



SURVIVAL CHALLENGE: CAN MARINE ANIMALS ADAPT TO CLIMATE CHANGE?

Kyra Fitz
Rutgers University

Grade Level
Middle School

Subject area
Life Science / Environmental Science

VA SEA is a collaborative project between the Chesapeake Bay National Estuarine Research Reserve, the Virginia Institute of Marine Science's Marine Advisory Program, and Virginia Sea Grant. The VA SEA project is made possible through funding from 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.



Title: Survival Challenge: Can Marine Animals Adapt to Climate Change?

Focus: Create adaptations that will help a marine animal survive in their new climate-change impacted environments.

Grade Level: 6-8

Virginia Science Standards

LS.7 The student will investigate and understand that adaptations support an organism's survival in an ecosystem. Key ideas include physical and behavioral characteristics enable organisms to survive without a specific ecosystem.

LS.8 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include large scale changes such as eutrophication, climate change, and catastrophic disturbances affect ecosystems.

New Jersey Science Standards

MS-LS-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS1-4. Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Learning Objectives

Students will:

- Design adaptations that help marine animals to better survive in their environment based on the impacts of climate change.
- Analyze what traits would be advantageous to animals as waters warm, sea levels rise, and storms become stronger.

Total length of time required for the lesson

Initial preparation: 20 minutes to review PowerPoint and pass out coloring supplies.

Total time for lesson: 45-60 minutes.

*This lesson references basic evolutionary concepts such as adaptation and natural selection. It would be ideal to teach this lesson after students have been introduced to these concepts.

Key words, vocabulary

- **Acclimation:** an individual adjusting or changing their behavior to survive in a new environment.
- **Adaptation:** a trait that helps an organism survive and reproduce at higher rates in a given environment.
- **Climate Change:** long-term shifts in temperature and weather patterns, currently mainly caused by the burning of fossil fuels.
- **Greenhouse Effect:** a process where gasses released into the atmosphere (e.g. carbon dioxide from burning fossil fuels) trap the sun's heat, leading to a warming planet.
- **Natural Selection:** a process where some individuals have traits that allow them to survive and reproduce at higher rates. As generations pass, more individuals will possess these favorable traits.
- **Ocean Acidification:** a process where the pH of the ocean drops as excess carbon dioxide dissolves into seawater.
- **Range Shift:** a change in the geographic area a species inhabits.
- **Sea-Level Rise:** an increase in the water level of the Earth's oceans.
- **Stressor:** a factor such as high temperature or low oxygen that affects the ability of an organism's body to function properly.

Background Information

Animals are faced with surviving in environments that continue to change due to climate change. In marine environments, animals are challenged with multiple impacts of climate change including warmer water temperatures, water with lower pH (termed ocean acidification), rising sea levels, and stronger storms.

Rapid evolution has been proposed as one possible mechanism for animals to be able to survive in these new environments. Following natural selection, individuals with advantageous adaptations for their environments will survive at higher rates and produce more offspring, making these adaptations more common in the population. Adaptations that may assist individuals survive and reproduce in their climate-altered environments may include adaptations to thermoregulatory systems to help the body shed heat, metabolic adaptations to help the body produce energy in hot and low pH environments, changes to reproductive systems to increase the chances of more offspring being produced, and more. Students will be tasked with creating adaptations for one marine animal. The following paragraphs introduce each animal and the challenges they face due to climate change.

Animal Card Information

Loggerhead Sea Turtle: Loggerhead sea turtles need sandy beaches to lay their eggs on. Sea-level rise has washed out some beaches that the sea turtles use, leading to some females not having a place to lay their eggs. Sea turtles have what is called temperature-dependent sex determination, which means the temperature around the nest controls whether the baby sea turtles will be males or females. Cooler nests produce males, and hotter nests produce females. This risks the sea turtle population having many more females than males and could lead to females unable to reproduce because they cannot find a mate.

Humpback Whale: Humpbacks traverse the Earth's oceans. We see mostly juvenile male humpback whales around the Mid-Atlantic coast. Scientists hypothesize that the juveniles are attracted to the abundance of small schooling fish and plankton to eat. Warming waters are changing where the fish and plankton that whales eat is located, causing the whales to travel longer distances to new locations for food. This means whales need to spend more time and energy obtaining food.

Atlantic Croaker: Atlantic Croaker is a species of bottom-dwelling fish found along the East Coast from New Jersey to Florida. They spend the early years of their lives as larvae and juveniles in marsh and estuary habitats to be protected from predators. If the water temperature is too high, these fish struggle to get enough oxygen from the water into their gills and can die.

Surf Clam: Surf clams are found off the East coast between Maine and North Carolina and are harvested and sold. Surf clams have higher rates of cellular respiration in warmer waters and eventually become deconditioned and die when they cannot ingest enough food to keep up with the high rate of respiration.

Materials & Supplies

- Blank paper (for students to draw/write their species on)
- Coloring supplies
- Print out the provided animal and climate change scenario cards (can either print one animal card for each student or have 2-3 students share a card)

Teacher Preparation

- Pass out blank paper and coloring supplies to each student.
- Give each student (or a group of 2-3 students) an animal card and a climate change scenario card (feel free to either let students choose their cards or assign them a card).

Procedure

- Following **slides 1-5**, introduce the topic of climate change and the threats it poses to marine animals. The slides headers are phrased as a question. The teacher can ask the students to give answers to the questions before clicking for the answer bullets on the slide. On **slide 5**, allow students to brainstorm answers to the “What do you think might happen to animals in these conditions?” question at the bottom of the slide. Possible answers are: overheating, having trouble eating or finding food, not enough oxygen, getting pushed away from habitat by storms etc. If these impacts are severe enough, they can lead to extinction of a species.

- Using **slide 6**, introduce adaptation and how species may be able to use adaptation to survive in their changing environments.

- Introduce the activity students will do on **slide 7**.
 - Students will be assigned one out of the four animals to create adaptations for. They will read the animal card for their species to get background information. Then they will draw a climate change scenario card (or the teacher can assign them a scenario card). The scenario cards are 1) warmer water, 2) sea-level rise, 3) stronger storms. The animal cards mostly discuss how warmer waters affect the species. If you would like students to have more guidance when designing their adaptations, all students can be assigned “warmer water” as a scenario. The “sea-level rise” and “stronger storms” options allow for more creativity.

 - They will then create an adaptation or adaptations for their species to survive the condition listed on the climate change scenario card and draw their newly adapted animal on blank paper. For example, a student could draw an adaptation for a fish to cool down if assigned the warmer water scenario card. Adaptations can be for external or internal body parts. To scale down the activity, students could focus on adaptations for external body parts. For a challenge, students could be encouraged to think about the organ systems their animal possesses and adaptations for those internal organs. Students will then write a few sentences explaining their adaptation and how it will help their animal survive in its climate change scenario. Students can be creative; it is okay if adaptations are imaginative or traits not displayed in species currently on Earth!

- If students are struggling to get started, the teacher can ask a few guiding questions:
 - **Warmer Waters:** What systems in the body might overheat (think about the heart, lungs, brain etc.)? Can you think of an adaptation that would help these body systems not overheat?
 - **Sea-Level Rise:** Does this animal depend on a habitat that would be lost to sea-level rise? Would they need an adaptation to deal with this loss of habitat? Would the animal's food source be impacted by rising sea levels? Would they need an adaptation to eat another food source or travel farther to find their food?
 - **Stronger Storms:** How will this animal find food and shelter after a big storm? Would they need an adaptation to swim farther to find food? Would the animal need an adaptation to be better protected during a storm?

- **Slides 8-11** are the same as the animal cards. Teachers may choose to go through each slide, or they can skip these slides and have the students read the animal cards themselves or in groups.

- **Challenge:** For more advanced students (or high school students), the concept of ocean acidification can be introduced with surf clams. To grow their shells, surf clams need to extract calcium from the water around them. Less calcium is available as the water becomes more acidic, and surf clams have weaker shells as a result. This makes them more vulnerable to being eaten by predators. Students can be tasked with designing adaptations for surf clams to ocean acidification as a challenge activity.

- Have students share their drawings and the adaptation(s) they created (**slide 12**). Ask students to explain how their adaptation will help their species survive in its environment.

- Acclimation and real-world examples: On **slide 13**, discuss how evolution can be a long process (especially for species with longer generation times) and that some species need to respond by acclimation (changing their behaviors) to survive in the meantime. We don't yet have clear scientific evidence of adaptation to climate change by the species in this activity (likely because there has not been enough time for multiple generations to be exposed to climate change conditions), but we do have evidence of acclimation. Ask students to write one idea for how they think their animal has been acclimating on the back of their paper before moving onto slide 13. **Slides 14-17** display ways the species from this activity are acclimating such as by moving to new locations that are cooler or diversifying their food sources.
- Wrap-Up: On **Slide 18**, ask the students to share out what they learned from this activity as a wrap-up.

Assessment

Students should be assessed based on completion of the activity (drawing and writing about an adaptation they designed) and their ability to explain how their adaptation will help their animal survive in their assigned climate change scenario. Students should be able to provide at least one reason their designed adaptation will assist their species.

References

- Askin, N., Belanger, M., & Wittnich, C. (2017). Humpback Whale Expansion and Climate Change-Evidence of Foraging Into New Habitats. *Journal of Marine Animals and Their Ecology*, 9(1), 13–17. <https://jmate.ca/wp-content/uploads/2020/12/communication2.pdf>
- Fleming, A. H., Clark, C. T., Calambokidis, J., & Barlow, J. (2015). Humpback whale diets respond to variance in ocean climate and ecosystem conditions in the California Current. *Global Change Biology*, 22(3), 1214–1224. <https://doi.org/10.1111/gcb.13171>
- Hofmann, E. E., Powell, E. N., Klinck, J. M., Munroe, D. M., Mann, R., Haidvogel, D. B., Narváez, D. A., Zhang, X., & Kuykendall, K. M. (2018). An overview of factors affecting distribution of the Atlantic Surfclam (*Spisula solidissima*), a continental shelf biomass dominant, during a period of climate change. *Journal of Shellfish Research*, 37(4), 821–831. <https://doi.org/10.2983/035.037.0412>
- Mancino, C., Canestrelli, D., & Maiorano, L. (2022). Going west: Range expansion for loggerhead sea turtles in the Mediterranean Sea under climate change. *Global Ecology and Conservation*, 38. <https://doi.org/10.1016/j.gecco.2022.e02264>
- Timbs, J., Powell, E., & Mann, R. (2019). Changes in the spatial distribution and anatomy of a range shift for the Atlantic Surfclam *Spisula Solidissima* in the Mid-Atlantic Bight and on Georges Bank. *Marine Ecology Progress Series*, 620, 77–97. <https://doi.org/10.3354/meps12964>
- US Department of Commerce, NOAA. (2017, April 21). *What causes a sea turtle to be born male or female?*. NOAA's National Ocean Service. <https://oceanservice.noaa.gov/facts/temperature-dependent.html#:~:text=This%20is%20called%20temperature%2Ddependent,the%20hatchlings%20will%20be%20female>
- Verberk, W. C., Sandker, J. F., van de Pol, I. L., Urbina, M. A., Wilson, R. W., McKenzie, D. J., & Leiva, F. P. (2022). Body mass and cell size shape the tolerance of fishes to low oxygen in a temperature-dependent manner. *Global Change Biology*, 28(19), 5695–5707. <https://doi.org/10.1111/gcb.16319>
- Weishampel, J. F., Bagley, D. A., & Ehrhart, L. M. (2004). Earlier nesting by loggerhead sea turtles following sea surface warming. *Global Change Biology*, 10(8), 1424–1427. <https://doi.org/10.1111/j.1529-8817.2003.00817.x>
- Whales of the Jersey Shore*. Save Coastal Wildlife. (2023). <https://www.savecoastalwildlife.org/whales-of-the-jersey-shore>