Climate Change, temporal, and spatial patterns in invasive European green crab (*Carcinus maenas*) abundance after nine years of sampling in Harpswell Sound

Eva McKone, Class of 2026

Carcinus maenas or the European green crab is an invasive species introduced to the Americas in the 1800s after being transferred from Europe across the Atlantic on the bottom of ship hulls (Yamada, 2001). Their primary success as invaders is attributed to their broad tolerance to environmental fluctuation, especially to temperature and salinity (Young and Elliot, 2019). Originally introduced to NY in the US, they have been spreading northward to the Gulf of Maine for two decades. In Maine especially, *C. maenas* is problematic, deteriorating Maine fisheries by depleting populations of blue mussel, *Mytilus edulis,* (Fulton et al. 2013; DeGraff and Tyrell, 2004) and soft-shell clams, *Mya arenaria* (Welch, 1968; Department of Marine Resources, 2019). Additionally, these crustaceans are known to burrow in eelgrass (*Zostera marina*) beds, destroying the eelgrass rhizomes below the sediment surface and invertebrate populations, both of which are nutritionally critical for sea-dwelling birds (Garbary et al. 2014; Aman and Grimes, 2016).[1]

To understand the underlying drivers of population dynamics in Harpswell Sound, the Carlon Laboratory has been monitoring *C. maenas* populations in Harpswell Sound and Casco Bay since the spring of 2014. In this monitoring program, four sites are sampled weekly during the spring and summer months. Two baited eel traps are deployed at each site and "soak" for 24 hours prior to their retrieval. For each trap, the number of crabs, in addition to the carapace width and sex of each crab, are recorded. This summer, I ran the monitoring program and organized and collected crabs from my two weekly trips by boat to the four sites. After collection, I recorded all data, and transferred these data to a central spreadsheet. A second component of my fellowship was editing the 9 years of data for downstream analysis in the R programming language. After completing this task, I analyzed the spatial and temporal trends using R, employing both time-series and correlation analysis. The complete data included long-term temperature and chlorophyll data from Casco Bay derived from NASA satellites.

My analysis has shown distinct trends in *C. maenas* sex ratio, specimen size, and population size. Regarding sex ratio, a strong and consistent male bias in Harpswell Sound was detected. This sex ratio is interesting because other studies in New England have shown either female biases, or sex ratios that are close to 50:50 (Fulton et al. 2013; Young and Elliot, 2017).

Another key trend is that the median carapace width, especially that of males, has greatly increased over the past nine years. In 2014, the median male crab was approximately 4.5 centimeters in carapace width. However, in 2022, the median male crab was approximately 5.7 centimeters. This growth in size is positively and significantly correlated with increasing water surface temperatures. Given that crabs are ectotherms, warming waters could result in increased metabolic activity, thereby stimulating their appetite. Thus, heightened foraging in *C. maenas* populations is a potential explanation for their enlargment.

The final trend I observed was the rapid increase of *C. maenas* numbers over time. This trend was determined using Catch Per Unit Effort (CPUE), or the number of crabs per site divided by the total number of sampling dates. The rise in *C. maenas* is positively, but not significantly, correlated with rising mean water temperatures. This increase in population size could possibly be attributed to the enlargment of females over time and their increased capacity for eggs.

In the future, I plan to further analyze these data for publication under the guidance of my mentor, Doctor David Carlon.

[1] This paragraph was adapted from my initial research proposal submitted in March 2023.

Faculty Mentor: David Carlon

Funded by the Henry L. and Grace Doherty Charitable Foundation Coastal Studies Research Fellowship

Literature Cited

Aman J, Grimes K. 2016. Measuring Impacts of Invasive European Green Crabs on Maine Salt Marshes: A Novel Approach Report to the Maine Outdoor Heritage Fund.

DeGraaf, J. D., and M. C. Tyrell. 2004. Comparison of the feeding rates of two introduced crab species, Carcinus maenas and Hemigraspus sanguineus, on the blue mussel, Mytilus edulis. Northeastern Naturalist 11: 163-166.

Department of Marine Resources. 2019. Green Crabs in Maine | Department of Marine Resources. Mainegov. https://www.maine.gov/dmr/science/species-information/invasives/green- crabs.

Fulton, B. A., E. A. Fairchild, and R. Warner. 2013. The green crab Carcinus maenas in two New Hampshire estuaries. Part 1: spatial and temporal distribution, sex ratio, average size, and mass. Journal of Crustacean Biology **33**:25-35.

Garbary, D. J., A. G. Miller, J. Williams, and N. R. Seymour. 2014. Drastic decline of an extensive eelgrass bed in Nova Scotia due to the activity of the invasive green crab (Carcinus maenas). Marine Biology **161**:3-15.

Welch, R. W. 1968. Changes in the abundance of the green crab, Carcinus maenas, in relation to recent temperature changes. Fishery Bulletin 67: 337-345.

Yamada SB. 2001. Global Invader: The European Green Crab. Oregon State University.

Young, A. M., J. A. Elliott, J. M. Incatasciato, and M. L. Taylor. 2017. Seasonal catch, size, color, and assessment of trapping variables for the European green crab Carcinus maenas (Brachyura: Portunoidea: Carcinidae), a nonindigenous species in Massachusetts, USA. Journal of Crustacean Biology **37**:556-570.

Young, A. M., and J. A. Elliott. 2019. Life history and population dynamics of green crabs (Carcinus maenas). Fishes **5**:4