Hemigrapsus sanguineus

Invasive Species Population Study

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Fairhaven High School Grade: 10-12

Affiliated Research Scientist: Nancy O'Connor, Ph.D.
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Area of Specialization: Ecology of estuarine benthic invertebrates, biology of marine larvae, nonindigenous species

I. **Theme/Topic**: Ecology-Population Study of nonindigenous species

The objective of this unit was to conduct a population study on the nonindigenous species *Hemigrapsus sanguineus* (Asian shore crab). The foundation objective was to introduce students to field research. Since there is much that is still not known about the *H. sanguineus*, the opportunity exists to conduct novel research. Following the initial studies, a data presentation and discussion will be held with the affiliated research scientist. The students will develop their research into an independent research project to be presented as a poster at a science fair. In addition, the students will participate in a High School Symposium at UMASS-Dartmouth breakout session and will instruct other high school students how to *handle H. sanguineus*.

II. **Student Objectives**. Student will be able to:

1. Define and give examples of invasive species.
2. Explain how invasive species are introduced into a new environment.
3. Discuss how an invasive species has an impact on an ecosystem.
4. Identify the species and sex of different species of crabs that inhabit the intertidal zone.
5. Assess the water quality of the site.
6. Conduct different population sampling techniques to determine the population of crabs at a site.
7. Graph and analyze the population data for sex ratios, size ratios, and distribution within the intertidal zone.
8. Communicate their findings by either PowerPoint or Poster.
9. Generate questions that could be developed into a research hypothesis.

III. Links to Frameworks:

Grade 6-8: Life Sciences

Living Things and their Environment (14). Give examples of the ways organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.

Grade 9-10: Biology

Ecology (6). Broad concept: Ecology is the interaction between living organisms and their environment.

6.3 Identify the factors in an ecosystem that influence fluctuations in population size.

6.4 Analyze changes in an ecosystem resulting from natural causes, changes in climate, human activity, or introduction of non-native species.

IV. Incorporation of Research Scientist

Nancy O'Connor, Ph.D. was incorporated into the study initially through planning conversations in designing the unit. After the students collected, compiled, and organized their data into a PowerPoint presentation, they presented their data and findings in a data meeting. Through discussions with Nancy O'Connor we realized we had a design flaw in the study that had to be remedied. In the spring, when the beach is accessible, the study will continue. In addition, other sites along the Acushnet River will be evaluated for the presence of *H.sanguineus* and the data will be communicated to Nancy O'Connor.

V. Resources

A. Teacher Background Information

1. Location of *Hemigrapsus sanguineus*

Hemigrapsus sanguineus was first found in Cape May, New Jersey in 1988 (Williams and McDermott, 1990) and quickly spread along the eastern seaboard from North Carolina to Maine. It is found in most rocky intertidal coastal and estuarine environments in southern New England (Ledesma, M.E., and N.J. O'Connor. 2001). *H. sanguineus* was found in salinities as low as 24 ppt and was more abundant in lower and middle

intertidal elevations. It can be found year round under rocks.

2. Identifying the *Hemigrapsus sanguineus*

H. sanguineus is easily differentiated from the indigenous Atlantic mud crab *Panopeus herbstii* and an earlier intertidal invasive species, the European green crab *Carcinus maenas*. The first distinguishing characteristic is the coloring of the carapace. *H. sanguineus* has a banding pattern on the walking legs and a dark carapace ranging from brownish orange to greenish black (Williams and McDermott, 1990). In comparison, the carapace of *P. herbstii* is dark blue-green, brown or buff with purplish speckles on the front portion of the carapace. While *C. maenas's* carapace is dark green, mottled with black and brownish spots. The most reliable way to differentiate the crabs is by the number of anterolateral teeth on the carapace. *H. sanguineus* has three anterolateral teeth in comparison to the five anterolateral teeth of *P. herbstii* and *C. maenas*. Another distinguishing factor are the claws. The male *H. sanguineus* has a fleshy knob at the base of the dactyl of the chelipid, which neither of the other two crabs have. *P. herbstii* can be identified from the other two by dark brown claw fingers.

3. Handling the *C. maenas, H. sanguineus,* and *P. herbstii*.

Crabs differ in their response to being handled. Each crab species has its own characteristic temperament, from aggressive to relaxed. It is the claw of the crab that the handler must respect. Crabs do not bite, they pinch. As a rule the larger the claw, the more powerful it is, and the more caution should be taken. Of the three crabs discussed above, *P. herbstii* is the most relaxed, followed by *H. sanguineus.* Due to the greater range of motion *C. maenas* relative to the other two the can be the more difficult to handle. The best way to capture these crabs is by pinning the crab’s carapace down and holding the claws from the outside tight against the carapace. All three crabs can be handled for measuring by pinching the

crab from underneath with the thumb such that the thumbnail faces toward the front of the crab. In this manner, all that the claws can reach is the thumbnail. Have the students practice handling and measuring the crabs with calipers before entering the field.

4. Determining the Sex of the Crab

After having mastered handling the crabs, then practice determining the sex of the crabs. After securing a crab turn it over, examine the telson (See figure below). The wider abdomen, often compare to the Washington Capital building, indicates a female, while the thinner telson, resembling the Washington Monument, indicates a male.

5. Determining the Size of Crabs

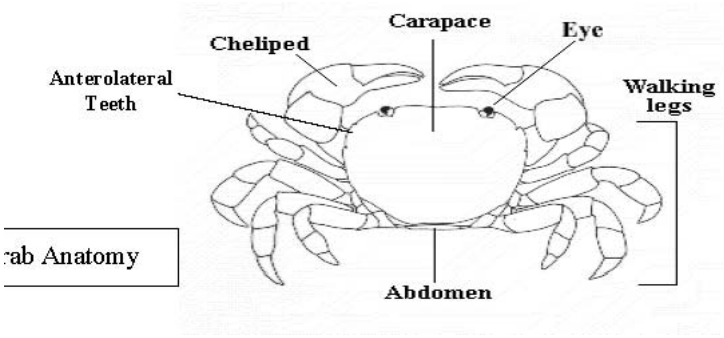
To determine the size of crabs, purchase calipers from a science supply house. Both stainless steel and plastic models were evaluated. The plastic model had many advantages over the metal calipers: 1) lower cost ($6.80 compared to $12.95,Carolina) 2) does not require immediate rinsing, 3) they do not rust, and 4) easier to adjust graduated dial. The calipers used in this study were purchased from Carolina: Plastic Vernier Caliper (ER-70-2647, $6.80) and Plastic Vernier Caliper (ER-70-2651, $12.95).

Explaining how to use calipers to determine the width of an object can be difficult so practice with a peer. After instructing the students how to use a caliper, have the students practice determining the width of a standard sized object such as a penny. If they can be located, collect the molted shells of crabs from local beaches that have washed up in the strandline. These will give the students practice determining the width of the carapace without the added challenge of a wiggling, pinching crab. After the students have mastered measuring the carapace, bring out live crabs for the students to practice on. The crabs can be kept in a plastic cooler with seawater from the same area they were caught. Purchase a battery powered air pump to keep the water oxygenated.

6. Planning a field study for *H. sanguineus*

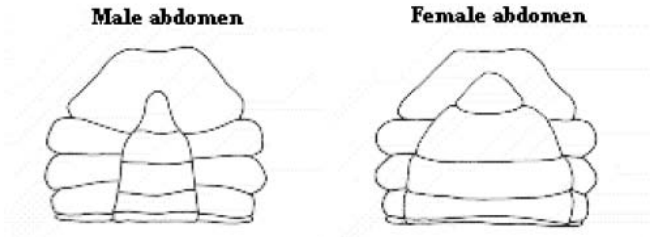
Consult a tide chart before scouting a site. Since the crabs inhabit the middle and lower intertidal zone, it is important to plan a visit as close to low tide as possible. The www.maineharbors.com/ma/tidemabb.htm website has many local waterways and can be consulted to plan a trip in advance. Plan to visit the survey site at low tide and conduct an informal survey to

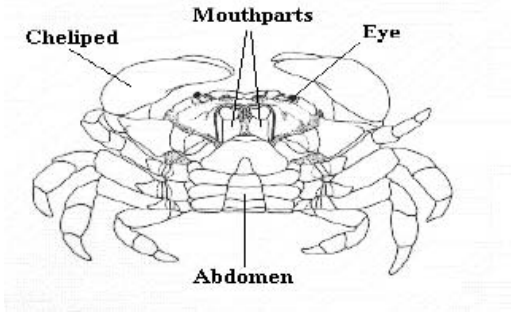
see if the site will be satisfactory.



Anterolateral Teeth

General Crab Anatomy





B. Lesson Plans

Day 1: Introduce ecosystems and food webs from established curriculums.

The students read an article from Marla Cone entitled "From a subtle ecological change, big problems grow" and discussed the significance of the article. The following questions were used to prompt discussion:

1) What observation have lead scientist to study the Gulf of Alaska?
2) What is the Aleutian paradox?
3) What is being influenced by an event in 1977?
4) What did Tim Tinker first look for?
5) What food chain is mentioned?
6) Was the impact limited to the food chain? (Try to get them to make the connection between food chains and a food web)

7) Describe the basis of the ecological problem.

The students are then placed into groups of three and given some local, indigenous species that would form an ecosystem. Following the group exercise, *H. sanguineus* is introduced. The rapid expansion, resistance to salinity and density are discussed along with the omnivorous diet, which includes crustacean, mussels, clams, snails, algae, and vascular plants. The students were then instructed to compose an essay to hypothesize what would happen to their ecosystem upon introduction of *H. sanguineus.*

Day 2: Introduce Marine Invasive Species.

Depending on the students, different levels of literature can be supplied. Along with many websites, I used three pieces of literature in addition to conversations with Nancy O'Connor.

1. Marine Bioinvaders by Sue Nourse
2. Hitchhikers by the MIT Sea Grant
3. The Science of Invasive Species by the Union of Concerned Scientists

There are many examples that can be used. *H. sanguineus* was likely introduced by release of larvae in the ballast water transported from the western North Pacific Ocean to the mid-Atlantic coast of the United States. Following a discussion of marine invasive species, the students share their writings from the night before.

Following sharing their writing samples, the students are given a summary of a paper entitled, "Predation of Juvenile Lobsters by the Asian Shore Crab." A teacher led discussion relating their writing to the article brings out some of the potential problems. The students were then given handouts that included primary research from Nancy O'Connor's lab and sections from Crabs of Cape Cod. The students were told to read the articles and come to class with 5 questions they had from the reading.

Day 3: Preparation for Field Work

The students were introduced to sampling techniques for determining the density of a species in an area (total catch, catch and release, random sampling, and uniform sampling along a transect) and water quality testing (water temperature, salinity, and dissolved oxygen). Sample population density problems were introduced and practiced by the students. Following, the students were given live *H.sanguineus* crabs (caught earlier in the

morning) to practice handling, sexing, and determining size.

Practice Problems:

1. Using a uniform sampling of a 20 m X 10 m area of rocky intertidal coastline which appears to have uniform distribution, 1 m^2 quadrants were placed in a pre-planned pattern. From a sampling of 40 quadrants, 312 crabs were captured.

    A. What is the density of the sampled area? *7.8 crabs/ m^2*
    B. How many crabs inhabited the area? *1560 crabs*
    C. I clumping occurred how could the results be different?

2. Using a random sampling of a 5 m X 16 m area of rocky intertidal coast line which appears to have uniform distribution, plastic balls were tossed randomly and 1 m^2 quadrants were placed where the ball landed. From a sampling of 50 quadrants, 188 crabs were captured.

    A. What is the density of the sampled area? *3.76 crabs/ m^2*
    B. How many crabs inhabited the area? *300 crabs*
    C. How could the results be different if the distribution of crabs was clumped?

3. Using a capture-mark-release approach from a 10 m x 5 m area of rocky intertidal coastline, 112 crabs were captured, marked, and released. Two days later, she captured 88 crabs of which 32 were marked crabs.

$$N = \frac{\text{(Number marked x total catch second time)}}{\text{Number of marked recaptures}}$$

    A. What is the population size? *308 crabs*
    B. What is the density? *6.2 crabs/ m^2*
    C. Upon examining the capture site, it is determined that 1/2 of the area is sand and not inhabited by crabs. How will this influence the determination of density? *12.4 crabs/ m^2 for rocky coastline*

The students were sent home with the following protocol to copy into their lab book and a data collection sheet (**Data Collection from Acushnet River-New Bedford Harbor Beach**).

Hemigrapsus sanguineus Population Study

Purpose: To determine the population of *Hemigrapsus sanguineus* along a stretch of the Acushnet River-New Bedford Harbor using a transect line.

Research Method:

1. Work in Pairs to perform Population Study at low tide.
2. Run a transect line perpendicular to the shore within the intertidal zone.
3. Place 0.25 m^2 quadrants along transect line, alternating left and right. Record the position of the quadrant.
4. Estimate the amount of rock cover in each quadrant.
5. Collect all the crabs in the quadrant by turning over rocks and digging into the sediment to a 5cm depth. Any crabs collected from a quadrant should be placed in a bucket. Each bucket should have one rock to provide some cover.
6. Measure the carapace of each crab. Determine sex. Note any injuries to the crabs. Record all the data for the quadrant.
7. Before returning crabs to their rocks put a spot of nail polish on the carapace.
8. Note other organisms in study site.
9. Determine temperature, salinity, and dissolved oxygen.
10. Keep detailed records in a data log

Protocol adapted from Nourse, 2003.

Day 5: Data Analysis

Compile class data such that all the students have the same data. Divide the class into groups to analyze the data for sex, size, and species ratios. In addition, have the students graph the intertidal distribution of the crabs.

Data Processing:

1. Compile data
2. Compute Population Density
3. Place data in Excel file
4. Prepare Graphs of the data
5. Submit graphs

Day 11: Return for Capture of released marked *H. sanguineus*

One week later, have students return to the same site and perform a sampling of the site looking for previously marked crabs. Determined the

number of crabs in the area and calculate the population density using the formula:

$$N = \frac{\text{(Number marked x total catch second time)}}{\text{Number of marked recaptures.}}$$

C. Literature

Berrick, S. 1986. Crabs of Cape Cod. ISBN 0916275001.

Bourdeau, P. E. and N.J. O'connor. 2003. Predation by the nonindigenous Asian shore crab *Hemigrapsus sanguineus on macroalgae and molluscs.* Northeastern Naturalist. 10(3) 319-334.

Cone, M. 2001. From a subtle ecological change, big problems grow. The Philadelphia Inquirer, 01/28/01.

Ledesma, M.E., and N.J. O'connor. 2001. Habitat and diet of the non-native crab *Hemigrapsus sanguineus* in southeastern New England. Northeastern Naturalist. 8(1) 63-78.

Nourse, S. 2003. Marine Bioinvaders. Flotsam & Jetsam. 32 (2) 5-7.

Williams, A.B. and J.J. McDermott. 1990. An eastern United States record for the western Indo-Pacific crab *Hemigrapsus sanguineus* (Crustacea: Decapoda: Grapsidae). Proceedings of the Biological Society of Washington 103:108 -109.

D. Websites:

http://www.state.me.us/dmr/rm/asian_shore_crab.htm

http://massbay.mit.edu/exoticspecies/

http://massbay.mit.edu/exoticspecies/invaders/hemi.html

http://www.ucsusa.org/global_environment/invasive_species/page.cfm?pageID=975

http://www.lobsterinstitute.org/library/publications/bulletin/winter2003.htm

VI. Material/Technology Used

Each group will need quadrants, buckets, and calipers.

0.25 m^2 quadrants 10 meter transect tape 2 gallon buckets
Dissolved oxygen kit Thermometer Calipers
Hydrometer Field Notebook Fingernail polish

Computer with Excel, Word, and PowerPoint.

Draft:1-28-2004

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