

Dueling decapods: observing aggression levels in one-on-one interactions between the European Green Crab *Carcinus maenus* and the Asian Shore Crab *Hemigrapsus sanguineus* in the Gulf of Maine

Honors Thesis

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iii. Abstract

European green crabs *Carcinus maenus* have invaded the shores of the Gulf of Maine since the early 1800's, devastating native crab populations in the sandy shores and rocky intertidal zones. In the early 2000's the Asian Shore Crab *Hemigrapsus sanguineus* was introduced to the Gulf of Maine, and has since dominated rocky intertidal zones, overtaking the green crab populations in those areas. A study performed at the Cat Cove Marine Lab at Salem State University looked into the level of aggressive behavior between these crab species. An individual of each species was introduced into a round glass arena (1.65 L in volume, 16.5 cm in diameter), lined with a thin layer of sand to replicate a sandy shore, and shucked blue mussel, *Mytilus edulus*, placed in the center to attract the crabs. The crab-on-crab interactions were videotaped for 6 minute intervals, then statistically analyzed using numbers assigned to specific aggressive traits in each minute segment. The data showed that the European green crab was 11.56 times more dominant than the Asian shore crab in all of the trials combined. This information can be utilized to understand the behavior of the two invasive species and why Asian Shore Crabs are outcompeting the European Green Crab populations in rocky shorelines.

iv. Introduction

Invasive species disrupt native communities, often displacing endemic species and modifying local food webs. Invasive marine species are easily transported to new areas via ballast water or as fouling organisms on ships (Grosholz 2002); the Gulf of Maine has experienced numerous species introductions resulting in dramatic changes within intertidal communities. In 1817, the first appearance of European Green Crabs was recorded (Weis 2010) in the Mid-Atlantic region; over time, green crabs have moved



Figure 1. Female European Green Crab



Figure 2. Female European Green Crab ventral side

along the coast, dominating intertidal zones along the Atlantic coast of the US as well as Canada. In the late 1980's, green crabs extended their range to the Pacific coast of the U.S (MacDonald et. al 2007). Green crabs are harmful to fisheries and biodiversity (Cohen et al. 1995, Lohrer and Whitlatch 2002a), pushing native crab populations such as *Cancer borealis* (Jonah Crab) and *Cancer productus* (Red Rock Crab) further into the subtidal zone (Donahue et al. 2009). Another invader, the Asian shore Crab invaded New England waters around 1988 in New Jersey, showing up in Cape Cod in 1998 (MacDonald et al 2007), making them a more recent invasive species. Since then, shore crabs have dominated rocky intertidal zones, while green crabs have become limited to

sandy intertidal zones and mud flats (Jensen et al 2002). Shore crabs disrupted the food web in certain areas where they were particularly dense, and this effects the local common habitat and food availability due to the additional competition (Dauvin et al 2009). As shore crab populations increase in rocky intertidal zones and green crab



Figure 3. Male Asian Shore Crab Carapace



Figure 4. Male Asian Shore Crab ventral side

populations decrease in these areas, likely this is due to competition between the two. The question remains, are shore crabs more aggressive than green crabs? If so, is this the basis for the increase in shore crabs in rocky areas, and if not, then what is causing these population fluctuations? This research project examines the one-on-one interactions between the green crabs and shore crabs using videotaping to document aggressive behaviors.

v. Materials and Methodology

In August 2018, five male and five female green crabs, along with 5 male and five female Asian shore crabs were captured. The green crabs were collected from Smith Pond in Salem MA, which is a muddy subtidal pool. The shore crabs were collected off of Forest River Park in Salem MA, which is composed of rocks over coarse sand. The crabs were kept at the North Eastern Massachusetts Aquaculture Center, located at the Cat Cove Marine Lab (CCML) in separate 0.76 L Rubbermaid containers. Each container had holes punched through the bottom and plastic window screening covering the top for water flow. The crabs were maintained at 32 ppt. salinity, 16 °C, and natural light cycles. The crabs were each fed 0.5g of Lansey Breed Maturation pellets once a week.



Figure 5. Containers used for crab housing in a saltwater tank located at the CCML

Each Monday, starting October 15th 2018, a series of 10 trials were carried out, in which a specific pair of crabs, one green and one shore crab, of similar size were introduced into an experimental arena. The arena consisted of a glass bowl (1.65

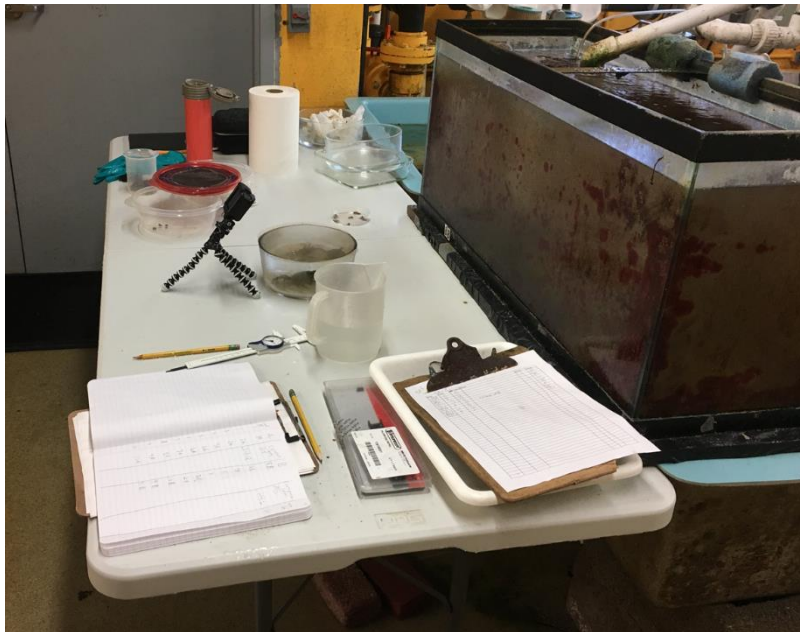


Figure 6. Experimental setup on a table at the CCML with the glass arena and GoPro used for filming.

L in volume, 16.5 cm in diameter), lined with a thin layer of sand held down by glue to replicate a sandy shore was used for each trial. In the center of the sand layer, a small loop of glue held a food sample, shucked mussel meat. To prevent the crabs from escaping, a water sealed plastic circle covered the arena during each trial. The arena was filled with fresh, ambient sea water. After attaching the bait to the loop in the center, a

pair of crabs were placed in the arena simultaneously, and their interactions timed and videotaped for a total of 6 minutes, as seen in Figure 6.

In between each trial run, the arena water was replaced with fresh salt water to prevent accumulation of pheromones. After 5 series extending over 5 weeks with 10 trials per series, the timing and video data were recorded onto an excel spreadsheet. In evaluating the video data, it was determined which crab was dominant for each one minute time interval based on which crab controlled the center of the arena and the food. Using this criteria of dominance, an interaction scale was developed to score each of the one-minute intervals in a trial. If neither crab occupied the middle, and failed to make any aggressive advances, the minute was characterized as N for neither individual as dominant. If the shore crab held the central position, it was considered dominant and the specific one-minute interval, was labeled S. If the green crab was more dominant for a majority of the interval, the time interval was labeled G. If both were fighting and holding the central location evenly for a majority of the interval, encounter was classified as a draw labeled F. The interaction data from 60 trials were tabulated to examine the level of aggressive behavior between the two crab species.

vi. Results

Green crabs were dominant during 104 out of 300 minutes, which is 34.67% of the trials, as seen in both Figures 7 & 8. The shore crabs were dominant during 8 out of the 300 minutes, which is 2.67% of the time. The green crabs also won the food in their one-on-one interactions 9 out of 10 times, as determined by the “bait takeovers” in which one crab obtained and consumed the food in a trial, shown in Figure 9.

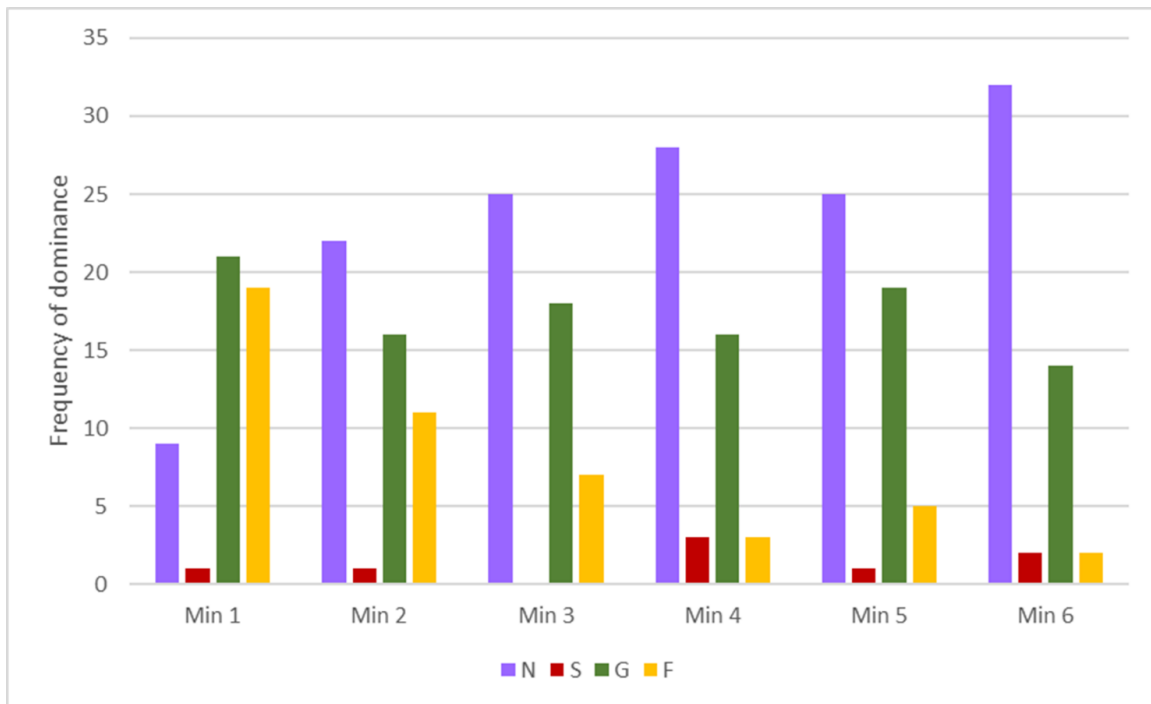


Figure 7. Aggressive interactions of the two crab species over time for all five series' combined.

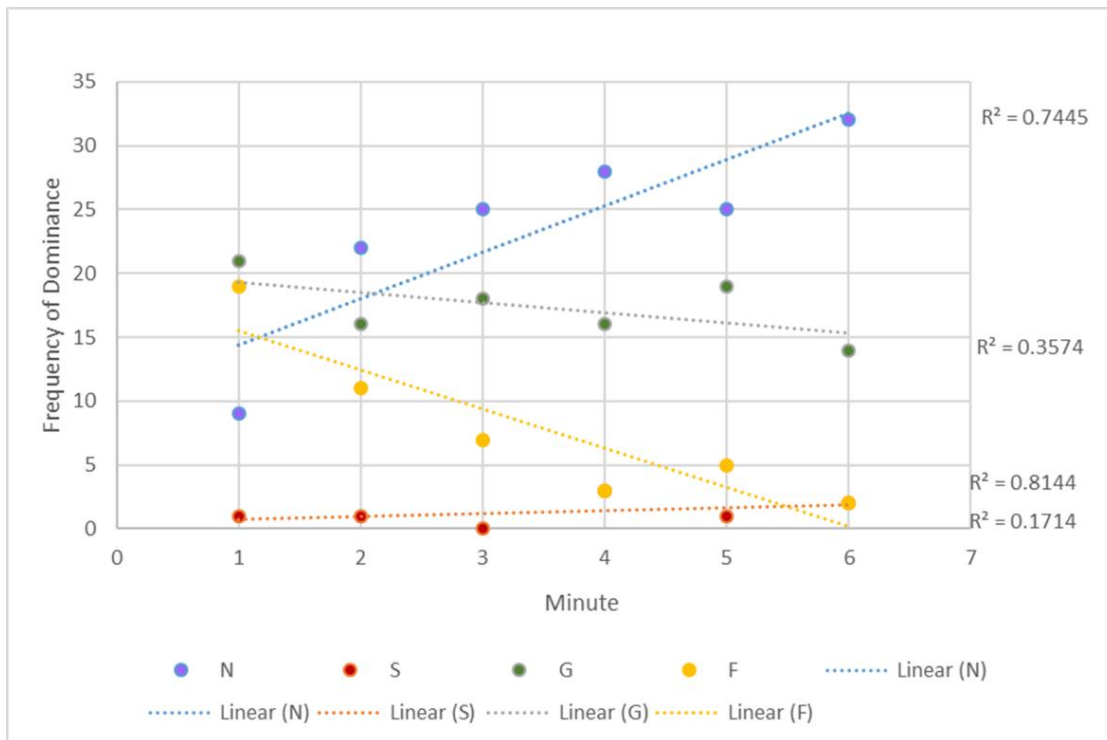


Figure 8. Aggressive Interactions of the two crab species over time showing dominance trend lines.

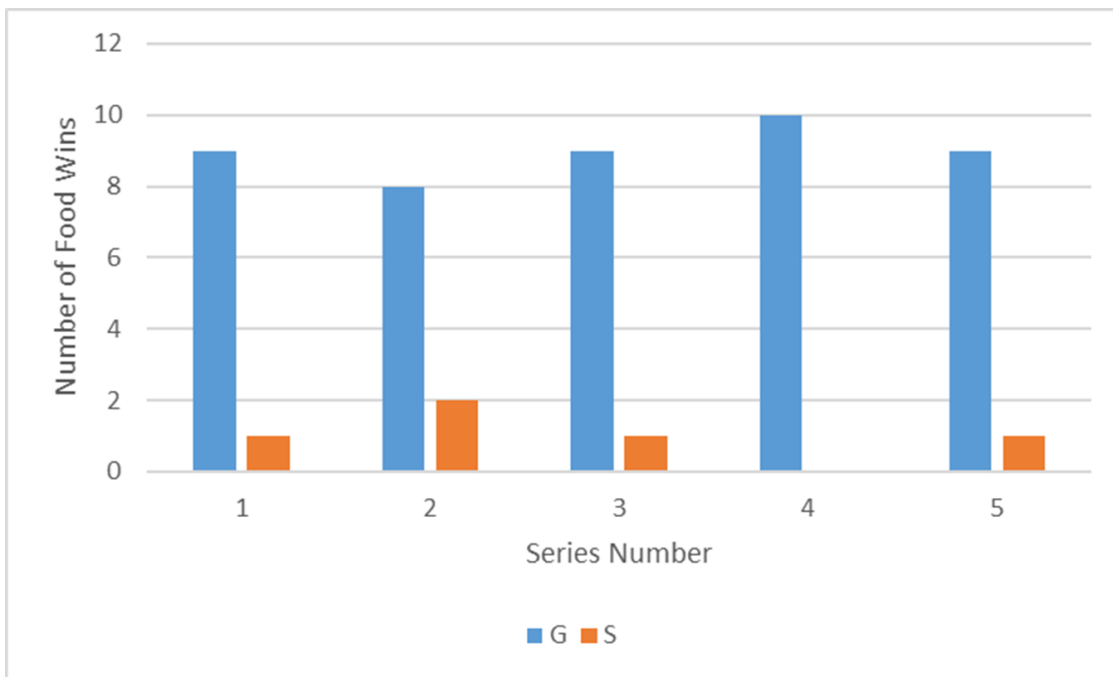


Figure 9. “Bait takeovers” in each trial for all 5 weeks of trials (5 series)

vii. Discussion

Asian shore crab populations have become more established in New England rocky intertidal zones in recent years; as European green crabs become increasingly scarce. Although green crabs seemed more aggressive in the arena, and concur with lab results of others, apparently they are still being displaced. A potential factor for the prevalence of shore crabs may involve the extent of their breeding seasons. According to research done by Berrill & Arsenault (1982), the duration of the green crab breeding

season is 2 months, while green crabs have a generation time of three years minimum with a total of three breeding years for each female (Ricketts & Calvin 2000).

Considering the long generation times for green crabs, it is likely that shore crabs breed more frequently, and may overwhelm green crab populations in rocky intertidal zones.

viii. Conclusion

Green crabs have shown higher levels of aggression during one-on-one interactions over short time periods. Green crabs have also displayed greater ability to reach the food first, as they won 90% of the trials in regards to getting the bait. The Asian shore crabs often remained passive during these interactions, since green crabs displayed aggression 13 times more often than shore crabs. This study does not include population numbers or how aggressive each individual is in the long term.

ix. References

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