CANNIBALISM AND COMPETITION IN THE CHESAPEAKE BAY

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Grade Level
7th Grade

Subject Area
Life Science

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National Science Foundation

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CHESAPEAKE BAY NATIONAL ESTUARINE RESEARCH RESERVE VIRGINIA

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Title: Cannibalism and Competition in the Chesapeake Bay

Focus: Understanding a predator-prey relationship and how competition for resources such as habitat space can influence cannibalism in the blue crab population.

Grade Level: 7th grade Life Science

Virginia Standards of Learning:

- LS.6: The student will investigate and understand that populations in a biological community interact and are interdependent.
    - LS.6 a: Relationships exist between predators and prey and these relationships are modeled in food webs
    - LS.6 b: The availability and use of resources may lead to competition and cooperation

Learning Objectives:

- Students will observe cannibalism in blue crabs and discuss why it occurs within the blue crab population.
- Students will graph the percent cannibalism for blue crabs through a hands-on predator-prey simulation
- Students will evaluate how cannibalism changes with prey density
- Students will assess how low prey density provides refuge from predation in blue crabs.

Total length of time required for the lesson: 50-70 minutes (depending on class size)

Vocabulary:

- **Cannibalism**: When an animal consumes individuals of its own species.
- **Competition**: Two or more organisms that utilize the same resource
- **Prey density**: The number of prey organisms in an area.
- **Refuge**: A situation where prey can avoid predators and get to safety.
- **Carrying Capacity**: The highest number of individuals that can live in one area/habitat.
- **Opportunistic omnivore**: An organism that eats a variety of food, both plant and animal.
- **Predator**: An animal that hunts and eats other animals.
- **Prey**: An animal that is hunted and eaten by other animals.
- **Predator-prey relationship: W**hen one animal (the predator) catches and eats another animal (the prey)
- **Ecosystem**: A community of living organisms and their environment.
- **Population**: All the organisms of the same group or species that live in a specific area.
- **Model**: A way to visualize a concept or scenario so others can better understand what is happening in real life.

Background Information:

Blue crabs are interesting creatures that live along the Atlantic Coast of the USA and in the Gulf of Mexico. They have been an important part of fishing in the coastal bays of Virginia and Maryland for over 100 years. In the Chesapeake Bay, female blue crabs move to the mouth of the bay to lay their eggs. Here, the young crabs, or post-larvae, are carried by ocean currents into places like seagrass beds. These areas help protect young crabs from predators as they grow big. Young blue crabs are very likely to be eaten by bigger predators, including other blue crabs and fish. Specifically, in blue crabs, mortality of small juveniles can reach up to 95% (Heck et al. 2001). So, these seagrass beds act like a "home" to keep them safe from danger.

Blue crabs are unique because they are both predators and prey. They are opportunistic omnivores, which means they eat many different kinds of food. When food is scarce, or when there are a lot of blue crabs in one place, they will sometimes eat each other. In fact, other blue crabs can make up almost half of a crab's diet! This behavior is called cannibalism. It happens more often when there are many crabs in an area, as it helps control the population.

Cannibalism helps keep the crab population balanced. As more crabs fill the area, or as population density increases, they start eating each other to reduce competition for resources like food, shelter, and space. This prevents the crab population from growing too large and running out of resources over time.

Materials & Supplies:

- blue crab cutoutsPrinted and laminated juvenile blue crab icons (see Appendix)

Teacher Preparation (~30 minutes):

- Print and cutout the juvenile blue crab pictures. Laminate each blue crab cutout so that these can be reused for future lesson plans.
- Print out one student graphing worksheet per pair/group. Set aside blue crab cutouts

Procedure:

Hook: Show an image or video of a blue crab cannibalizing another blue crab **(slide 3)** and ask, "Can you take a wild guess at what is happening here?"

- Explain that blue crabs are opportunistic omnivores and exhibit cannibalism **(slide 4)**, especially when certain conditions are right, such as when there are many juvenile crabs around.
- This leads us to the concept of density **(slide 5)**. Blue crabs in these seagrass patches can be found at many different densities, but first, what is density? Imagine a scenario with a forest. We can have few trees in a forest which means the trees are at a low density. OR we can have many trees in the forest, and it is very thick and "dense" which is a high density of trees.
    - Now that we have learned about density, let us talk about it with blue crabs **(slide 6).** Discuss with students the concept of carrying capacity and how an increased number of individuals in the population in each habitat will cause them to start competing for

resources such as food and space. Some students may not know what carrying capacity is, so make sure they understand this concept first. This is also the time to mention that predators will move around habitats looking for prey, and that adult blue crabs will have an easier time finding prey to cannibalize if there is a higher prey density!

- Then, ask the students if they can detect which density scenario will reach carrying capacity first **(slide 7-8)**. *There are notes in the PowerPoint for talking points for ALL slides.*
- Make sure to emphasize the idea that cannibalism is a way for these blue crabs to alleviate competition so that they have more access to space and food in their habitat that would otherwise be taken up. Explain that we can model cannibalism using graphs **(slide 9)**. *Let students attempt to answer if models have been taught before in their education* Otherwise, go straight to definition. Show them the example that with increasing class size, we have increased the number of students in the class.

- Now, move onto the predator prey simulation **(slides 10-11).**

Activity 3: Prey Density Simulation (30-40 minutes)

Set Up Simulation:

<u>*NOTE* If your class is SMALLER, then proceed with the following layout. If your class is LARGER, see modifications note at the end denoted with *</u>**

Split the class into two groups: one representing adult blue crab predators and the other representing juvenile blue crab prey.

- Partner the students up so that there is one prey and one predator for each pair. They will be recording their data together.

The first group of adult blue crab predators and juvenile blue crab prey at high density will switch roles for the low-density scenario.

<u>Begin with a "high prey density" scenario</u>: have the group of students representing juvenile blue crabs scatter **many** "prey crabs" around the classroom or outdoor area (represented by blue crab cutouts).

- Predator crabs must close their eyes.
- With eyes open, the predator crabs (students) move around *one person at a time* to "capture" juvenile crabs by collecting as many blue crab cutouts as they can in each timed trial (depending on classroom space/outdoor space. i.e.: small classroom 15 seconds, outdoor area 30 seconds per student).
- Can start with 30 blue crab cutouts for high density. Encourage students to walk.
- Start the timer and allow the first student to collect blue crab cutouts.
- Indicate the end of their time and ensure each student gets the same amount.
- Have the student record how many they "catch".
- Replenish the 30 blue crab cutouts after each student's turn so the next student has the same number of total blue crab cutouts to collect.
- ***Repeat*** until each assigned student in the predator crab group has gone and again, make sure each student has recorded how many blue crab cutouts they have received.

<u>Now SWITCH to Low Density Scenario</u>:

- Have the previous group of predator crabs now become the prey crab group.

- Decrease the number of blue crab cutouts you give out by a third and allow the new "prey" group of students to scatter them around the space.
- Again, predator crabs close their eyes.
- Have the predator crabs group try catching the remaining prey crabs like the first scenario and record.
- Repeat replenishing of the blue crab cutouts for each student's trial.

****** Have all predator crab students capture juvenile crabs at the same time instead of "one person at a time." When one person at a time acts as predator, that leaves 20+ students with nothing to do. Due to having all predator crabs hunt simultaneously, you will find that the number of blue crab cutouts used for high and low density require adjustment for class size. Smaller classes require fewer cutouts otherwise they will not notice a difference in % cannibalism between high and low density.***

Once both simulations are done, switch over to **slide 12** so the students have access to the calculations they need to do. Then, move on to slide 13 for an example plot.

- **Slide 13**: an example/expected blue crab bar graph. This is what students' graphs should look like at the end of the activity so it is included here for them to grasp an understanding of how cannibalism will increase with more prey.
    - Optional: It would be good to explain how blue crabs will eventually get full of eating and that they will not eat forever. A student may ask if they can eat 100 crabs or some extremely high number that is unrealistic. *Blue crabs, just like us, get full after a meal. Think of a buffet- you can only eat so much before your stomach starts to feel too full! Blue crabs also have the maximum number of blue crabs they can eat/cannibalize, so that is why the line does not go on forever. Otherwise, there would never be any blue crabs left in the wild and none left to cannibalize in the future.*

Conclusion and Wrap-Up (10 minutes)

1. Reflection:
After both simulations, discuss how it becomes harder for the adult crabs to find juvenile crabs at low density **(Slide 14)**. Then apply what the students observed by having them answer the questions on the back of the student graphing worksheet.

2. Review:
Summarize the key points **(Slide 15)**:

1. Blue crabs increase cannibalism when there are many juvenile crabs.
2. Prey can use a low-density refuge to avoid predators since it is harder for predators to find them.
3. Ecosystems rely on competition to remain balanced otherwise all resources will be used up and the individuals within a population will not survive when they cannot hide from predators or feed themselves.

a. For blue crabs, they do it through cannibalism.

2. Discussion: *Talk about these questions as a last interactive discussion or as a refresher for the next class.*

A. "What do you think would happen in real life if blue crabs couldn't find enough juvenile crabs?"
B. "What happens when there are many juvenile crabs around? What do adult crabs do?"
C. "What happens when there are only a few juvenile crabs?"

4. Extension Activity:

Option 1: For further exploration, students can investigate the food web for Chesapeake Bay and explore what predators and prey blue crabs have. We can then implement that into an activity where this would be prey switching. Students can get another cutout as a supplementary activity to fill time where the "alternate prey" cutout is very abundant throughout the designated space and students are allowed to collect cutout. Then, as a class you can assess how a predator would rather go for a more abundant prey item instead of cannibalizing if there is a low density of blue crabs for them to cannibalize from. (Do not tell them which is which and see if they eat more blue crabs or other prey.)

Option 2: Have students do a full class or homework assignment: Have students research a species that partakes in cannibalism and describe why they cannibalize each other. Some species use it as population control to ensure competition remains low while others will use it as a behavioral response when there are limited resources in their ecosystem (like a last resort). There are several mechanisms so this could be an extension homework activity.

Assessment:

Observe students during discussions and simulations to gauge understanding of why animals will compete for resources at carrying capacity.

Students will complete a short worksheet illustrating, through graphing, how prey density affects blue crab cannibalism.

References:

Heck Jr, K. L. and Spitzer, P. M. (2001). Post settlement mortality of juvenile blue crabs: patterns and processes. In Proceedings of the Blue Crab Mortality Symposium, volume 90, pages 18–27. Gulf States Marine Fisheries Commission, Ocean Springs, MS.

Integration and Application Network, University of Maryland Center for Environmental Science. (n.d.). *Media library*. https://ian.umces.edu/media-library

Handouts/Worksheets:

VASEA_Guennouni_Handouts_2025.docx

1. Student Graphing Worksheet

Name: _____ Predator or Prey: _____

Catching Data:

Introduction:

Ms. Guennouni is studying the blue crab, *Callinectes sapidus*, for her degree and wants to better understand how cannibalism impacts the blue crab population. Blue crabs are opportunistic omnivores which means that they eat everything they can get their claws on, including each other! She thinks that cannibalism is the major driver for the blue crab abundance in Chesapeake Bay and needs you to help her better understand how cannibalism works. Together, let's look at how changes in the number of prey, or the prey density, can impact how much cannibalism occurs in blue crab habitats.

Instructions:

- The teacher will partner you up and assign you as either a juvenile blue crab prey or adult blue crab predator. Make sure to write down on the top of this paper which one of you is the prey or predator.

The first scenario will be our high-density. One by one, the predator will collect as many blue crab cutouts as they can during their turn.

- Record the number of blue crab cutouts collected in the box below.

Student Name	Prey Density	Prey Caught	Total Available Prey	**Cannibalism %** (Blue crab cutouts caught ÷ Total blue crab cutouts) x100

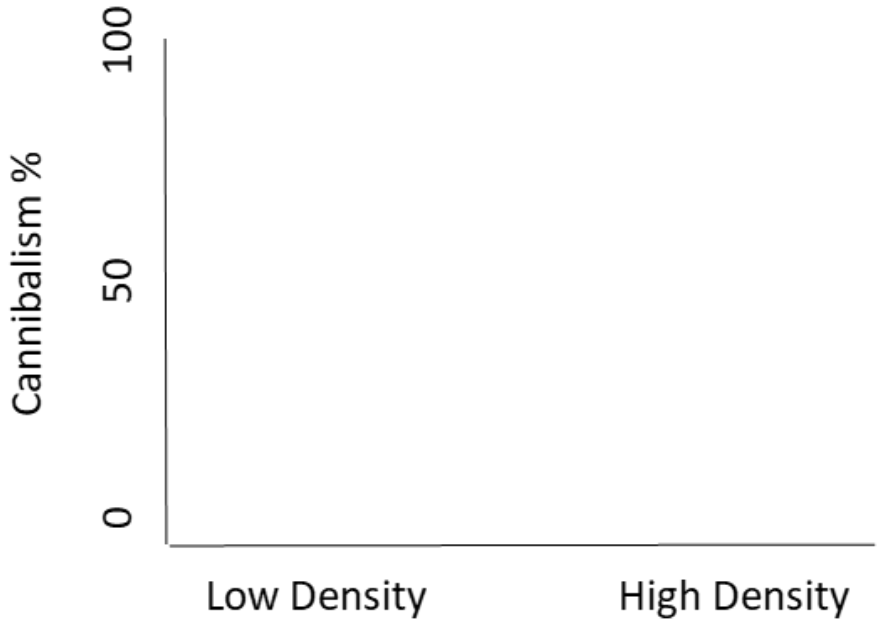
The second scenario will be our low-density. When the teacher signals, the two of you will switch roles and again, the predator will collect as many blue crab cutouts as they can.

- Record the number of blue crab cutouts collected in the box below.

Student Name	Prey Density	Prey Caught	Total Available Prey	**Cannibalism %** (Blue crab cutouts caught ÷ Total blue crab cutouts) x100

- Calculate the percentage of cannibalism that occurred using the number of blue crab cutouts you collected. Use the formula: # of prey (blue crab cutouts) you catch ÷ total number of blue crab cutouts *you could have collected* around the classroom.
- Calculate the MEAN cannibalism %. Use this formula: Sum of Prey Density (low or high) Cannibalism % ÷ Total # of density trials
- Graph the percentage of cannibalism that occurred (cannibalism rate) and answer the questions using the data and your knowledge from the lesson.

Make a bar graph of the Percentage of Cannibalism Occurring for each Density Type.



Questions:

1. What is one way that prey can avoid predators in their habitat?

2. Why do blue crabs cannibalize each other?

3. Why are models useful?

4. Why do you think it is important for some prey to have refuge? How might that help keep the ecosystem balanced?

Answer Keys:

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1A. Student Graphing Worksheet Answer Key

Name: _____ Predator or Prey: _____

Catching Data:

Introduction:

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Instructions:

- The teacher will partner you up and assign you as either a juvenile blue crab prey or adult blue crab predator. Make sure to write down on the top of this paper which one of you is the prey or predator.
- **The first scenario will be our high-density.** One by one, the predator will collect as many blue crab cutouts as they can during their turn.
    - Record the number of blue crab cutouts collected in the box below.

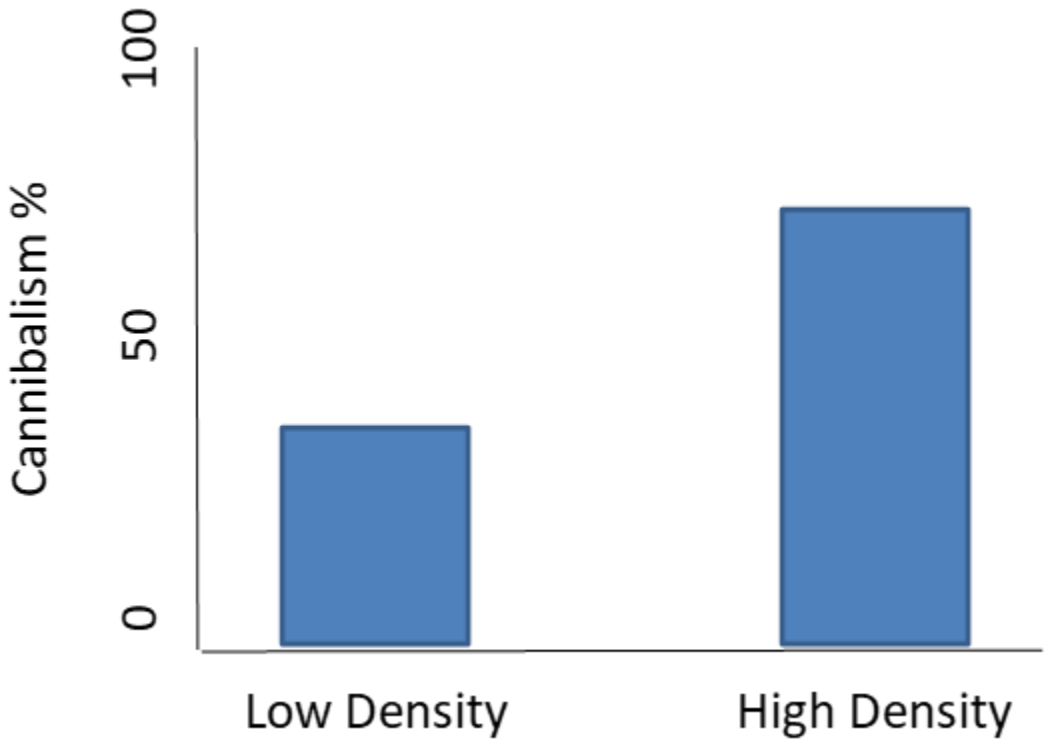
Student Name	Prey Density	Blue crab cutouts Caught	Total Available Blue crab cutouts	**Cannibalism %** (Blue crab cutouts caught ÷ Total blue crab cutouts) x100
Student 1	high	20	30	66%

- **The second scenario will be our low-density.** When the teacher signals, the two of you will switch roles and again, the predator will collect as many blue crab cutouts as they can.
    - Record the number of blue crab cutouts collected in the box below.

Student Name	Prey Density	Blue crab cutouts Caught	Total Available Blue crab cutouts	**Cannibalism %** (Blue crab cutouts caught ÷ Total blue crab cutouts) x100
Student 2	high	22	30	73%

- Calculate the percentage of cannibalism that occurred using the number of blue crab cutouts you collected. Use the formula: # of prey (blue crab cutouts) you catch ÷ total number of blue crab cutouts *you could have collected* around the classroom.
- Calculate the MEAN cannibalism %. Use this formula: Sum of Prey Density (low or high) Cannibalism % ÷ Total # of density trials
- Graph the percentage of cannibalism that occurred (cannibalism rate) and answer the questions using the data and your knowledge from the lesson.

Make a bar graph of the Percentage of Cannibalism Occurring for each Density Type.



Questions:

1. What is one way that prey can avoid predators in their habitat? Moving to a low-density seagrass area or finding a dense seagrass area/patch.
2. Why do blue crabs cannibalize each other? Because of competition and to bring the population down below carrying capacity where there will be more resources available for all the blue crabs.
3. Why are Models useful? They can help us better understand the natural world for future scientists.
4. Why do you think it is important for some prey to have refuge? How might that help keep the ecosystem balanced? This is an open-ended question given what they have learned about how communities interact in their other science classes. No wrong answers. **An example answer**: Prey need to survive to become adults so that they can reproduce and give us more blue crabs the following year. Other animals might want to eat blue crabs too, so we need to ensure there are next year to keep the ecosystem food web balanced.

Class discussion at conclusion of class:

A. “What do you think would happen in real life if blue crabs couldn’t find enough juvenile crabs?” **potential answers:** They would move to another seagrass area with high density and eat the crabs they find there. Also, since they are opportunistic omnivores, they will just look for a more abundant prey item instead of cannibalizing blue crabs.
B. “What happens when there are many juvenile crabs around? What do adult crabs do?” The cannibalism rate will increase as blue crabs eat more blue crabs.
C. “What happens when there are only a few juvenile crabs?” Cannibalism will decrease as they cannot find them with the low-density refuge

Appendices:

1. If the teacher would like to have group/class data, include the mean. This table can be added/removed from the lesson plan if the teacher does not want to talk about mean. It is currently in the handout.

Mean Low Density Cannibalism Rate (%) Sum of Low Prey Density Cannibalism % ÷ Total # of Cannibalism % values	**Mean High Density Cannibalism Rate (%)** Sum of High Prey Density Cannibalism % ÷ Total # of Cannibalism % values

Answer Key:

Mean Low Density Cannibalism Rate (%) Sum of Low Prey Density Cannibalism % ÷ Total # of Cannibalism % values	**Mean High Density Cannibalism Rate (%)** Sum of High Prey Density Cannibalism % ÷ Total # of Cannibalism % values
40%	70%

Sample Excel Graph from PowerPoint Presentation: