The Deadliest Catch: Population Density and Characteristic Study of the Invasive Green Crab (*Carcinus maenas*)

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Background

The European green crab (*Carcinus maenas*) is an invasive littoral crab that was first introduced to North America's eastern coast in the early 1800's[4]. It is an omnivorous scavenger and a voracious predator with a diet consisting mainly of clams, oysters and mollusks[2]. The green crab is a highly fecund species; a female crab can produce over 185,000 eggs in one clutch[6]. Green crabs are also able to tolerate a relatively wide range of temperature and salinity conditions. These characteristics, along with a lack of natural predators, have allowed green crabs to successfully and rapidly colonize along the New England coastline. They remain abundant in the near shore subtidal habitats of New Hampshire[2].

Green crabs compete with native flora and fauna for food and habitat, and are therefore harmful to local marine ecosystems. They have had a severely detrimental impact on New England fisheries due to their large-scale predation. Green crabs are principally blamed for the collapse of Maine's soft shell clam industry, as well as the depletion of various estuarine fish populations[2]. Additionally, their foraging and burrowing activity has done particular damage to eelgrass beds. Eelgrass communities provide an essential habitat and nursery ground for a variety of organisms, including those of commercial importance. Eelgrass also has vital ecological functions such as sediment stabilization and estuarine water purification[1].

In order to maintain the integrity of New England estuaries, it is necessary to restore eelgrass beds and restock populations of organisms that have declined due to green crab predation and activity. However, these endeavors prove to be ineffective if abundance and distribution of green crabs is poorly understood. Restocking target species in an area that has heavy crab density would likely result in rapid eradication of the newly-restored species, rendering the project a waste of time and money.

Increased knowledge regarding the spatial and temporal patterns of green crabs will not only aid in more efficient restoration and restocking efforts, but also provide useful information for future management of green crabs. The more we understand about the physiology and behavior of green crabs, the better equipped we will be to limit their coastal expansion. Our research project consists of two parts: 1) a trap saturation study and 2) a comparison study looking at the relative abundance and physical characteristics of the green crabs within two New Hampshire estuaries: Great Bay and Hampton-Seabrook.

Trap Saturation Study

Introduction:

In order to determine more about the relative population densities of green crabs in the Hampton-Seabrook Estuary (HSE) and Great Bay Estuary (GBE), we conducted a trap saturation study to determine how quickly a baited trap would become inundated with crabs. This information may be helpful in increasing the efficiency of future research, as it allows a scientist to know the optimal length of saturation time needed to obtain the greatest number of crabs. This study also provides insight regarding the virtual abundance of crabs within a New Hampshire estuary.

Methods:

The traps used for the experiments were supplied by New England Marine & Industrial in Portsmouth, NH. Each trap (30”x12”x12”) was made of heavy gauged wire and was rigged with a buoy and 25 feet of rope. The traps were baited with herring and were lowered onto the benthic substrate in sets of 3 replicates. The sets were hauled individually at varying time intervals over a period of 48 hours. Upon each haul of a set, the crabs were counted and the amounts from each trap within a set were averaged.

On November 1, 2009, the first trap saturation experiment was performed at the Jackson Estuarine Laboratory in Great Bay Estuary. The traps were dropped along the boat dock in 7 different locations during high tide. They were hauled at time intervals of 2, 4, 6, 8, 10, 24, and 48 hours.

On December 2, 2009, a similar experiment was conducted at the Hampton River Marina in the Hampton-Seabrook Estuary. The traps were dropped at high tide and were hauled at the same time intervals as the previous study.

On April 16, 2010, another trap saturation experiment was performed at the Hampton River Marina. Traps were hauled at time intervals of 3, 6, 9, 12, 15, 18, 21, 24, 36, and 48 hours.

Results:

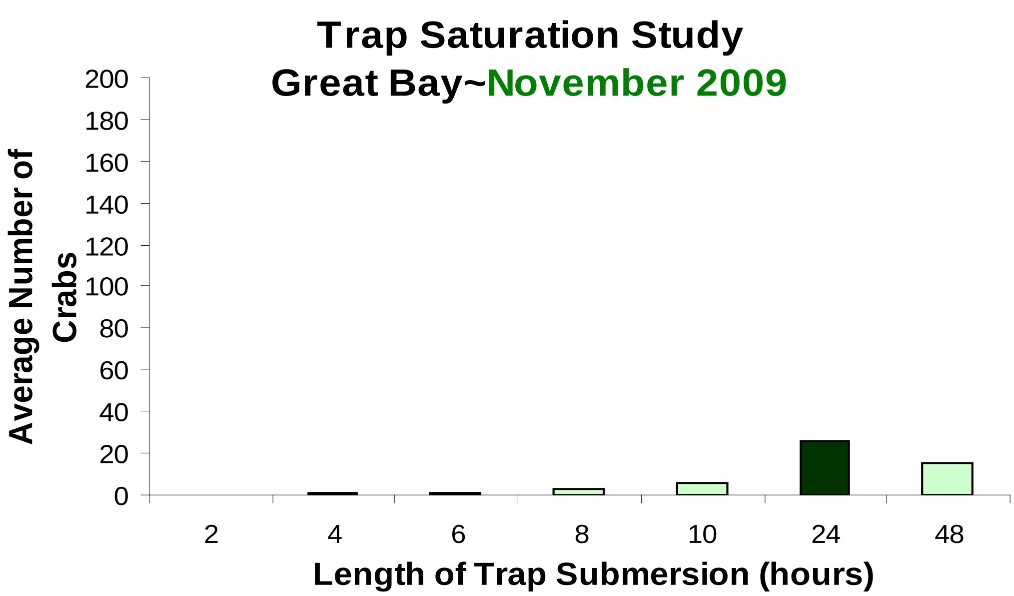

Figure 1- Green Crab Trap Saturation in Jackson Estuarine Lab, GBE

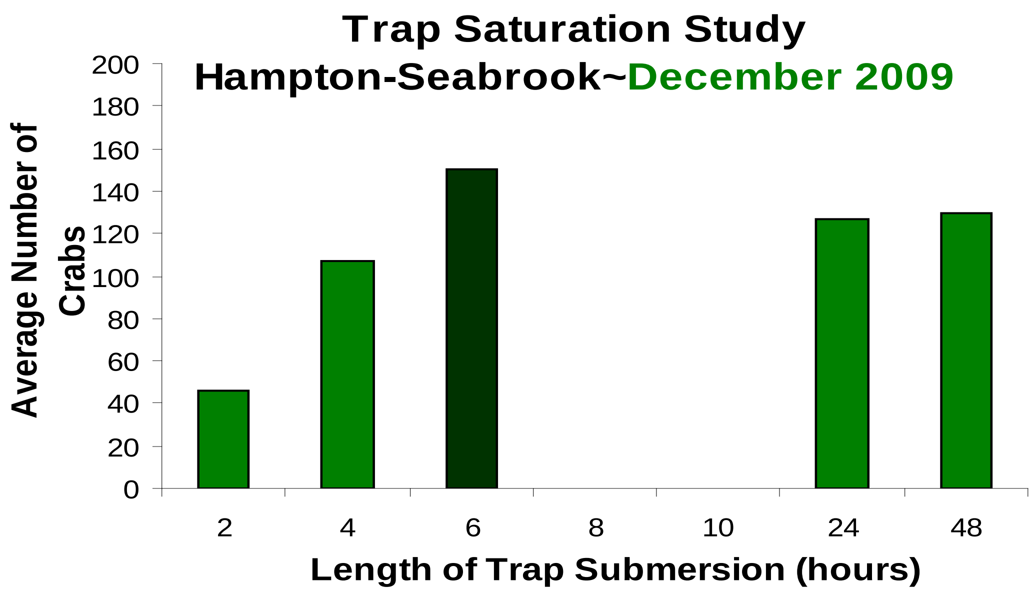

Figure 2- Green Crab Trap Saturation in Hampton River Marina, HSE.

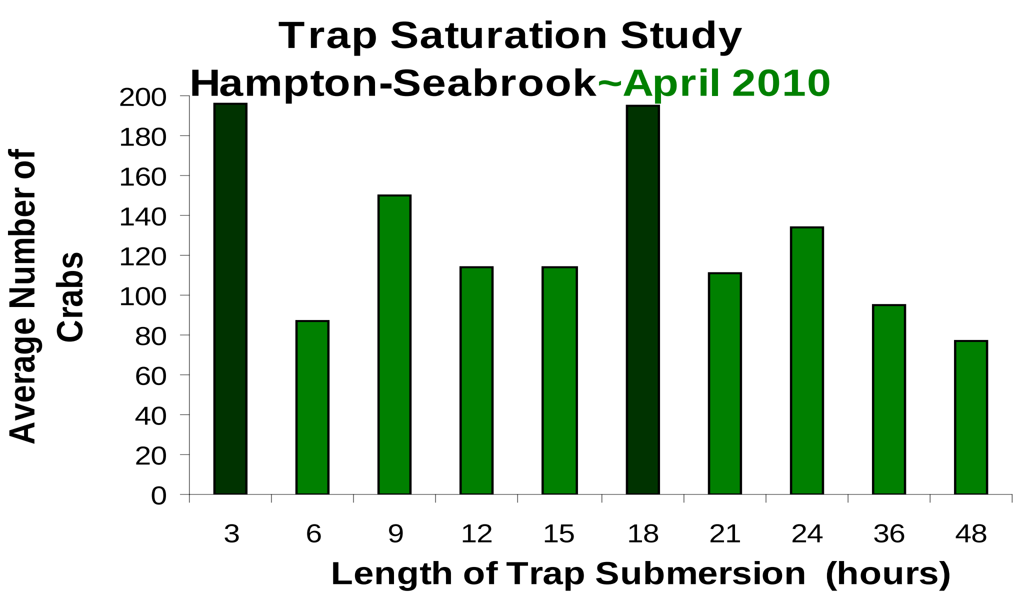

Figure 3- Green Crab Trap Saturation in Hampton River Marina, HSE

Figure 1 shows that maximum saturation ($\bar{x}$ = 26.3 crabs) occurred after 6 hours (collected at 7 pm). Unfortunately due to inclement weather, the 8 and 10-hour trap sets were not able to be hauled. Figure 2 shows that maximum saturation ($\bar{x}$ = 255 crabs) occurred after just 3 hours (at 3:30 pm), and after 18 hours (at 6:30 am) the average crab count was only slightly less (212 crabs).

Findings:

In both months (December and April), the decreased abundance of crabs in the time intervals following maximum saturation indicates that the crabs are able escape from the traps. This might occur once the bait has been completely eaten and there is nothing left to feed upon. Researchers have witnessed similar occurrences in baited lobster pots (7).

It is also possible that the crabs' activity increases during specific tidal events. The April study showed an interesting pattern of high to low abundances at approximately equal spaced time intervals. Overall, crab abundance was greater in April. This is most likely due to warmer water temperatures allowing for increased crab activity.

When comparing the November saturation experiment in GBE with the same experiment one month later in HSE, it seemed that crab density was much greater in Hampton-Seabrook Estuary. To test this further, we then transitioned the focus of our study to a Great Bay and Hampton-Seabrook estuary comparison.

Estuarine Abundance and Physical Characteristics Comparison

Introduction:

The purpose of this study was to compare relative abundance of green crabs in the Great Bay Estuary and the Hampton-Seabrook Estuary. We also compared the physical characteristics of the crabs within both estuaries, with the intent of learning more about their morphology and physiology. One specific physical aspect that we chose to focus on was color variation. Despite its name, the green crab can display a range in color from bright red to orange, yellow, green and brown[3]. Scientists hypothesize that whether a crab is in "green phase" (yellow to green) or "red phase" (orange to red-brown) has to do with both environmental conditions and life cycle[5]. A 2000 Connecticut College study showed that "red phase" crabs are often larger, stronger, and more aggressive[5]. We were interested to see if this might be the case in either of the estuaries, as it is possible that this phenomenon has reproductive implications.

Methods:

From November 2009 to March 2010, crabs were collected from a site within the Piscataqua River in the Great Bay Estuary and one at the Hampton River Marina in the Hampton-Seabrook Estuary. Weather did not permit field work collection during the month of February.

The sites chosen had similar depths of approximately 15 feet. On a monthly basis, two traps were dropped at each site and hauled after a 24-hour period. Once the crabs were collected, they were frozen and brought back to the laboratory for analysis. Processing in the lab involved determining each crab's sex, weight, egg clutch presence, carapace width, and color (Munsell value-hue-chroma color system). Based on hue, we divided the crabs into two categories: "green phase" or "red phase".

Results:

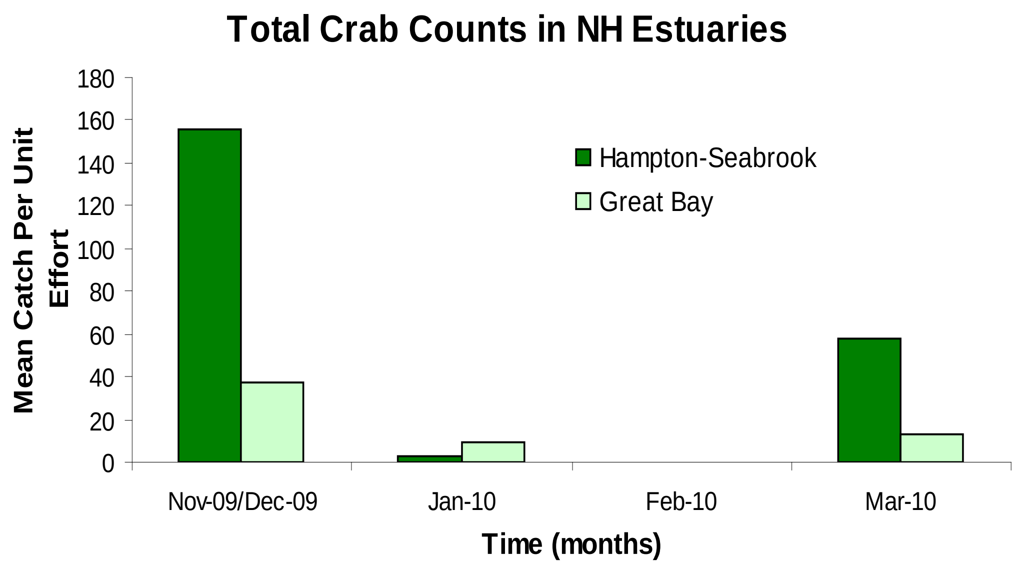

Figure 3-Crab Abundance in Great Bay vs. Hampton Seabrook Estuaries 11/2009-3/2010

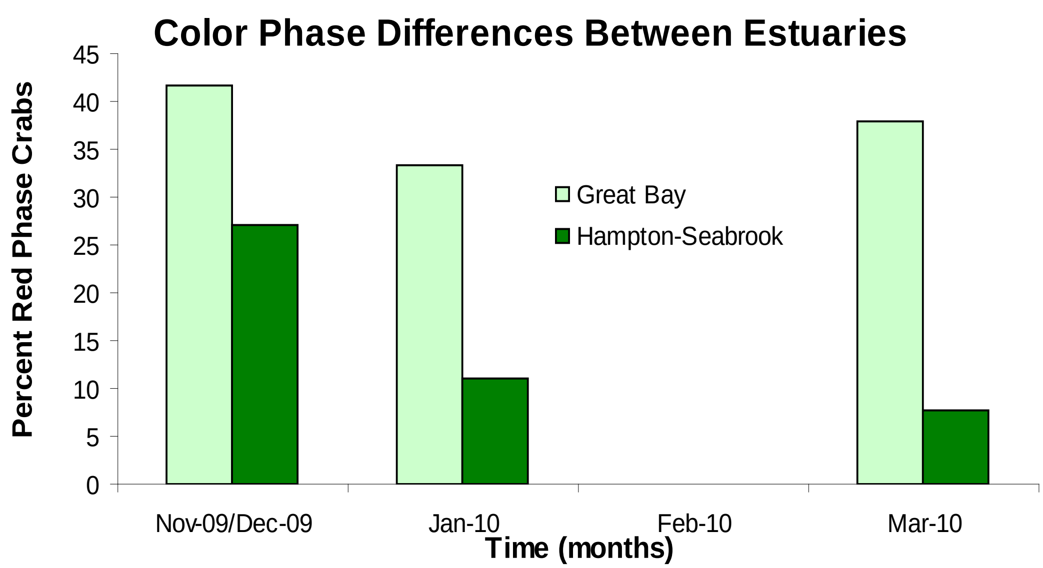

Figure 4- Percentage of "Red Phase" Crabs in GBE vs. HSE 11/2009-3/2010

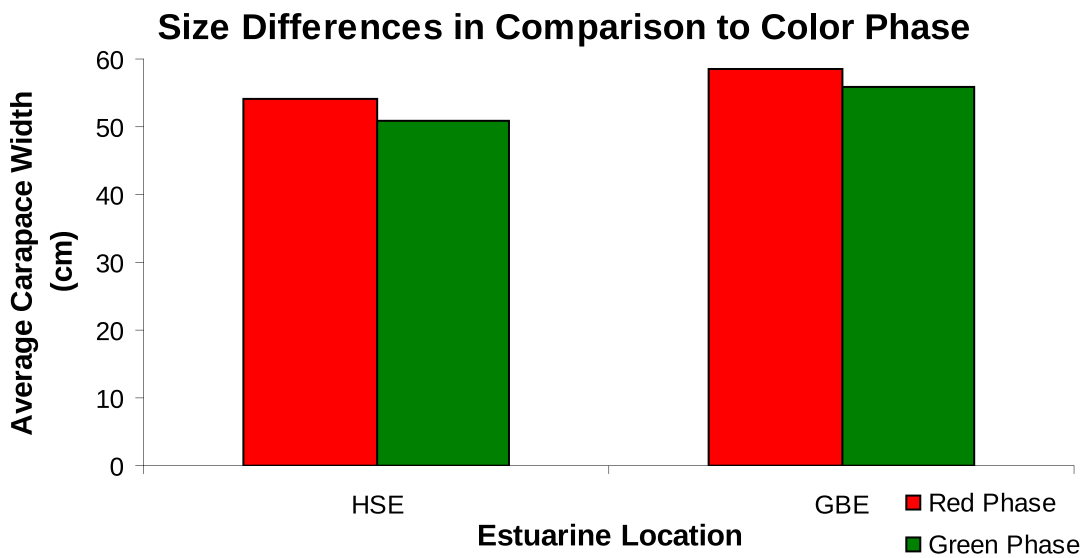

Figure 5- Shows the average carapace width of "Red Phase" crabs vs. "Green Phase" crabs in both estuaries

Figure 3 indicates that there was an overall greater abundance of green crabs in the Hampton-Seabrook Estuary ($\bar{x}$=72.3 crabs/month, excluding February) than in Great Bay ($\bar{x}$=20 crabs/month, excluding February). Figure 4 shows that during each month, percentages of red phase crabs in Great Bay were greater than the percentages of red phase crabs in Hampton-Seabrook. Figure 5 shows that there was no significant difference in average carapace width (size) between green phase and red phase crabs during the duration of the study.

Findings:

This study supplements prior research that indicates that there is a larger abundance of green crabs in the HSE than in the GBE. During each month, the majority of crabs in both sites was green phase crabs. However, Great Bay estuary displayed a trend of greater red phase percentages than Hampton-Seabrook did. The greater percentage of red phase crabs in GBE might show that there are different environmental conditions effecting the life cycle of the green crabs living there. From this information, it appears that there might be a negative correlation between high crab abundance and red phase percentage within an estuary. Due to the similar average carapace widths of green phase and red phase crabs in both estuaries, it is not evident that red phase crabs are significantly larger than green phase crabs. To make more statistically reliable conclusions, it would be necessary to replicate these experiments. In addition, if these studies were conducted during the entire year, it would provide a more solid representation of green crab population dynamics.

This project is a good example of the basic research being done in New England that aims to increase an understanding of the invasive species, *Carcinus maenas*. We hope that our work stimulates further green crab inquisition, which is a necessary precursor to the successful restoration of the New Hampshire coastline.

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