Everblue Education

Sustainable Stone Crabs

This lesson is about to get crabby! In this lesson, students will learn about crab biology and anatomy, test their reflexes, and engage in critical thinking about sustainable fisheries through an interactive crabbing game. This lesson is based on a paper by Stephanie M. Kronstadt, Ryan Gandy, and Colin Shea, published in 2018, that looks at the stone crab fishery in Florida, USA and how it affects the reflexes of the crabs.

Everblue is a 501(c)(3) nonprofit dedicated to encouraging ocean-conscious living by increasing scientific literacy. Our online education resources connect current science to daily life, allowing you to learn about the ocean at your fingertips! Stay in touch by following @oceaneverblue on your prefered social media platform or by visiting our website at www.oceaneverblue.org.

To help us keep the ocean ever blue, please share this program with the teachers and parents you know so we can spread ocean science far and wide. Partnering with marine scientists from around the world who study all parts of the ocean, we've created simple and engaging activities based on recently published papers! These activities connect you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well! More activities will be available to download for FREE off of our website, with a new activity added every month.

Research Paper:
Predicting discard mortality in Florida stone crab, *Menippe mercenaria,* using reflexes. *Stephanie M. Kronstadt, Ryan Gandy, Colin Shea. 2018.*

Grade Level:	Timing:
Grades 4-5	1 hour and 10 minutes

Materials:
Printer, scissors, tape, and coloring utensils

Common Core State Standards

English Language Arts:	Math:
Vocabulary Acquisition & Use	Operations & Algebraic Thinking Represent and Interpret Data

Next Generation Science Standards

Science & Engineering Practices:	Crosscutting Concepts:	Disciplinary Core Ideas:
Analyzing & Interpreting Data Argument from Evidence Developing & Using Models	Cause & Effect Stability & Change Structure & Function	Earth & Human Activity Organism Structures & Processes

Activity Overview

Title of Activity	Learning Cycle Stage	Time
Quick Crabs	Invitation, Exploration	5 minutes
Crab Biology	Concept Invention	20 minutes
Going Crabbing	Application	40 minutes
Reflection	Reflection	5 minutes

Appendix Contents

Appendix I Instructor Support	Appendix II Attached Lesson Materials
Ocean Vocabulary Common Questions	Crab Coloring Sheet Going Crabbing Table and Number Line

Activity

Quick Crabs

In this warm-up activity, we're going to test our reflexes! The research paper that this lesson focuses on is all about stone crabs. Can you pretend to be a crab? *Show students how to hold up their hands like mittens and tap their pointer finger and thumb together to "pinch" like a crab.*

Crabs have to have quick reflexes to catch food in the ocean. For this activity, pair up with another student or with your parent/teacher/instructor and follow these directions: The goal of Student A is to not have their hands tapped. The goal of Student B is to tap Student A's hands. Student A will hold both hands out in front of them, palms face down. Student B will place both of their hands palms face up directly beneath Student A's hands. Student A and Student B will look at each other and hold eye contact. While they are looking at each other, Student B will attempt to quickly flip their hands above Student A's hands and give Student A's hands a tap. To avoid the tap, Student A will quickly attempt to pull their hands towards their body, out of reach of Student B. Once the students have attempted a tap and pull, have both students place their hands back in the starting position and try again. Play a few rounds of the reflexes game, then have them switch roles and play again.

Crab Biology

We're going to learn about the **anatomy** of crabs. Anatomy is simply learning the names of body parts and what they do. Animals often have special names for their specific body parts, or structures, because they are specific to that animal. For example, your human legs are very different from crab "legs," so we as scientists gave them a special scientific name. Crabs are crustaceans, like lobsters and shrimp. Even though they look very different, they are all **decapods**, meaning they have 10 appendages (8 legs + 2 claws). Even though they share these same body parts, the structures have different shapes and functions, or purposes, that affect the animal's role in the ecosystem. *Print out the coloring sheet in Appendix II.* On your coloring sheet, you'll see a diagram of a crab from the top (as if you were looking down on it in a tidepool) and bottom (as if you picked up the crab and flipped it over). Different structures (body parts) of the crab are labeled with numbers. Use the key in Appendix II to color in and complete the diagram. Choose a different color for each number in the first column, then match the numbers to the diagram. Make sure to mark it on the key to keep track of your colors! As you color, learn the names and functions of the different structures of a crab.

Going Crabbing

Stone crabs are adapted to eat bivalves like mussels and oysters found in their tropical ecosystems. Because their prey are protected inside hard shells, stone crabs have evolved huge front claws, called chelipeds, that are strong enough to break through those shells. Their claws actually make up 40-60% of the crabs' total body weight. Imagine if your hands weighed almost half of your entire body weight… woah! These big claws mean that stone crabs are a popular fishery in the southeastern United States and the Caribbean.

The stone crab fishery is unique because when crabs are harvested, only one or two of their very large front claws are removed and then the crab is put back in the ocean alive. It is usually thought of as a sustainable fishery because it doesn't (usually) kill the animal to harvest it, and harvested crabs might someday be able to be harvested a second time since crustaceans can regrow lost legs! It might sound like a perfect system, but in this activity, we'll explore some ways in which this fishery isn't as perfect as it seems.

For this activity, you will need to print out the crab graphics included in Appendix II of this lesson and have students cut them out. You will also need to print out the number line, the miniature number line crab, and the table. The table is for the teacher/instructor/parent to keep track of crabs, and the number line is for students to count and keep track of how many crabs they have left in their fishery.

Before beginning, have students color the crabs! For this game, female crabs are drawn with their "skirts" facing up (refer to the second activity in this lesson for crab anatomy.) Male crabs are drawn with their carapace facing up. Have the students take 10 of the 20 female crabs and color their skirt red or orange to signify eggs that these females are carrying eggs in their skirt. These 10 crabs will be gravid females, or females carrying red and orange eggs. Gravid females cannot be harvested. After this step is done, allow the students to color the rest of the crabs however they like! Just be sure to keep track of the gravid females. You can even write a "G" on the blank side if it helps you remember. After coloring the crabs, turn them blank side down on the table and begin the game!

Follow the instructions below to play the game! Read the instructions out loud to your students.

1. In this game, you are fisherfolk in the stone crab fishery! *If there is just one student, the student can play alone. If there is more than one student, have them work together to play the game and make decisions together about how many crabs to take.*
2. The goal of the game is to always keep at least 30 crabs in the fishery with both claws - the 10 gravid females plus 20 others. Each round of the game will signify one year passing, and crabs regrow claws in three years (*after three rounds, tape the crab claws back onto the crabs and have them "re-enter" the fishery.*) You can move the tiny crab

that you printed out up and down the number line on your table in order to keep track of the crabs you have left. *Number line has numbers 30-40. Have the students place the tiny crab cutout on the number 40 at the beginning of the game and move it down and up the number line depending on how many crabs they harvest and how many re-enter the fishery each round. The students should move the tiny crab on the number line twice in each round: once up the number line if any crabs re-enter the fishery that round, and once down the number line with the amount of crabs they take.*

3. Begin by having students scatter their cutout crabs blank side down across a tabletop or other surface. This is the "ocean" we'll use for our fishing game.
4. In each round, up to 5 crabs can be taken ("harvested") from the ocean. The students have to take at least 1 crab each round - as fisherfolk, they have to harvest at least one crab in order to feed their families or keep up their fishing business. If any of the crabs you pick up are gravid females, throw them back into the "ocean." You then have the option to pick up another crab. Remember, you never want to have less than 30 two-clawed crabs in your ocean!
5. Once you have collected your crabs for the round, tear off one of the crabs' claws and then toss the one-clawed crabs back into the "ocean."
6. This is the end of the first round! Repeat steps 4-5 to play subsequent rounds.
7. As you continue playing, remember you can only harvest crabs that have two claws **and** that are not gravid females. *Be sure to keep track of how many rounds your students have played; crabs that were harvested in the 1st round do not reenter the fishery until the 4th round (three "years" after their claw was taken.) You can use the table in Appendix II to keep track of when to tape claws back onto crabs that are re-entering the fishery!*
8. If at any point your fishery becomes over harvested (i.e. fewer than 30 crabs with both claws), you have lost the game and must start over.
9. Once you have determined the best number of crabs to take each round to harvest your fishery at the `maximum sustainable yield` (taking as many as possible without the amount of two-clawed crabs in your fishery dropping below 30,) play through 6 rounds as a sustainable fishery.

When your students have played through 6 rounds as a sustainable fishery, ask them the following discussion questions and read the following paragraph:

1. What was most difficult about this game?
2. Even though you were allowed to take 5 crabs each round, was that "sustainable" (were you able to take 5 crabs each time and still keep 30 two-clawed crabs in your fishery)?
3. *If students played in a group:* What was it like to work together with other fisher-students to decide how many crabs to take?

In addition to the fishery, stone crabs deal with many other challenges to their survival. Let's brainstorm some ways that they might be affected by losing their crushing claw to the

fishery. Will it make it harder for them to survive? *Students should hopefully come up with things like making them more vulnerable to predation, harder to get food, can't compete well for shelter or mates, and the stress/injury of having a claw removed.* In addition to all these challenges, it takes a long time for stone crabs to grow a claw to full size, 3-4 years in fact! And since it is not unlawful for fishers to take both of the crabs' claws (although it is considered best practice to only take one), many crabs have to put energy into regrowing both claws at once. Since stone crabs only live 7-8 years, do you think that very many will be able to grow a claw to harvestable size more than once in their lifetime? Why or why not? *Allow students time to think about this question.* Studies have found that only about 20% of crabs are actually able to reenter the fishery to be harvested a second time. Now that we've seen what it's like to manage our own stone crab fishery, do you think it is sustainable? Why or why not? What could be done to make it more sustainable?

Reflection

As you and your student are cleaning up, talk to your student about what you just did together. Here are some guiding questions to help shape your conversation.

- ➢ What was your favorite part of our activity today?
- ➢ What is something that you learned about fisheries?
- ➢ Did you notice any patterns during our activity today?
- ➢ What is something you wonder about crabbing?
- ➢ What surprised you the most during our activity today?

Appendix I - Instructor Support

Ocean Vocabulary

- Bivalve - two-shelled mollusks like clams, oysters, and mussels
- Cheliped - the claw-bearing front limb of a crustacean
- Decapod - an order of crustaceans including crabs, shrimp, and lobster. All decapods have 10 main legs (including claws)
- Gravid - carrying eggs or young; pregnant
- Maximum sustainable yield - the largest amount of organisms that can be harvested from a fishery without causing ecological damage in the long term
- Sustainable fishery - a fishery which is managed in such a way that it can continue to be harvested indefinitely without becoming overexploited

Common Questions

How can we ensure fisheries are "sustainable"?

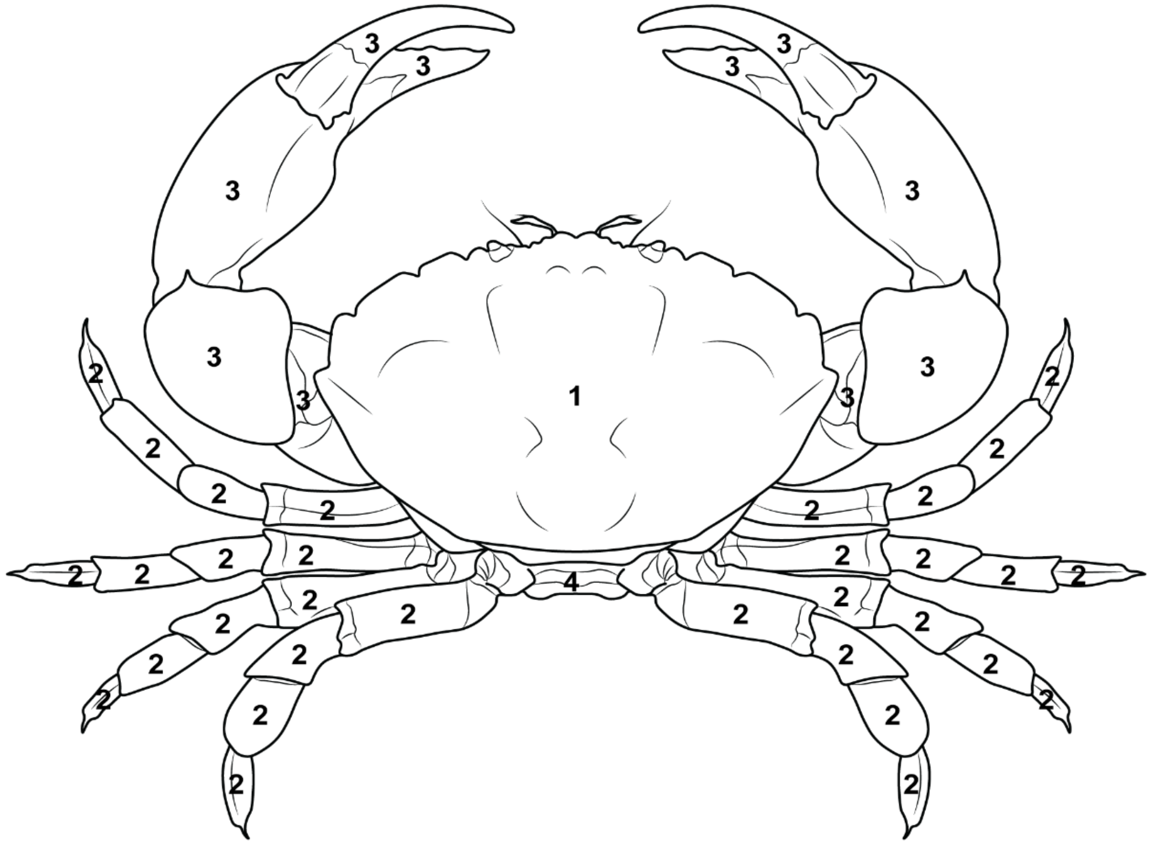
Sustainability relies on careful management to retain the ecosystem's function. The best way to make sure that fisheries are sustainable year after year is to have stakeholders co-manage the fisheries on a local scale. Fisheries management groups must partner with indigenous people and scientists to prioritize stewardship when designing best practices and rules for fishing regulations. Involving indigenous groups when creating fishing regulations is critical, because they have important perspectives on local fish populations and their communities' needs. We also must involve scientists in creating regulations because good data can inform exactly how many fish can be taken out of a fishery at a given time and maintain ecosystem health.

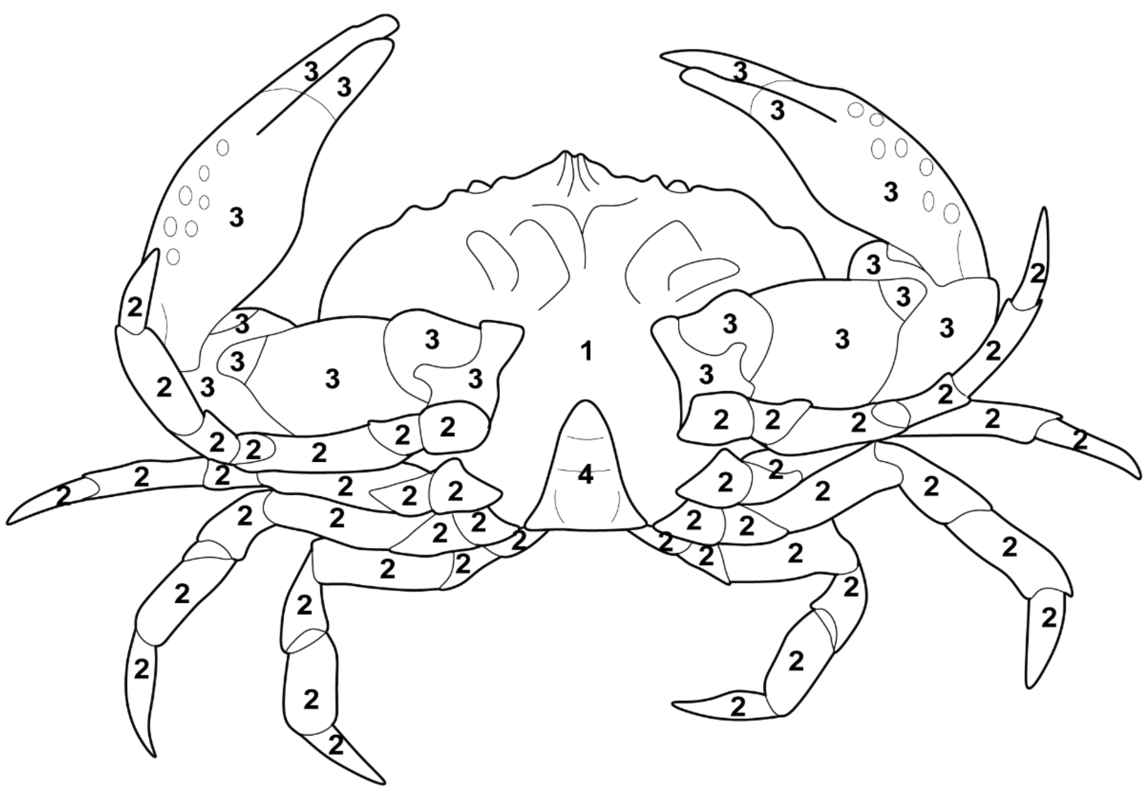
Appendix II - Attached Lesson Materials

Crab Coloring Key

Color	Structure	Function
1	Carapace (shell)	The carapace (also called a shell) covers the crab's back. Crabs don't have a skeleton on the inside, so the hard shell provides support for its internal organs and protection from predators.
2	Pereopod (leg)	The pereopods (or legs) are used for walking across the seafloor.
3	Cheliped (claw)	Chelipeds are the legs with claws. They can be very powerful and useful in feeding and defense.
4	Apron	The apron is a flap of shell on the crab's underside. The shape of the apron can be used to tell male and female crabs apart. Females have a wide apron that they use to store developing eggs

Crab Coloring Sheet *(on following page)*

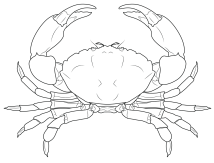


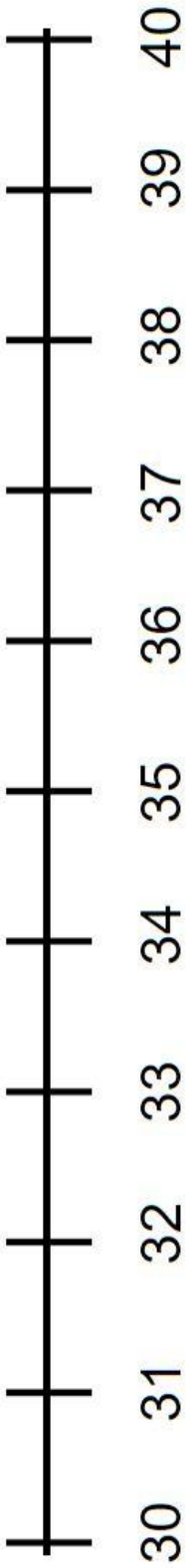


Going Crabbing Table and Number Line

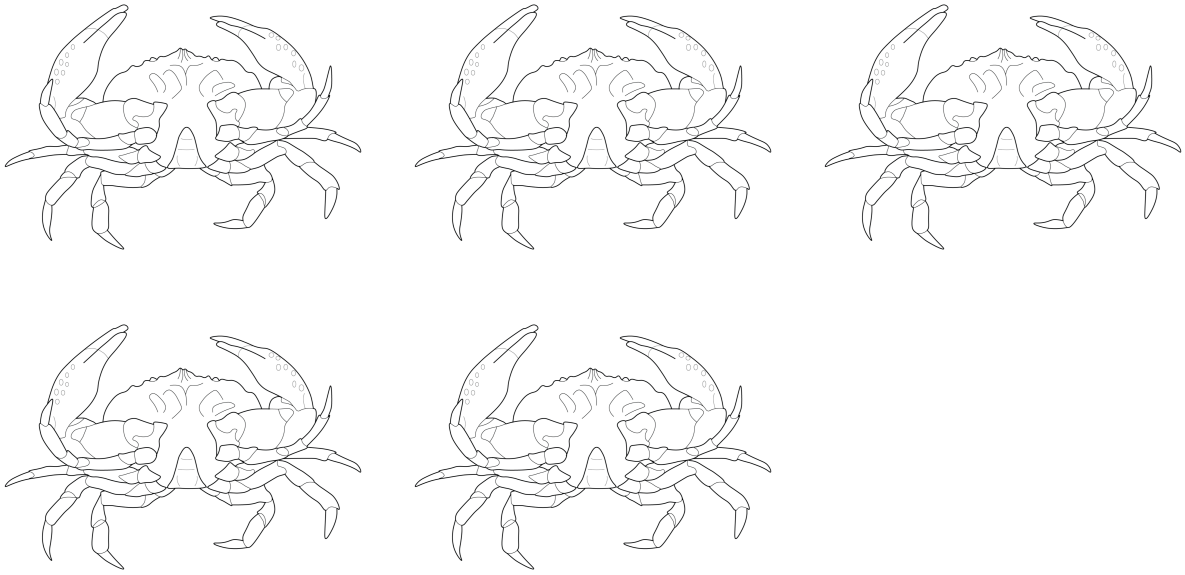
Round #	# of Crabs Harvested	Round # when crabs can re-enter the fishery
1		4
2		5
3		6
4		7
5		8
6		9
7		10
8		11
9		12

Crab counter for number line:





Going Crabbing - *Female Crabs*



Going Crabbing - *Male Crabs*