Assig4

Demographic analysis

Villaseñor-Derbez, J.C. & Faro, C

```
suppressPackageStartupMessages({
  library(readr)
  library(tidyverse)
  library(reshape)
  library(popbio)
})
```

Description of the demographic information

- Mortality: $Z = 1.39$ and $M = 0.63$ (Garbin & Castello, 2014)
- Fecundity: $a = -1.33354$, $b = 3.238$ (from FISHBASE)
- von Bertanalnffy growth parameters: $L_i nf = 102.0$, $K = 0.55$, $t_0 = -0.02$ (Uchiyama & Struhsaker, 1981)

Define demographic parameters

```
# Define Von Bert parameters
# Garbin & Castello, 2014
# L_inf <- mean(c(80, 80, 87.12, 94, 97.9, 97.3, 112.34, 89.38, 92.5))
# K <- mean(c(0.32, 0.6, 0.22, 0.38, 0.14, 0.25, 0.14, 0.38, 0.16))

# Or from Us and Stiurskjgfas, 1981
L_inf <- 102
K <- 0.55
t_0 <- -0.02

# Just to be clear, we use L-inf  and to from Ushisomething, and K from the review

# Define fecundity parameters
# From fishbase http://www.fishbase.se/Reproduction/FecundityList.php?ID=107&GenusName=Katsuwonus&Speci
fec_a <- -1.33354
fec_b <- 3.238
# Define mortality
m <- 0.63
z <- 1.39
```

Define the functions we will need

```
# Convert length to age using von bertalanffy model, solving for t
length2age <- function(length, l_inf, K, t_o){
  age <- (1/-K)*(log(1-(length/L_inf))) + t_o
  return(age)
}

# Convert age to length using von bertalanffy model
age2length <- function(age, l_inf, K, t_o){
  length <- l_inf*(1-exp(-K*(age-t_o)))
  return(length)
}

#Convert length to fecundity (number of eggs)
fecundity <- function(length, a, b){
  f <- 10^(a+(b*log10(length*10)))
  return(f)
}
```

Create the matrix

```
A <- matrix(0, 14, 14) #initial empty matrix with all 0

# Populate matrix with mortality
for (i in 2:14){
  A[i,i-1] <- exp(-z)
}

# Populate matrix with fecundity
ages <- seq(0:13)-1
lengths <- age2length(ages, L_inf, K, t_0)
A[1,] <- fecundity(lengths, fec_a, fec_b)

A[is.na(A)] <- 0
A[2,1] <- 0.0000001
A[1,1] <- 0

colnames(A) <- ages
rownames(A) <- ages

knitr::kable(t(A), digits = 2,
             col.names = paste0("$a_{",ages,"}$"),
             row.names = F,
             caption = "Table I - Population matrix A.
             The inferior diagonal represents survivals,
             while the first row
             represents facundities. Note that the table has been transposed to fit the page")
```

Table 1: Table I - Population matrix A. The inferior diagonal represents survivals, while the first row represents facundities. Note that the table has been transposed to fit the page

a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16572565	0	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70267367	0	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129440594	0	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
175824053	0	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
207232166	0	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
227012037	0	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
238998009	0	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
246108578	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
250276828	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
252703760	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
254111352	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00
254925922	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
255396708	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Build a population vector

```r
load("size_dist_1980.RData") #This is the n-vector for 1980, loads it to a vector called n

n <- n %>% {
  .$N}%>%
  c(rep(0, times = 8))

n_0 <- sum(A[1, 2:14]*n, na.rm = T)

n <- c(n_0, n)

n
```

```
##  [1] 2.562588e+19 8.674537e+06 3.136387e+11 2.711014e+10 4.391505e+08
##  [6] 3.880114e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
## [11] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
```

Project the population

We projected the population, stratified by ages, for 30 years in the future (Figure 1). The population seens to have a positive trend, which shows the population is increasing.

```r
project <- popbio::pop.projection(A, n, 30)
```

```r
pop <- project$stage.vectors %>%
  as.data.frame() %>%
  mutate(Age = as.factor(seq(0:13)-1)) %>%
  gather(Year, N, -Age) %>%
  mutate(Year = as.numeric(as.character(Year))) %>%
  select(Year, Age, N)
```

```r
ggplot(pop, aes(x = Year, y = log(N), color = Age)) +
  geom_line() +
  theme_bw() +
  geom_hline(yintercept = 40, color = "black", linetype = "dashed", size = 1) +
  geom_vline(xintercept = 22, color = "black", linetype = "dashed", size = 1)
```

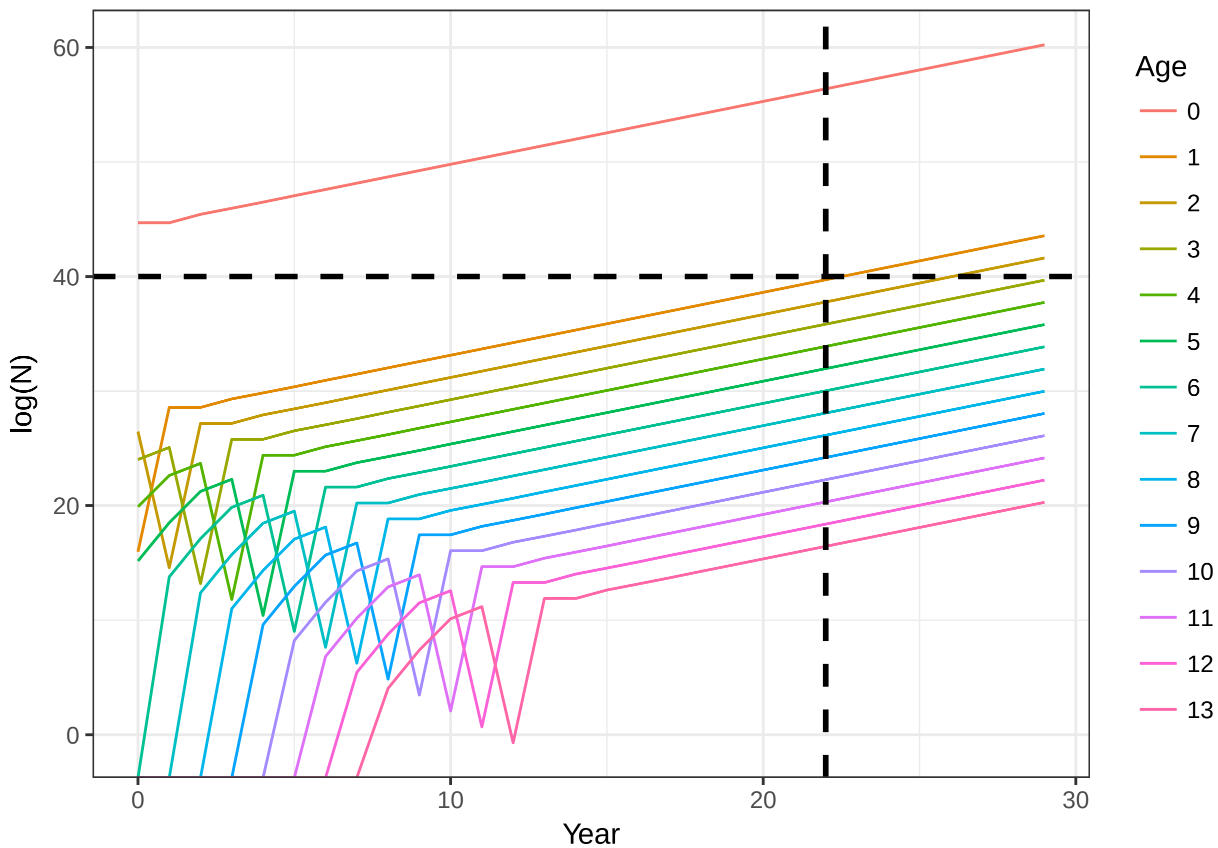

Figure 1: Figure 1 - Population size through time, represented by ages.

Minimum catch size

This time we projected the population for 30 years in the future with a management intervention on the minimum size of capture (Figure 2). Our projection assume total compliance on the intervention, wich means the fishing pressure is equal to 0. Therefore, the total mortality (Z) is equal to the natural mortality (M) for individuals of age 1. By protecting individuals of age 1 (the age at which they reach maturity), we observe a faster recovery in the fishery. Figure 3 shows that, with this management intervention, the total skipjack population achieves the same level 6 years earlier.

```
A_min <- A

A_min[3,2] <- exp(-m)

knitr::kable(t(A_min), digits = 2,
             col.names = paste0("$a_{",ages,"}$"),
             row.names = F,
             caption = "Table I - Population matrix A, modifying mortality of age 1 organisms.
             The inferior diagonal represents survivals,
             while the first row
             represents facundities. Note that the table has been transposed to fit the page")
```

Table 2: Table I - Population matrix A, modifying mortality of age 1 organisms. The inferior diagonal represents survivals, while the first row represents facundities. Note that the table has been transposed to fit the page

a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16572565	0	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70267367	0	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129440594	0	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
175824053	0	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
207232166	0	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
227012037	0	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
238998009	0	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
246108578	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
250276828	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
252703760	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
254111352	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00
254925922	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
255396708	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

```
project_min <- popbio::pop.projection(A_min, n, 30)
```

```
pop <- project_min$stage.vectors %>%
  as.data.frame() %>%
  mutate(Age = as.factor(seq(0:13)-1)) %>%
  gather(Year, N, -Age) %>%
  mutate(Year = as.numeric(as.character(Year))) %>%
  select(Year, Age, N)

ggplot(pop, aes(x = Year, y = log(N), color = Age)) +
  geom_line() +
```

```r
  theme_bw() +
  geom_hline(yintercept = 40, color = "black", linetype = "dashed", size = 1) +
  geom_vline(xintercept = 22, color = "black", linetype = "dashed", size = 1) +
  geom_vline(xintercept = 18, color = "red", linetype = "dashed", size = 1)
```

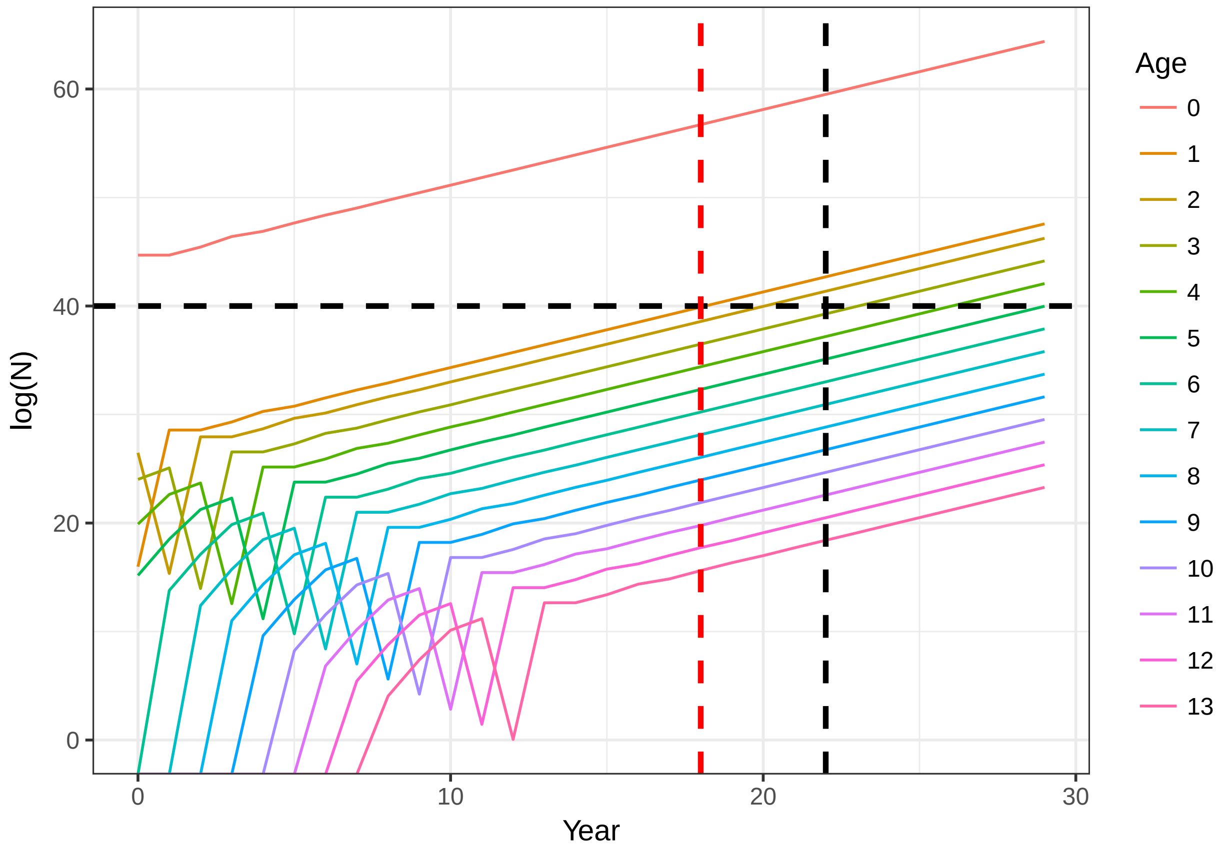

Figure 2: Figure 2 - Population size through time, represented by ages.

```r
tot1 <- project$pop.sizes
tot2 <- project_min$pop.sizes
time <- seq(1:30)

data.frame(time, BAU = tot1, Int = tot2) %>%
  gather(scenario, popsize, -time) %>%
  ggplot(aes(x = time, y = log(popsize), color = scenario)) +
  geom_point() +
  geom_line() +
  theme_bw()
```

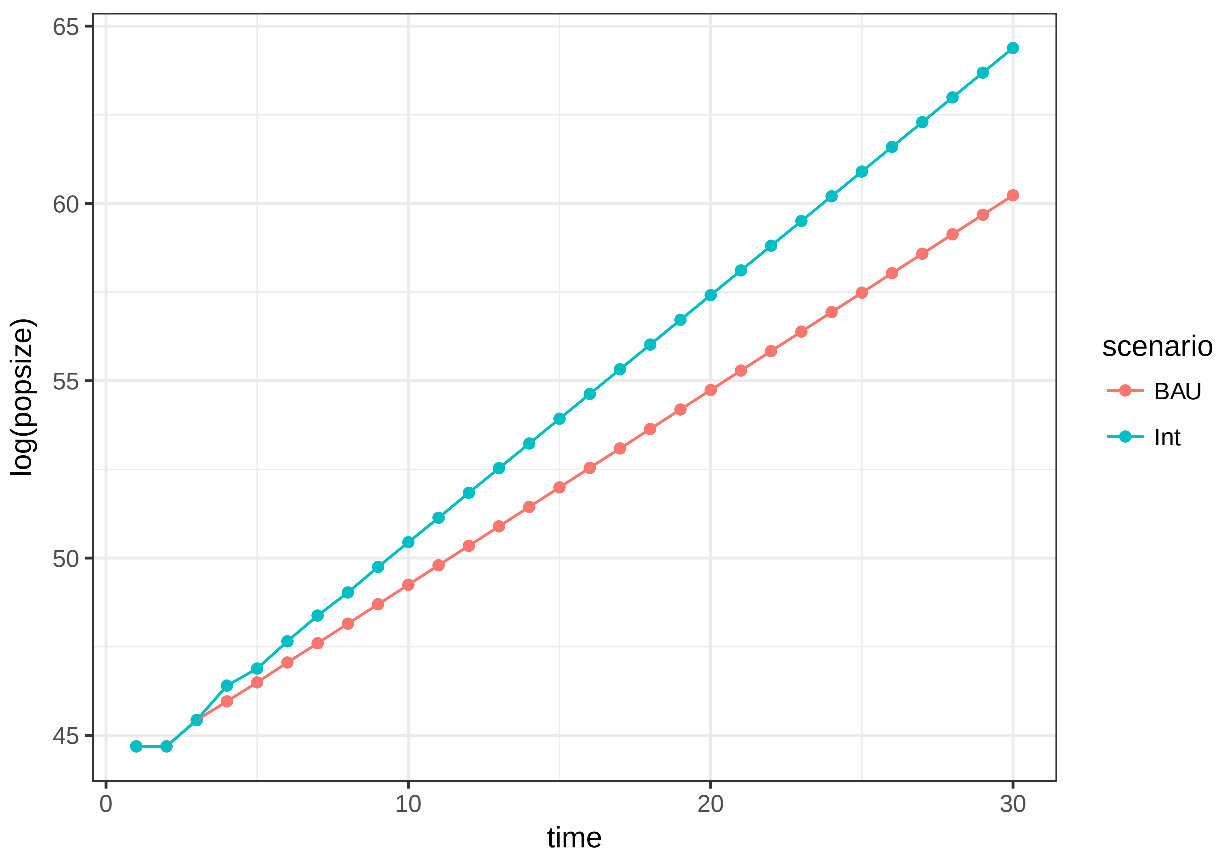

Figure 3: Figure 3 - Total population size through time.