Illustrations by Kelly Campbell

highschool

Tidepool Math

U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

Tidepool Math
High School

Learning Objectives

- Increased awareness of the diversity of animals and plants in rocky intertidal habitats.
- Understand the differences between random, systematic and targeted sampling approaches.
- Compare estimates, counts, and means. Discuss outliers.
- Understand simple statistical concepts and tools that are used to design a study and analyze environmental data.

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Adapted from Methods for Performing, Monitoring, Impact, and Ecological Studies on Rocky Shores
by Steve Murray, Richard Ambrose and Megan Dethier

Process Skills Used in this Lesson

- Be able to set up a random, systematic, and targeted sampling approach for a fixed plot of animals or plants.
- Be able to determine whether a count of individuals or a percent cover measurement is best to determine abundance for a given plot.
- Be able to compare two or more locations and determine if the living communities are statistically different from each other.

Background for Teachers

Proper adherence to the Scientific Method involves defining the question to be studied and setting up a study design which will answer the question being asked. Fundamental to applying scientific method is the student's ability to define hypotheses about the phenomenon, system or process being studied. The null hypothesis (e.g., there is no statistical difference between two populations) is central to proper scientific study as well as the basis for statistical analytic models.

In this first exercise, students will be shown how the study design, whether random, systematic or targeted, will answer different questions and have different advantages and disadvantages. This basic concept can be visually demonstrated using a standard rocky intertidal plot sampling design.

In the second and third exercises, the student is challenged to pose a hypothesis about the distribution of plants or animals that live in the rocky intertidal coastal environment. Students are shown the application of statistics and statistical analysis to contemporary problems in marine ecology.

Abundance of a given population is determined either through counts or measuring percent cover. In a rocky intertidal habitat, both are used. Percent cover is used for algae, densely populated animal communities such as barnacles, and colonial animals such as small anemones. Counts of individuals are used to determine the abundance of different invertebrates like snails, and sea stars. Depending on the study and the scale of the effort, mussels may be sampled either with counts or cover.

Biologists with several agencies and universities currently monitor rocky intertidal habitats along the California coast. This group, MARINe, or the Multi-Agency Rocky Intertidal Network, has established 55 permanent sites where they sample every fall and spring. Species photographed in fixed plots include mussels, anemones, acorn barnacles, gooseneck barnacles, turf algae, rockweed, and red fleshy algae. Notes about the plots are taken by biologists at the site but the " counts" of the species in the photos are done in the laboratory. Each photo is displayed on a computer screen and overlaid with 100 points. Species under each point are counted to determine the percent cover of each species identified. Species counted and measured as individuals in fixed plots include sea stars, owl limpets, and black abalone. Several varieties of small invertabrates such as snails and chitons are also counted and measured in the photoplots by biologists at the site.

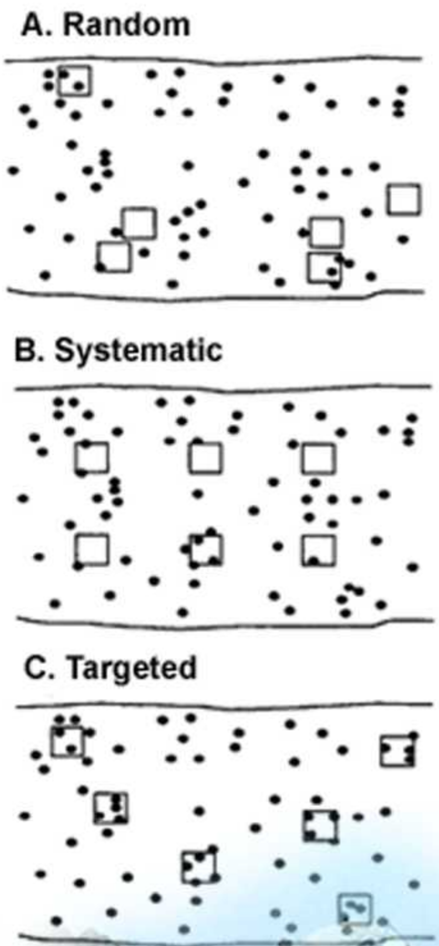
Concepts

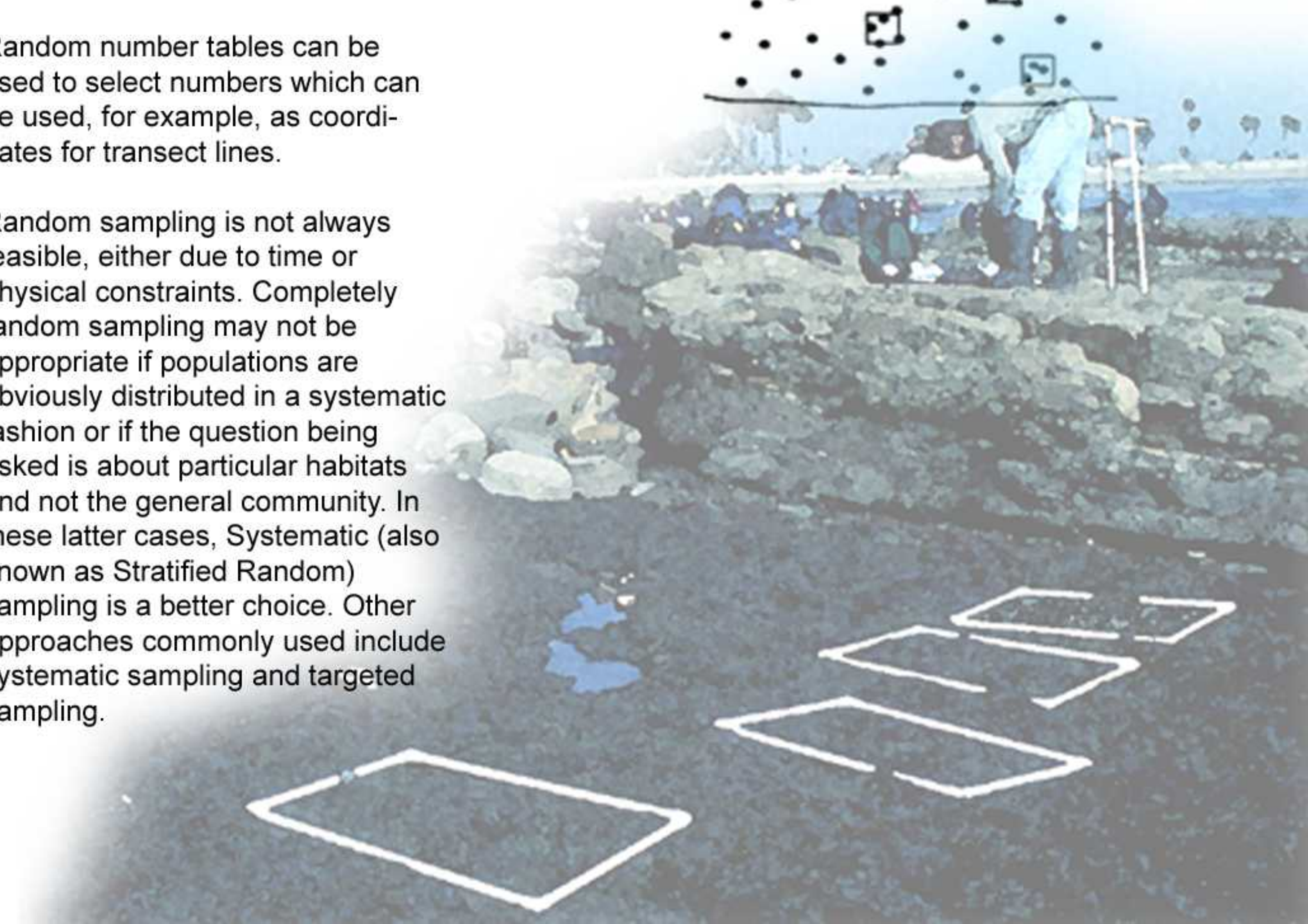
Random

If the question being asked is whether populations (numbers or density of animals) differ at different locations, the focus of the sampling design is to obtain representative samples of the populations being compared. The best statistical design for this question is random sampling within each population (or plot). This reduces the bias that the scientist might make in assigning sampling locations within a plot to denser or sparser areas, unintentionally avoiding edges of the study area, unintentionally aggregating samples etc. A disadvantage of random sampling is that a large number of samples may be required for good statistical power in populations that are patchy or unevenly distributed.

Random number tables can be used to select numbers which can be used, for example, as coordinates for transect lines.

Random sampling is not always feasible, either due to time or physical constraints. Completely random sampling may not be appropriate if populations are obviously distributed in a systematic fashion or if the question being asked is about particular habitats and not the general community. In these latter cases, Systematic (also known as Stratified Random) sampling is a better choice. Other approaches commonly used include systematic sampling and targeted sampling.





Concepts Con't

Systematic
A systematic sampling design places sampling units uniformly through the study site. Transect lines spaced at regular intervals is an example of a systematic approach. The advantages are that it can be much easier in practice to do, and the estimate of the mean may be more accurate than with random samples.

The main disadvantage is that it is not random, and therefore will not meet certain statistical test criteria.

Targeted
The rocky intertidal sampling chosen for the MARINe core monitoring program is a targeted design. This design focuses the time spent by researchers on sampling targeted populations where the abundance of a given species of interest is highest. For example, photoplots are targeted in low intertidal mussel beds for mussels, and the high intertidal for barnacles.

This design is appropriate when certain species are being targeted for study. It is an unacceptable design when the question asked is "what is the average density of a population in a habitat?"

This is a useful design in many biological habitats because species are often clustered by physical parameters such as tidal height, distance from shore, water depth, distance from a stream, elevation, etc.

To reduce bias in the sampling, it is best if individual sampling units are randomly placed within a targeted population. For example, in the MARINe program, five photoquadrats were randomly placed within each defined target population.