NOAA's aquarius America's Innerspace Station

Counting FishStix

Focus
Population biology

Grade Level
9-12

Focus Question
How do scientists estimate the population size of a particular group of fishes?

Learning Objectives
Students will be able to describe and demonstrate a visual census technique commonly used to survey reef fish populations.

Students will be able to analyze and interpret data from surveys of coral reef fish populations.

Materials
- Fish Census Data Sheets, one for each student
- Master Data Summary Sheet (Optional: copy onto an overhead transparency)
- Cover stock or poster board for Fish Cards (see Learning Procedure)
- Fish Family Flash cards (see Learning Procedure)
- Craft sticks, two for each student
- Glue or tape to attach craft sticks to fish cards
- Colored markers or pencils for coloring fish cards
- Survey Activity Area: A 6-meter diameter circle in a cleared area of a classroom, hallway, auditorium, or outdoors

Audio/Visual Materials
- (Optional) Overhead projector

Teaching Time
Three 45-minute class periods, plus time for student research and coloring Fish Cards

Seating Arrangement
A cleared area for the survey activity, classroom-style for discussions

Maximum Number of Students
30

Key Words
Population sample
Census
Variability

Background Information
Aquarius is an undersea laboratory owned by the National Oceanic and Atmospheric Administration (NOAA). Its purpose is to support research on oceans and coastal resources by allowing scientists to live and work on the seafloor for extended periods of time. *Aquarius* is presently deployed three and a half miles off-shore in the Florida Keys National Marine Sanctuary. It operates 62 feet beneath the surface at Conch Reef. Missions typically last 10 days and aquanaut candidates undergo five days of specialized training before each mission starts. Visit **http://www.uncw.edu/aquarius/** for more information, including a virtual tour of the *Aquarius* laboratory.

Aquarius missions are focused on understanding our changing ocean and the condition of coral reefs. Coral reefs are threatened locally, regionally, and globally by increasing amounts of pollution, over-harvesting of fisheries, disease, and climate change. National Marine Sanctuaries (NMSs) are recognized as an important management tool for marine conservation, and can help stop dwindling fish populations, conserve critical habitats and biodiversity, and manage sites to avoid conflicts among fishers, boaters, and divers. Effective design and management of NMS s to protect coral reefs requires specific information on the complex ecosystems typically associated with these reefs, particularly fish populations. In recent years, visual censuses by SCUBA divers have become increasingly important to marine conservation programs. In addition to research conducted by professional scientists, many fish population surveys are also conducted by volunteers. The Reef Environmental Education Foundation's Fish Survey Project, for example, allows volunteer SCUBA divers and snorkelers to collect and report information on marine fish populations. The data are collected using a standardized method, and are archived in a publicly-accessible database on REEF's web site (http://www.reef.org).

In August, 2002, scientists used *Aquarius* as a base of operations to study reef fish biodiversity and population sizes in the Florida Keys National Marine Sanctuary. Surveys of fish populations were conducted using a method known as the Bohnsack-Bannerot Stationary Visual Census Technique. This technique consists of a stationary diver who attempts to count all fish observed in an imaginary cylinder 15 meters in diameter extending from the bottom to the limits of vertical visibility (usually the surface). Divers begin by facing in one direction and listing all species within the field of view. When no new species are noted, new sectors of the imaginary cylinder are scanned over a five-minute period until the entire cylinder has been observed. After the initial five minutes, data are then collected on the abundance and minimum, mean, and maximum lengths for each species sighted. Divers use a 30-cm ruler connected perpendicularly to the end of a one-meter PVC pipe as a reference device to assist with fish size estimates and to calibrate their sample radius.

This activity is intended to simulate a reef fish population census, and to familiarize students with some of the ways census data can be analyzed to better understand these populations.

Learning Procedure

[Note: This lesson is based on an activity developed by Mark Tohulka (MAST Academy), David Makepeace (Coral Shores High School), Susan Haynes (Virginia Institute of Marine Science), and Julie Lambert (University of Miami).]

1. a. Calculate how many "fishes" of each family will be needed, based on the total number of students who will be participating in the activity:
   - Angelfish (family *Pomacanthidae*): multiply the total number of students by 0.2
   - Barracuda (family *Sphyraenidae*): multiply the total number of students by 0.08
   - Damselfish (family *Pomacentridae*): multiply the total number of students by 0.66
   - Grouper (family *Serranidae*): multiply the total number of students by 0.08
   - Grunt (family *Haemulidae*): multiply the total number of students by 0.66
   - Parrotfish (family *Scaridae*): multiply the total number of students by 0.32

   So, for a class of 20 students you would have 4 Angelfish, 2 Barracudas, 13 Damselfish, 2 Groupers, 13 Grunts, and 6 Parrotfish.

b. Prepare one or more sets of flash cards with the outline of the typical body shape for each family.

2. Assign each student one or two of the families listed above. Tell students that they are to prepare Fish Cards for their assigned fishes. These cards should be drawn on cover stock or poster board, should be appropriately colored and about the average size of the fishes in the assigned families. Students should also find out what and when their assigned fishes typically eat, and where they are likely to be found on the reef during the day and at night. The necessary information is available from many books and web sites (see Resources). The Reef Environmental Education Foundation web site (http://www.reef.org/) has color pictures as well as outlines of fishes and provides information on typical sizes.

3. Have students working in groups of 2 – 4 learn to identify the general body shape of the six families of fishes listed in Step 1. Flash cards may be used to facilitate this process.

4. Move to the Survey Activity Area. Have students distribute themselves more or less uniformly around the perimeter of a 6-m diameter circle with their two Fish Cards held up so they can be easily seen from the center of the circle. Students may mill around a bit, but should not move more than 2 meters from their starting position. Select one student at a time to act as the Diving Scientist. This student should be equipped with a Fish Census Data Sheet, clipboard, and pencil and be positioned in the center of the 6-m circle. On your "Go!" signal, the student has 60 seconds to identify and count as many fishes as possible. The best procedure is for the Diving Scientist to survey one-fourth of the area for 15 seconds, then rotate to the next quarter-circle, and so forth until the time limit is reached. Repeat this procedure with the remaining students. Students should resume their places among the other fishes when they have completed their turn as Diving Scientist.

5. Have each student transcribe his/her data onto a Master Data Summary Sheet or overhead transparency, then copy these data sets onto their own Data Sheet for analysis. Have students calculate the mean observed frequency and standard deviation for each family in the pooled data set.

6. Lead a discussion of the survey data, analysis results, and sources of variability that could affect the results of the simulated survey as well as actual underwater surveys. Students should recognize that errors in identification are always a possibility, and may be more likely in the simulation due to inaccuracies in the student-constructed Fish Cards. They may also point out that the simulated population changes every time the Diver Scientist changes, since the Scientist's Fish Cards are temporarily removed from the "population." A similar effect occurs in actual underwater surveys when fish enter or leave the survey area during the counting period. Be sure students realize that actual surveys involve larger sampling areas, many more species and individual fishes, and often include estimates of the size of individual fishes.

Based on their research, students should realize that different fish species are typically doing different things in different ways at any given reef location. These differences are part of the reason so many different species can co-exist in the same area. These behaviors can be a major source of bias in visual census projects. For example, many species of grunts live on the reef during the day, hanging out in schools close to the coral, not doing much at all. But at dusk, their behavior changes and they move off the reef (often along the same route every night) into grassbeds where the schools break up and individuals feed throughout the night. At dawn, the fish start to get together again and move back to the reef. Just the opposite happens for several species of parrotfish. The Rainbow Parrotfish, for example, is mostly herbivorous and travels alone or in schools on the reef and into grassbeds during the day. At dusk, they gather on the reef in schools before moving alone into various holes and crevices where they sleep throughout the night. Things can get even more complicated because some fish, like red grouper, seem to be attracted to divers and follow them around almost like a lost puppy during the course of a dive. Other snappers and groupers take off at the first hint of a diver, never to be seen except possibly during the first moments of the dive.

Discuss how these behavioral characteristics could affect visual population surveys, and how survey techniques might be modified to give a more accurate picture of fish populations on a reef. The reality is that it is almost certain that some species are present but rarely if ever seen by divers. Some surveys try to deal with this problem by poisoning a section of reef and collecting all the floating fish. This technique has some obvious limitations, including the likelihood that fish under ledges or other shelter may not float and will still be missed by the survey. Despite these problems, visual surveys can be extremely useful in identifying changes in fish populations over time, and these changes can provide indications of stability and change in the overall reef ecosystem.

The BRIDGE Connection

www.vims.edu/bridge/ – Click on “Ocean Science” in the navigation menu to the left, then “Biology,” then “Bony Fishes.”

The “Me” Connection

Have students write a short essay on how fish population surveys could be important to their own lives. If students have trouble with this, you may want to lead a discussion that explores the idea of fishes as indicators of overall reef health, as well as the potential importance of coral reefs as sources for new pharmaceutical agents (see http://www.science.fau.edu/drugs.htm for more information on the latter topic).

Connections to Other Subjects

English/Language Arts, Mathematics

Evaluation

Individual data analyses and participation in group discussions provide opportunities for assessment.

Extensions

Discuss how the *Aquarius* habitat itself may influence fish populations by providing shelter to fishes. It functions, in part, as an artificial reef.

Calculate the density index (Den) and percent sighting frequency (%SF) parameters used by the Reef Environmental Education Foundation’s Fish Survey Project to provide measures of the relative density of fish species and the frequency with which these species were observed (for purposes of this lesson, calculate Den and %SF for each of the six families).

Den is a measure of how many individuals of a species are observed based on a scale of 1-4. It is representative of the abundance categories (1-4) that REEF surveys use to record the abundance of species when they are observed: Category 1 "Single" = 1 individual; Category 2 "Few" = 2-10 individuals; Category 3 "Many" = 11-100 individuals; Category 4 "Abundant" = over 100 individuals. Den is calculated as a "weighted density average" by assigning a multiplier to each abundance category. Abundance category weights are Single = 1, Few = 2, Many = 3, and Abundant = 4. Den is calculated as:

$$Den = (S * 1) + (F * 2) + (M * 3) + (A * 4)$$

(Where S is the number of surveys in which species was observed in Category 1, F is the number of surveys in which species was observed in Category 2, etc.)

SF is a measure of how often the species was observed. It indicates the percentage of times out of all surveys that the species was recorded. SF is calculated as:

$$SF = [(S + F + M + A) \div (\text{total number of surveys})] * 100$$

See http://www.reef.org/ for more information.

Resources

http://www.uncw.edu/aquarius/virtual_tour/ipix.html – Virtual tour of the *Aquarius* undersea laboratory

http://www.marinebiology.org/science.htm – Odyssey Expeditions web site, with lots of information about coral reef fishes and reef ecology

http://www.reef.org/ – Reef Environmental Education Foundation web site

http://www.aqua.org/animals/species/prprfish.html – Focus on parrotfish

http://www.marinebiology.org/fish.htm – Lots of general information about fish

http://www.coralrealm.com/homepage.html – General site with lots of information about fishes

Human, P. and N. Deloach. 1999. *Reef Fish Behavior.* New World Publications, Inc.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- Interdependence of organisms
- Behavior of organisms

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Environmental quality

Master Data Summary Sheet

Survey Number	Family					
	Angelfish	Barracuda	Damselfish	Grouper	Grunt	Parrotfish

Fish Census Data Sheet

Survey Number	Family					
	Angelfish	Barracuda	Damselfish	Grouper	Grunt	Parrotfish
My Survey						