Name _____ **Date** _____
A.P. Environmental Science **Mr. Romano**

Partners _____

Mark and Recapture Lab

Estimating Population Size

Problem: How can the population size of a mobile organism be measured?

***Introduction*:**

One of the goals of population ecologists is to explain patterns of species distribution and abundance. There are many ways to determine the population of an organism. Direct observation is the best way to get an accurate result and is accomplished by literally counting all the individuals in that population. The actual methodology used to do the count can run into obstacles. Before the actual count can be performed, the general boundaries of the population must be established, but sometimes boundaries can be unclear. For instance, some aquatic ecosystems (such as lakes and ponds) have very distinct boundaries. Terrestrial biomes usually blend into each other through ecotones, so specific lines must be drawn to establish an area of study, and determining where an ecosystem really ends can be subjective. Additionally, some ecosystems, such as the arctic tundra and North American prairies allow for aerial surveys to perform a count. However, this approach becomes ineffective in forests, at night, in deeper waters, or in soil habitats. Another complication with conducting an accurate population count is the issue of mobility. To determine the population size of trees or other relatively immobile organisms, counting each individual organism is very practical. If the organism is mobile, however, such as a fish, bird, or even insects, counting every individual would be difficult. Some individuals might be counted twice or not at all, since the experimenter would not know which organism had been counted and which had not. To overcome some of these obstacles, ecologists have developed a method known as "mark and recapture" in conjunction with statistical analysis using a formula known as the Lincoln Index.

For estimates of absolute numbers, **mark-recapture methods** can be very effective. The first step is to capture and mark (tag) a sample of individuals. Marking methods depend on the species: birds can be banded with a small aluminum ankle bracelet, snails can be marked with waterproof paint on their shells, butterflies can have labels taped to their wings, large mammals can be fitted with collars, fish fins can be notched, and amphibians can have nontoxic dyes injected under the skin. Marked animals are immediately released as close as possible to the collection site. After giving the animals time to recover and to mix randomly with the whole population, the ecologist goes out on a second collecting trip and gathers a second sample of the organisms. The size of the population can then be estimated from the number of marked individuals recaptured again at a later time because the Lincoln Index works based on the idea that the proportion of marked animals in the second sample is the same as the proportion of marked animals to non-marked within the whole population.

In this investigation, you will model a population of mobile organisms, capture and mark a sample of the population, and then capture a second sample. You will then estimate the size of the model population using the Lincoln Index and then compare it to the actual population. The accuracy of the Lincoln Index will be determined by calculating the percent error.

The Lincoln Index Formula: $\mathbf{P = \frac{N_1 \times N_2}{R}}$

P is the total size of the population,
$\mathbf{N_1}$ is the size of the 1st sample
$\mathbf{N_2}$ is the size of the 2nd sample
R is the # of marked individuals recaptured in the 2nd sample.

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

- 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.

Procedure:

1. The plastic container represents the habitat of the model population.
   The beans represent the organisms in the model habitat.
   DO NOT COUNT THE TOTAL NUMBER OF BEANS IN THE CONTAINER UNTIL THE VERY END OF THE EXPERIMENT (step 13).

2. Remove a small handful of beans from the container. This handful will be the first sample.
   The sample should be at least 20 beans, but less than half of the total population.

3. Count the beans collected. Record the size of the first sample under $\mathbf{N_1}$.

4. "Mark" the beans with the red grease pencil and let the red marks dry for a minute. Place the marked beans back in the container. Replace the container lid and shake the container well to thoroughly mix the beans.

5. Remove the lid and, without looking, another member of the group should obtain a new handful of beans. The sample should be about the same size as the first sample. Count the total number of beans in this sample ($\mathbf{N_2}$), and then count the number of beans in the sample that are marked (**R**). Record these numbers in the appropriate places on Data Chart 1.

6. Return the beans to the container, replace the top, and shake well.

7. Repeat steps 5 and 6 two more times. Be sure to mix the beans well in between each collection.
   Record the data under $\mathbf{N_2}$ and **R**, trials 2 and 3.

8. Calculate the **Average** $\mathbf{N_2}$ and **R** and record on Data Chart 1.

9. Place all the beans back into the container and shake well.

10. Repeat procedure steps 2-8, but this time ignore the red marks, and instead use a blue or black grease pencil to tag the beans. This time, record all of your data on Data Chart 2.

11. Calculate **P (experimental)** values on Data Chart 1 and Data Chart 2 using the formula: $\mathbf{P = \frac{N_1 \times N_{2\,avg}}{R_{avg}}}$

12. Calculate your **Average P (experimental)** and record on Data Chart 3.

13. Work together with others in your group to count the total number of beans in the container:
    Record this number on Data Chart 3 – Summary Data as the **Actual P of the Habitat**

14. Calculate your percent error using the formula: $\mathbf{\%\ error = \frac{|\ actual - experimental\ |}{actual} \times 100}$

Data Chart 1: Experiment 1 – Red Marks

N_1 (number of beans, first sample)	
N_2 trial 1 (number of beans, 2nd sample)	
R trial 1 (number of beans marked in 2nd sample)	
N_2 trial 2	
R trial 2	
N_2 trial 3	
R trial 3	
Average N_2 (nearest tenths place)	
Average R (nearest tenths place)	
P (experimental value) (nearest whole #)	

Clearly show all work to all calculations made in this laboratory. Make sure each calculation is neat, organized, and easy to follow in the space provided on the side of each data chart. Write any formula necessary, substitute appropriate data, and attach correct units. You may use a calculator to complete all of the calculations.

Data Chart 2: Experiment 2 – Blue or Black Marks

N_1 (number of beans, first sample)	
N_2 trial 1 (number of beans, 2nd sample)	
R trial 1 (number of beans marked in 2nd sample)	
N_2 trial 2	
R trial 2	
N_2 trial 3	
R trial 3	
Average N_2 (nearest tenths place)	
Average R (nearest tenths place)	
P (experimental value) (nearest whole #)	

Data Chart 3: Summary Data

Average P (experimental) (nearest tenths place)	
Actual P of Habitat	
Percent Error (nearest tenths place)	

Conclusion Statement:

Briefly discuss your findings. Here are some items to be addressed in the conclusion:
How far off were your findings from the actual population? What might account for sources of error?
Compare your results with other groups. How did other results compare to yours?