Green crabs have not gone away, they are in high densities.
- Crabs were smaller in 2014 than in 2013 Warmer winter in 2013).
- Even at small sizes green crabs have the ability to reduce clam populations.
- #s increased as water warmed through the summer and into the fall, especially in the intertidal.

Management: It does not appear to be possible to reduce crab populations locally through trapping. We need to adapt management methods to the high populations of green crabs and predation.

2014: Predator Exclusion Fencing

28 30 x 30ft plots,
14 plots fenced in

Findings:

- Fencing has no more ability to reduce/deter green crabs (and other predators) than netting alone.
- Mud snails are a problem.

Management: Fencing is not recommended, especially when factoring in labor costs.

2014, 2015, 2016: Ocean Acidification studies

2014 (1 site) & **2015** (2 sites)
Large-scale: 30 10ftx 10ft plots- 6 treatments replicated 5x w/ different amounts of buffering agent (crushed shells), netting, and controls.
Small-scale: 1 site, 80 plant pots (8 treatments replicated 10xs)

2016: (2 sites) w/120 pots- 12 treatments replicated 10xs

Findings:
- Large-scale: at none of the three sites did the presence of crushed shell result in a significant enhancement of wild soft-shell clam recruits.
- Small-scale: There was a significant enhancement of 0-year class individuals in the netted treatments compared to treatments without netting.

Management: Ocean acidification is not a significant source of shellfish mortality at this time. Currently, there is no need to spread crushed shell onto the surface of intertidal plots to encourage clams to settle and recruit.

Lots of different experiments protecting clams under netting

2015 & 2016: Growth/Survival of Clams in Protective Boxes

2015: 6 sites, 221 boxes
2016: 3 sites, 135 boxes (4-ft long x 2.5-ft wide x 6-inches deep)

Findings: Predation is the #1 threat to shellfish populations.

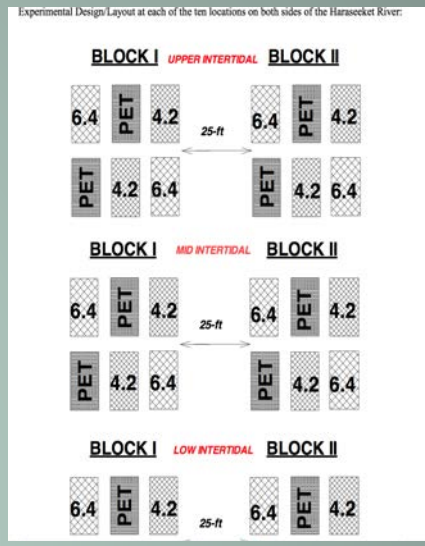
- Green crabs have not "gone away"
- Milky ribbon worm densities are high.

Combined these predators pose serious impediments to wild and cultured clam populations.

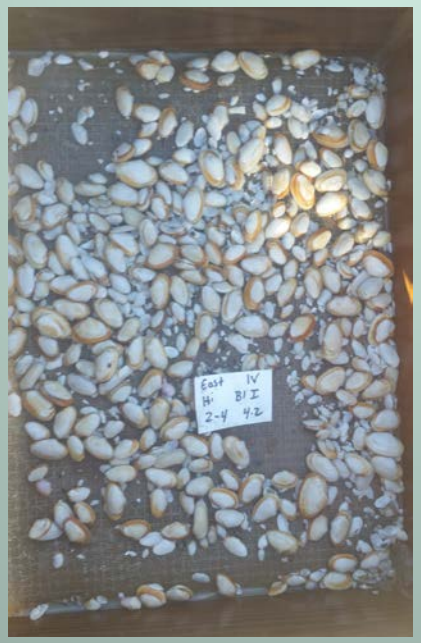
Management: Site selection for enhancement or clam farming cannot be a random decision. Again, management methods need to adapt to account for high levels of predation.

2015 & 2016: Recruitment boxes

2015: 120 boxes at 20 locations
2016: 840 boxes @ 20 locations @ all tidal heights



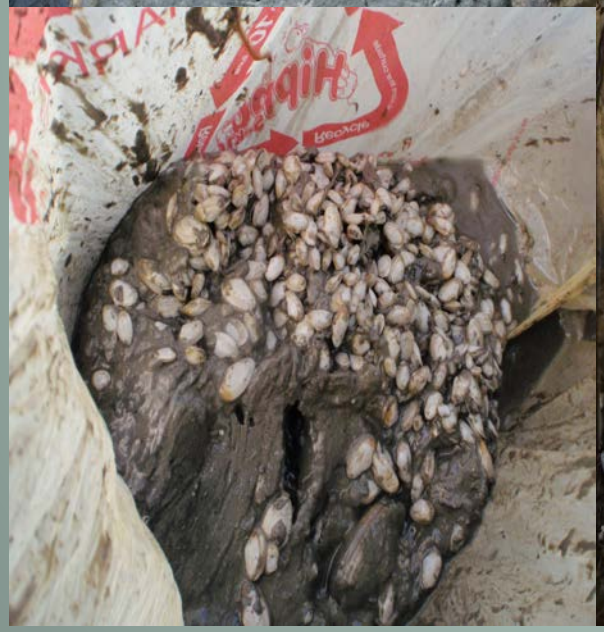
Findings: Areas with few commercial size or juvenile clams may actually be tremendously productive. They may have tons of settling clams on them, clams are just not surviving due to high levels of predation.



Management:

1) Rethink the terms “productive” & “dead mud”.
2) Limiting effects of predation on small clams by protecting them may be a strategy to increase clam abundance.
3) Recruitment boxes could be used as a tool to learn about the production of a particular flat.

Lots of clams in protective recruitment boxes, none in unprotected areas beside the boxes.



2014 & 2015: Clammers growing clams in an upweller

2014: 1 upweller, 1 million clams

2015: 2 upwellers, 2 million clams

Findings:

- Upweller clams grew very fast in the first 2 months (average growth of ca. 11 mm in 39 days in 2014.)
- High maintenance: requires a lot of cleaning (every other day),heavy barrels, and lots of fouling from tunicates, mussels, etc.

Recommendation: Given the investments of labor and time required to grow clams in an upweller, Municipal Shellfish Programs that do so would be wise to protect their investment by protecting clams when they are transplanted to the mud.

A lot of effort to deploy, maintain, collect and process data

A lot of DATA and INFORMATION to sustain fishery

Top Significant Findings (so far)

1. It does not appear to be possible to reduce green crab populations locally with trapping. Can't protect clams by trapping clams.
2. Green crabs can grow very fast, numbers increase in warming waters.
3. A large amount of clams are settling in certain areas, but these clams are not surviving to commercial sizes.
4. Currently, it is predation, not ocean acidification, that is the most important factor impacting clam survival.
5. Milky ribbon worms, *Cerebratulus lacteus,* are also having a major negative impact on clam populations and these clams tend to prefer to eat larger clams (rather than small seed clams).

Clam Protection Methods:

6. Green Crab Exclusionary Fencing is not the best choice for predator exclusion.
7. Flexible netting is a promising clam protection tool, but it will work best in areas where there are low milky ribbon worm populations.
8. Clam boxes are a better method to protect planted clams from both milky ribbon worms and green crabs.

Safeguarding the Future of Clams in ME

- **Maine's waters are among the fastest warming in the world and are predicted to continue to warm.**
- **Green crabs thrive in these warmer waters.**
- **Warmer waters mean more and more predation.**
- **Green crabs are a permanent part of the marine system in Maine.**
- **We must must focus on adapting to their presence and impact.**

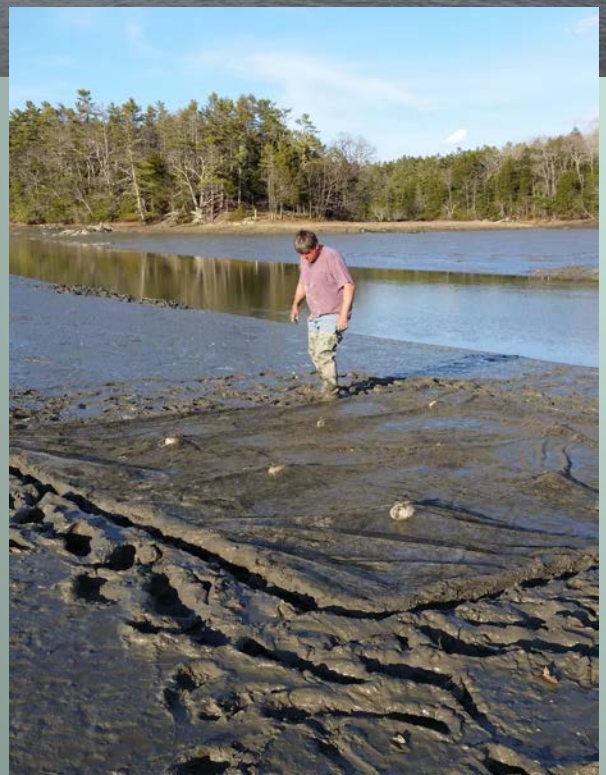
It's All About Adaptive Shellfish Management!

1) Moving forward, we will need to expect and work around high levels of green crabs and predators.

2) To ensure the future viability of the clam fishery it will be necessary to update and innovate commonly used shellfish management tools. For example, municipal Shellfish Programs will need to expand from a passive enforcement-only approach to a more directed, ecology-based active management approach.

3) Large-scale clam protection projects should be swiftly implemented.

Research continues into 2017



Summary

- Clams are in crisis due to increased predation caused by warming waters.
- To sustain commercial soft-shell clam production we are going to need to adapt to rising levels of predation and implement large-scale clam protection methods.
- The Freeport Clam Experiments, and other experiments along the coast conducted by Dr. Brian Beal, have tested some of these clam protection techniques.

Learn More

- The information about all years of the field experiments can be viewed on the Downeast Institute web site:

http://www.downeastinstitute.org/freeport.htm