CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE
BEST OF COSEE HANDS-ON ACTIVITIES

Activity Title: Ocean Home – Swimming Fishes

Learning Objectives

With the expected change in average ocean temperatures due to global climate change, many commercially and recreationally important fish populations will move in response. As a result, the distributions of some species' populations will shift, either expanding or contracting their range due to physiological stressors. In this activity, students will model, on a human-sized board game, how changes in water temperature may affect fish distributions and, ultimately fisheries.

Objectives:

- Demonstrate how fishes' physiological constraints (cold-blooded) affect their response to changes in water temperature.
- Connect fisheries to the broader climate change issue and develop a better understanding of how global physical processes have the ability to instigate local changes (i.e. economically, biologically).
- Develop an understanding of sea surface temperature data/mapping; touching on the concept of ecological niches (i.e. how ocean temperatures affect the niches of various marine organisms).

Ocean Literacy Essential Principles:

#3 -- The ocean is a major influence on weather and climate.

f. The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.

#5 -- The ocean supports a great diversity of life and ecosystems.

f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e. it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

#6 -- The ocean and humans are inextricably interconnected.

e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

Supplies and Materials

- Large tarp (approximately 20'x20')

- Duct tape
- Flip Chart / Swimming Fishes PowerPoints
- Fish Playing Cards (attached)
- Example sea surface temperature map (http://www.esrl.noaa.gov/psd/map/clim/sst.shtml)
- Swedish fish candy (to be used as prizes for the winners of the game)

Background

The Earth's climate has changed numerous times throughout the planet's history. However, beginning in the late 1800s, human activities have drastically impacted the normal fluctuations in Earth's climate. The combustion of fossil fuels and changes in how we use the landscape, such as cutting down trees (deforestation), has led to enhanced warming of the planet. One of the main reasons for this is the increase flux of greenhouse gases into the atmosphere, especially carbon dioxide (CO2), into the atmosphere.

The effects of climate change will be felt at both the local and global level. These effects include alterations in temperature and precipitation patterns and negative impacts on species such as ocean acidification, species displacement, and an increase in vector borne diseases and other health issues.

This lesson focuses on how climate change plays a role in the change in distribution and abundance of marine species in a region. The surrounding environment largely influences an organism's lifecycle and behavior. Therefore, with the expected change in ocean temperatures due to increased greenhouse gas emissions and global climate change, the distribution of, many commercially and recreationally important marine populations will move in response.

Duration

This lesson takes 45 minutes.

Audience

Geared for 10-15 year olds, but the activity is amenable to older teens and adults. The concepts are not difficult, but the instructions for the game may be hard for younger students to follow.

Procedure

I. Preparation:

A. Assemble the game board - To construct the game board, use duck tape to divide the tarp into a 9x4 grid (see diagram below). The nine numbered rows represent different temperature regimes and represent "southern" (lower numbers) and "northern" (higher numbers) waters. The lettered columns denote the paths that players must move in during their turns. There can be a total of twelve players and a minimum of six players.

Figure 2. Schematic of "Warming Oceans, Swimming Fishes" Game Board

Northern ↑ Colder ↑

9A	9B	9C	9D
8A	8B	8C	8D
7A	7B	7C	7D
6A	6B	6C	6D
5A	5B	5C	5D
4A	4B	4C	4D
3A	3B	3C	3D
2A	2B	2C	2D
1A	1B	1C	1D

Southern ↓ Warmer ↓

B. Print out copies of the Fish Playing Cards so that each player gets one card.

C. If you will not have access to a computer and projector, transfer the information in the Swimming Fishes PowerPoint to a flip chart. Keep in mind however that the images must be large enough for all players to see.

II. Procedure:

A. Ask the students if they have ever taken their body temperature with a thermometer? Do they remember what their temperature was? Would that change depending on if they were outside or inside (i.e. if they were in locations with different temperatures)?

B. Explain that today they are going to learn about fish and their body temperatures. Share some or all of the following information with the students:

- ✓ Humans and other mammals are warm blooded, meaning they try to keep the inside of their bodies at a constant temperature. They do this by generating their own heat when they are in a cooler environment, and by cooling themselves when they are in a hotter environment. To generate heat, warm-blooded animals convert the food that they eat into energy. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/coldwarm.html)
- ✓ Fish are cold blooded and take on the temperature of their surroundings. They are hot when their environment is hot and cold when their environment is cold. In hot environments, cold-blooded animals can have blood that is much warmer than warm-blooded animals, like humans. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/coldwarm.html)

C. Ask the students to describe the different temperatures environments that fish might live in (cold-water, warm-water, tropical) and if they can think of any fish species that may live there. Also, ask what they think would happen if ocean temperatures were too warm. Would the fish move northward or southward, or stay in the same area?

D. Before the game officially starts, each player must randomly select a card that will assign him or her to be a certain type of species. On each card for each species, there will also be colors representing at least two temperatures that the species can live in, a photograph, the common and scientific name, and the starting position on the board. Each player should hold his or her card throughout the game for reference.

E. Directions and Rules

- Use the Swimming Fishes PowerPoint or your flipchart to walk through the activity with the students.
- During each round (representing ten years time), the temperature regime will change. The

first decade represented will be 2000-2010 and the activity will continue to 2100 or until all players are eliminated, whichever comes first.

- The initial "Start…Year 2000" map shown in the Swimming Fishes PowerPoint will represent ocean temperatures where all fish species can survive.
- During each round, the players must decide whether to move forward one cell, move back one cell, or remain in the same location. A player can only stay in a cell for two consecutive rounds.
- There can only be one person in a cell at a time.
- During a change in temperature, if a player is found within a row with a color that is not on their playing card, they are eliminated.
- Before each new round begins, the facilitator will check to see who has been eliminated and ask them to leave the board.
- At the end of ten rounds, the players still remaining will win the game.

F. Ask the students which direction were the fish moving and why? What would happen to your species if the waters became warmer? How would this change where you would go fishing?

G. Based upon the students responses, share some or all of the following information:

- ✓ With the expected change in average ocean temperatures due to global climate change, many commercially and recreationally important fish populations will move in response.
- ✓ As a result, the distributions of some species' populations will shift, either expanding into new areas or becoming limited to few areas due to physiological stressors.
- ✓ One specific example of this is the surf clam (*Spisula solidissima*) fishery of the Mid-Atlantic Bight. The increase in water temperatures from climate change has threatened this industry by driving surf clam populations northwards towards cooler waters. This movement of species has forced the surf clam industry to send its ships farther towards New England and to harvest alternate clam species. (For more information, check out http://coseenow.net/surfclams/)

Assessment

In addition to the questioning and debriefing within the activity, have the students brainstorm the answers to the following questions:

- What are some impacts of climate change?
- How would climate change impact where you would go fishing?
- What biological factors influence whether marine organisms will migrate?
- What other organisms, besides fish, might be affected by climate change?
- Can climate change have "local" impacts?

Additional Resources

This lesson was originally written by Jason Turnure and Jason Werrell as a final project for the "Communicating Ocean Science to Informal Audiences (COSIA)" class at Rutgers University. It is based upon an activity created by Katie Gardner and was adapted for classroom use by Laura Dunbar. Other

resources used in learning, developing, and promoting the concepts in this game include:

Cheung, William W.L. et al. (2009). Projecting global marine biodiversity impacts under climate change scenarios. Fish and Fisheries, v.10 I. 3 pp. 235-251.

Cheung, W., V. Lam, J. Sarmiento, K. Kearney, R. Watson, and D. Pauly. The capacity and likelihood of climate change adaptation in the world's fisheries. Fish and Fisheries. February 13, 2008

Conover, D.O. Effects of climate changes on fisheries. Written testimony from congressional hearing: Effects of climate change and ocean acidification on living marine resources. May 10, 2007

Moyle, P.B. and J.J. Cech, Jr. Fishes: an introduction to ichthyology. 4th ed. New Jersey: Prentice Hall, 2000.

Rothschild, B.J. "How bountiful are fisheries?" Consequences. 2.1 (1996)

Woods Hole Oceanographic Institute's "Common Misconceptions about Abrupt Climate Change"

This lesson plan was provided by COSEE NOW. For more information, please contact: Carrie Ferraro at ferraro@marine.rutgers.edu

PLAYING CARDS

This activity works best with no more than 12 players. To include all students, you can pair them in teams, with just one person of the team standing on the board.
The cards are below. If you print them, cut them out, then laminate – you can re-use them every year.

Ocean Pout

Macrozoarces americanus

Start: 8A

Atlantic Cod

Gadus morhua

Start: 8B

Atlantic Herring

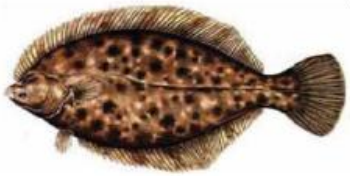
Clupea harengus

Start: 8C

Winter Flounder

Pseudopleuronectes americanus

Start: 8D



Striped Bass

Morone saxatilis

Start: 5A

Weakfish

Cynoscion regalis

Start: 5B

Summer Flounder

Paralichthys dentatus

Start: 5C

Atlantic Menhaden

Brevoortia tyrannus

Start: 5D

Southern Stingray

Dasyatis americana

Start: 2A

Gray Triggerfish

Balistes capriscus

Start: 2B

Red Drum

Sciaenops ocellatus

Start: 2C

Lemon shark

Negaprion brevirostris

Start: 2D