SPLASH!
Population Ecology of Humpback Whales in the North Pacific

Teacher Notes

Grades: 6-8

Timeline: 3-4 40-minute class periods

Issue or Problem: The North Pacific humpback whale population, which had been significantly reduced due to commercial whaling, has been protected under the U.S. Endangered Species Act since 1973. Population biologists would like to reassess the abundance and distribution of humpbacks to determine if the protective measures have had an impact on humpback population recovery.

Core Question: What is the current population size and distribution of humpback whales in the North Pacific?

Background Information for Teachers:
The following activities are based on actual research conducted by researchers from the SPLASH Project, which stands for: Structure of Population, Levels of Abundance and Status of Humpback Whales. Students will be divided into research "teams," and, like the researchers from the SPLASH project, assigned the task of estimating the size and distribution of the population of humpback whales, *Megaptera novaeangliae*, in the North Pacific. Some questions to consider prior to the activity:

- How do scientists define a population? Is a population determined by geographical boundaries, breeding habits, genetic similarities, other factors?
- What are some challenges in assessing the size of a population in a marine environment? Is it possible to count every individual or is it more likely to estimate population size?
- What are some techniques scientists can use to estimate the size of a population in a marine ecosystem? (i.e., visual surveys, photo ID, acoustic surveys, genetic analysis)

Objectives:

- Students will evaluate research methods used by the SPLASH team, including line transect surveys, photo ID and capture-recapture.
- Students will analyze data collected during a SPLASH line transect survey to assess the distribution of humpbacks in the Gulf of Alaska.
- Students will match humpback fluke photographs taken during a SPLASH line transect survey to fluke photographs documented in previous fluke catalogs and make inferences about the abundance of humpbacks in Prince William Sound, a feeding area within the Gulf of Alaska.

Standards Addressed:
National Science Education Standards - Science Content Standards: 5-8

Content Standard A: *Science as Inquiry*
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: *Life Science*
- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard F: *Science in Personal and Social Perspectives*
- Populations, resources and environments
- Natural hazards
- Risks and benefits

Going Further: Extensions of SPLASH Population Ecology Activities

Using Nautical Charts I: *Plotting Humpback Distribution*

In this activity, students will work in cooperative groups of 4-5 individuals to plot the course of the *McArthur II* and the number of humpbacks seen during Leg 1 of the 2004 SPLASH voyage. For this activity, students will need the latitude and longitude data provided in Figure 1 (*SPLASH Line Transect Data—Leg 1*) a laminated version of NOAA nautical chart #531 (*Gulf of Alaska: Strait of Juan de Fuca to Kodiak Island*), and wipe-off transparency markers.

Using Nautical Charts II: *What is the "next step" for the SPLASH team?*

The 2004 SPLASH survey of the humpback summer feeding grounds in the Gulf of Alaska was just the first step towards the ambitious goal of estimating the size of the entire humpback population of the North Pacific. In this activity, students will write a proposal outlining the "next step" for the SPLASH research team.

Working in cooperative groups of 4-5 individuals, students will first conduct background research on the biology and behavior of the humpback whales of the North Pacific. Specific questions to consider include: What are the feeding habits of North Pacific humpbacks? What are their breeding habits? Are humpbacks solitary or social? What other factors might impact the distribution of humpbacks?

Based on their background research, students will then use NOAA nautical chart #530 (*San Diego and Hawaiian Islands to Aleutian Islands*) to plot a proposed course for the next SPLASH research cruise. SPLASH scientists will have access to the NOAA ship *McArthur II* for 3 months. In their proposal, students will need to propose the preferred dates (time of year) and the location and path of the research cruise.

Keep in mind that the *McArthur II*, traveling at a maximum speed of 10 knots, can cover at most 240 nautical miles per day. So given that the *McArthur II* will be at sea for approximately 12 weeks, the maximum distance traveled would be a little over 20,000 nautical miles. Using the scaling information on chart #530, students can cut a piece of thread representing 20,000 nautical miles. Students can then use this thread to loosely map out a voyage, trying out a number of different possibilities. Once the group has agreed upon a plan, students can use the transparency markers to sketch the final research plan on their chart. One spokesperson from each group will then present the group's plan to the class.

Acoustic Surveys and Population Ecology:

Humpbacks and other cetaceans spend much of their time submerged; therefore, biologists may only "see" whales in their brief time spent at the surface. By using acoustical techniques, such as a towed hydrophone or a sonobuoy, scientists can detect whales using sound, even if they are not visible at the surface. To hear samples of acoustical recordings of various marine mammals, visit the Discovery of Sound in the Sea web site: www.dosits.org

Capture-Recapture Simulation: ***Estimate the size of a "humpback" population***

In this activity, students will apply the "capture and recapture" methods to a simulated population of humpbacks, represented by "goldfish" crackers. For a complete description of this activity, see "Capture and Recapture" by June G. Morita (Mathematics Teaching in the Middle School, Vol. 4, No. 6, March 1999. To order: http://my.nctm.org/eresources/).

Capture-Recapture Calculations: ***Formulas for estimating the size of a "humpback" population***

Cetacean biologists have devised several different mathematical formulas for estimating population size based on capture-recapture data. More complicated versions of these formulas may account for factors such as geographic sampling bias, birth and death rates and other sources of variance. (See Calambokidis and Barlow, 2004.)

However, a simplified version of these more advanced formulas gives us a reasonable estimate of population size based on the capture-recapture data. For example, to estimate the size of the group of whales feeding in Prince William Sound, we can use the data generated in our "Prince William Sound Fluke Matching Activity." This formula is set up in a ratio listing three known variables and one unknown variable as follows:

$$\frac{\text{Number of Whales "Recaptured"}}{\text{Number of Whales "Captured"}} = \frac{\text{"Known" Whales}}{\text{Total Number of Whales}}$$

Number of Whales "Recaptured" = Number of whales photographed by the SPLASH team that "match" whales in the Prince William Sound catalog.

Number of Whales "Captured" = Total number of whales photographed by SPLASH team in Prince William Sound.

"Known" Whales = Number of whales previously reported by biologists in the Prince William Sound catalog.

Total Number of Whales = Number of individual whales that frequent Prince William Sound feeding ground.

Genetic Analysis and Population Ecology: *Using DNA samples to estimate population size*

In addition to taking photographs of individual humpbacks, SPLASH scientists also collected skin samples to be used in genetic analysis. How could this information be used to help estimate the size of a population?

To explore whale DNA fingerprinting and genetic analysis in greater depth, try the "Whale Pod" genetics activities at the following web site: http://biotech.biology.arizona.edu/labs/labs.html.

Resources and References:

Primary Sources and Publications:

1) J. Calambokidis and J. Barlow. Abundance of Blue and Humpback Whales in the Eastern North Pacific Estimated by Capture-Recapture and Line-Transect Methods. Marine Mammal Science, 20(1): 63-85. January 2004.
2) J. Calambokidis, G. Steiger, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urban, J. Jacobsen, O. V. Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladron, M. Yamaguchi, F. Sato, S. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. Quinn. Movements and Population Structure of Humpback Whales in the North Pacific. Marine Mammal Science, 17(4): 769-794. October 2001.

Links to the SPLASH Project and NOAA Ship *McArthur II*:

1) NOAA Southwest Fisheries Science Center – SPLASH Project
   http://swfsc.nmfs.noaa.gov/prd/PROJECTS/splash/default.htm
   - -Visit the SPLASH project--peruse photos and read weekly cruise reports.
2) NOAA Ship McArhur II
   http://www.moc.noaa.gov/mt
   - Take a tour of the NOAA ship McArthur II.

General Information on Humpbacks:

1) Field Guide to the Humpback Whale. Oceanic Society Expeditions. Sasquatch Books. 1993.
   - Includes information on humpback natural history, feeding, breeding, and behavior.
2) Pacific Biodiversity Institute - Humpback Whale Biography
   http://www.pacificbio.org/ESIN/Mammals/HumpbackWhale/humpback.html
   - General information on humpbacks of the North Pacific.
3) Vancouver Aquarium Aqua News - Humpback whale researchers make a SPLASH
   http://www.vanaqua.org/aquanew/fullnews.php?id=1841.
   - Include a map of known humpback feeding and breeding grounds in the North Pacific.
4) National Marine Sanctuaries- Hawaiian Islands Humpback Whale NMS
   http://www.hawaiihumpbackwhale.noaa.gov
   - Information on the Hawaiian humpback sanctuary and winter breeding grounds.

Line Transect Information and Activities:

1) Research on Whales in the Arctic from Institute of Cetacean Research - “Counting Whales in the Arctic”
   http://luna.pos.to/whale/icr_rw_kasa.html
   - -Background information on cetacean line-transect methodology.
2) Lewis Center for Educational Research
   http://www.lewiscenter.org/users/mhuffine/subprojects/Wildlands%20Curriculum/www_animal signs .htm
   - A schoolyard “line transect” activity.

Capture-Recapture Information and Activities:

1) PBS Scientific American Frontiers- Alien Invasion, a teaching guide
   http://www.pbs.org/saf/1204/teaching/teaching3.htm
   - An on-line capture-recapture activity.
2) PBS Scientific American Frontiers- Alien Invasion, a teaching guide
   http://www.pbs.org/saf/1204/teaching/teaching3.htm
   - Students use paper capture-recapture simulations to assess various populations.
3) Access Excellence at the National Health Museum- The site for Health and Bioscience Teachers and Learners
   http://www.accessexcellence.org
   - A schoolyard “capture-recapture” activity.

Fluke Catalogues and Nautical Charts:

1) Humpback Whale Photo-Identification Project
   http://www.discoverpacifictours.com/PIP/gallery.html
   - On-line gallery of fluke photos of humpbacks from the winter breeding grounds of Banderas Bay, Mexico.

2) Whale Net- An interactive educational website
   http://whale.wheelock.edu/Welcome.html
   - Excellent source of reference material and educational activities relating to North Atlantic humpback populations, including an on-line fluke catalogue. A complete version of the fluke catalogue can be purchased in CD format. See web site for details.
3) A Catalog of Humpback Whales in Prince William Sound Alaska: 1997-2001. Compiled by: Olga Von Ziegesar, Beth Goodwin, Rene DeVito.
   - To order, write: Eye of the Whale Research. P.O. Box 15191. Homer, AK 99603; or e-mail: olga@xyz.net.
4) NOAA Office of Coast Survey- Nautical Charts
   http://chartmaker.ncd.noaa.gov/
   - Provides info on purchasing NOAA nautical charts.

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