Title: Population Estimates: Bringing Math and Science Together

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Grade Level: Middle School Life Science

Type of Lesson: STEM

Learning Objectives: 1) Learn how to estimate population size using two techniques, by density extrapolation and mark and recapture, 2) understand the close relationship between math and science and how math used to answer scientific questions, 3) understand why population estimates are important, and 4) understand how to create and interpret a graph from data.

Materials Required:

- __ White Beans (great northern white beans work very well)
- __ Sharpie (1 per group for marking captured beans)
- __ Plastic spoons or other bean-sampling device (1 per group)
- __ Population container for holding the beans with enough space for beans to be mixed thoroughly (small plastic containers work well)

Duration: approximately 1 hour

Audience: This lesson was developed for grades 6-8 but can be simplified for younger grades or complexity can be added for older grades.

Background Information: 1) Familiarity with division, multiplication, and graphing.

References:

Wetzel, R.G. and G.E. Likens. 2000. Limnological Analyses. Springer, N.Y., NY.0

Lesson Vocabulary:

Population - All the organisms that constitute a specific group or occur in a specified habitat.

Error - Difference between a computed or measured values and a true or theoretically correct value.

Population Density - A measurement of population per unit area or volume.

Assumptions - Accepted existence of a fact or set of facts based on other facts or knowledge.

Preparation (<15 minutes): 1) Measure out ≈1/4 cup great Northern Beans (may need 1/3 cup for larger beans like lima beans) and place in the population container, 2) print copies of the Population handout.

Engage: First, ask the students to answer the question "what is a population?" Now, ask the students to answer "Problem 1a" in their handout, "Why is knowing population size important?" By estimating population size for different organisms, scientists can learn many things. For example, fisheries managers can decide how many of a certain fish species can be harvested without damaging the population. They can also learn if a population is threatened by extinction. If population estimates over many years exist, different management strategies can be adopted to protect species if they are in need of protection.

Ask the students to answer "Problem 1b" in their handout, "What is a population."

Explore: Ask small groups to discuss the following question: How would you estimate an insect population in a shallow lake? Ask the students to think about if they ever had to guess the number of jellybeans in a jar in school or at a fair. Then ask them how they did that? (Answer: Obtain a value for the number in a measured area [a density measurement] and then multiply that by the entire area.)

Look at "Problem 2" on the handout. Ask the students if they can estimate the population size without being able to count all of the organisms.

Explain: Typically, scientists do not have enough time or money to sample an entire population in an ecosystem. Instead, they come up with an average population density for that ecosystem by counting the organisms in several small areas to come up with an average population density. Then they multiply the average population density by the entire area of that ecosystem. This results in a population estimate for the entire ecosystem.

Average population density is calculated using the following equation:

Number of organisms counted / Area sampled = Average population density

Then, to estimate the population of the entire ecosystem, not just the area sampled, the following equation can be used:

Average population density X Total area of the ecosystem = Ecosystem Population

Make sure the units are correct if you are using your own example

Extend: Sometimes, individuals in a population move as a group (think of a school of fish) or are not distributed evenly in an ecosystem. Under these conditions, using average density to come up with a population estimate may not work unless we take a lot of samples. In these cases scientists can use a different method to estimate the population. This method is called the mark-recapture method. In this method a small portion of the population is captured and marked and then released back into the population. Then, a small portion of the population is captured and by using the ratio of marked to unmarked organisms, the population size can be estimated.

Pass out the spoons, bean bowls, and permanent markers. Have the students work through "Problem 3" from the handout. Remind them the "marks" should be noticeable. Remind them to mix the beans after completing the first half of "Problem 3".

Once the students are finished marking and counting, work through the math problems for estimating population together. Then have each group count out the true value of their population and remove the marked individuals (so that you can be set up for the next class). Have each group fill in their numbers on the "Class Data Table" and, as a class, finish the table. Ask the students to discuss why each group got different estimations for the population and where this error may have come from.

After the students have filled out the sheet and concluded the lab ask the students to come up with problems that might limit the use of mark recapture. If they are stumped ask them questions A) Will I get a good bear population estimate if I sample bears in Glacier National Park in February and then again in July? B) If I put a sticker on the back of a snake, will I be able to use mark recapture next year to learn about snake populations? C) If I catch a fish, mark it (and then do 10 minutes of other measurements on it, causing the fish to be very stressed), have I created a good mark and recapture study? Why? D) If I use a net with a large mesh size to capture small trout in a lake, have I created a good mark and recapture study?

Then talk about the list of assumptions we have for the mark-recapture technique (see assumptions):
Assumptions for the mark-recapture formula

1. The population is "closed", so the number of individuals is constant (i.e. none of the organisms can leave or arrive in the population during the time between samples).
2. All animals have the same chance of getting captured.
3. Marking individuals does not affect their catchability.
4. Animals do not lose marks between the two sampling periods.

Evaluate: As a follow up, have the students work on graphing any two of the class variables against each other. Remind the students that there are no incorrect answers for this portion, but it is important for them to develop a question or story before they begin graphing.

Name: ________________________________

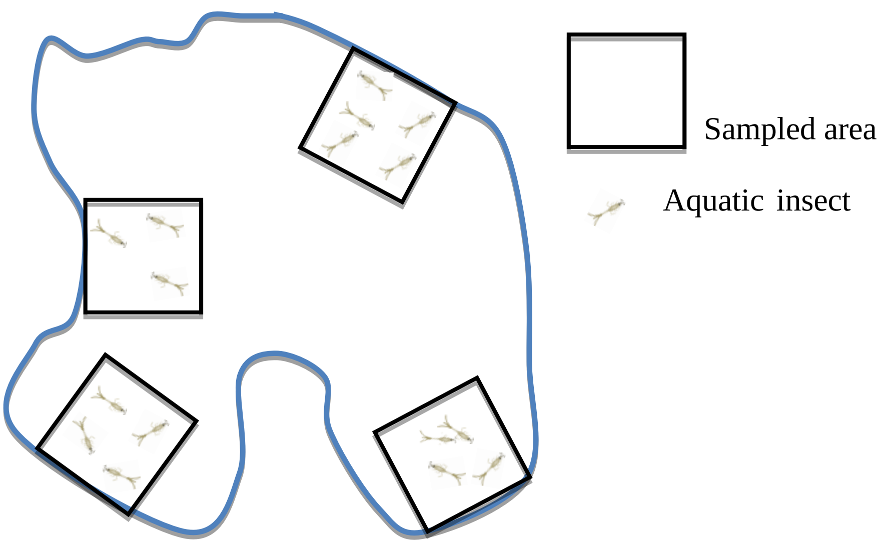
Period/Section: _____________________

Problem 1a: List two examples where estimating population size for different types of organisms is important:
1.

2.

Problem 1b: Explain in one sentence what a population is:

Problem 2: Come up with a population estimate for the lake below based on the knowledge that only ¼ of the lake was sampled. Each sampled portion represents 1/16 of the total area.



Write one example of a system that you think this technique would work well in and one example of a system where you this technique would not work well.

Problem 3:
Sample Period 1
Remove five spoonfuls of beans from the bowl and place each spoonful into its own pile (Don't mix all five spoonfuls together!). Mark each bean with the permanent marker, count the number of beans in each spoonful, and place all the beans back in the bowl.

Spoonfull	1	2	Total Marked (sum of 1 + 2)
# of beans in spoon			a

Sample Period 2
Mix the beans in the bowl so the marked beans are evenly distributed throughout the bowl. Remove two spoonfuls of beans from the bowl and place each spoonful into its own pile. If you want a super challenge, don't mix all two spoonfuls together and do the calculations for each spoonful as well as the total. Count the number of beans in each spoonful, record how many beans have a mark in each spoonful, and return the all the beans to the bowl.

Spoonfull	1	2	Total (sum of 1 + 2)
# in spoonful (marked + unmarked)			b
# marked in spoonful			c

Problem 4:
Population Estimate = (Captured from sample period 2) X (Marked in sample period 1) / Number captured in sample period 2 with a mark

Population Estimate = (____________________b) X (_____________________a)

______________c

Class Data Table

Table Group	1	2	3	4	5	6	7	Average
Total Marked								
Total Captured								
Total Recaptured with Mark								
Population Estimate								
True Population								
% difference between true and estimated population 1- (true population / estimated population)								

Describe two examples where this method would not work and why.

Graphical Depiction of Data

Scientists frequently try to understand their data visually by using graphs to find trends. Choose two of the variables in the class data table to graph and answer the below questions about your graph. Don’t forget to include title, axis labels, and legend.

Briefly explain why you chose your independent (x-axis) and dependent (y-axis) variables: