Help Nemo Find His Home!

Photo: Claire Fackler, NOAA

Grade Level

4-8

Timeframe

30-45 minutes

Materials

- Game boards
- Game data sheets
- Game markers
- Stopwatches/Timers
- Paper and markers for data graphs

Photo: Claire Fackler, NOAA

Activity Summary

This lesson focuses on understanding the impacts of ocean acidification on the olfactory senses of clownfish.

Learning Objectives

Students will be able to define ocean acidification and understand how specific species such as the clownfish may be affected by the increasing acidity of the ocean.

Background Information

In their ocean habitat, clownfish use an exceptional sense of smell as a mechanism to help determine which direction to swim, called "olfactory homing". When given a choice between two water currents, one with the scent of an anemone and the other with the scent of the open ocean, clownfish will choose the anemone scent nearly every time! They can also tell the difference between the scent of a predator and the scent of a friendly non-predator…like Dory...choosing the non-predator nearly every time! However, recent research in Australia has shown that the olfactory homing ability of clownfish is severely disrupted by ocean acidification (through interference with neuron function).

Photo: Claire Fackler, NOAA

Larger fish such as lionfish will prey on clownfish.
Photo: Claire Fackler, NOAA

Ocean acidification occurs when excess carbon dioxide gas, produced when humans burn fossil fuels such as coal and gas. This rampant carbon dioxide mixes with seawater, forms a weak acid and lowers the ocean pH. This process has been accelerating on Earth ever since the Industrial Revolution, when we started using fossil fuels (coal, oil and natural gas), and it has increased the acidity of the ocean by 30% in just 200 years. It is predicted that the amount of carbon dioxide expected to be in the atmosphere and ocean by the end of the century will cause the pH to decrease to levels the global ocean has not experienced in millions of years. This drop in seawater pH can impact the neuron function of some types of fish, including clownfish, which means that clownfish such as "Nemo" in the popular movie "Finding Nemo" may have a very hard time finding their way home or avoiding predators in the future

Preparation

Prepare game boards and fish markers for each group. Provide data sheets and timers/stopwatches for each group.

Procedure

Start with sharing the background information with students.

Clownfish Game:

Read this script to students:

In this activity, you will help Nemo (a clownfish) and his friends find their home anemone on the reef, while avoiding predators and trying not to get lost in the open ocean!

Your challenge, should you choose to accept it, is to place as many clownfish as you can onto the anemone at the center of the game board…within 5 seconds. You'll do this twice. The first time will simulate the clownfish swimming in an ocean with present day water chemistry (pH = 8.1). The second time will simulate the future ocean, with ocean acidification (pH = 7.7). The catch is that you'll have to spin around three times first to become disoriented, kind of like a clownfish might feel under conditions of ocean acidification.

Vocabulary

Ocean acidification - decrease in pH of the ocean caused by the uptake of atmospheric carbon dioxide

pH - a logarithmic scale of hydrogen ion concentration

Olfactory homing – using sense of smell to navigation to a location (i.e. home)

Fossil fuels – any combustible organic material derived from the remains of former life (i.e. oil, coal, or natural gas)

Carbon dioxide - a colorless, odorless gas present in the atmosphere

Predator – a carnivorous animal

You receive one point per fish that gets home safely. Which scenario do you think will win? Try it and challenge your friends!

Rules

1) Begin with the fish spread around the perimeter of the game board.

2) Time limit is five (5) seconds per attempt.

3) During the second attempt, you must spin around **three** times before the timer starts.

4) One point per "safe" fish.

5) A "safe" fish is one that does **NOT** overlap the red lines that outline the anemone picture, **or** fall anywhere within the predator or open ocean pictures. They must be **completely** inside the red borders of the anemone picture to the "safe".

6) Highest score wins.

Evaluation

First off, evaluate the data. In groups, have your students produce a graph, table or chart to represent the data collected from the experiment. Draw conclusions from the data and share it in both written and oral forms.

Write a summary of the data, describing the effects that the lower pH (higher acidity) had on the experiment. Describe what you think will happen to organisms in the ocean and the acidity rises. What will happen to the clownfish when the acidity rises, and how will that also effect sea anemones?

Students will study and discuss data figures from Dixson et al. What conclusions can be drawn from these figures?

Create a labeled diagram to show a clownfish and anemone in today's ocean and a more acidic future ocean. For middle and high school have students include the chemical equations that show the process of ocean acidification. Have materials available so that students can build 3-D models of their equations.
Research clownfish and other fishes that may be affected by ocean acidification. Then have the groups of students present material in written and verbal forms.

Students will investigate how to calculate their own carbon footprint and develop and present ideas on how they individually, as a family and as a school community can lower their carbon footprint and help decrease the amount of CO_2 (produced by the burning of fossil fuels, such as coal, oil and natural gas) being absorbed by the world's ocean. Have students present and

Education Standards

Common Core ELA Standards	**Informational Text Grades 4-8:** 1 – Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text 4 – Determine the meaning of general academic and domain-specific words or phrases in a text 7 – Interpret information presented visually, orally, or quantitatively and explain how the information contributes to an understanding of the text in which it appears. **Writing Standards Grades 4-8:** 1 – Write opinion pieces on topics or texts, supporting a point of view with reasons and information 2 – Write informative/explanatory texts to examine a topic and convey ideas and information clearly 4 – Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
Common Core Math Standards	**Mathematical Practices:** • Construct viable argument and critique the reasoning of others • Attend to precision **Measurement and Data Grades 4-5:** • Represent and interpret data
Next Generation Science Standards	**4 Structure, Function, and Information Processing:** • **4-LS1-1** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. • **4-LS1-2** Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. **Science and Engineering Practices:** • Engaging in Argument from Evidence **Crosscutting Concepts:** • Cause and Effect • Systems and System Models

Next Generation Science Standards (cont.)	**3-5 Engineering Design:** • **3-5ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **Science and Engineering Practices:** • Constructing Explanations and Designing Solutions **Crosscutting Concepts:** • Influence of Science, Engineering, and Technology on Society and the Natural World **MS Structures and Properties of Matter:** • **MS-PS1-1** Develop models to describe the atomic composition of simple molecules and extended structures. **MS Human Impacts:** • **MS-ESS3-3** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment **Science and Engineering Practices:** • Constructing Explanations and Designing Solutions **Crosscutting Concepts:** • Cause and Effect • Influence of Science, Engineering, and Technology on Society and the Natural World
Ocean Literacy Principles	Principle 5: The ocean supports a great diversity of life and ecosystems. Principle 6: The ocean and humans are inextricably interconnected.
Climate Literacy Principles	Principle 3: Life on Earth depends on, is shaped by, and affects climate. Principle 6: Human activities are impacting the climate system.

compare their solutions to reduction of carbon footprint and have them use individual plans to come up with the best overall plan. For middle and high school students have students devise a way to evaluate the effectiveness of their solution(s).

Extensions

Students will read Earth's Acid Test published in Nature March 10, 2011 and answer questions about the text.

Students will explore the acidocean.org website (with supervision of teacher) to learn more about ocean acidification. Investigate what other types of organisms may be the first to be affected by ocean acidification and why.

Utilize the International Student Carbon Footprint Challenge website: http://footprint.stanford.edu/calculate.html. Students will investigate how to calculate their own carbon footprint and develop and present ideas on how they individually, as a family and as a school community can lower their carbon footprint and help decrease the amount of CO_2 (produced by the burning of fossil fuels) being absorbed by the world's ocean.

Have students present and compare their solutions to reduction of their carbon footprint and have them use individual plans to come up with the best overall plan.

For middle and high school students have students devise a way to evaluate the effectiveness of their solution(s).

Students will explore ways they can effect change in the use of fossil fuels beyond their home and school communities.

Share portions of archived SOARCE (Sharing Ocean Acidification Resources for Communicators and Educators) Ocean Acidification webinars with students: http://oceanacidification.noaa.gov/AreasofFocus/EducationOutreach/SOARCEWebinarSeries.aspx

Resources

http://www.cisanctuary.org/ocean-acidification/
http://oceanacidification.noaa.gov/
http://oceanacidification.noaa.gov/AreasofFocus/EducationOutreach/SOARCEWebinarSeries.aspx

Acknowledgement
This lesson is one in a series exploring ocean acidification. Original lesson created by Sean Bignami with additions and correlation to Common Core and Next Generation Science Standards by Maria Petueli.

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The figures below are from Dixson et al. (2010).

Figure 1 illustrates that fish in normal seawater spend most of their time swimming towards the scent of either “untreated” (no scent) water instead of towards the scent of another fish, or towards a “non-predator” instead of towards a “predator”.

Figure 2 illustrates that after exposure to acidification, 11-day-old fish (panel b) will swim towards the scent of ANY fish, with no aversion to predators.

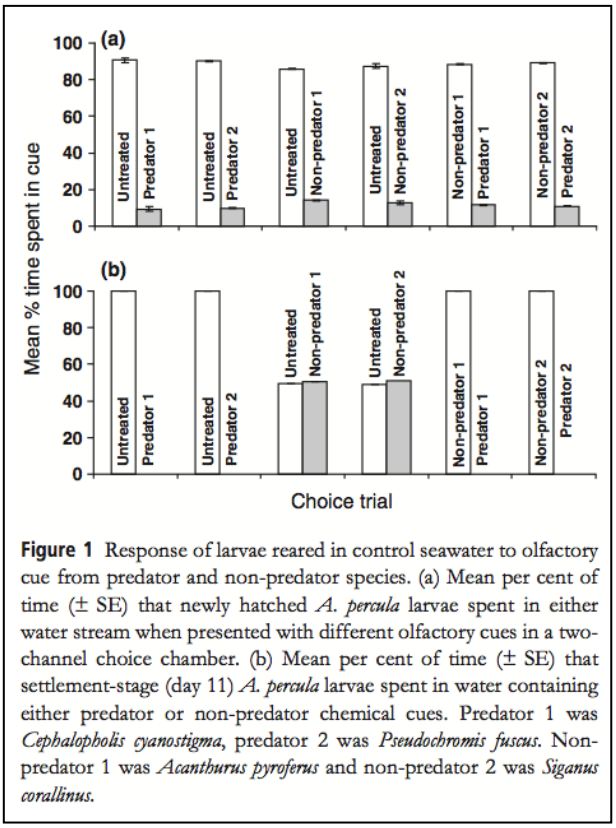

Figure 1 Response of larvae reared in control seawater to olfactory cue from predator and non-predator species. (a) Mean per cent of time (± SE) that newly hatched *A. percula* larvae spent in either water stream when presented with different olfactory cues in a two-channel choice chamber. (b) Mean per cent of time (± SE) that settlement-stage (day 11) *A. percula* larvae spent in water containing either predator or non-predator chemical cues. Predator 1 was *Cephalopholis cyanostigma*, predator 2 was *Pseudochromis fuscus*. Non-predator 1 was *Acanthurus pyroferus* and non-predator 2 was *Siganus corallinus*.

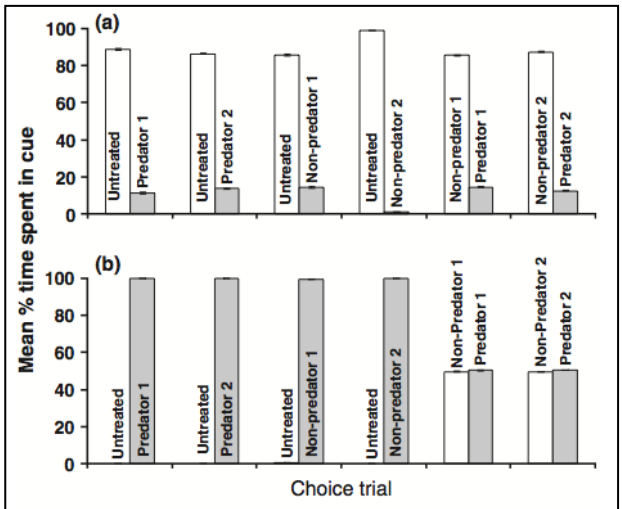

Figure 2 Response of larvae reared in CO_2-acidified seawater (pH 7.8 and *c.* 1000 p.p.m. CO_2) to olfactory cue from predator and non-predator species. (a) Mean per cent of time (± SE) that newly hatched *A. percula* from acidified seawater spent in either water stream when presented with different olfactory cues in a two-channel flow chamber. (b) Mean per cent of time (± SE) that settlement-stage (day 11) *A. percula* larvae from acidified seawater spent in water containing either predator or non-predator chemical cues. Predator 1 was *Cephalopholis cyanostigma*, predator 2 was *Pseudochromis fuscus*. Non-predator 1 was *Acanthurus pyroferus* and non-predator 2 was *Siganus corallinus*.

Clownfish Game Board

Clownfish Game Data Sheet

Record the number of fish that made it home in under 5 seconds

	pH 8.1	**pH 7.7** **Must spin three (3) times each turn**
Round 1		
Round 2		
Round 3		
Round 4		
Round 5		