2017

Counting Blue Crabs in the Bay! Subjects: Life Science / Biology, Environmental Science, Marine / Ocean Science Grade Level: 6-8

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COUNTING BLUE CRABS IN THE BAY!

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Grade Level
Middle School

Subject area
Life Science, Biology, or Environmental Science

This work is sponsored by the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.

1. Activity Title: Counting Blue Crabs in the Bay!

2. Focus: Blue crab biology and life cycle; animal – habitat relationships; sampling marine animal populations; design of scientific surveys

3. Grade Levels/Subject: 7th Grade Life Science

4. VA Science Standard(s) Addressed:

Grade 7 Life Sciences

- LS.1 – Student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
  - A) Data are organized into tables showing repeated trials and means;
  - E) Sources of experimental error are identified;
  - H) Data are organized, communicated through graphical representation, interpreted, and used to make predictions;
  - I) Patterns are identified in data and are interpreted and evaluated.
- LS.6 – The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment.
- LS.11 – The student will investigate and understand the relationships between ecosystem dynamics and human activity.

Grade 7 Mathematics

- 7.3 – The student will model addition, subtraction, multiplication, and division of integers; and add, subtract, multiply and divide integers.
- 7.4 – The student will solve single-step and multi-step practical problems, using proportional reasoning.
- 7.5b – The student will solve practical problems involving the volume and surface area of rectangular prisms and cylinders
- 7.12 – The student will represent relationship with tables, graphs, rules and words.

5. Learning objectives/outcomes

Students will:

- Identify the Chesapeake Bay blue crab, distinguish between adults of both sexes, and describe the blue crab life cycle;
- Estimate the densities of adult and juvenile “blue crabs” in two “habitat types”;
- Present the results graphically;
- Compare estimates between different amounts of replication;
- Generate hypotheses concerning the mechanisms that lead to observed patterns of blue crab habitat use and population size;
- Describe the challenges faced by scientists in population sampling;

6. Total Length of Time Required for Lesson:

Lesson: 75-90 minutes over two class periods
- Period 1: Introduction (30 – 45 minutes, depending on discussion)
- Period 2: Hands-on activity and discussion (45 minutes)

Set Up: 10 – 15 minutes (Period 1)
30 - 45 minutes (Period 2)

7. Key words & Vocabulary

See Appendix A

8. Background Information for Educators

This lesson is an introduction to the challenges faced by marine scientists as they try to quantify the use of different habitats by marine animals and estimate the sizes of marine animal **populations***. I will use the Chesapeake Bay's blue crab (*Callinectes sapidus,* Latin for 'beautiful' or 'savory swimmer') as a model **species** around which to frame the lesson. This lesson covers both life science concepts (populations, interactions between organisms and the environment) and general scientific skills. The questions at the heart of my lesson are these: How many blue crabs are in the Bay and where do we find them? What are the challenges that scientists face in answering this question, and how do scientists attempt to address these challenges and uncertainties? Why is this research relevant to society?

A charismatic **invertebrate crustacean**, the blue crab is intimately tied to the Chesapeake Bay from ecological, socioeconomic, and historical perspectives. It supports the most valuable **fishery** in the Chesapeake Bay (2014 fishery **landings** worth nearly 81 million dollars) and is a key player in the Bay's food web (National Marine Fisheries Service 2014). Blue crabs are voracious predators, consuming a wide range of **benthic** animals (including clams, worms, and oysters), fishes, plant material, and **detritus.** In turn, they serve as an abundant food resource for a number of species, including sharks, red drum, croaker, striped bass, and even other blue crabs (NOAA 2015). Blue crabs typically live between 2 – 3 years, and exhibit a complex, multi-stage life cycle that involves transport into coastal Atlantic Ocean waters as **larvae**, settlement in Bay seagrass **nursery habitats** as **juveniles**, and a sequence of growth and **molting** until reaching maturity (See Life Cycle Handout in Appendix). Mature male and mature female blue crabs can be distinguished by the characteristic markings on their abdomen (see Identification Handout).

Distinguishing habitats that are valuable to juvenile and adults is a key component of promoting **sustainable** fisheries. Similarly, knowledge of population size helps inform decisions regarding the number of blue crabs that can be harvested each year. Both of these objectives require surveys that sample the population and provide enough data to estimate animal abundance and density. Key components of designing useful surveys include: sampling randomly, e.g., sampling where crabs may or may not be, as opposed to only where you suspect they occur; replication, or repeated observations in both time and space; and lastly, using an appropriate **fishing (sampling) gear** that collects the species or life stage of interest. Students will investigate the concept of replication in the lesson. Students will also have the opportunity to examine published data on blue crabs from past research that showcases the difference in habitat use that can occur in the real world and suggests some potential mechanisms. These include differences in food availability (crabs tend to occur in areas of high food concentration), improved opportunities for growth (often habitats with the most food), or increased protection (areas where they are less likely to be eaten by predatory fish or other blue crabs).

How does this lesson relate to my own research and research interests? One of my laboratory's ongoing projects at VIMS is the Winter Dredge Survey a long-running program designed to estimate the size of the blue crab population and understand population dynamics through time. The survey findings are used to inform blue crab stock assessment and fishery management. We also conduct a variety of research related to other aspects of blue crab biology and life history.

* Words in **Bold** indicate key vocabulary for lesson. See Appendix A for full list with definitions. Additionally, the Reference Section includes several useful websites with more detailed information, as well as links to all recommended videos

9. Student Handouts

- Data Sheets (2 per 6-person group)
- Making Sense of Research Handout (1 per student)
- Assessment Worksheets (1 per student, if needed)
- See Appendix C for handouts

10. Materials & Supplies, A/V/Tech Support

Period 1 (Introduction)

- Required:
  - Computer and projector for displaying PowerPoint and playing recommended videos
- Optional:
  - Bucket or cooler
  - Ice
  - 1 – 5 adult blue crabs (ideally both male and female), with claws duct-taped

Period 2 (Activity)

- Rubbermaid Container (2 for each group)
  - Size: 12 qt.
- Marbles
  - 2 distinct sizes (small and large)
- Sand (enough for 1.5 – 2 inches in each Rubbermaid container)
  - If sand is not available, soil will work; however, sand is likely to be least messy
- Scratch paper (for calculations)
- Graph paper
- Rulers
- Plastic spoon (2 per group)
- Pencils (2 per group)

See Appendix B for photos of equipment

11. Classroom/Lab/Field Study Set Up

Period 1 (Introduction): Load PowerPoint and videos

Period 2 (Hands on Activity): The activity will require large tables for groups of six. The activity is likely to be messy; it involves digging in sand for marbles. Putting down a tarp on the table and floor will assist with clean up. Students will need to use the sink to wash up afterwards.

Each group of six students will receive:

- 2 Rubbermaid containers
    - Containers should be labeled *Habitat 1* and *Habitat 2*
        - Habitat 1 receives:
            - 60 small marbles
            - 20 large marbles
        - Habitat 2 receives:
            - 20 small marbles
            - 60 large marbles
        - If marbles are limited, it is okay to use fewer marbles, but keep the ratios similar (e.g., more small marbles in Habitat 1 compared to Habitat 2)
    - Add sand to each habitat (about 2 inches)
    - Stir up marbles in sand so that they are well mixed and mostly covered with sand
- Two data sheets (one for each habitat container)
- Two sheets of graph paper
- Some scratch paper
- Pencil, ruler, plastic spoons

After Activity, provide each student with Blue Crab Habitat Use Research Results Handout

See Appendix B for photos of hands-on activity set up, and Appendix C for a diagram of habitat container set up.

12. Procedure

Summary

The lesson includes an introduction (PowerPoint presentation), hands-on activity, short informative videos, class discussion, an in-class or take-home assignment, and assessment worksheets.

In the first period, students will first be introduced to the blue crab and the blue crab life cycle, then discuss the problem of sampling marine animals. Several videos will help keep the students engaged. The introduction will conclude with a discussion of the importance of population sampling for the conservation and management of natural resources.

The second period is a hands-on-activity. Groups of students will investigate how the amount of replication (repeated trials) can affect estimates of a "blue crab population" in two different habitats. Students will make graphs of their results and discuss their findings.

Detailed Description

Period 1: Introduction (30 - 45 minutes)

1. First, the teacher will describe the Blue Crab, its life cycle, its importance in the food web and its role as a fishery, with help of the provided PowerPoint presentation. The presentation includes suggested talking points and discussion questions in the comments section on each slide. (10 – 15 minutes)
    a. The presentation also includes links to two videos to show to students. The links are also listed in the Reference section of this document.
        i. Video 1: Blue Crab Shedding - A short time-lapse of a juvenile blue crab shedding its exoskeleton and molting
        ii. Video 2: Animal Attack! Blue Crab vs. Clam – A short National Geographic segment focused on predator-prey relationships between the blue crab and a preferred prey item, the hard clam

2. Second, the teacher will discuss population sampling and its importance. (10 – 15 minutes). Some questions for discussion are included here:

    a. Why might we be interested in determining the number of crabs that are in the Chesapeake Bay, and where they occur?
        i. Estimates of the number of crabs are useful to scientists, managers, and fishermen.
        ii. These estimates help us understand the health of the population over time and decide how many blue crabs to harvest each year.
        iii. Habitats that hold more blue crabs may be important nursery or spawning habitats, and may need to be protected from fishing or other human impacts. For example, fishermen are not allowed to harvest adult female blue crabs from the lower Chesapeake Bay for several months in the year to protect them during spawning.

    b. What might make population sampling challenging?
        i. Crabs move, there are millions of them, and we can't see well in the Chesapeake Bay
        ii. To prompt discussion, teacher could ask the students: *"Imagine you had to count the number of trees in the forest, except that 1) you are blindfolded 2) the trees move about. It would be difficult, wouldn't it?"*

    c. What may happen if we don't know how many crabs there are?
        i. There is potential to overfish (remove too many crabs from the system and reduce their population below a healthy level)

    d. If students might have a difficult time connecting with blue crabs or the Chesapeake Bay, using an example close to home might be helpful. For example, one teacher who tested this lesson asked her class to think about how they might estimate the number of cardinals in their county, and what potential problems they might encounter, then shifted to discussing blue crabs.

3. Lastly, teacher will show short video about the VIMS Winter Dredge Survey (link in References), as an example of population level sampling in real life. (5 minutes)

Period 1: Alternative Introduction (Optional, 15 - 20 minutes)

Blue Crab ID & Show-and-Tell

- If the teacher has access to live blue crabs and is comfortable with animals, the teacher can bring blue crab(s) into the classroom (with claws taped for safety) for students to see and touch.
  - o Holding the crabs in ice water will relax them enough to tape of claws and keep them relatively docile for students to hold

- Questions for discussion:
  - o What features of this crab are unique? What makes a crab a "crab"?
    - ▪ Key features of arthropod crustaceans include a hard exoskeleton and jointed appendages
      - Note the large claws – used for defense and feeding
      - Antennae near the crab's eyestalks allow the crab to detect chemical and physical stimuli in the water – vibrations, scents, etc.
      - The last jointed appendage ("leg") on the blue crab, and other crabs of the Portunidae family, is modified to resemble a paddle. These are the crabs "swimming legs", which allow them to swim in the water column and move quickly to find food or escape predators
  - o How do we tell males/females apart?
    - ▪ The markings on the bottom of the abdomen. Mature male crabs abdomen (also called an apron) resemble the Washington Monument, while mature female crabs resemble the Capitol Dome

Period 2: Hands-On Activity (45 minutes total)

Hands on Activity (15 - 20 minutes)

1. Teacher breaks class up into groups of six students, and gives each group the two labeled Rubbermaid containers prepped with sand and marbles
   a. The Rubbermaid containers represent habitat types
   b. One Rubbermaid container (labeled Habitat #1) has more juveniles than adults, the other has more adults than juveniles (labeled Habitat #2)
      i. Small marbles are the juvenile crabs, large marbles are the adult crabs

   c. Note: If marbles or containers are limited, groups of students can also work through the sampling in shifts.

2. Introduce the problem and goal of the activity
   a. Students are blue crab biologists in the Chesapeake Bay.
   b. The Rubbermaid Containers represent two different habitats
   c. There may be a difference in the number of adult and juvenile blue crabs in each habitat type, but we do not know for sure.
      i. Question for class: Why would it be important to know if there is a difference between habitat types?
         1. We often can't protect all habitats because of limited resources. Understanding the relative value of certain habitats can help prioritize our actions in order to make the most difference

d. Activity Goal: Sample the different habitats with replication (repeated trials) to estimate the total number of juvenile and adult crabs in each

3. Within each 6-person group, 3 students are assigned to each habitat container and given a role for sampling
    a. Sampler: Digs for marbles
    b. Data collector: Counts number of marbles
    c. Data recorder: Writes down number of marbles on data sheet
    d. Students will conduct three trials in each habitat and switch roles after each trial

4. Sampling Procedure
    a. 'Sampler' will use ruler to measure an approximately 2 in x 2 in square in the sand
    b. Using a spoon or their hands, 'Sampler' will excavate the area inside the cylinder and remove any marbles
    c. Data collectors will tally the number of large and small marbles within the sampling cylinder
    d. Data recorders will write results down on the provided data sheet
    e. Students will switch roles after each trial

Working with the Collected Data (10 minutes)

1. As a 6-person group, students will tally the total number of juveniles and total number of adults sampled in each habitat (i.e., calculate the sum of all three trials)

2. As a 6-person group, students will determine average number of marbles collected per sample (formula included on data sheet).

3. Using graph paper, each 6-person group will make two bar plots, each broken down by age (juvenile/adult) and habitat (#1 or #2)
    a. Barplot 1: Number of marbles collected in first trial
    b. Barplot 2: Average number of crabs collected
    c. See Appendix B for an example of the bar plots students should make

4. Finally, students will estimate the total number of juvenile and adult crabs in each their habitat (#1 or #2; formula provided on data sheet).

Discussion (5 - 10 minutes)

1. Each 6-person group will report how many total juvenile and adult crabs they estimated in each of their habitats

2. As a class, students will compare the results and make a decision about which habitat supports more juveniles and which habitat supports more adults

3. Some questions for discussion:

    a. What are the issues with only taking one sample (conducting one trial)?
        i. One sample is probably not representative of the whole population

b. How many replicates/trials do you think enough to estimate how many total crabs there are?
    i. A 'magic number' is typically three, because three replicates allows you to calculate the variability between samples. However, the number of replicates usually depends on the question. Typically, more is better, but taking more replicates can be expensive. Designing experiments involves tradeoffs between what is desired and what is feasible.

c. What might limit scientists from taking as many replicates as they would like?
    i. Limited resources! Time, money, staff, boat availability or boat time, bad or unexpected weather, mechanical issues. There is also always the chance of something unexpected happening that complicates the plan.

d. Was our sampling random? What is the importance of randomly sampling, as opposed to sampling somewhere where you know there are lots of crabs?
    i. Yes, attempted to be. Sampling only where you know the crabs are may bias your estimates of the average number, density, or total population size. You might end up with only large samples that only had high numbers.

e. What is a valid replicate or trial? What if you sampled in the same spot, or an overlapping spot?
    i. A valid replicate is independent of the previous replicate. Sampling in the same spot may not be independent.

Placing the Activity in Context ~ Juvenile Blue Crab Habitat Use (5 – 10 minutes)

1. Using the Making Sense of Research Handout, teacher will ask students to work as a group to interpret the bar plots and graphs

2. Question One Answers:
    a. The figure is a graph of average juvenile blue crab density (crabs per meter squared) measured in three habitat types (Seagrass, Shallow Water, and Deep Water) in two locations (River Mouth, Downriver) in the York River, Virginia.
    b. More blue crabs were collected on average at the mouth compared to downriver
    c. The most blue crabs were collected in seagrass beds (Black bar on left).
        i. Note the break in the y-axis scale – this may throw students off. The break allows a variable (in this case, Seagrass-River Mouth) with a much higher value to be included on the same plot.
    d. Several reasons could explain why more blue crabs were collected in seagrass. These include increased prey to feed on, protection from predators, or simply location and environmental conditions (juvenile blue crabs tend to settle there first when they reenter the Bay from the ocean)

3. Question Two Answers:
    a. The figure is a plot of blue crab density versus clam density. Clams are an important food source for the blue crab. The figure shows a positive relationship between clam and crab density; as clam density increases, crab density tends to increase, especially at high clam densities. Crabs like to be where the food is!

4. Note: This worksheet could be finished as a take home assignment

Optional Take Home Assignment

1. A graph of the Chesapeake Bay blue crab population over time is included in the Making Sense of Research Handout. Teacher can point out and ask the following questions for a later discussion

2. What might affect the size of the blue crab population?
    a. Fishing
    b. Predators (fishes, sharks, other blue crabs) – For example, an overly high abundance of red drum, a large predator, is thought to have contributed to the drop between 2012 and 2013.
    c. Food availability (low years could be the result of years with low clam abundance)
    d. Weather/Climate/Environmental conditions – maybe larval crabs don't make it back to the Chesapeake Bay in high numbers, or vice versa

3. Who or what do changes in the size of the blue crab population, or changes in the amount that can be harvested, affect?
    a. Commercial harvesters (watermen) and their families
    b. The Bay ecosystem, other fisheries
    c. You & Me (Seafood eaters, restaurant goers)
    d. Future generations?

13. Assessment

- Presented with photos or actual blue crab specimens, students will recognize the difference between adults and juveniles and correctly identify specimens

- Provided with abundance data in barplot form, students will interpret and summarize results, as well as hypothesize potential mechanisms any observed differences (see Assessment Worksheet #1 & #2; answers included as well)

- Provided with scientific data regarding organism abundance in repeated trials, students will organize, calculate the total and the mean, and present graphically using a barplot (see Assessment Worksheet #3; answers included as well)

14. References

Websites and Articles

Blue Crab Archives. http://www.bluecrab.info

Chesapeake Bay Quarterly. 2016. Photo Essay: The blue crab winter dredge survey completes its course. http://www.chesapeakebay.net/blog/post/photo_essay_the_blue_crab_winter_dredge_survey_completes_its_course

Maryland Department of Natural Resources. 2015. Blue Crab Winter Dredge Survey. http://dnr2.maryland.gov/fisheries/Pages/blue-crab/dredge.aspx

Maryland Sea Grant. 2015. Blue Crabs. http://www.mdsg.umd.edu/topics/blue-crabs/blue-crabs

NOAA Chesapeake Bay Office. 2015. Blue Crab. http://chesapeakebay.noaa.gov/fish-facts/blue-crab

NOAA. 2006. Fisheries Glossary. https://www.st.nmfs.noaa.gov/st4/documents/FishGlossary.pdf

South Carolina Department of Natural Resources. Blue Crabs. http://www.dnr.sc.gov/marine/pub/seascience/bluecrab.html

Virginia Institute of Marine Science. Blue Crab Winter Dredge Survey. http://www.vims.edu/features/programs/blue_crab_winter_dredge.php

Videos

Chesapeake Bay Program. 2013. From the Field: Winter dredge survey counts Chesapeake Bay crabs (Video, 2:22). https://www.youtube.com/watch?v=28mvEE7ydXA

Jukin Media. 2016. Blue Crab Shedding. (Video, 0:54). https://www.youtube.com/watch?v=oIJXy2_1A7c

National Geographic. 2010. Animal Attack! Blue crab vs. Clam. (Video, 1:13). https://www.youtube.com/watch?v=vJUG8UvY-lk

Virginia Education Standards

Virginia Department of Education. 2010. Science Standards of Learning for Virginia Public Schools: Life Science. http://www.doe.virginia.gov/testing/sol/standards_docs/science/2010/courses/stds_life_science.pdf

Virginia Department of Education. 2009. Mathematics Standards of Learning for Virginia Public Schools: Grade Seven http://www.doe.virginia.gov/testing/sol/standards_docs/mathematics/2009/stds_math7.pdf

Appendix A: Key Terms and Vocabulary

Benthos: Organisms that live at the bottom of the estuary, sea, or ocean. From the Greek meaning "depths of the sea".

- Source: The Bridge, VIMS, (http://www2.vims.edu/bridge/search/bridge1output_menu.cfm?q=benthos)

Crustacean: A group of freshwater and saltwater invertebrates with jointed legs and a hard shell made of chitin, including shrimps, crabs, lobsters and crayfish.

- Source: NOAA (Fisheries Glossary – see References for link)

Detritus: Dead organic matter and the decomposers that live on it.

- Source: NOAA (Fisheries Glossary)

Dredge: A fishery gear dragged along the bottom to collected benthic organisms. Often rigid with teeth to disturb organisms buried in the mud.

- Source: Modified from Maryland Department of Natural Resources (see References)

Ecosystem: The community of animals and plants interacting with the land, water, weather, and the surrounding human activities.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Estuary: A partially enclosed, coastal water body where freshwater from rivers and streams mixes with salt water from the ocean. They are highly productive environments with many different structured habitat types.

- Source U.S. EPA (https://www.epa.gov/nep/basic-information-about-estuaries#whatis)

Fishery: The combination of fish and fishermen in a region, the latter fishing for similar or the same species or the same gear types.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Fishing (Sampling) Gear: the equipment or tools used to catch or collect fishes and other aquatic organisms.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Habitat: Specific type of environment occupied by an organism, a population, or a community.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Harvest: Total number or weight of fish caught and kept from an area over a period of time.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Invertebrates: Organisms lacking a backbone and/or a skeleton made of bone. The majority (97%) of all animal species.

- Source: NOAA Fishery Glossary

Juvenile: A member of a species that is not sexually mature.

- Source: NOAA Fishery Glossary

Landings: The number or poundage of fish unloaded by commercial fishermen or brought to the shore by recreational anglers for personal use.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Larvae: Immature juvenile stages of fishes and crustacean often very distinct in form, physiology, ecology, and behavior compared to the later juvenile and adult life stages.

- Source: modified from Blue Crab Archive (https://www.bluecrab.info/lifecycle.html)

Molting: The process of an individual shedding its rigid exoskeleton, allowing for growth and change in body shape.

- Source: modified from Blue Crab Archive (https://www.bluecrab.info/lifecycle.html)

Nursery Habitat: Habitats that promote the survival and growth of juvenile fish, crustaceans, mollusks, and other marine species.

- Source: Ecological Society of America (http://www.esa.org/ecoservices/marine/body.marine.scie.areas.html)

Observation: The act of making and recording a measurement.

- Source: Wolfram Alpha (https://www.wolframalpha.com/input/?i=observation)

Population: The number of individuals of a particular species that live within a defined area.

- Source: NOAA Fisheries Glossary

Replication: Repeated observations in space or in time, or repeated experimental treatments

- Source: N/A

Sample Size: Number of observations in a sample.

- Source: Wolfram Alpha (http://mathworld.wolfram.com/SampleSize.html)

Selectivity: The ability to target and capture fish by size and species while fishing

- Source: NOAA Fisheries Glossary

Species: A group into which animals or plants are divided according to their shared characteristics.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Submerged Aquatic Vegetation (Seagrass): Plants that grow in the shallow waters of the Bay, providing food and habitat for fishes, crabs, waterfowl, etc.

- Source: Chesapeake Bay Program, (http://www.chesapeakebay.net/fieldguide/categories/category/bay_grasses_sav)

Stock Assessment: The processing of collecting and analyzing biological and statistical information to determine changes in abundance of fishery stocks in response to fishing

- Source: NOAA (http://www.fishwatch.gov/glossary)

Survey: Sampling, collecting, observing, or surveying fish or fishery resources, on board scientific research vessels, to increase scientific knowledge of fishery resources

- Source: NOAA (http://www.fishwatch.gov/glossary)

Sustainability: Ability to persist in the long-term.

- Source: NOAA (http://www.fishwatch.gov/glossary)

Uncertainty: The incompleteness of knowledge and the state and processes in nature. Can come from measurement estimation error or natural variability

- Source: NOAA Fisheries Glossary

Appendix B: Equipment & Activity Set Up

Photo 1: Marbles

Photo 2: Habitat Containers, Marbles, and Tarp

Photo 3: Habitat container with sand (~ 2 inches worth)

Figure 1: Example of the barplot students will create to summarize data from hands-on activity.

Appendix C: Hands On Activity Data Sheet, Lesson Plan Diagram, and Blue Crab Handouts

Blue Crab Sampling Data Sheet

Group Name: ______________________

Date: ______________________________

Habitat: ____________________________

Trial	Number of Juveniles	Number of Adults
1		
2		
3		
Total		
Average		

Total Number of Adults in the Habitat (estimate): ________________________________

Total Number of Juveniles in the Habitat (estimate): ________________________________

Formulas to use

1. **Average:**

$$\frac{Total\ Number\ of\ Marbles\ Collected}{Number\ of\ Repeated\ Trials}$$

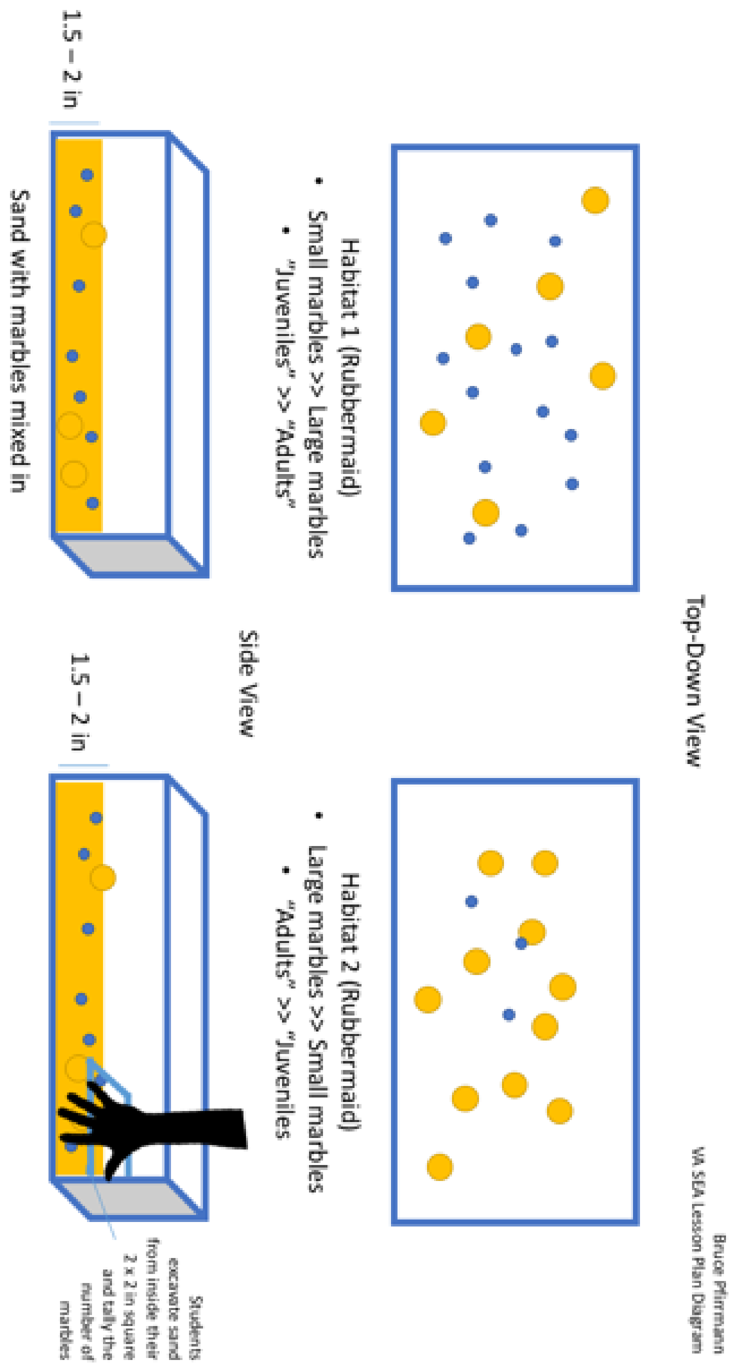
2. **Total Number of Marbles in the Habitat:**

$$\frac{Average\ Number\ of\ Marbles}{Area\ Sampled}\ x\ Total\ Area\ of\ Habitat$$

Notes:

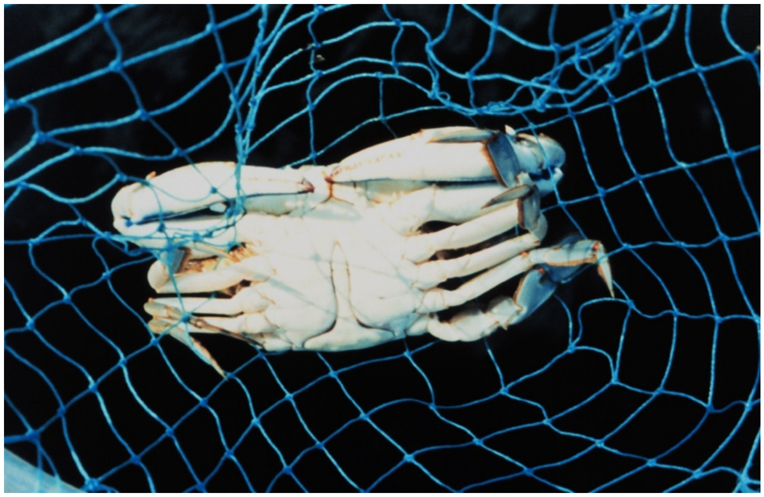
- Number of Repeated Trials = 3
- Area Sampled = 2 inches x 2 inches
- Total Area = $Length\ of\ Habitat\ x\ Width\ of\ Habitat\ (inches)$

Lesson Plan Diagram



Blue Crab Identification

Mature Male



Source: NOAA Photo Library, Mary Hollinger

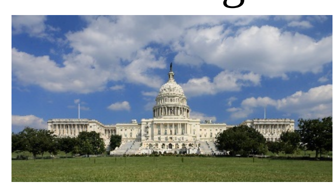
"Washington Monument"

David Iliff

Mature Female

Source: NOAA Photo Library, Mary Hollinger

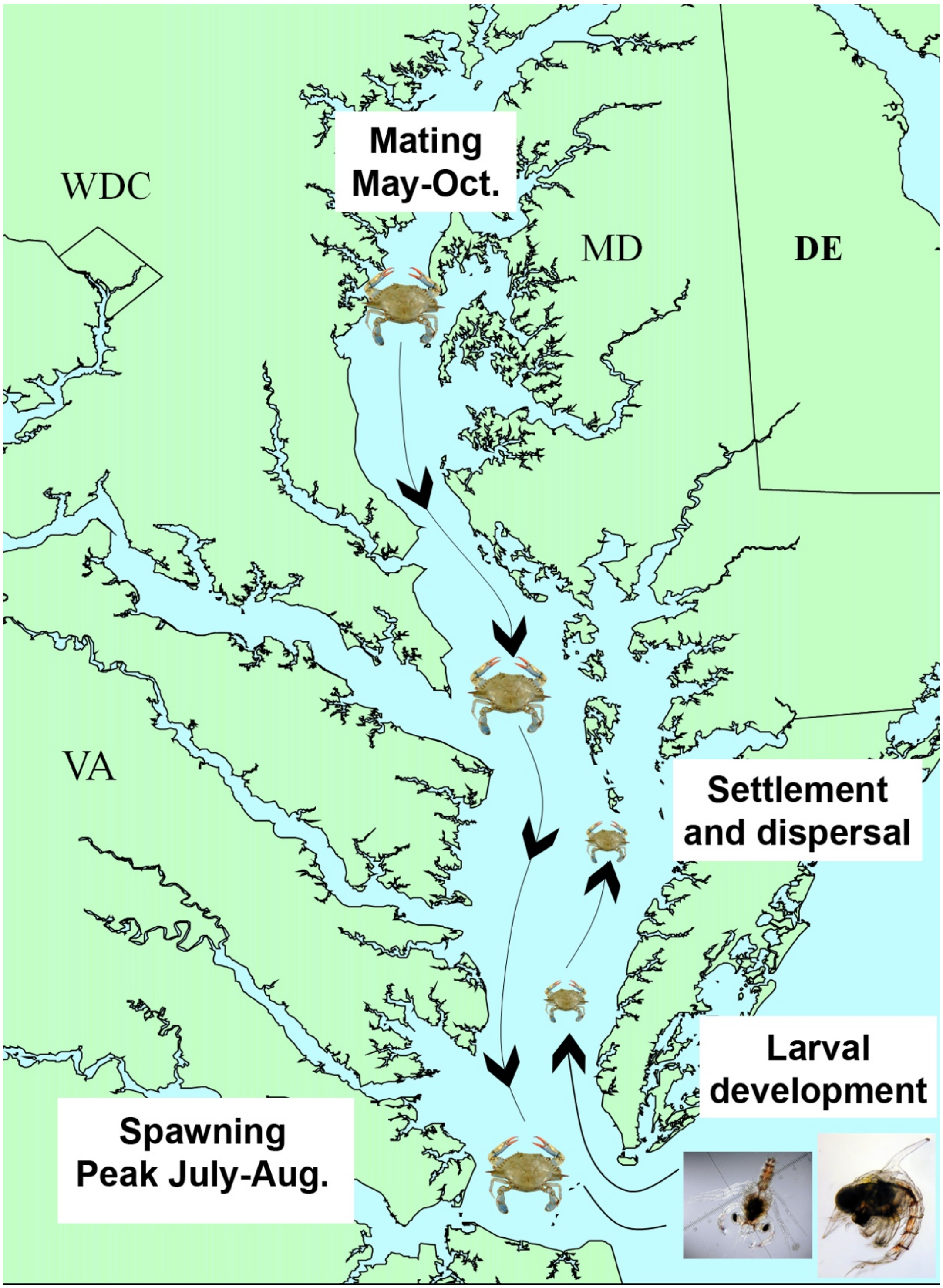
"Capitol Building"



Martin Falbisoner

*Note: Also in PowerPoint presentation

Blue Crab Life Cycle



Source: Smithsonian Environmental Research Center

*Note: Also in PowerPoint presentation

Photo/Diagram Full Attributions

Male Blue Crab:

- NOAA Photo Library, line0806
- Photographer: Mary Hollinger, NODC Biologist, NOAA
- Date: July 25th, 1999
- Link: https://www.flickr.com/photos/noaaphotolib/5114130763/

Female Blue Crab

- NOAA Photo Library, line2243
- Photographer: Mary Hollinger, NODC Biologist, NOAA
- Date: June 17th, 2001
- Link: https://www.flickr.com/photos/noaaphotolib/5114129843/

Washington Monument

- Photo by David Iliff.
- License: CC-BY-SA 3.0
- Link: https://en.wikipedia.org/wiki/Washington_Monument#/media/File:Washington_Monument_Dusk_Jan_2006.jpg

Capitol Building

- Photo by Martin Falbisoner.
- License: CC BY-SA 3.0
- Link: https://en.wikipedia.org/wiki/United_States_Capitol#/media/File:US_Capitol_west_side.JPG

Life Cycle Diagram:

- Smithsonian Environmental Research Center (SERC)
- Link: http://ecosystems.serc.si.edu/top-predator/

Making Sense of Research

Published Data

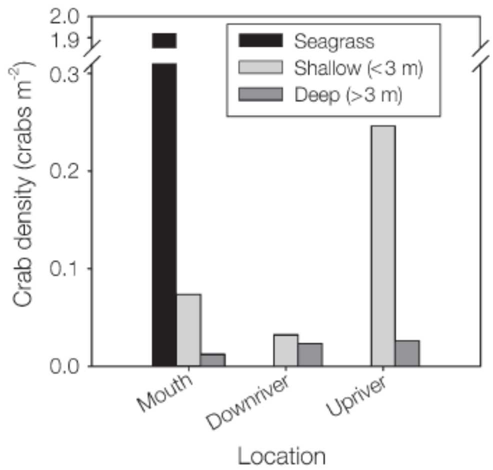


Figure 13. Density of blue crab juveniles in mouth downriver, and upriver locations in the York River, Vir ginia, Chesapeake Bay. Habitats were shallow subtida (mud or sand) and deep-water (mud) at all location whereas SAV (seagrass) habitats only occurred at th mouth location. Adapted from Lipcius et al. (2005b).

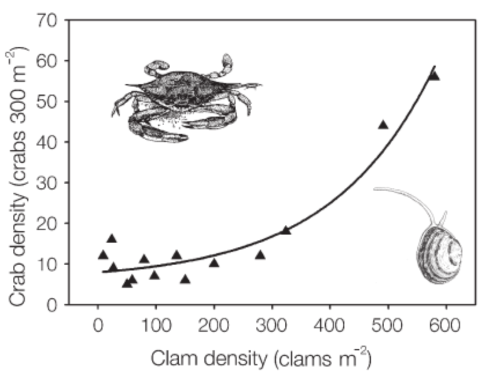


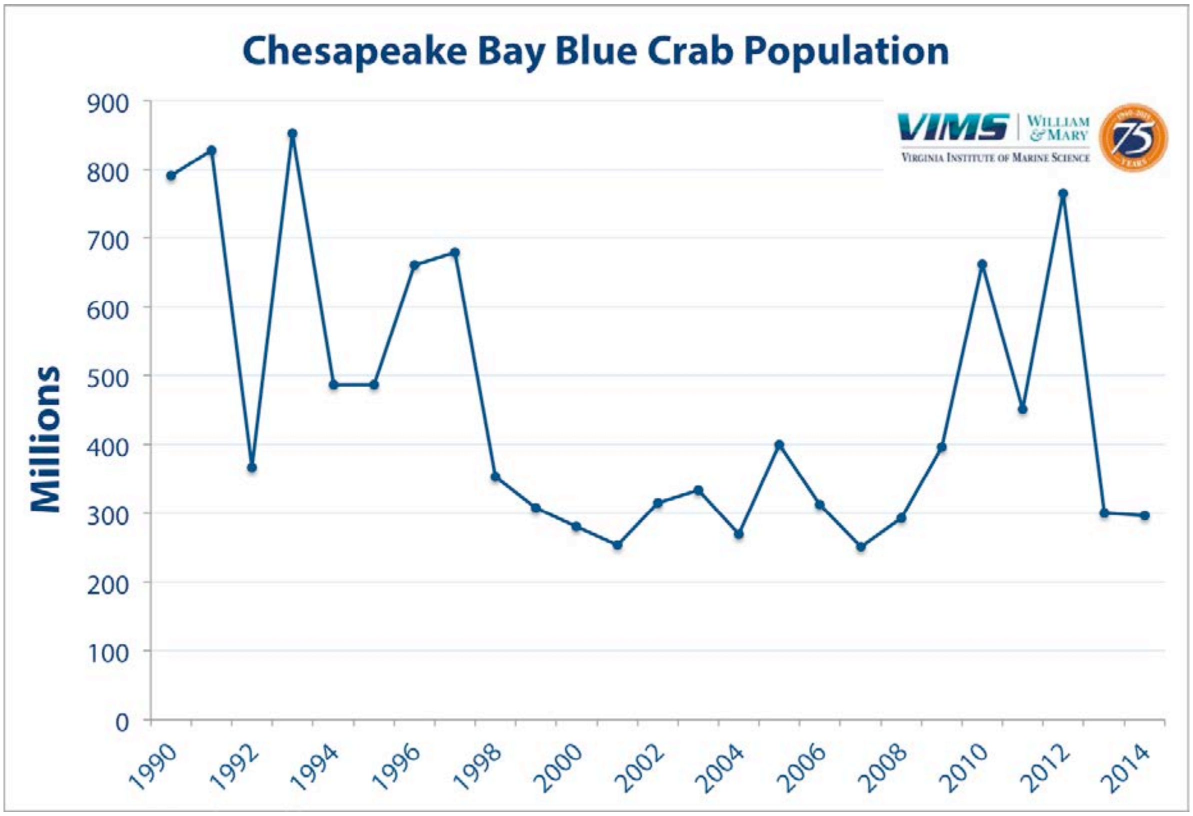
Figure 9. Relationship between blue crab and Baltic macoma densities in the York River, Chesapeake Bay. Adapted from Seitz et al. (2003).

Questions

1. Which habitat type do juvenile blue crabs appear to be most abundant? Why might that be the case?

2. What does this graph suggest about the relationship between blue crabs and clams?

Making Sense of Research



Question: Based on what you've learned in this lesson, what are some reasons that might explain why the blue crab populations goes up and down?

Figure Sources:

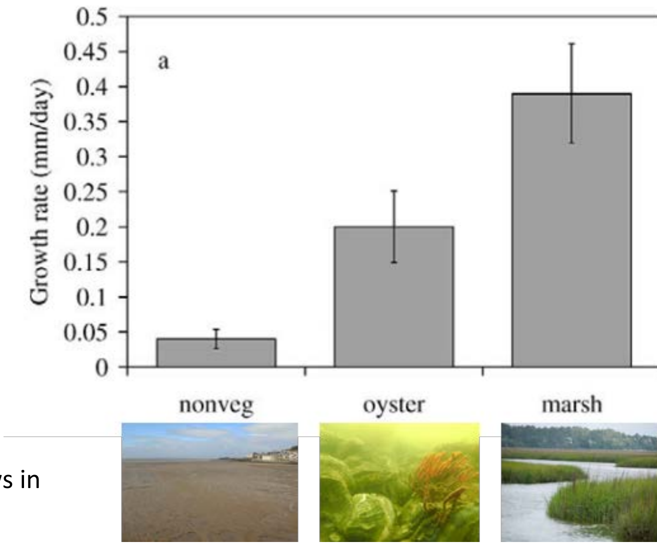
Modified from: Lipcius, R. N., Eggleston, D. B., Heck Jr, K. L., Seitz, R. D., & van Montrans, J. (2007). Post-settlement abundance, survival, and growth of postlarvae and young juvenile blue crabs in nursery habitat. *The Blue Crab Callinectes Sapidus. Maryland Sea Grant College, College Park, Maryland*, 535–564.

Virginia Institute of Marine Science. 2015. "Survey Results". Retrieved from http://www.vims.edu/research/units/programs/bc_winter_dredge/results/index2.php

Assessment Worksheet #1: Pinfish

Background: Pinfish (*Lagodon rhomboides*) are a common fish in estuaries like the Chesapeake Bay. Biologists conducted an experiment to see how fast pinfish grew in different habitats types They compared three different habitats: A mudflat ('Non-veg'), an oyster reef ('oyster'), and a salt marsh ('marsh'). The results are shown in the graph. The units are millimeters per day.

Question 1) In which habitat did the pinfish grow fastest? Slowest?



Question 2) About how fast did pinfish grow in oyster habitat?

Question 3) Why would scientists be interested in figuring out how fast a fish grows in different habitat types?

Question 4) What animals are common where you live? If you had to do a similar experiment, what different habitat types might you compare?

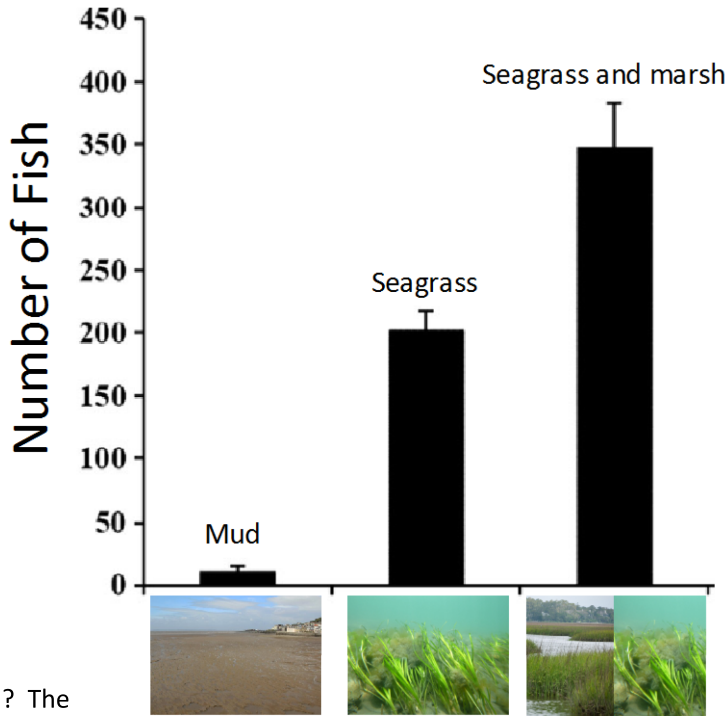
Assessment Worksheet #1: Answers

1. Fastest in Marsh, slowest in Non-Veg/Mudflats
2. About 0.2 mm/day
3. Possible responses: Helps to determine which habitat is more or most important, which habitats are 'better' or more favorable

Assessment Worksheet #2: Fish Habitat

Background: Marine biologists in North Carolina wanted to figure out which habitat had the most fish. They used a net to collect fish in three different habitats: mudflat ('mud'), seagrass, and a mix of seagrass and salt marsh.

Below is a graph of their results.



Question 1) Which habitat had the most fish? The least?

Question 2) How many fish were collected in 'seagrass and marsh' habitat?

Question 3) What are some possible reasons some habitats hold more fish than others?

Assessment Worksheet #2: Answers

Question 1) Most: Seagrass and marsh; Least: Mud/mudflat

Question 2) Around 350

Question 3) Possible responses: more food or prey items to feed on, more places to hide/refuge from predators

Assessment Worksheet #3: Fish & Oyster Reefs

Background: Scientists in Virginia wanted to see whether oyster reefs (A) or mudflats (B) were better for fish as habitat. They used nets to collect fish several times in each habitat, and they counted how many fish were collected in each trial. The data are recorded in the table below.

	Number of Fish	
Trial Number	Oyster Reef	Mud
1	4	0
2	5	4
3	6	10
4	8	9
5	2	2

Question 1) What was the total number of fish caught in oyster reef habitat? Mudflat?

Question 2) Calculate the average number of fish caught per trial.

Remember, Average = $\frac{Total\ Number\ of\ Fish\ Collected}{Number\ of\ Repeated\ Trials}$

Assessment Worksheet #3: Fish & Oyster Reefs (cont.)

Question 3) Using graph paper, draw a barplot of your answer from Question 2. Make sure to label both of the axes with the proper label and units.

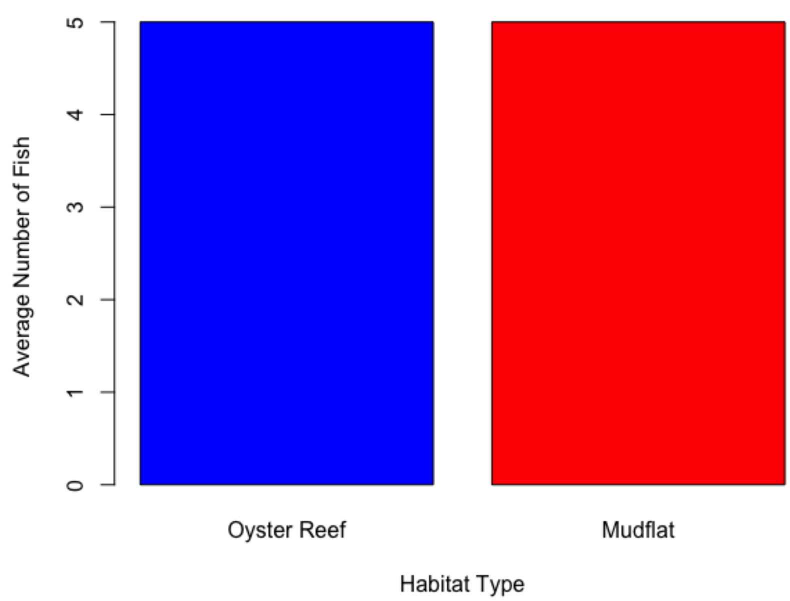
Question 4) Was there are difference in the mean number of fish between habitats? What are some possible reasons why or why not?

Assessment Worksheet #3: Answers

Question 1) 25 fish for both habitats

Question 2) 5 fish for both habitats

Question 3) Example barplot:



Question 4) No difference.

Possible explanations:

- Maybe both habitats are equally preferred
- Fish might move around between the two types of habitat
- Maybe they didn't sample enough or at the right times to see a difference.
- Sometimes scientists don't find a difference in their experiments; this is an equally important result, because it helps to inform future experiments.

Photo/Image Sources

Pinfish
- Nicholls State University.
- Link: https://www.nicholls.edu/biol-ds/biol348/fishsets/pics/Lagodon%20rhomboides.jpg

Mudflat Photo 1
- Beautiful England
- Link: http://www.beautifulengland.net/photos/var/resizes/somerset/Weston-super-Mare/mudflatsfromgrandpierwestonsupermare.jpg?m=1376364962

Mudflat Photo 2
- Link: https://zottoli.files.wordpress.com/2010/11/5-mud-flat-maquoit-bay-august-9-2004-7202.jpg?w=1000

Seagrass
- Paul Richardson, Virginia Institute of Marine Science

Marsh:
- Bald Head Island Conservancy
- Link: https://www.bhic.org/salt marsh/w/845/h/615/sm/2/p/Images/bhiconservancy/site/Scenery/BHI_2.jpgx

Fish & Oyster Reef
- Nathan Geraldi
- Link: http://blogs.qub.ac.uk/ngeraldi/

Remaining Photo: Bruce Pfirrmann

Figure Sources

Pinfish Growth, modified from: Shervette, V. R., & Gelwick, F. (2007). Habitat-Specific Growth in Juvenile Pinfish. Transactions of the American Fisheries Society, 136(2), 445–451. https://doi.org/10.1577/T06-097.1

Fish Abundance, modified from: Baillie, C. J., Fear, J. M., & Fodrie, F. J. (2015). Ecotone Effects on Seagrass and Saltmarsh Habitat Use by Juvenile Nekton in a Temperate Estuary. Estuaries and Coasts, 38(5), 1414–1430. https://doi.org/10.1007/s12237-014-9898-y

Data on fish and oyster reefs modified from Bruce Pfirrmann's M.S. Thesis work.

Next, it is important to realize that the environmental parameters (water temperature, salinity, dissolved oxygen, etc.) within an estuary are not stable all the time. Because estuarine environments are usually shallow, tidal cycles, snow falls, hurricanes etc. can have large influence on these parameters.

Speckled trout is one of the most economically important sportfish from U.S. South Atlantic and the Gulf of Mexico. This species is rarely caught north of Chesapeake Bay. The species is largely non-migratory, meaning that they spend almost entire of their lives in their natal estuaries. During some winters, rapid drop in water temperature can lead to moribund fish or even death, commonly known as cold stuns. The low temperature tolerance has been studied in controlled environment in North Carolina and South Carolina. Generally, prolonged exposure below 5C or short exposure to 3C can lead to mortality. Winter 2013-2014 was one of the coldest on record and fish kills were reported from multiple locations in Virginia and North Carolina (see map in slideshow). As a result, fishery management agencies in both Virginia and North Carolina issued temporary closures to speckled trout fishery.

Presentation slideshow contains information about some general biology of speckled trout, explanations of tolerance ranges and maps.

Materials & Supplies

If computers are an option, have the student access data online and print the graphs. Instructions are included as a separate file. If students have no access to computers, the teacher should make copies of the student master including the graphs. Or depending the desired length of this activity, the teacher can choose whether let the students use computers or not.

Teacher Preparation

1. Download and view the presentation speckled trout (available as ppt file, explanations and suggestions are included in comment section).
2. Familiarize with Chesapeake Bay Interpretive Buoy System (buoybay.noaa.gov/). Instructions included as a word file.
3. Copy Student Master.

Procedure

1. Show your students with presentation slideshows. Give students some background about speckled trout. Point out the locations of fish kills in Jan/Feb 2014. Tell the students that Dr. Jan McDowell and her students are asking them to join the hunt for answers. Your students' challenge is to try and solve this real-life speckled trout mystery and to suggest reasons why the die-offs have occurred, using real data.
2. Ask students what information do they need in order to solve the mystery? Answers will vary. Then you should tell them, NOAA (National Oceanic and Atmospheric Administration) keeps track water quality at multiple locations inside the Chesapeake Bay. One of them is called Chesapeake Bay Interpretive Buoy System (http://buoybay.noaa.gov/). There is even a smartphone app for it.

3. Project map of the monitoring stations by CBIBS. Right next to it is a map of one of the most severe fish kill event which is in Corrotoman River. Ask the students if we want to find out what has happened, data from which station should be used? Answer should be SR (Stingray Point).
4. Divide your students into groups of four. Give them Student Master.
5. Now have the student team examine the graphs on student master and complete the clues and questions. Team members should discuss. Walk around and assist if needed.

Assessment

Question in Student Master

References

1. O'Donnell, T. Characterizing the genetic population structure of and genetic effects of cold winters on spotted seatrout (Cynoscion nebulosus) in the southeastern United States. *ProQuest Dissertations and Theses* M.S.**,** (College of Charleston, 2013).
2. Stephen A. Bortone. *Biology of the Spotted Seatrout*. (2002).
3. Ellis, T. A. Mortality and Movement of Spotted Seatrout at Its Northern Latitudinal Limits. *ProQuest Dissertations and Theses* Ph.D.**,** (North Carolina State University, 2014).
4. Anweiler, K. V, Arnott, S. A. & Denson, M. R. Low-Temperature Tolerance of Juvenile Spotted Seatrout in South Carolina. *Trans. Am. Fish. Soc.* 143**,** 999–1010 (2014).