Estimation of Rainbow Trout Abundance in Upper Niagra Springs Pond using the Single Census Mark-Recapture Methods

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Introduction

Warren *et al.* (2004) examined the population of Rainbow Trout (Oncorhynchus mykiss) in the Upper Niagara Springs Pond in 2000. Fish were captured at two times by using an electrofishing unit attached to a driftboat. The capture history of all fish examined in the two samples that were 100 mm and longer is in RBTroutUNSP.

1. Use these data to answer the following questions.

- Create a summary of the capture histories. From your capture history summary assign values to each of M, n, and m Construct an appropriate population estimate, with a 95% confidence interval, for Upper Niagara Springs Pond Rainbow Trout in 2000.
- Carefully interpret the results. Which method did you use to construct the confidence interval? Explain why you chose that method.

Data Collection and Importation

```
library(tidyverse)
library(car)
library(knitr)
```

```
trout_data <- read_csv('data-raw/RBTroutUNSP.csv')
view(trout_data)
trout_data |>
  str()
```

```
spc_tbl_ [173 x 2] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
 $ first : num [1:173] 1 1 1 1 1 1 1 1 1 1 ...
 $ second: num [1:173] 1 0 0 0 0 0 0 0 1 0 ...
 - attr(*, "spec")=
  .. cols(
  ..   first = col_double(),
  ..   second = col_double()
  .. )
 - attr(*, "problems")=<externalptr>
```

Summary of Capture of Histories

Summary of the Rainbow Trout Abundance data

```
trout_data |>
  summary() |>
  kable(
    align = 'lccr',
    caption = 'Summary of the Rainbow Trout Abundance'
  )
```

Table 1: Summary of the Rainbow Trout Abundance

first	second
Min. :0.0000	Min. :0.0000
1st Qu.:0.0000	1st Qu.:0.0000
Median :0.0000	Median :1.0000
Mean :0.4277	Mean :0.6358

first	second
3rd Qu.:1.0000	3rd Qu.:1.0000
Max. :1.0000	Max. :1.0000

Summary of the First Time Capture History

```
trout_data |>
  summarise(
    mean_first_year = mean(first),
    median_first_year = median(first),
    max_first_year = max(first),
    min_first_year = min(first)
  ) |>
  kable(
    caption = 'Summary of the First Time Capture History'
  )
```

Table 2: Summary of the First Time Capture History

mean_first_year	median_first_year	max_first_year	min_first_year
0.4277457	0	1	0

Summary of the Second Time Capture History

```
trout_data |>
  summarise(
    mean_second_year = mean(second),
    median_second_year = median(second),
    max_second_year = max(second),
    min_second_year = min(second)
  ) |>
  kable(
    caption = 'Summary of the Second Time Capture History'
  )
```

Table 3: Summary of the Second Time Capture History

mean_second_year	median_second_year	max_second_year	min_second_year
0.6358382	1	1	0

Number of Tagged and Un-tagged Fish caught the First time

```
trout_data |>
  group_by(first) |>
  summarise(count = n()) |>
  kable(
    caption = 'Summary of Tagged and Untagged Fish caught the First time'
  )
```

Table 4: Summary of Tagged and Untagged Fish caught the First time

first	count
0	99
1	74

Number of Tagged and Un-tagged Fish caught the Second time

```
trout_data |>
  group_by(second) |>
  summarise(count = n ()) |>
  kable(
    caption = 'Summary of Tagged and Untagged Fish caught the Second Time'
  )
```

Table 5: Summary of Tagged and Untagged Fish caught the Second Time

second	count
0	63
1	110

Construction of the Population Estimate Key using the Lincoln-Peterson Estimator

In this study:

- N is the total number of fish in the population.
- C is the total number of fish captured in both samples.
- R is the number of recaptures.

To assign these values, we can calculate them directly from our data:

```
# Assign values to N, C, and R
C <- nrow(trout_data) # Total captures from both samples
R <- sum(trout_data$first == 1 & trout_data$second == 1) # Sum of Recaptures
N <- C + R # Total population estimate (using lincoln-petersen estimator)
```

Calculation of Population Estimate using Lincoln-Petersen Estimator

Using the Lincoln-Petersen estimator, we can estimate the population size and calculate a confidence interval. The formula for estimating population size is:

$N = (C_1 + 1)\ (C_2 + 1)\ /\ (R + 1)$ - 1

Where:

- C is captures in the first sample,
- C is captures in the second sample,
- R is recaptures.

We will also calculate a confidence interval using a normal approximation method.

```
# Calculate population estimate using Lincoln-Petersen Estimator
C1 <- sum(trout_data$first == 1)
C2 <- sum(trout_data$second == 1)

estimate_size <- ((C1 + 1) * (C2 + 1)) / (R + 1) - 1
```

Calculation of Standard Error and Confidence Interval

```r
# calculate standard error for confidence interval
SE <- sqrt((C1 * C2 * (C1 - R) * (C2 - R)) / ((R + 1)^2 * (R + 2)))

# Calculate Confidence Interval
con_lower <- estimate_size - qnorm(0.975) * SE
con_upper <- estimate_size + qnorm(0.975) * SE
```

Results

```r
estimate_size
```

```
[1] 692.75
```

```r
con_lower
```

```
[1] 369.9785
```

```r
con_upper
```

```
[1] 1015.522
```

Discussion

The normal approximation method was used in developing the confidence interval due to its conventional use when large sample approximations are valid. This method simply offers readable techniques for estimating the confidence intervals on standard errors estimated from samples. This approach facilitates accurate prediction of the fish population in ecological surveys hence playing an important role in species management and conservation.

Conclusion

The estimated population size of Rainbow Trout in Upper Niagara Springs Pond in 2000 is approximately 693. The confidence interval indicates that we are 95% confident that the true population size lies between 370 and 1020.

References

1. Ogle, D. H. (2018). Introductory Fisheries Analyses with R. United States: CRC Press.
2. Warren, C. D., Frank, K. A. and Partridge. F. E. (2004). Regional fisheries management investigations - Magic Valley region. Completion Report, Idaho Department of Fish and Game.