FISH 621 Homework #1: Basic Abundance Estimators and Simple Mark-recapture

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Instructions

Please make sure to follow the instructions in the homework and, to the extent you can, feel free to **work with others to learn from each other**. If you get hung up and can't figure out things on your own, feel free to e-mail others in this class or your peers. For homework purposes, perhaps you can work together via e-mail, Google Hangout, or whatever works best for you. However, each of you will need to submit your own completed homework assignment for evaluation.

Please post to the Canvas Discussion Forum and feel free to e-mail me if you get hung-up, and have exhausted your immediate options (google, classmates, friends). No need to bang your head against the wall, first ask your peers for help and if all else fails feel free to email me directly.

This homework assignment is due by 11:59 pm on Friday February 11, 2021.

Please submit all components of the homework assignment (i.e. word, R script, or Excel file) via Canvas, and name each file with the homework number and your first and last name (e.g. **Hwk1_FirstName_LastName.docx**, **Hwk1_FirstName_Last.xlsx**, **Hwk1_FirstName_LastName.R**). In the word document please describe your results and answer any questions posed in the homework document, along with any useful and/or necessary model output or figures. Please ensure that the R script you submit would allow anyone with the same input files to recreate your analysis, include comments as necessary to guide review of your work.

In the event you are unable to submit your completed assignment via Canvas, please email it to me at: cjcunningham@alaska.edu. Late homework assignments will be penalized 2 points per day overdue. Please contact me ***ahead of time*** if there are circumstances requiring late submission.

Evaluation

This homework assignment will be graded out of ***40 possible points***.

Homework Contents

- **621_Homework 1.pdf** (this file)
- **Length Sample 50.csv** Beach seine sample of 50 2-spine stickleback lengths.

- **Length Sample 250.csv** Beach seine sample of 250 2-spine stickleback lengths.

Problem 1 – Simple Random Sampling Length Composition (4 points)

You are hiking among a small series of ponds in the Iliamna Lake region of southwest Alaska, and interested in quantifying the length distribution of 3-spine stickleback (*Gasterosteus aculeatus*). You use a beach seine to sample the length composition of the stickleback in Grass Pond. The first beach seine set comes up with a sample size of $n = 50$ individuals, while the second set catches a whopping $n = 250$ individuals.

The length composition data for these stickleback are contained in two input data files:

- Length Sample 50.csv
- Length Sample 250.csv

Assuming you are sampling ***without*** replacement, for your two length composition samples please compare the:

1. Sample mean
2. Sample variance
3. Sample CV
4. The unbiased estimate of the variance of your estimator $\bar{y}$.

Please summarize your results and inference in the word (.docx) document you submit for this assignment along with your R script.

Problem 2 – Quadrat Sampling (7 points)

For some reason you are determined to estimate the abundance of your favorite wildflower in your favorite high mountain field. To do so you sample $n = 15$, 1-meter by 1-meter square quadrats randomly within this high mountain field. Your observations for the number of flowers in each quadrat are:

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# of flowers	10	15	1	23	18	12	19	9	5	8	3	26	20	12	31

Please calculate:

1. Sample mean
2. Sample variance
3. Sample CV
4. The unbiased estimate of the variance of your estimator $\bar{y}$.

Your favorite high mountain field is approximately 50-meters long by 120-meters wide. Please estimate:

1. The total number of wildflowers in the field
2. The variance associated with the estimate of the total
3. The CV for the estimate of the total

Please summarize your results and inference in the word (.docx) document you submit for this assignment along with your R script.

Problem 3 – Vole Estimator (3 points)

Sadly, you have a vole problem in the basement apartment where you reside. While you would love to spend your Friday night conducting a complete census of the total number of voles that are cohabitating with you in the apartment, it is impossible to do so because the voles scatter whenever you enter the apartment.

However, all is not lost! When you look through the window on the front door of your apartment you can count the number of voles you see at a given time point. You estimate that about 15% of your apartment floor is visible from this window. The first time you look through the window you count 12 voles, the second time you count 22 voles, and during the third observation event you count 19 voles.

Please estimate the total number of cohabitating voles in your apartment for each of the three sampling events. Next, to evaluate how uncertain you are about these vole abundance estimates please calculate the relative probability of your three different abundance estimates $\widehat{N}$ across a suitably large range and visualize them in such a way that they can be readily compared. Please comment on what assumptions must be met for estimates from your vole experiment to be valid.

Please summarize your results and inference in the word (.docx) document you submit for this assignment along with your R script.

Problem 4 – Whale Mark-Recapture (12 points)

This problem shows the connection between probability density functions, expected values, and the application to mark-recapture. For specified values, ***it is possible*** to describe the probability density function for the Chapman estimator of abundance from a Petersen simple mark-recapture experiment. Suppose that a Petersen mark-recapture experiment (sampling without replacement) is done on a population of 1000 whales with photo-ID of their flukes. The number marked is 50, and the number examined for marks is 100.

1. Please determine the number of marked individuals you expect to observe.
2. Across a suitably large range calculate please calculate the probability of observing different numbers of marked individuals, plot this distribution.
3. To prove your original estimator for the expected number of marks is accurate, calculate the expected number of marks as $\mu = \sum m_2 f(m_2)$, where $f(m_2)$ is the probability of observing some number of marked individuals.

Please describe what happens if:

1. The number of whales inspected for marks is decreased to 50, or increased to 200. ***How does your expectation for the number of marked individuals observed change?*** Please provide plots comparing the probability for observing different numbers of marked individuals under these conditions.
2. The true abundance is decreased to 500, or increased to 2000. ***How does your expectation for the number of marked individuals observed change?*** Please provide plots comparing the probability for observing different numbers of marked individuals under these conditions.

Please summarize your results and inference in the word (.docx) document you submit for this assignment along with your R script.

Problem 5 – Simple Mark-Recapture (14 points)

Congratulations, you have just accepted a job as a research scientist with a fishery management agency! As your first assignment, you are charged with estimating the abundance of rainbow trout in a small river system that is popular with local anglers. Under current regulations anglers are allowed to keep and retain fish they catch and you are worried that over the course of the summer fishing season the abundance to trout in the lake may decline.

To test this hypothesis you conduct a mark-recapture experiment during the first week of each month over a 5 month period. On Monday of each week you capture some number of fish n_1, mark them with an easily identifiable yellow t-bar tag, and release them back into the stream. On the following Wednesday you return and sample some number of fish n_2 by hook and line sampling and inspect them for marks, of which some number m_2 do indeed have marks.

The data from your experiment are:

Month	**May**	**June**	**July**	**August**	**September**
Marked (n_1)	65	25	40	45	60
Sampled (n_2)	120	150	110	80	70
Recaptures (m_2)	19	12	15	35	42

For each time period (month) please calculate the Chapman estimator for $\widehat{N}$, the variance of the abundance estimate, and the CV. Next, construct a probability profile for your Chapman abundance estimate at each time period using an appropriate probability density function (pdf), and plot these for comparison.

But, what if we are sampling marked and unmarked individuals ***with replacement***, given that our marks (tags) are easily identifiable but not unique? Please calculate the abundance estimate $\widehat{N}$, the variance of the abundance estimate and the CV, for each time period using an appropriate alternative estimator. As before, construct a probability profile for your abundance estimate ***assuming replacement***, at each time period using an appropriate probability density function (pdf), and plot these for comparison.

Given the results of your experiment, what is your inference about the population of rainbow trout under your purview? Is abundance changing across the summer season? Please describe to what extent this experiment meets or does not meet the assumptions of a Petersen simple mark-recapture experiment.

Please summarize your results and inference in the word (.docx) document you submit for this assignment along with your R script.

Time Allocation

At the end of the word (.docx) document you submit for this assignment, please estimate the amount of time you spent in total on this assignment.