FISH 621 Homework #2: Removals, Ratios, and Repeated 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 stuck on a problem and can't figure out how to proceed 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, Zoom, Google Hangouts, 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 stuck 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 March 4, 2022.

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. **Hwk2_FirstName_LastName.docx**, **Hwk2_FirstName_Last.xlsx**, **Hwk2_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, and 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 2.pdf** (this file)
- **Pike.csv** Data from pike depletion experiment.

- **Schnabel Data.csv** Number of captured and marked rainbow trout across sampling periods.

Problem 1 – Removal Estimator (6 points)

You are interested in estimating the abundance of rabbits in a series of five fields surrounding your home town. You decide that the easiest way to estimate abundance is to use a removal experiment. For each field, you send ***Observer 1*** into the field to catch and remove all caught individuals. The removed individuals are sent to a farm upstate to live out their happy lives.

On the next day you send ***Observer 2*** out into each field to search and report back on the number of rabbits they catch in each field.

The results are as follows:

Field	1	2	3	4	5
Number Removed by Observer 1	100	160	160	50	10
Number Caught by Observer 2	90	90	50	15	8

Please calculate the following quantities for each field:

1. An estimate of rabbit abundance at the start of the experiment ($\widehat{N}$).
2. An estimate of rabbit abundance when Observer 2 surveys the field ($\widehat{N}_2$).
3. The probability of observing rabbits in each field.

Please describe what assumptions must be met for your estimates to be robust, and how you would design the experiment to ensure these assumptions are met.

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

Problem 2 – Leslie Depletion (6 points)

You are currently working in a series of small ponds in southcentral Alaska where Northern Pike (*Esox lucius*) are an invasive species. Specifically, you are interested in two ponds Pond A (2 km^2) and Pond B (3 km^2) for which you want to estimate pike abundance. As this species is invasive in your area, you feel that a depletion experiment is appropriate for estimating abundance.

Your method of sampling uses hook and line gear to capture individual pike across successive days in each pond. Each fish you capture is killed and you record the number of hours you spend fishing each day and each day's total catch.

The data you record is contained within the file: ***Pike.csv***

Please do the following for each of the two ponds:

1. Estimate catchability (q).
2. Estimate the abundance of pike in each pond at the start of your experiment.
3. Plot the relationship and fitted models that allow you to estimate pike abundance.

What assumptions must be met for your abundance estimate to be robust?
What is the meaning of the catchability coefficient (q) you have estimated?

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

Problem 3 – Change in Ratio (9 points)

You are charged with monitoring the abundance of the deer population in a particular game management unit. In this unit it is legal to hunt both male and female deer during the months: September - January. You have several pieces of information available to you.

First, from harvest records you know the total number of deer harvested each month, by sex:

Month	September	October	November	December	January
Males	279	51	330	210	74
Females	15	180	140	149	18

Second, you conduct a visual survey $n = 50$ deer each month September – February and record the number of male and female deer you observe:

Month	September	October	November	December	January	February
Males	27	24	26	22	19	17
Females	23	26	24	28	31	33

Based on this information please estimate:

1. The total abundance of deer in the management unit in each month September – February.
2. The abundance of ***male*** deer in the management unit in each month September – February.
3. The abundance of ***female*** deer in the management unit in each month September – February.

Please describe what assumptions you must make for these abundance estimates to be accurate.

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

Problem 4 – Repeated Schnabel Mark-Recapture (19 points)

To estimate the abundance of rainbow trout (*Oncorhynchus mykiss*) in a popular fishing lake you decide to conduct a Schnabel mark-recapture experiment. In each of $s = 15$ sampling periods you capture some number of trout with a beach seine (n_i), of which some number are marked with external t-bar tags (m_i). During each sampling period you record your total catch (n_i) and the number of marked individuals (m_i) in your sample, and you tag (mark) all unmarked fish in your sample and return all fish to the lake alive and unharmed.

The ***Schnabel Data.csv*** file contains the observed ***number of fish captured*** and the observed ***number of marks*** in each sampling period.

Based on this information please:

1. Calculate the number of fish marked in each sampling period (u_i).
2. Calculate the total number of marked fish in the population ***at the start*** of each sampling period (M_i).
3. Determine the total number of trout in the lake using the basic ***Schnabel estimator***.
4. Determine the total number of trout in the lake using the ***Chapman extension*** to the ***Schnabel estimator***.
5. Using the ***Chapman extension to the Schnabel estimator***, please calculate an approximate 95% confidence interval for this estimate.
6. Calculate separate Chapman abundance estimates for each sampling period: $\mathbf{2}:\boldsymbol{s}$.
7. Calculate the variance estimate for each of the Chapman abundance estimates for sampling periods: $\mathbf{2}:\boldsymbol{s}$.
8. Find the ***mean Chapman estimator*** for total trout abundance from this experiment.
9. Calculate the ***theoretical*** variance for the mean Chapman estimator, and approximate 95% confidence interval for this estimate.
10. Calculate the ***empirical*** variance for the mean Chapman estimator, and approximate 95% confidence interval for this estimate.
11. Include a table describing n_i, m_i, u_i, M_i, Chapman estimates, and the coefficient of variation for Chapman estimates, across sampling periods $\mathbf{1}:\boldsymbol{s}$.

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.