APES Mini-Lab: Estimating Population Size

Introduction

The best way to measure the size of a population is to count all the individuals in that population. When determining the population sizes of trees or other relatively immobile organisms, this method is practical. If the organism is mobile, however, such as a fish, counting every individual would be difficult. Some individuals might be counted twice or not at all, since the experimenter would not know which fish had been counted and which had not.

Knowing the size of a population of animals is important in making environmental decisions that would affect the population, but estimating the size of wild populations is extremely difficult. In the case of ocean dwellers, such as whales, the task is especially challenging. Estimates of the number of minke whales, for example, have differed by as much as a factor of 10. Deciding whether to allow hunting of minke whales, based on population estimates that are too high, could lead to extinction of the species. On the other hand, basing a decision on an estimate that is too low could unnecessarily ban hunting of minkes by people that depend on whales for food. One method for estimating population size, the "line-transect survey", involves observing every animal seen while traveling in a straight line. Although traditionally used for counting land animals, the line-transect survey method has recently been applied to whales, providing more reliable data.

Another method often used to estimate population size is the "mark and capture" technique, in which scientists capture some animals from the population, mark them, and release them. At a later time, the scientists again capture animals from the same population and observe how many of them are marked. The method assumes that the ratio of the actual population to the sample size is the same as the ratio of the number of marked animals to the number marked in the recapture sample. Knowing three of the four values [recapture sample size (N_2), number originally marked (N_1), and number marked in the recapture sample (R)], scientists can calculate an estimate of the actual population size (P). This method of estimation is called the **Lincoln Index**.

$$\mathbf{P = \frac{N_1 \times N_2}{R}}$$

- **P** = total size of population
- **N_1** = size of first sample (the ones originally marked)
- **N_2** = size of second sample (the ones recaptured: some will be marked, some won't)
- **R** = number of marked individuals recaptured

The Lincoln Index makes several assumptions that must be met if the estimate is to be accurate:

- The population of organisms must be closed, with no immigration or emigration.
- The time between samples must be very small compared to the life span of the organism being sampled.
- The marked organisms must mix completely with the rest of the population during the time between the two samples.

IN-CLASS ACTIVITY: Simulate the mark and capture method using marbles.

MATERIALS

60 marbles
plastic container, lid optional

PROCEDURE

1) Select 60 marbles: 45 white and 15 colored. The colored marbles are considered "marked."
2) Place all 60 marbles in the container and cover with the lid if desired. Shake the container to mix them thoroughly. If you are using a lid, take it off and without looking, withdraw 10 marbles. Count the number of "marked" marbles and record in the data table.
3) Put the 10 marbles back in the container and replace the lid if desired. Shake the container again and withdraw a second set of 10 marbles without looking. Again, record the number of "marked" marbles in the sample in the data table. Continue in this manner until you have completed 10 trials.
4) Estimate the population size* to 0.1 for each trail by multiplying the number of marbles marked (15) by the number of marbles in both sample (20) and dividing the product by the number of "marked" marbles for that trial. The result is an estimation of population size. When you have done this for all 10 trials, find the average** by adding the estimates and dividing by 10. Round to the nearest whole number.

DATA TABLE

A	B	C	D	E	F	G
Trial number	Total # of marbles marked **(N_1)**	Size of both recapture samples **(N_2)**	# marked marbles in sample #1, out of 10 **(R_a)**	# marked marbles in sample #2, out of 10 **(R_b)**	**Total R** for the trial (D + E)	**Population size estimate***
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Average population size estimate**: _____

QUESTIONS

1) How does the average value compare to the actual population size of 60?
2) If there is a difference, explain what might cause the difference.
3) What problems might scientists encounter in using this method in the field that you would not have encountered in the simulation?