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FISH 558

Lab 9 HW

3/25/2024

1. **Describe the concept of catch curves. Include assumptions and discuss multiple situations where the assumptions might not be valid.**

Catch curves estimate total mortality by looking at the decline of fish through time, analyzing abundance and time/age. This uses catch-at-age data. A year-specific approach uses one year of data to estimate mortality by comparing the relative abundances of age classes. Assumptions and possible cases that would violate those assumptions are listed below:

* Constant recruitment: will not be valid if variable environmental factors influence recruitment or if multiple cohorts exist with different recruitment rates between them.
* No error in age estimates: can be violated if those gathering data aren’t sufficiently trained.
* Constant mortality: can be violated in species that have significant differences in mortality throughout their lifespan. For example, fish that achieve large body sizes may experience lower mortality rates in old age, or fish that develop cryptic coloration after the larval stage may experience lower mortality afterward. Conversely, male fish that develop flashy, conspicuous coloration during mating season may experience higher mortality during that period than females.
* Constant catchabilty: can be violated in species where certain age classes are more prized commercially or recreationally, such that gear is largely developed to target that age class. It’s not hard to imagine small, cryptic, or shy young fish being less catchable than their large older counterparts.

1. **Use one a catch-at-age dataset from FSAdata and catc curve methods to estimate total instantaneous mortality.** 
   1. **Identify the dataset used and what the data are from (species, location, study, etc).**

For Question 2, I used the “FHCatfishATL” dataset from the FSAdata package. This is catch-at-age data for flathead catfish. It was sourced from a study published in 2006 by Kwak, Pine, and Waters that examined growth and mortality from introduced populations of flathead in three rivers on North Carolina’s Atlantic slope. Ultimately, the study found that these fish had higher growth rates than comparable native populations.

I found that this dataset was pretty data-poor for this analysis (generally, single-digit numbers of fish for each age class in each of the three rivers, with many zeroes). As a sort of “stop-gap” to help with this assignment, I decided to combine these three populations by adding together the catches for each age class across the three sites. The analysis is therefore of a sort of informal “meta-population” of the three river populations. I’m not sure whether there’s any scientific value in this case (the rivers don’t seem to be in the same watershed), but there is academic value for this assignment!

* 1. **Provide a table of Z estimates and 95% CI using a basic catch curve and the Chapman-Robson method.**

Table 1: Summary of mortality estimates for flathead catfish in North Carolina, with 95% confidence interval. Estimates were obtained using a catch curve regression and the Chapman-Robson method.

|  |  |  |  |
| --- | --- | --- | --- |
| **Method** | **Z Estimate** | **Lower CI** | **Upper CI** |
| Basic catch curve | 0.256 | 0.111 | 0.401 |
| Chapman-Robson | 0.295 | 0.236 | 0.355 |

* 1. **Plot log(catch) vs. age for the dataset, with a fit of the basic catch curve:**

**A graph of a fish catch curve

Description automatically generated with medium confidence**

Figure 1: Plot of log-transformed catch vs. age of flathead catfish in three North Carolina rivers, with a fit of the basic catch curve regression (Z = 0.256). The catch curve was fit for ages 4-14.

1. **Choose a species with different studies from fishbase to develop instantaneous natural mortality estimates for.**
   1. **State the species, brief description of it (distribution, life history, etc.). Provide estimates for at least two important parameters. Include screen shot of fishbase parameters table.**

I used the threespine stickleback (Gasterosteus aculeatus). It is a well-studied small anadromous fish that is common in coastal waters across the northern hemisphere. This includes Humboldt County, where it is found in abundance. Stickleback have relativelty complex reproductive behaviors, building nests, caring for eggs, and defending fry. Nests are built by males, and a single female may lay as many as 300 eggs in one. The reproductive season, typically April and May, is temperature-cued.

From a population in Kiel Bay, Germany:

Linf = 6.9 (asymptotic average for max length)

K = 1.79 (growth rate coefficient)

Temperature = 8.2°C

A screenshot of a computer

Description automatically generated

* 1. **Use 1 study to generate many estimates of M using different empirical methods. Include the annual rate v in the table as well.**

Table 2: Summary of instantaneous natural mortality (M) and annual natural mortality (v) estimates for threespine stickleback in Germany, obtained using a variety of empirical methods.

|  |  |  |
| --- | --- | --- |
| **Method** | **M** | **v** |
| HoenigNLS | 3.609 | 0.973 |
| PaulyLNoT | 3.330 | 0.964 |
| PaulyL | 2.230 | 0.892 |
| HoenigO | 3.042 | 0.952 |
| HoenigLM | 3.975 | 0.981 |
| HewittHoenig | 3.023 | 0.951 |
| Tmax1 | 3.660 | 0.974 |
| K1 | 3.029 | 0.952 |
| JensenK1 | 2.685 | 0.932 |
| AlversonCarney | 3.389 | 0.966 |

* 1. **Table of mean, standard deviation, min, and max for M and v**

Table 3: Summary statistics for the estimates of instantaneous natural mortality (M) and annual natural mortality (v) seen in Table 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Mean | SD | Min | Max |
| M | 3.197 | 0.508 | 2.230 | 3.975 |
| v | 0.954 | 0.026 | 0.892 | 0.981 |

* 1. **Select one method and generate M estimates from different studies on fishbase. Also describe central tendency and variability as in 3c.**

Table 4: Summary of instantaneous natural mortality (M) and annual natural mortality (v) estimates for various threespine stickleback populations, obtained using the K1 method. Also included is growth coefficient K, a required parameter for the K1 method.

|  |  |  |  |
| --- | --- | --- | --- |
| **Population** | **K** | **M** | **v** |
| Roscoff, France (M) | 4.200 | 7.106 | 0.999 |
| Roscoff, France (F) | 2.400 | 4.061 | 0.983 |
| Navarro River (inland), California | 2.090 | 3.536 | 0.971 |
| Navarro River (upstream), California | 1.770 | 2.995 | 0.950 |
| Navarro River (estuary), California | 1.780 | 3.012 | 0.951 |
| Ooster Schelde, Netherlands | 2.320 | 3.925 | 0.980 |
| Cheshire, UK | 0.640 | 1.083 | 0.661 |
| Kiel Bay, Germany | 1.790 | 3.029 | 0.952 |
| Kandalaksha Bay, Russia (M) | 0.570 | 0.964 | 0.619 |
| Kandalaksha Bay, Russia (F) | 0.670 | 1.134 | 0.678 |

Table 5: Summary statistics for the estimates of instantaneous natural mortality (M) and annual natural mortality (v) seen in Table 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Mean | SD | Min | Max |
| M | 3.085 | 1.837 | 0.964 | 7.106 |
| v | 0.874 | 0.154 | 0.619 | 0.999 |

* 1. **Based on 3c and 3d, discuss and compare sources of uncertainty for empirical estimates of M.**

Comparing table 3 and table 5 lets us ask whether more uncertainty comes from choosing the right method of estimation (table 3) or from the data itself (table 5). Both tables show a very similar mean mortality (M = 3.1, M = 3.2). The most conspicuous difference was in the standard deviation. There was considerably more variation in the estimates coming from different studies (SD = 1.8) than in the estimates coming from different estimation methods (SD = 0.5). Certainly, neither of these sources of variation is negligible. However, there more variation in the M estimate can be attributed to variation in the original data sets than in the differences between the empirical methods.

* 1. **Describe why these M estimates make biological sense. Why would M be related to K, Linf, or T?**

Instantaneous mortality estimates are tricky to make quick sense of, so it’s best to look at the annual natural mortality rates (v) in this case. Lifting a number from Table 5 gives us a mean annual natural mortality rate of 0.874 for stickleback. This means that 87.4% of stickleback die every year. This is consistent with the reproductive strategy of stickleback. Though they show more parental care than many fish, the overall strategy is still characterized by high fecundity and low survival. In the case of the K growth parameter, it is easy to understand why growth may affect mortality. For example, individuals that grow too slow may not be hardy enough to survive the overwintering period, and fast-growing indivudals might be stronger competitors. Linf, or the asymptotic average max length, can impact mortality as well. For example, large individuals might be less vulnerable to predation or be stronger competitors, and therefore have lower mortality. The relation between temperature and morality is maybe an even clearer one. Many fish have strict temperature ranges which, when exceeded, can lead to stress and mortality. Stickleback can tolerate a relatively wide range: 4 – 20 °C

1. **Additional questions**
   1. **How many hours?**

7 hours.

* 1. **Group work?**

Solo.

* 1. **Particular struggles?**

The fish I initially chose from Fishbase was a bust and didn’t have enough information, but I was a fair bit into the question before I realized the problem.

1. **Grad student question**
   1. **Spend time working on research project, briefly describe what you did.**

To work on the project, I decided to brush up on RMark and particularly the CJS models. That seems to be the right choice for the salamander data. Luckily, I already took WLDF 578 and that class included a CJS lab in RMark. I worked back through the whole lab to refresh myself in preparation for bringing the salamander data in.

**Appendix: CODE pasted below**

setwd("~/Dropbox/Grad/FISH 558/Labs/Lab 09 - Catch curve and mortality")

library(ggplot2)

library(FSAdata)

library(FSA)

library(tidyverse)

# Question 2 ####

#a - choose dataset

data("FHCatfishATL")

cat<-data.frame(age=seq(0, max(FHCatfishATL$age), by=1), number=rep(0, max(FHCatfishATL$age)+1))

#some rivers are data-poor. Decided to combine the three populations and analyze together

#combines numbers for each age across the three rivers

for(i in 1:length(cat$number)){

for(j in 1:length(FHCatfishATL$age)){

if(FHCatfishATL$age[j]==cat$age[i]){

cat$number[i]<-cat$number[i]+FHCatfishATL$number[j]

}

}

}

#zeroes ruin the catchCurve calculations

cat.short <- cat %>% slice(1:15)

#b - Z estimates using basic regression and Chap-Rob method

cc.basic <- catchCurve(number~age,data=cat.short,ages2use=4:14) #peak occurs at age 4, age 18 outlier must be excluded b/c 0s break it

summary(cc.basic)

confint(cc.basic)

cbind(Est=coef(cc.basic),confint(cc.basic))

cc.chaprob <- chapmanRobson(number~age,data=cat,ages2use=4:17)

summary(cc.chaprob)

cbind(Est=coef(cc.chaprob),confint(cc.chaprob))

plot(cc.basic, main="Basic Catch Curve")

# Question 3 ####

#b - M and v table

#data: threespine stickleback, Kiel Bay, Germany

Linf <- 6.9 #from von bertalanffy model

K <- 1.79 #k from von bertalanffy model

t0 <- -0.28 #t0 from the von bertalanffy model

tmax <- t0+3/K # The maximum age for the population of fish

T <- 8.2

name <- c("HoenigNLS","PaulyLNoT", "PaulyL", "HoenigO","HoenigLM","HewittHoenig","tmax1",

"K1", "JensenK1","AlversonCarney")

M <- c(metaM("HoenigNLS", tmax=tmax), metaM("PaulyLNoT", K=K, Linf=Linf), metaM("PaulyL", Linf=Linf, K=K, T=T),

metaM("HoenigO", tmax=tmax), metaM("HoenigLM", tmax=tmax), metaM("HewittHoenig", tmax=tmax),

metaM("tmax1", tmax=tmax), metaM("K1", K=K), metaM("JensenK1", K=K),

metaM("AlversonCarney", tmax=tmax, K=K))

v <- 1-exp(-M)

ybh<-data.frame(name, M, v)

#c - summary M and v

mean <- c(mean(M), mean(v))

SD <- c(sd(M), sd(v))

min <- c(min(M), min(v))

max<- c(max(M), max(v))

ybh.summary<-data.frame(mean, SD, min, max)

rownames(ybh.summary)<-c("M", "v")

#d - one method, different studies

#method: K1

#M and v table

Population <- c("Roscoff, France (M)", "Roscoff, France (F)", "Navarro River (inland), California",

"Navarro River (upstream), California", "Navarro River (estuary), California", "Ooster Schelde, Netherlands",

"Cheshire, UK", "Kiel Bay, Germany", "Kandalaksha Bay, Russia (M)", "Kandalaksha Bay, Russia (F)")

K <- c(4.2, 2.4, 2.09, 1.77, 1.78, 2.32, 0.64, 1.79, 0.57, 0.67)

M<- rep(0, 10)

for(i in 1:length(K)){

M[i]<-c(metaM("K1", K=K[i]))

} #warning for first iteration: "K value seems unreasonable", related to Males in Roscoff, France

v <-1-exp(-M)

sticky<-data.frame(Population, K, M, v)

#sumamry M and v

mean <- c(mean(M), mean(v))

SD <- c(sd(M), sd(v))

min <- c(min(M), min(v))

max<- c(max(M), max(v))

sticky.summary<-data.frame(mean, SD, min, max)

rownames(ybh.summary)<-c("M", "v")