Ogunquit River
Youth Citizen Science Invasive Crab Population Survey
June - September, 2022


Introduction

In partnership with the Wells High School Environmental Club and with permission from the Town of Ogunquit, Healthy Rivers Ogunquit proposed to engage summer visitors (youth) to trap invasive European green crabs (*Carcinus maenas)* at popular spots within the Ogunquit River estuary during the summer of 2022, with the goal of creating a snapshot of the crabs' population, a necessary step in limiting their spread and the damage they are causing in these critical habitat areas.

The explosion in the population of green crabs in Maine's intertidal areas has had a well-established negative impact on important wading bird and finfish/shellfish nursery habitat, the integrity of marsh banks— which are critical carbon sinks – and the capacity for natural filtration and other ecosystem services. This project, funded by a Discovery grant from the Onion Foundation, helped determine the feasibility of using recreational crabbers (Ogunquit's summer tourists) as citizen scientists in the effort to document and reduce green crab numbers in an intertidal zone.

Expected outcomes included:

- A greater awareness in the community of the issues confronting the estuary
- An assessment of whether and how summer visitors can be enlisted to assist in citizen science

- A snapshot of the European green crab population in the Ogunquit River
- An understanding of where and when egg-bearing females may be found
- A survey of other non-native, invasive, and native crustaceans in the river

Materials

(2) Ketcham Green Crab Box Traps
(1) Modified Ketcham, Juvenile Green Crab Box Trap
(1) ½" aperture Ketcham holding cage
(3) Wire bottom (1" mesh) ring-net Traps
(5) Hand Nets
Frozen Herring
(1) "Crabbing Today" Volunteer Recruitment Flag
(2) 5-gallon Buckets
(4) 1-2 gallon Buckets
(1) set stainless steel Calipers

Study Sites

The four sampling sites were positioned roughly equidistant along the river (Figure 1.) They differed in distance to the ocean, primary bottom substrate, and type of habitat. Though they had varying levels of public foot traffic, the sites all offered convenient access and a safe crabbing experience.

Figure 1: Trapping sites, Ogunquit River Estuary

1) Footbridge

The furthest site from the ocean and deepest into the estuary, the Ocean Street Footbridge is a large wooden bridge spanning the Ogunquit River which receives a significant amount of foot traffic everyday.

This site's habitat ranges from about one foot of water at low tide, to approximately seven foot depths at high tide, covering a sandy bottom penetrated by wooden piles, and high density of gravel and cobble sized rocks. The vast majority of our trapping effort here was concentrated on using box and ring traps deployed from the bridge at slack (high) tides.

2) Tides Hotel

The kayak launch at The Ogunquit Tides hotel was the next-furthest site from the ocean in our study. Very little foot traffic occurred here so engagement with public and citizen scientists was often one-on-one. The main trapping methods used here were ring traps and box traps, with limited hand-netting.

This site is situated on the Ogunquit River clam flats, and its habitat features vegetated salt marsh bank with small amounts of gravel sized rock amidst a generally muddy bottom that is completely exposed at low tide. A small freshwater tributary runs parallel to the dock, emptying into the clam flats. At high tide, this tributary floods with tidal water and holds green crabs. We trapped here exclusively above the promontory sea wall at the high (slack) tide.

3) Riverside Beach

Riverside Beach is situated next to downtown Ogunquit and the Beach Street bridge. This trapping venue was the second-closest site to the ocean, as well as our most heavily trafficked site. At low to mid tide in the summer, it is common to see visitors crabbing with nets under the Beach Street bridge. It was very easy to engage the public and 'recruit' on average, 10 - 20 citizen scientists to help catch crabs.

This location's habitat is characterized by algal and seaweed-covered cobble and boulder-sized rocks that cover a sandy river bottom. Currents here are pronounced as the river narrows under the bridge, with depths ranging from a foot at low tide, to approximately 10 ft at high tide. While the box traps were deployed from the bridge at several high tide outings, most of our trapping events here consisted of ring traps being thrown from the bridge or shore, in conjunction with a crowd of children and parents searching for crabs with nets.

4) River Mouth

The mouth of the Ogunquit River (Rivermouth) was the closest site to the ocean, situated on the sandy shores below Ogunquit's Marginal Way and across the river from Ogunquit's Main Beach, at the mouth of the estuary. "Foot traffic" consisted primarily of families wading or floating across the river from Main Beach. Recruitment was moderate but steady when compared to our other sites; the crabbing was rewarding here and volunteers tended to engage until we had caught our limit. We trapped here exclusively at low tide, when there was easy access by foot to the habitat. While both nets and box traps were made available, most of the crabs caught here were from shore-thrown ring traps.

The habitat here is exposed to the ocean and river currents, and consists of sandy bottoms with several larger, partially-submerged rock formations, covered in barnacles and seaweeds such as rockweed and sea lettuce. Ring traps were thrown from shore at the bases of these rock formations in several feet of water, while volunteers stood nearby with nets to harvest the crabs that were pulled in.

The study design included trapping once per week at each of the four sites for the 10 week duration of the study.

Methods

Methodology varied by site and by local conditions, with a goal to trap a representative sample of approximately 100 crabs from the population during each session, while engaging as many volunteers and members of the public as possible.

Four (4) team leaders and ten (10) research assistants were trained to catch green crabs using the following equipment:

1) Small recreational green crab trap: 9″ x11″x18″ wire trap with 1″ (25.4mm) square mesh. Ketcham Supply Company, New Bedford MA. Top entry funnel measures 135mm x 90mm.

Figure 2: Recreational green crab trap

2) Juvenile crab trap, 6” x 6” x 18” Chum Pot with 1/2″ (12.7mm) square vinyl coated wire mesh from Ketcham Supply Company, New Bedford MA, modified with (4) 38mm diameter pvc pipe top entry funnels secured with hog rings.

Figure 3: Juvenile crab trap in use

3) Wire Grid Bottom Crab Nets - Two Ring Crab Kit with Harness and Bait Clip 24”x20”x12”

Figure 4: Wire bottom ring trap

4) Telescopic light-weight aluminum handle landing net

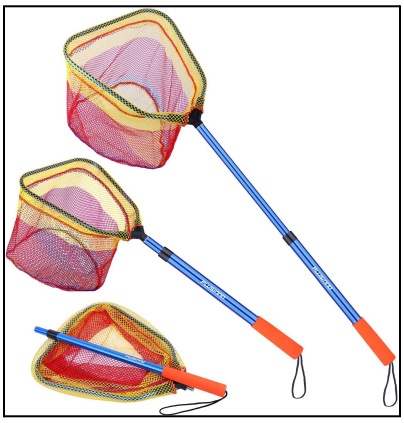

Figure 5: Landing net

Team leaders for each event assessed the site conditions and volunteer base to determine which trapping methods to employ. Every effort was made to include methods that were more likely to trap crabs that do not typically engage with a box trap – including egg-bearing females, molting crabs, and juveniles– in order to provide a better snapshot of the local population. All harvesting events were conducted over a maximum 2 hour window at slack (high or low) tide, when currents are weakest and crabs are known to move more freely along the river bottom.

Outreach

Outreach to the public was of equal importance during these sessions. Residents and summer visitors were invited to engage with the research team, participate as citizen scientists, and share their stories of how invasive species have affected their communities. Team members wore Crab Patrol logo T-shirts and hung a “Crabbing Today” banner to advertise the event. Volunteers and children who were curious and engaged were given a Crab Patrol Data Team sticker as a token of thanks. Participants, their families, and curious passersby were given the opportunity to learn about the European green crab, understand the research project and its purpose, and explore the roles played by native shellfish, grasses, and other components of a healthy estuarine ecosystem.

Crabs that were harvested during the session were combined into a dry, 5-gallon bucket and moved off-site for data logging. Team members collected the following information for each crab harvested:

- Shell carapace width (in mm)
- Sex
- Presence or absence of eggs, if female
- Egg color, if applicable
- Shell stage (soft or hard)

Team members also made notes on the volunteer engagement level and weather conditions.

Upon completion of data collection, crabs were dispatched by immersing in fresh water and then buried in the Ogunquit Transfer Station compost pile on the following day.

Results

A total of 4285 crabs were pulled from the Ogunquit River Estuary in the 34 sessions spaced out over 10 weeks (June 22 - September 1, 2022). These included:

9 sessions at Footbridge
10 sessions at Tides
10 sessions at Riverside

6 sessions at River Mouth*

Overall, researchers and citizen scientists were quite successful at catching the target lower limit of 100 crabs at each session. In fact, when engagement was high, and the research team was immersed in their outreach efforts, the daily catch could be double (or more) of the target. In all cases, the entire catch was logged in, since crabs in the collection bucket would generally array themselves with males and larger individuals at the top, and females and juveniles at the bottom, making it difficult to pull a random selection of 100 crabs from the catch. Table 1, below, presents the data on the total catch.

*Of the four sites, the River Mouth was the most difficult to access – and to schedule. It had a tighter requirement for acceptable tides, and had greater exposure to currents and waves. Two sessions were also canceled due to inclement weather and lack of volunteer availability.

Population snapshot

	Footbridge	Tides	Riverside Beach	River Mouth	Totals
Total sample	1294	1065	1129	797	4,285
# males	794	626	554	311	2,285
# females	500	439	575	486	2,000
% males	61%	59%	49%	39%	53%
% females	39%	41%	51%	61%	47%

Table 1: Population sample

The most significant finding from the study emerges from this breakdown by sex: that the ratio of male to females caught differed by site, with the percentage of females increasing as the sites approached the ocean.

Graphically, we can see in Figure 6 that females outnumber males at both Riverside Beach and the River Mouth, though note that these are raw numbers, not percentages. Fewer sessions took place at the River Mouth, resulting in a lower total catch than the other sites.

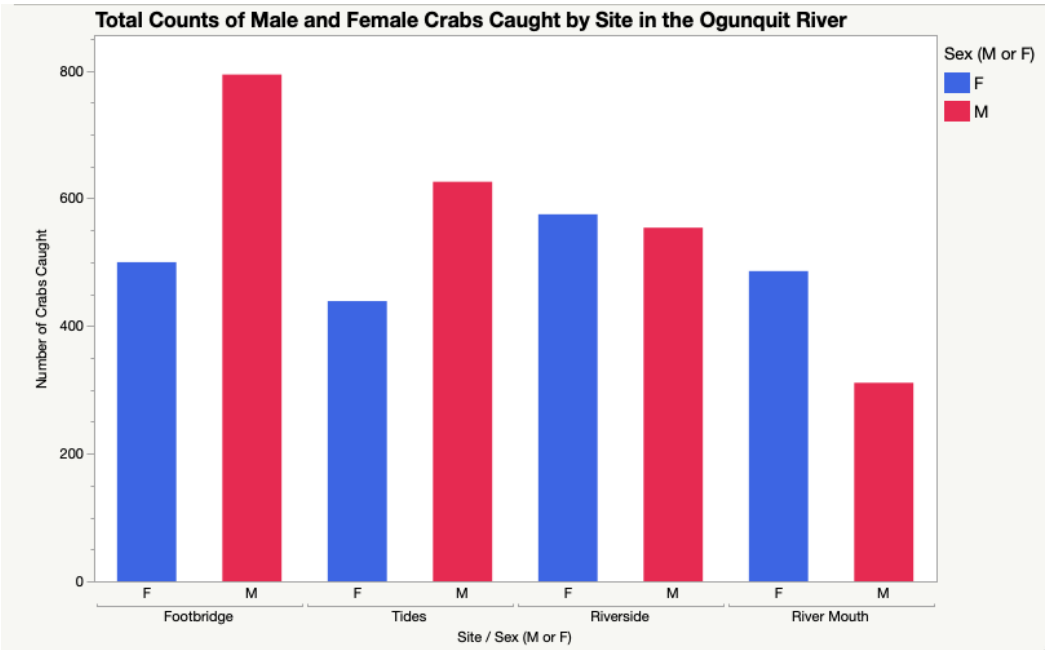

Figure 6: Green crab population sample, by sex and site

Size of individuals caught

We were interested in determining if we could get a more representative sample of the total population than is typically caught when using 1” square mesh commercial or recreational crab traps. By employing a variety of trapping methods, we were able to capture crabs as small as 5mm in carapace width and as large as 73mm. For reference, we noted that even crabs of 40mm width or more could move in and out (sideways) through 1” wire mesh.

Figure 7: Measuring shell carapace width

Though we did not break down the catch by method, we can report anecdotally that the modified juvenile trap was successful at capturing and retaining smaller crabs. Unfortunately, the bait inside also attracted much larger crabs, who could not enter but crawled on the trap and stayed nearby. Their presence most likely limited the engagement of the smaller, more vulnerable crabs, reducing the value of having a trap with smaller mesh.

Overall, males were on average slightly larger than females, and there was good representation of all size classes. Of interest, perhaps, is that the crabs caught at The Tides – a site with exposed mudflats at low tide – were somewhat smaller on average.

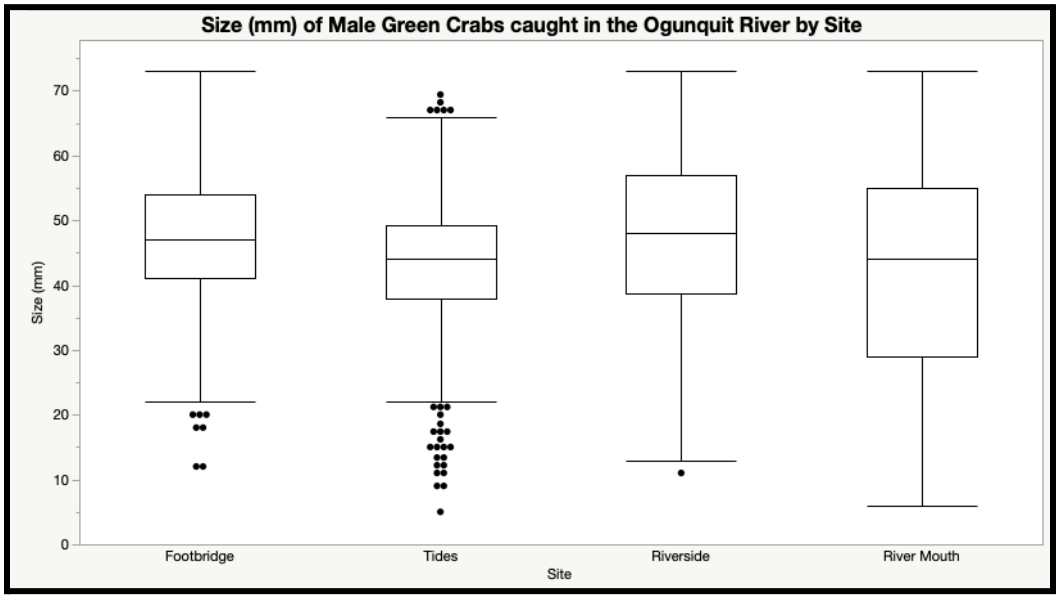

Figure 8: Male green crabs, by size and site

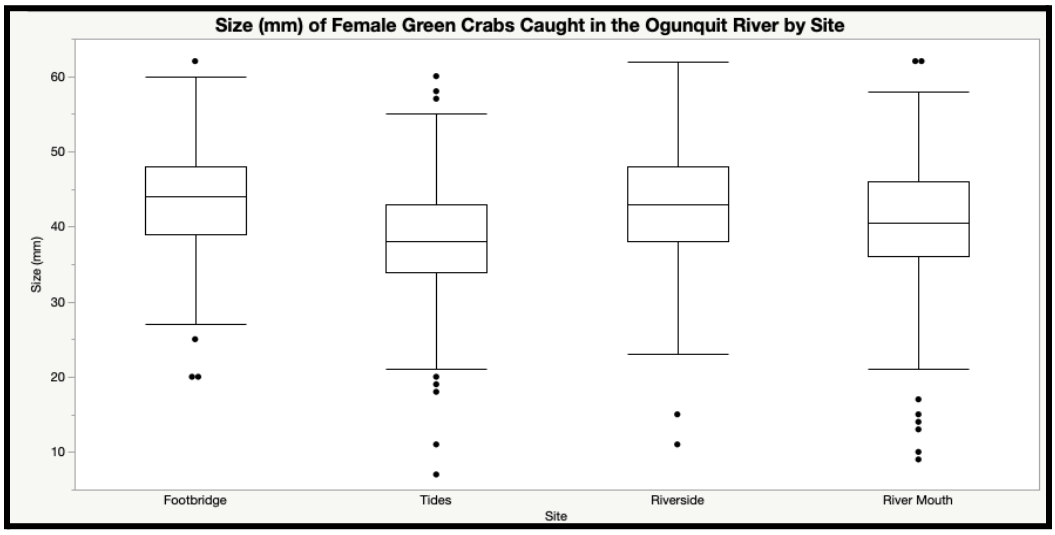

Figure 9: Female green crabs, by size and site

Soft shell crabs

Green crabs are vulnerable to predation during their brief period of molting, and for their own protection, stay hidden. The fact that we were able to capture molted (soft-shell) crabs is a reflection of the diligence of our citizen scientists with hand nets, chiefly at Riverside.

Figure 10: A newly molted crab (right) and its discarded shell (left)

Though soft shell green crabs represent an emerging market for this invasive species, they are not typically harvested in their soft shell state. Instead, its fishery relies upon identifying signs of pre-molting and isolating those individuals until they shed. Looking at the soft shells harvested from the river may give us a clue, however, as to their mating habits. Females mate immediately after they shed their shell, so the timing and location of molting females (Figures 11 & 12) gives us a window into when and where we might expect to see egg-bearing individuals.

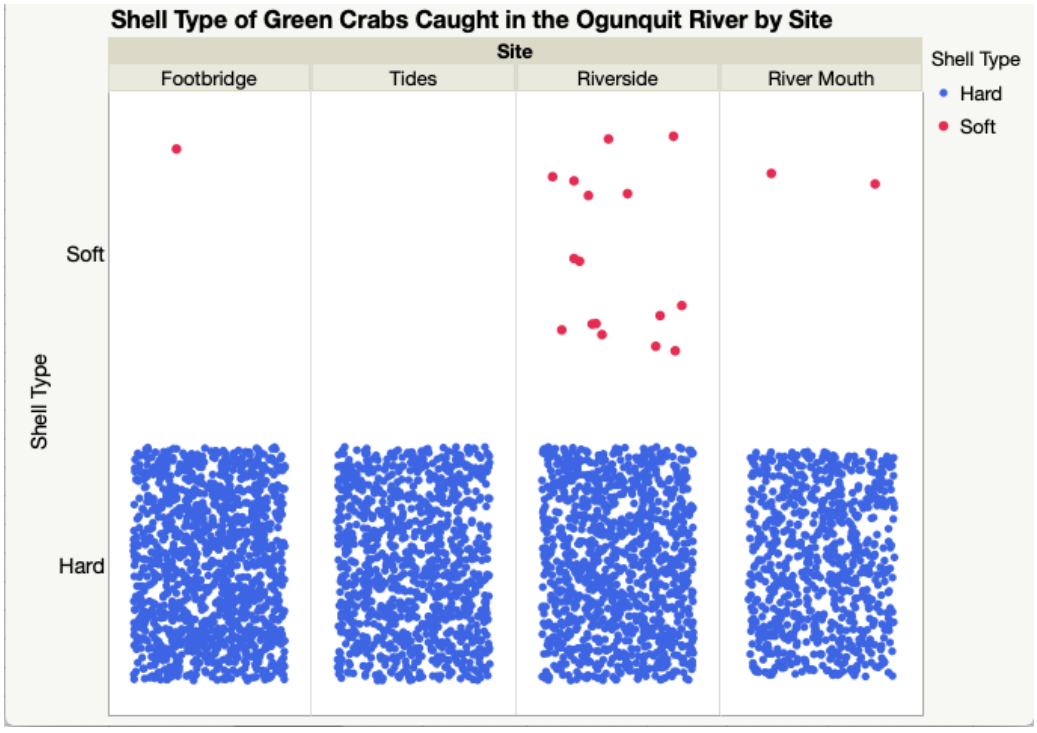

Figure 11: Shell type, by site

Soft Shell Green Crabs by Location, Sex, and Date Harvested

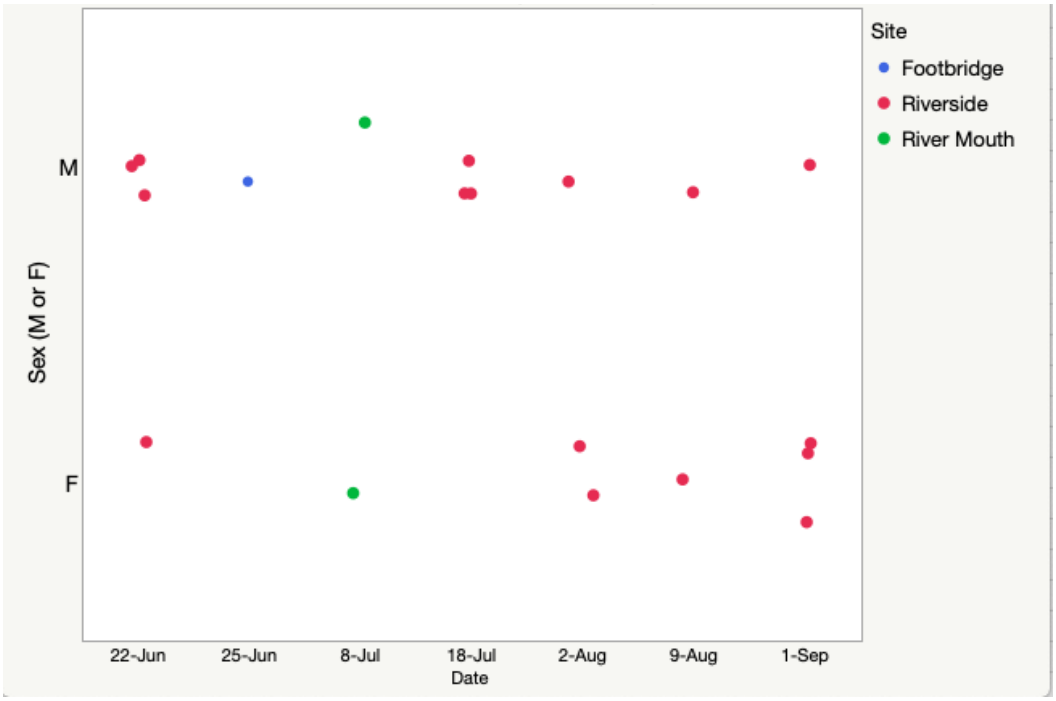

Figure 12: Soft shell crabs harvested, by sex and date
Egg-bearing (ovigerous) females

One of the more useful data points of this population study may be the numbers of egg-bearing females that were harvested. By most accounts, females can carry 150,000 or more eggs in a clutch on their abdomen (Figure 13) and identifying a means to remove egg-bearing females may offer a valuable measure of population control. Like soft shell individuals, egg-bearing females are more vulnerable to predation and are less likely to engage with a baited trap. That our team of citizen scientists were able to capture 44 egg-bearing females by net signals a possible future opportunity to pursue. (Figure 14)

Figure 13: Early stage (orange) and late stage (brown) eggs in a clutch on the underside of two female green crabs harvested in the Ogunquit River

Egg-Bearing Green Crabs Harvested in the Ogunquit River

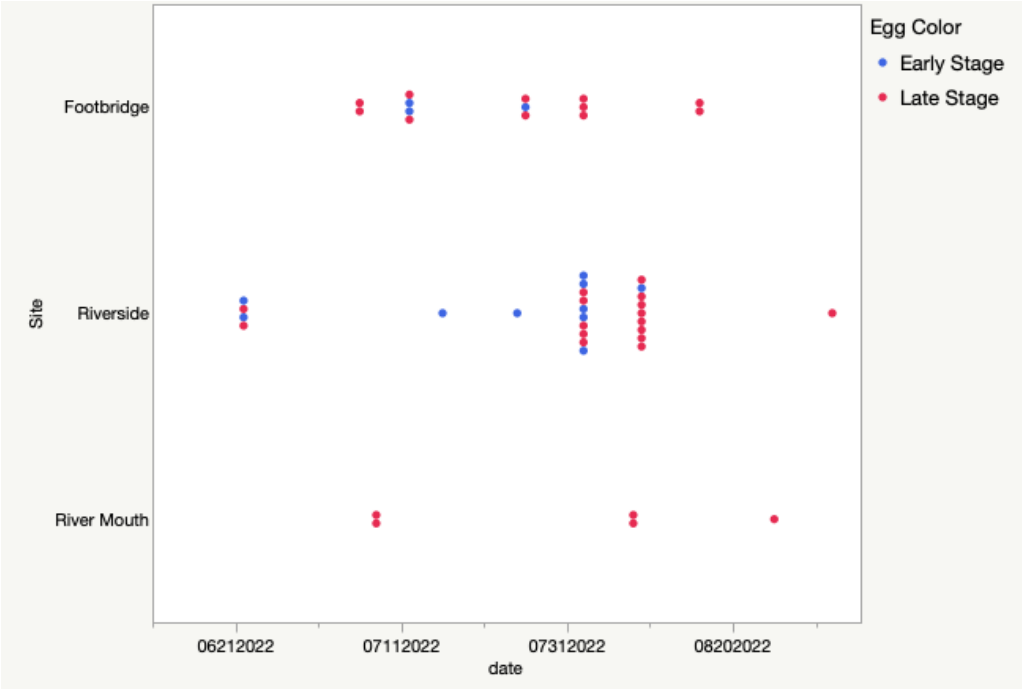

Figure 14: Egg-bearing crabs caught on the Ogunquit River, by site, date, and stage

Outreach and Engagement

Though we did not strictly track the number of contacts our team made, the number of volunteers (citizen scientists) we were able to recruit to assist us, or the number of conversations that ensued, it is safe to say that our outreach goals were met. At every session we had meaningful engagement with residents and visitors, and were able to find willing recruits to assist us. We handed out approximately 350 Crab Patrol “data team” stickers to young helpers, and – with the exception of the Tides, a private boat launch – routinely drew a crowd. Although we had fewer citizen scientists at the Tides, the families our outreach attracted were generally deeply engaged.

Most critically, our citizen scientists at Riverside Beach (and to a lesser extent, the River Mouth) were able to canvas the area in a way that our research team could not have, finding egg-bearing and soft shell crabs under rocks and in crevices that are difficult to reach.

Discussion

Though yearly cycles and variables such as local weather and marine conditions undoubtedly influence the population dynamics of green crabs in the Ogunquit River estuary, we are pleased to present this data as a snapshot of invasive green crab activity in the estuary in the summer of 2022.

Our analysis of captured crabs' size showed that the catch was predominantly mature individuals averaging around 45 mm, suggesting that these were the easiest class size to target, even with our mixed methodology. Though we were able to harvest juvenile crabs in a size that would elude many other trapping methods, there was little indication that we could be successful in targeting only the smaller class size.

Soft-shelled crabs were almost exclusively found at the Riverside site. It was anecdotally noted that all soft-shell crab captures in this study occurred by net, so the greater amount of public engagement and net usage at Riverside compared to the other sites may be a possible explanation for this observation. It is worth noting that female crabs are known to molt and mate in the colder waters near the mouth of the estuary.

Egg-bearing females were found by our volunteers throughout the summer, with the majority caught in the first two weeks of August. These crabs were netted by volunteers who sought them out amongst boulder and cobble sized rocks at the Riverside site. Eggs in both their early and late stages of development were netted in this period. Since research from the NH coast has shown comparably few egg-bearing females in August, this finding suggests that there is more to learn about the mating and spawning habits of green crabs in this estuary.

Lastly, with public engagement levels consistently in the high to "overwhelming" category at our 3 public survey sites, this study provided proof of concept that summer visitors could be enlisted as citizen scientists in the effort to document and reduce green crab numbers in the Ogunquit River. While education and outreach was successful at all sites, the assistance provided by citizen scientists at Riverside Beach was of great value to the effort of harvesting egg-bearing and soft shell crabs.

Implications

Given the well-established negative environmental and economic impacts of the invasive European green crab in the Gulf of Maine, communities are seeking ways to reduce their numbers. Though this study was not designed to assess the overall prevalence and impact of the crab on our estuary, our research suggests that *Carcinus maenas* is, in fact, abundant in the Ogunquit River. Any non-native species found in abundance within an ecosystem can be assumed to have upset the natural balance, and green crabs are no exception. They feed on soft shell clams, mussels, oysters, and other filter feeders, destroy eelgrass beds and nursery habitat for lobsters, mollusks, and fish, and physically degrade the marsh banks. With an eye toward reducing their negative impact, we believe that the data collected in this study may be of interest to the following groups:

- Shellfish conservation professionals and licensed clammers
- Conservation organizations looking to conduct targeted removal of green crabs in vulnerable estuaries
- Municipalities and organizations looking to tap into the power of youth volunteers

- Scientists looking to add data points to the existing body of research on the population of green crabs in the Gulf of Maine

Our results indicate that, for the purpose of removing a portion of the next-year class of green crabs from the Ogunquit River estuary during the summer months, intensive efforts to remove egg-bearing females in late July and early August may be successful. The majority of egg-bearing crabs and soft-shell females were caught closer to the ocean, and by many hands rather than few. This implies that the targeting of egg-bearing and soft shelled (pre-mating) females may best be done by recruiting larger teams of volunteers who trap with nets during key dates, as opposed to a few volunteers using baited crab traps over a longer period of time.

Additionally, since proportionally more females were caught at the sites closer to the ocean, mass trapping at Riverside and the River Mouth might streamline our efforts to remove potentially fertile females. The ability of green crabs to travel distances with river and ocean currents, however, may limit the utility of this – or indeed any method – of population reduction. The stakes are high, however, and targeting fertile females for removal may prove to be an effective way to reduce the negative impact of green crabs on the Ogunquit River estuary.

Acknowledgements

This study would not have been possible without the assistance of a dedicated group of students from Wells (ME) High School Environmental Club, the efforts of our college-aged summer interns, the support of the Town of Ogunquit, and a generous Discovery grant from the Onion Foundation. We are also grateful to the Ogunquit Tides Resort for allowing us to work from their boat launch, and the Ogunquit Transfer Station for composting our crabs. Thank you!