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FISH 558

Lab 7 HW

3/5/2024

1. **Yield per recruit under 5 scenarios**
   1. **Generate a plot with colored lines representing each of the 5 scenarios.**

A graph with different colored lines

Description automatically generated

Figure 1: Yield per recruit curves under five different scenarios. The curves plot yield per recruit (y-axis) vs. instantaneous fishing mortality (x-axis). Each curve corresponds to a scenario of knife-edge selectivity where age at first capture (tc) varies.

* 1. **Create a table that identifies the F0.1 reference points for each of the five scenarios. Explain F0.1.**

Table 1: Summary table of F0.1 reference points for the five age at first capture scenarios.

|  |  |
| --- | --- |
| **tc Scenario** | **F0.1** |
| tc = 1 | 0.212 |
| tc = 2 | 0.307 |
| tc = 3 | 0.428 |
| tc = 4 | 0.546 |
| tc = 5 | 0.643 |

F0.1 is the level of fishing mortality at the point where the slope of the YPR curve is at 10% of its original slope. It can be used as a “conservative” reference point.

* 1. **What is your recommendation for a fishing mortality rate and age at first capture to a fisheries manager targeting high yields and no growth overfishing. Justify and explain growth overfishing.**

A graph of different colored lines

Description automatically generated

Figure 2: Yield per recruit curves under five different scenarios. The curves plot yield per recruit (y-axis) vs. instantaneous fishing mortality (x-axis). Each curve corresponds to a scenario of knife-edge selectivity where age at first capture (tc) varies. Vertical dotted lines highlight F0.1 for each scenario, with points indicating where they cross the corresponding yield per recruit curve.

The management goal is to maximize yield per recruit while avoiding growth overfishing. Growth overfishing occurs when fishing pressure prevents fish from growing large, resulting in reduced yields. In Figure 2, this can be seen in the “dip” after the maxima of the tc=1 and tc=2 curves. Using the conservative F0.1 as a benchmark, Figure 2 shows that the tc=3 and tc=4 curves have the highest yield per recruit at this level. It’s hard to discern visually, but it is slightly higher for the tc=4 scenario (YPR = 0.375) than for tc=3 (YPR = 0.371). So, I would recommend setting age at first capture to 4, with a fishing mortality rate F0.1 = 0.546.

1. **Spawner per recruit analysis**
   1. **Is the current F (0.55) too high or too low based on 40% MSP objective? What % is it actually achieving? Include a plot.**

5 hours

A comparison of a line graph

Description automatically generated with medium confidence

Figure 3: Percent of the maximum spawning potential ratio for haddock versus fishing mortality.

Figure 3 shows that the current F is too high for the 40% MSP objective, since the F value corresponding to 40% is clearly smaller than 0.5. Under the current fishing pressure, the model output indicates that the population is only achieving 29.12% MSP.

* 1. **What would be a more appropriate fishing mortality rate to achieve 40% MSP? Express F for both scenarios as annual rates.**

The model ouput indicates that, when limiting F to two decimal places, it is closest to 40% MSP at F = 0.36 (39.77%).

To express this clearly as an annual rate, it must be converted with the following equation:

Where u is the annual fishing mortality rate and Z = instantaneous mortality, calculated as F+M. In this scenario, natural mortality is set to M = 0.4

For this scenario, at F = 0.36 (40% MSP), the annual fishing mortality rate is 0.252. This means that 25.2% of fish are harvested annually.

This can be compared to the current scenario, where F = 0.55, and the annual fishing mortality rate is 0.355. Taking the management action to achieve 40% MSP would result in the percentage of the population being harvested annually to fall from 35.5% to 25.2%.

* 1. **Describe the following terms:**

*Spawner per recruit:*

A measure of the potential of an individual recruit to contribute to the spawning population. Typically, this is the recruit’s contribution to future spawning stock biomass, or the number of eggs it produces.

*40% MSP:*

The maximum spawning potential (MSP) occurs when there is no fishing pressure, since spawning will always be highest. %MSP refers to the spawning potential ratio, the percentage of MSP that is achieved at some fishing mortality rate. 40% MSP is a common benchmark.

*Recruitment overfishing:*

Recruitment overfishing occurs when a population has been overexploited until recruitment is reduced and there are fewer young fish.

1. **How much time?**

6 hours

1. **Grad student question**
   1. **Create a contour plot to represent how YPR changes as a function of F and tc and include code.**

A chart of different colors

Description automatically generated

Figure 4: Contour plot demonstrating the effects that age at first catch and fishing mortality have on yield per recruit for a population of haddock. The y-axis is age at first catch (tc), and the x-axis is the instantaneous fishing mortality rate (F). The z-axis is the yield per recruit, represented by bands of color. Cooler colors represent lower yield per recruit, while warmer colors represent greater yield per recruit.

The code for Figure 4 is included in the code appendix on this assignment. The section corresponding to this question is clearly commented as “GRAD STUDENT QUESTION.” The y-axis has a shorter range than asked. Models for ages 9 and 10 froze R, troubleshooting notwithstanding. Since the rest of the plot was correct, I elected to leave off those ages.

* 1. **Use figure to discuss relationship between F, tc, and YPR**

Figure 4 shows the effects of parameters F (fishing mortality) and tc (age at first catch) on the yield per recruit of a haddock fishery. It shows that, generally, yield per recruit increases at lower ages at first catch, and increases at higher levels of fishing mortality. In question 1c, I made a management recommendation: tc = 4, F = 0.546. However, identifying that point on Figure 4 shows that yield per recruit can be increased by lowering tc and raising F further.

**Appendix: CODE pasted below**

setwd("/Users/cpadamson/Dropbox/Grad/FISH 558/Lab 08 - YPR, SPR")

library(ggplot2)

library(fishmethods)

# Question 1 ####

# a - plot 5 scenarios

haddock <- read.csv("haddock.csv")

haddock$tc.1 <- ifelse(haddock$age<1, 0, 1)

haddock$tc.2 <- ifelse(haddock$age<2, 0, 1)

haddock$tc.3 <- ifelse(haddock$age<3, 0, 1)

haddock$tc.4 <- ifelse(haddock$age<4, 0, 1)

haddock$tc.5 <- ifelse(haddock$age<5, 0, 1)

mod.ypr.1=ypr(age=haddock$age,wgt=haddock$ssbwgt,partial=haddock$tc.1, M=0.4,

plus=FALSE,maxF=2,incrF=0.01, graph=T)

mod.ypr.2=ypr(age=haddock$age,wgt=haddock$ssbwgt,partial=haddock$tc.2, M=0.4,

plus=FALSE,maxF=2,incrF=0.01, graph=T)

mod.ypr.3=ypr(age=haddock$age,wgt=haddock$ssbwgt,partial=haddock$tc.3, M=0.4,

plus=FALSE,maxF=2,incrF=0.01, graph=T)

mod.ypr.4=ypr(age=haddock$age,wgt=haddock$ssbwgt,partial=haddock$tc.4, M=0.4,

plus=FALSE,maxF=2,incrF=0.01, graph=T)

mod.ypr.5=ypr(age=haddock$age,wgt=haddock$ssbwgt,partial=haddock$tc.5, M=0.4,

plus=FALSE,maxF=2,incrF=0.01, graph=T)

#extract data from each model

ypr.1.data<-mod.ypr.1$F\_vs\_YPR

ypr.2.data<-mod.ypr.2$F\_vs\_YPR

ypr.3.data<-mod.ypr.3$F\_vs\_YPR

ypr.4.data<-mod.ypr.4$F\_vs\_YPR

ypr.5.data<-mod.ypr.5$F\_vs\_YPR

#plot

plot.1<-ggplot(data=ypr.1.data, aes(x=F, y=YPR, color = "tc = 1"))+geom\_line()+

geom\_line(aes(y=ypr.2.data$YPR, color="tc = 2"))+

geom\_line(aes(y=ypr.3.data$YPR, color="tc = 3"))+

geom\_line(aes(y=ypr.4.data$YPR, color="tc = 4"))+

geom\_line(aes(y=ypr.5.data$YPR, color="tc = 5")) + theme\_bw()

plot.1

# b - F(0.1) for each scenario

F.01.1 <- mod.ypr.1$Reference\_Points[1,1]

F.01.2 <- mod.ypr.2$Reference\_Points[1,1]

F.01.3 <- mod.ypr.3$Reference\_Points[1,1]

F.01.4 <- mod.ypr.4$Reference\_Points[1,1]

F.01.5 <- mod.ypr.5$Reference\_Points[1,1]

F.vector <- c(F.01.1, F.01.2, F.01.3, F.01.4, F.01.5)

# c - recommend mortality rate and age at first capture

# add f0.1 lines to the plot

plot.2 <- plot.1 + geom\_vline(aes(xintercept=F.01.1, color="tc = 1"), linetype="dashed") +

geom\_vline(aes(xintercept=F.01.2, color="tc = 2", lty="dashed"), linetype="dashed") +

geom\_vline(aes(xintercept=F.01.3, color="tc = 3", lty="dashed"), linetype="dashed") +

geom\_vline(aes(xintercept=F.01.4, color="tc = 4", lty="dashed"), linetype="dashed") +

geom\_vline(aes(xintercept=F.01.5, color="tc = 5", lty="dashed"), linetype="dashed")

plot.2

#add points to emphasize intersections

YPR.01.1 <- mod.ypr.1$Reference\_Points[1,2]

YPR.01.2 <- mod.ypr.2$Reference\_Points[1,2]

YPR.01.3 <- mod.ypr.3$Reference\_Points[1,2]

YPR.01.4 <- mod.ypr.4$Reference\_Points[1,2]

YPR.01.5 <- mod.ypr.5$Reference\_Points[1,2]

YPR.vector <- c(YPR.01.1, YPR.01.2, YPR.01.3, YPR.01.4, YPR.01.5)

color.vector <- c("tc = 1", "tc = 2","tc = 3","tc = 4","tc = 5")

points.df <- data.frame(F=F.vector, YPR = YPR.vector, color = color.vector)

plot.3 <- plot.2 + geom\_point(data=points.df, aes(color=color))

plot.3

# Question 2 ####

# a - is F too high or too low to achieve 40% MSP? What % is F=0.55 achieving

SBPR <- sbpr(age=haddock$age,ssbwgt=haddock$ssbwgt,partial=haddock$tc.3,pmat=haddock$pmat,

M=0.4, pF=0.5, pM=0.5,MSP=40,maxF=2,incrF=0.01, graph=T)

# b - what would be a more appropriate F? Express as an annual rate and compare to F = 0.55

#when PSPR = 40.53, F = 0.35

#when PSPR = 39.77, F = 0.36

#M=0.4, Z = F + M = 0.75

#equation: u = F/Z (1- e^-Z)

u.36 <- (0.36/0.76)\*(1-exp(-0.76))

u.55 <- (0.55/0.95)\*(1-exp(-0.95))

# GRAD STUDENT QUESTION ####

# a - create a contour plot

#setup a data frame with appropriate age and F for this question

F.col <- seq(0, 1.5, length.out = 10)

age.col <- seq (1,10, by = 1)

contour.df <- data.frame(age=age.col, wgt=haddock$ssbwgt[1:10], partial = haddock$partial[1:10], YPR = 0)

mod.ypr.x=ypr(age=contour.df$age, wgt=contour.df$wgt, partial=contour.df$partial, M=0.4,

maxF=1.5,incrF=0.15, graph=T)

contour.df$YPR <- mod.ypr.x$F\_vs\_YPR$YPR[2:11]

contour.df$F <- mod.ypr.x$F\_vs\_YPR$F[1:10]

#make a data frame with columns for each age at first capture regime

tc <- data.frame(tc1=haddock$tc.1[1:10], tc2=haddock$tc.2[1:10],tc3=haddock$tc.3[1:10],tc4=haddock$tc.4[1:10],tc5=haddock$tc.5[1:10])

tc$tc6 <- ifelse(contour.df$age<6, 0, 1)

tc$tc7 <- ifelse(contour.df$age<7, 0, 1)

tc$tc8 <- ifelse(contour.df$age<8, 0, 1)

tc$tc9 <- ifelse(contour.df$age<9, 0, 1)

tc$tc10<- ifelse(contour.df$age<10, 0, 1)

#"expanded" data frame with unique row for each age-F combination

contour.exp = data.frame(age = rep(c(1:8), each=10), F = rep(contour.df$F, 8), YPR = 0)

#get YPR for each

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc1, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec1= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc2, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec2= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc3, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec3= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc4, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec4= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc5, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec5= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc6, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec6= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc7, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec7= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc8, M=0.4,

plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

vec8= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

#ypr function stopped working at tc = 9 and up.

#mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc9, M=0.4,

# plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

#vec9= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

#mod.ypr.temp=ypr(age=contour.df$age,wgt=contour.df$wgt,partial=tc$tc10, M=0.4,

# plus=FALSE,maxF=1.5,incrF=0.01, graph=T)

#vec10= mod.ypr.temp$F\_vs\_YPR$YPR[2:11]

#add these together and add to expanded data

vec.comp = append(vec1, vec2)

vec.comp = append(vec.comp, vec3)

vec.comp = append(vec.comp, vec4)

vec.comp = append(vec.comp, vec5)

vec.comp = append(vec.comp, vec6)

vec.comp = append(vec.comp, vec7)

vec.comp = append(vec.comp, vec8)

contour.exp$YPR = vec.comp

#make plot

ggplot(contour.exp, aes(x = F, y = age, z = YPR)) +

geom\_contour\_filled() + labs(fill="YPR")+

labs(x = "F", y = "age", z = "YPR") + theme\_minimal()