Green Crab Research at Bates: genetics, diet, metabolism, and heavy metal concentration in tissues

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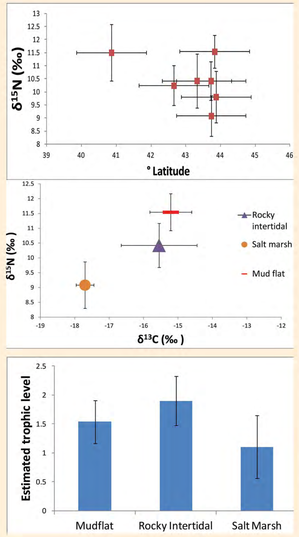


Diet analysis

Tanner Cunningham '14

Objective:

-Determine whether or not *Carcinus* exhibits distinct dietary trends in the northeast U.S. to help determine their ecological impacts and inform management strategies.

-Stable carbon and nitrogen analyses were performed on *Carcinus* spanning nearly 4 degrees of latitude and three different habitats: rocky intertidal, salt marsh, and mud flat.

Results:

-Little change in nitrogen and carbon signature with latitude, with greater differences between different habitats in Maine.

- Salt marsh crabs have a depleted ^{15}N signature, indicating that they feed lower on the food chain. Gut content analyses often showed high volumes of ingested plant matter inlcuding *Spartina* spp.

- Normalizing ^{15}N to trophic level (via emperically derived primary producer ^{15}N values) confirmed the above, and indicates that *Carcinus* is closest to a secondary consumer.

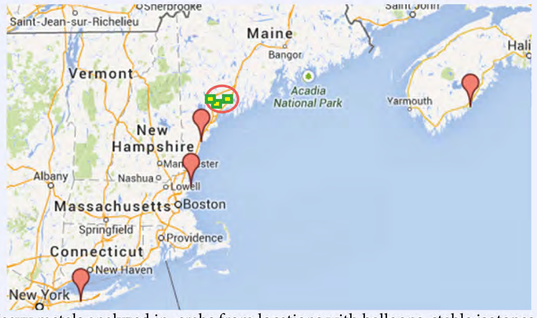
- Neither ^{15}N nor ^{13}C was not found to be correlated with carapace width, indicating diet may not change significantly with growth.

Future:

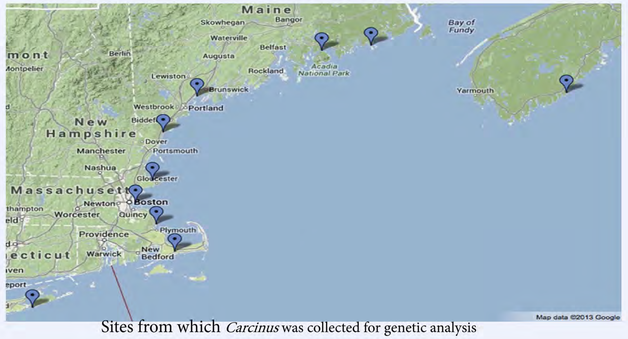
While much study is afforded the impacts of *Carcinus* on shellfish stocks, the diversity of it's diet, especially the direct consumption of plants and algae, indicate that more holistic ecological studies of the crabs effect on ecosystems are necessary.

Acknowledgments: All those who collected specimens used in analyses here, the Bates College Biology department, and Phil Dostie in the Environmental Geochemistry Lab, Bates College.

Sample locations



Heavy metals analyzed in crabs from locations with balloons, stable isotopes from these locations as well as three others within circle



Sites from which *Carcinus* was collected for genetic analysis

Temperature effects on metabolism

Victoria Dahlhoff '15

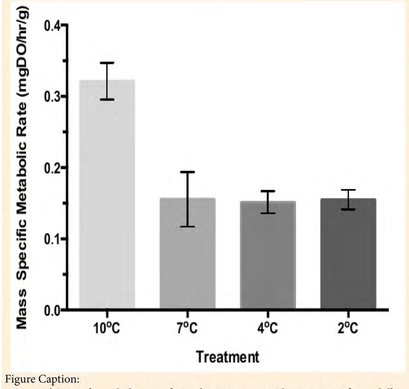


Figure Caption:
Mean and SEM of metabolic rates for each temperature. There is a significant difference between means (ANOVA; p-value = 0.0006), and a significant difference between 10°C and the other three treatments (Tukey's multiple comparisons).

Summary:

The invasive green crab species, Carcinus maenas, has expanded from its native Europe to several temperate regions across the globe. This study examines a population at Recompense Bay in Freeport, Maine. Increases in the local population may be the result of crabs of a different genetic strain that may have expanded southward from Nova Scotia, which have much superior cold tolerance. To test this hypothesis, crabs were collected and treated to four different temperatures (10 °C, 7°C, 4°C, and 2°C),while changes in mass specific metabolic rates were measured. Results show that after the initial drop in metabolic rate from the 10°C treatment to the 7°C treatment, metabolic rates leveled out, even as low as 2°C. This suggests that these crabs are tolerant of temperatures as low as 2° C and that low winter temperatures may not cause a winter decline in abundance.

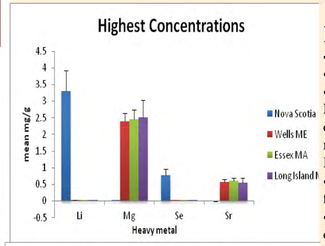
Future Research

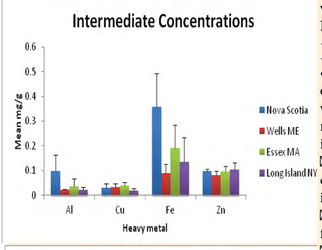
-Measure metabolic rate after exposure to lower temperatures down to -1° C (just above freezing point of seawater) to see if plateau in metabolic rate is maintained

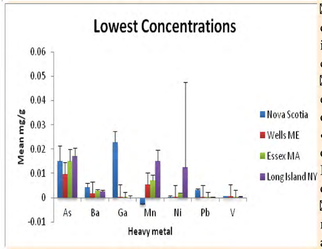
- Examine crabs from more than one site, to see if tolerance is site specific
- Acclimate crabs to low temperature before measurement, to see if tolerance is acquired or genetically hard-wired

Heavy metal accumulation

Amy Wyeth '15







Results:

- No significant difference between sex for any of the 19 heavy metals tested
- 15 out of the 19 heavy metals were detected at significant levels
- Al, Ba, Ga, Li, Pb, and Se were found in significantly higher concentrations in Nova Scotia ($p<0.0001$) with the post-hoc tests showing that L=E=W≠N. In addition to this, Fe was significantly different between sites ($p=0.0003$) and almost matched this pattern with a post hoc analysis of all the sites being equal except L≠N and E≠N.
- Concentrations of Mg and Sr were significantly lower in NS crabs than crabs from other locations
- All metals excluding V and Zn (As, Cu, Mn, and Ni) showed significant differences between sites, but there was not a consistent pattern. An important observation, while not statistically significant, is that there are higher levels of Mn and Ni at Long Island than the other three sites.

Interpretation/ Future directions:

- Nova Scotia: higher concentrations of heavy metals could be due to:
  - Large open-pen finfish farming industry in Port Mouton Bay, Nova Scotia, where the samples were collected. Open-pen fish farming has potential environmental impacts due to the large amount of fish feed, fish excretion, and antibiotics that leak from pens.
  - A report put together by Friends of Port Mouton Bay (FPMB) found an increase in heavy metals in the sediment since the beginning of finfish aquaculture in 1992.
  - Specifically, high concentrations of Cu, Zn, and Li were found around fish farms in Nova Scotia
  - A study by Rossong (2012) found that green crabs in Nova Scotia with genetic differences had strikingly different foraging behaviors with one genetic strain being a much more effective forager others. This could be tied to heavy metal concentrations in their tissue.
  - Several laboratory studies demonstrated that different genomes have different sensitivities to metals resulting in an inter-individual variability in metal handling (Nissen, 2005).
- Long Island: High levels of Mn and Ni
  - Pollution from East connecting Manhattan (high population of people) and Long Island
  - Atmospheric Deposition:
    - Ni is introduced into the atmosphere through the burning of fuel particularly residential fuel oil. In New York specifically, high levels of Ni were found in the atmosphere close to areas of high population

Genetic variation

Camilla Nivison '14

Population Genetics:

The past few years have seen a surge in the abundance and destructive behavior of C. maenas from Long Island to Nova Scotia, which may reflect a new strain of C. maenas introduced into the region. As a marker of genetic diversity and gene flow between populations, we are studying haplotypes caused by silent mutations in the mitochondrial cytochrome c oxidase I gene, which do not affect the fitness of the crab. Prior to 1980, individuals from Canada had the haplotype of the southern populations. After 1980, this region had many new haplotypes, which were all present in European populations, indicating recent additional invasion events to the Canadian coast (Roman 2006). The most recent genetic study (Pringle et al 2011) is based on crabs collected in 2007, in which the northern haplotypes are present in only the most northern of the Maine sites. Since then, there has been ample time for the northern strain to move down with the southward currents and fully integrate into the existing populations of the Gulf of Maine, creating an admixture of linages and increasing their genetic diversity and fitness.

We are analyzing the cytochrome c oxidase I gene from crabs sampled from ten sites between Nova Scotia and Long Island Sound (Fig. 1). With these data, we will be able to assess the current population structure, genetic diversity, and gene flow between populations. We will evaluate the extent of the southward spread of the northern strain and the genetic cline between the strains, as this may help elucidate the cause of the recent upsurge in abundance and negative effects of C. maenas in the region.