Population dynamics module assignment

YOUR NAME HERE

SUBMISSION DATE HERE

Data Setup

In this assignment you are going to modify the age-structured simulation that we used earlier in the course to match the basic biology of your stock. There should be a CSAS report or other stock assessment document that contains much of this information, if it exists for your stock. If it doesn't exist in a government report, I would like you to find a different citation for the biological information for your stock. If there is no research on your particular stock for the specified life history information, then you can use Fishbase or some other source that describes that information for your species. Finally, if there is no research on your species for a life history trait, you can give it your best guess, but you will need to indicate this and I will search to see if there is truly no research on your species for that trait.

Similar to the example in class, the simulation will run for 50 years, lets say from 2000 to 2050.

```
yrs<-seq(from=2000, to=2050)
nyears<-length(yrs)
```

Number of ages (2 points)

What is the maximum age of your stock? (1 pt) Provide a citation (1 pt).

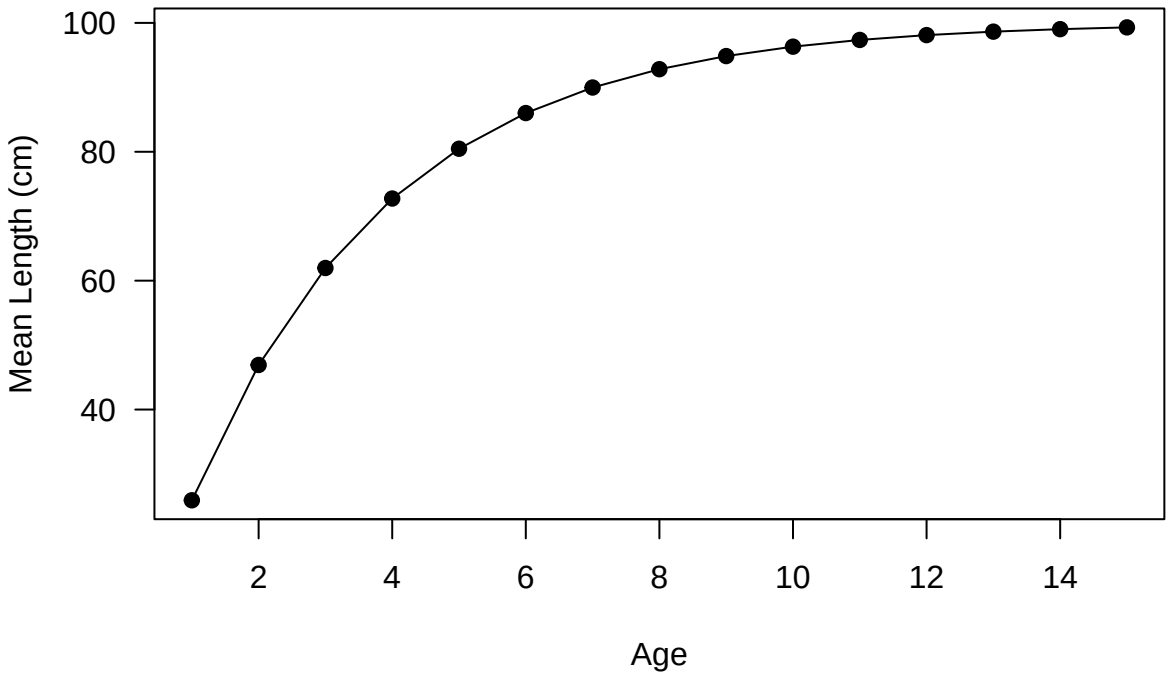
```
#Change the value to match your stock's value
nages<-15
```

Maximum length (2 points)

What is L_{inf} for your stock? (1 pt) Provide a citation (1 pt).

```r
#Change the value to match your stock's value
linf<-100
```

```r
laa<-rep(NA, nages)
for(i in 1:nages){
laa[i]<-linf*(1-exp(-(5/nages)*(i-(linf/1000))))
}

plot(laa~seq(from=1, to=nages, by=1), pch=19, xlab="Age",
     ylab="Mean Length (cm)", las=1)
lines(laa~seq(from=1, to=nages, by=1))
```

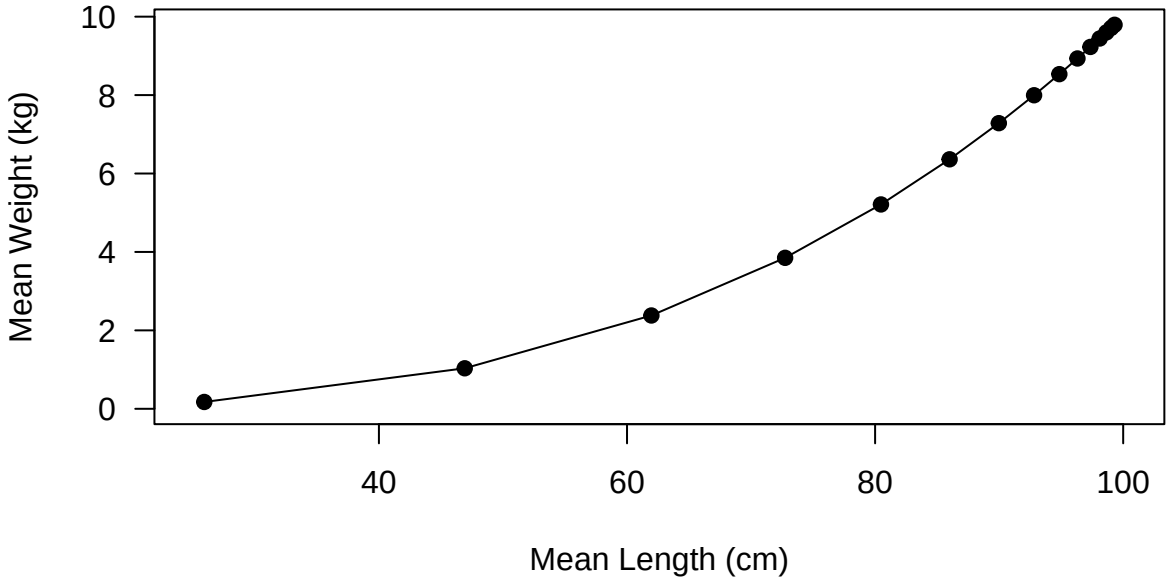


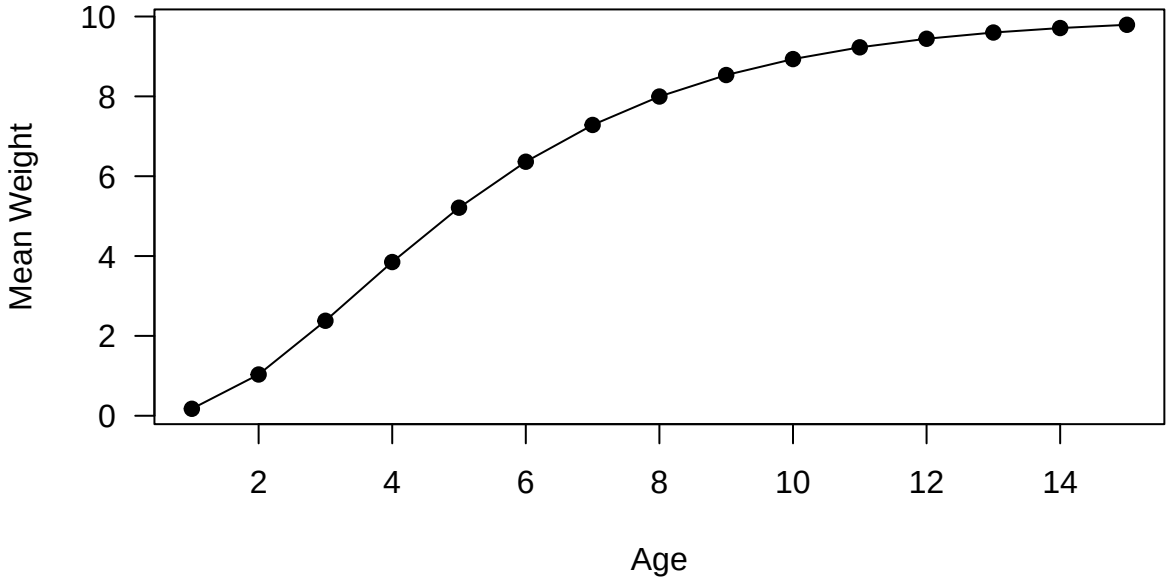
Length-weight relationship (2 points)

What is the allometric growth coefficient (b) for your stock? (1 pt) Provide a citation (1 pt).

```r
#Change the value to match your stock's value
b<-3
```

```r
waa<-rep(NA, nages)
for(i in 1:nages){
  waa[i]<-(0.001*laa[i]^b)/100
  }

par(mfrow=c(2,1))
plot(waa~laa, pch=19, xlab="Mean Length (cm)", ylab="Mean Weight (kg)",
     las=1, xlim=c(min(laa)-1,max(laa)+1), ylim=c(0,max(waa)))
lines(waa~laa)
plot(waa~seq(from=1, to=nages, by=1), pch=19, xlab="Age", ylab="Mean Weight",
     las=1)
lines(waa~seq(from=1, to=nages, by=1))
```


Mean Weight (kg)
0
2
4
6
8
10
40
60
80
100
Mean Length (cm)

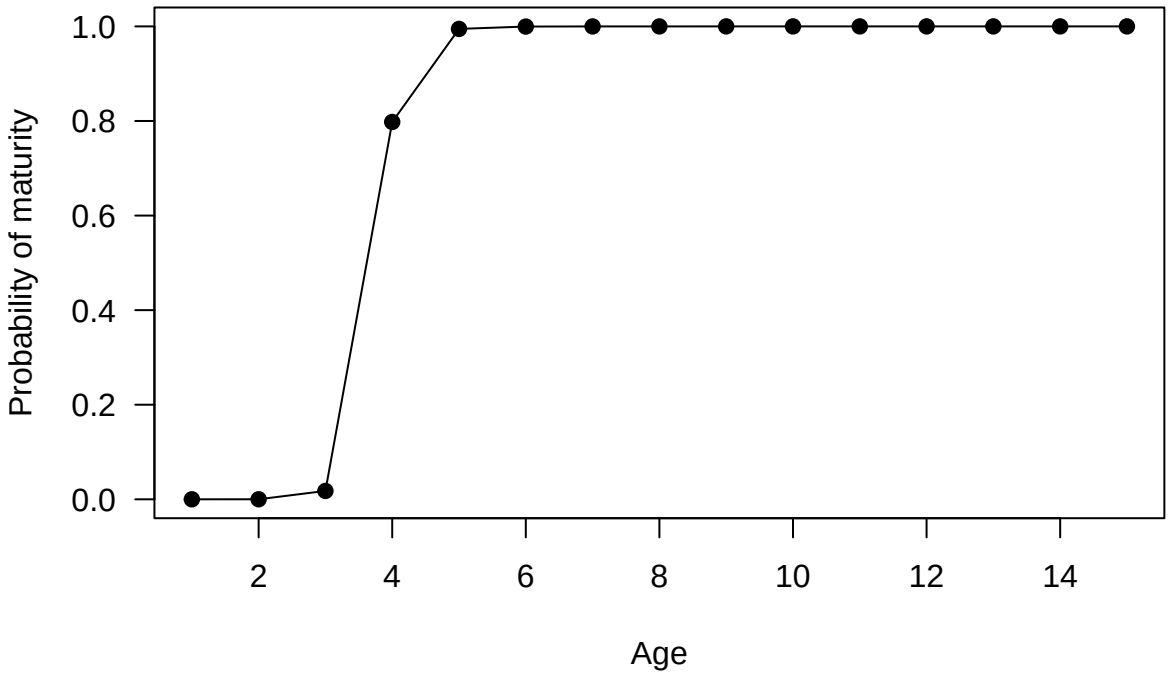

Mean Weight
0
2
4
6
8
10
2
4
6
8
10
12
14
Age

Maturity (2 points)

What is the length at 50% maturity (L_{50}) for females of your stock? (1 pt) Provide a citation (1 pt).

```
#Change the value to match your stock's value
l50<-70
```

```
maa<-rep(NA, nages)
for(i in 1:nages){
  maa[i]<-1/(1+exp(-0.5*(laa[i]-l50)))
}
plot(maa~seq(from=1, to=nages, by=1), pch=19, xlab="Age",
     ylab="Probability of maturity", las=1)
lines(maa~seq(from=1, to=nages, by=1))
```



Like was discussed in lecture, we are going to assume that natural mortality (M) is constant at 0.2. No need to change this for the assignment.

```
M<-matrix(0.2, nyears,nages)
```

Once all of these components for the population have been set-up, we can start to think about the fishery.

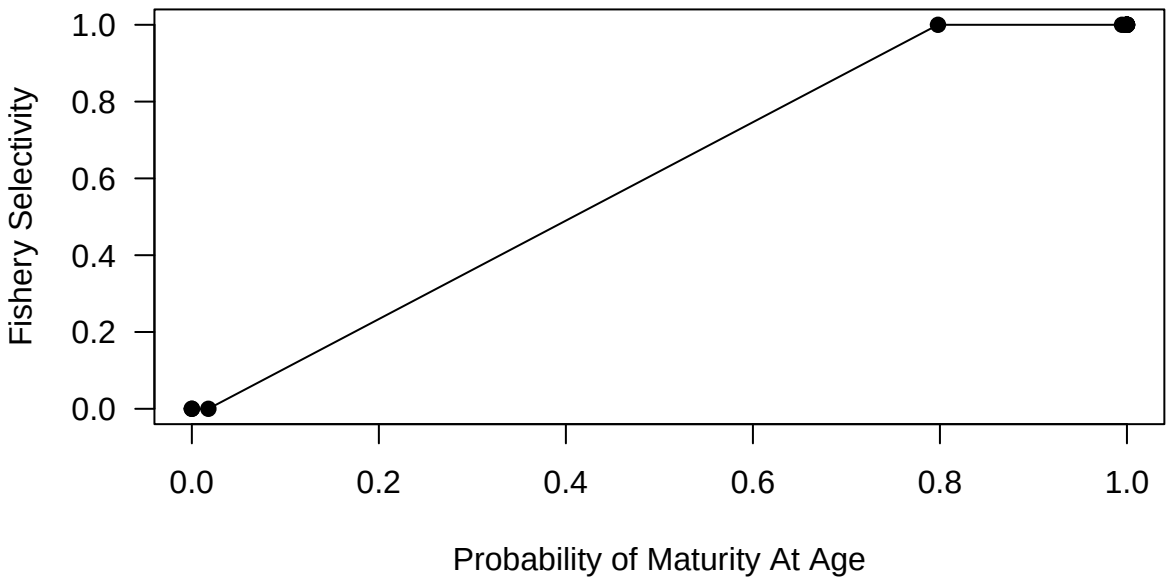
The fishery

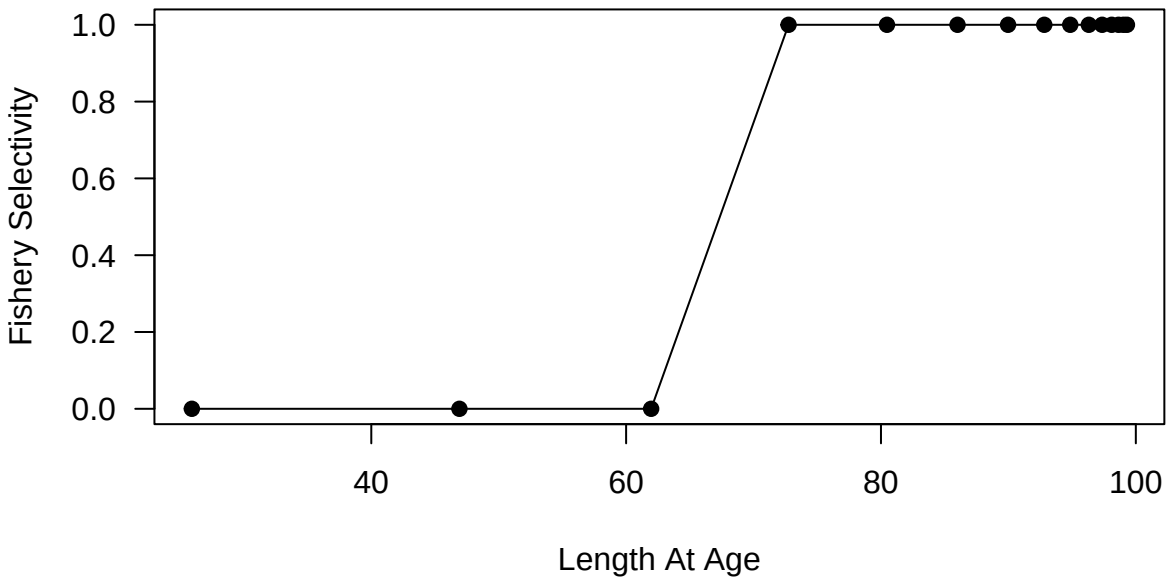
For the purposes of this simulation, I am going to assume that the fishery only targets mature fish and also has followed a specific pattern of exploitation over time.

In this case, fishing mortality will start at 0 in 2000 and steadily increase to a maximum value of 0.3 at which point it will level off and the fishery will maintain at a steady amount of fishing pressure until the end of the simulation.

None of the code in this section needs to be modified.

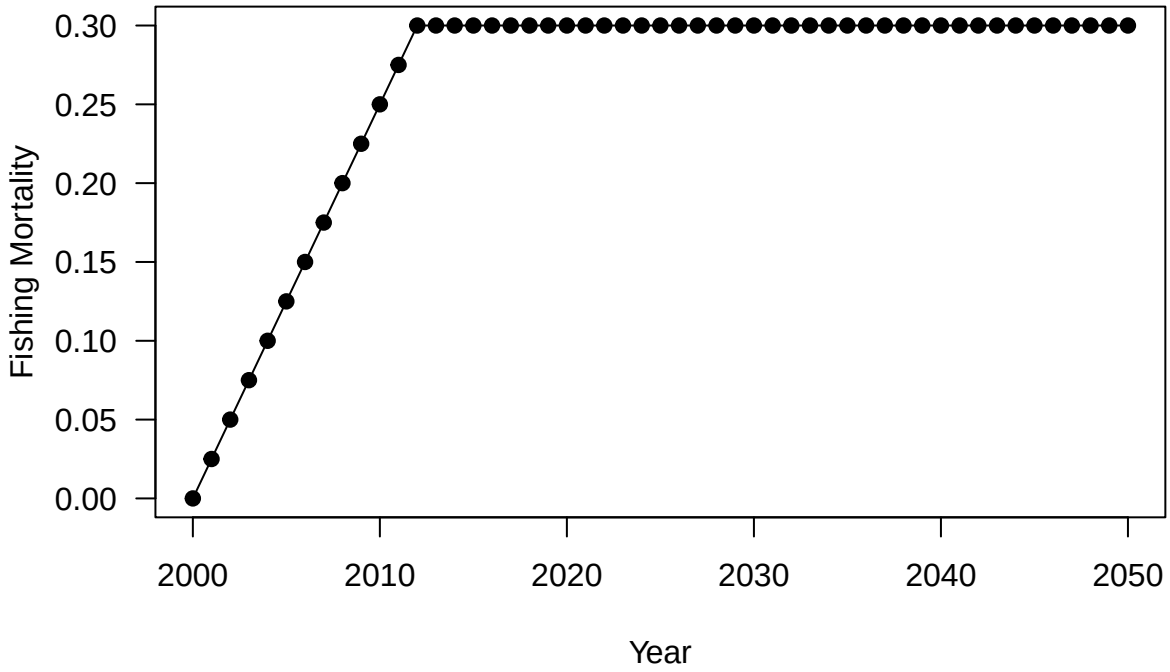
```
Fsel<-ifelse(maa<0.5, 0,1)
par(mfrow=c(2,1))
plot(Fsel~maa,pch=19, xlab="Probability of Maturity At Age",
     ylab="Fishery Selectivity", las=1)
lines(Fsel~maa)
plot(Fsel~laa,pch=19, xlab="Length At Age", ylab="Fishery Selectivity",
     las=1)
lines(Fsel~laa)
```






```
Ftrend<-rep(NA, nyears)
incF<-round(nyears*0.25,0)
Ftrend[1:incF]<-seq(from=0, to=0.3, length=incF)
Ftrend[(incF+1):nyears]<-0.3
```

```r
plot(Ftrend~yrs,pch=19, xlab="Year", ylab="Fishing Mortality", las=1)
lines(Ftrend~yrs)
```



Simulation

Now that the species biology and fishery have been defined, we can run a theoretical simulation of how this fishery would impact a theoretical population with your stock's biology.

None of the code in this section needs to be modified.

Population dynamics comparison

After the simulation runs, we can examine how the population actually changed over time. In the following sections I will ask you questions, including to compare your stock to mine. Any comparisons should focus on large changes rather than interannual variability. Much of the noise will be driven by the simulation and will not be meaningful, but you should be able to identify large changes that are driven by differences in life-history traits.

The life-history traits for "Matts stock" are the same as what we examined for the age-structured model in class. So, $nages = 15$, $L_{inf} = 100$, $b = 3$, and $L_{50} = 70$. When describing differences in the population dynamics, think about how our simulated fishery might be impacting these populations differently based on the defined life-history traits. I will mark your assignment based on thought process rather than being correct about why a specific change occurred.

To make sure you can identify which figure is for your stock please modify the following code to include your stock name:

```
# modify the following code with your stocks name
stock<-"YOURSTOCK"
```

Age and growth (2 points)

Examine your length-at-age and weight-at-age plots. Which age classes contribute most to total biomass, and why (1 pt)? How does the maximum age of your stock influence total biomass accumulation and the stock's resilience to fishing (1 pt)?

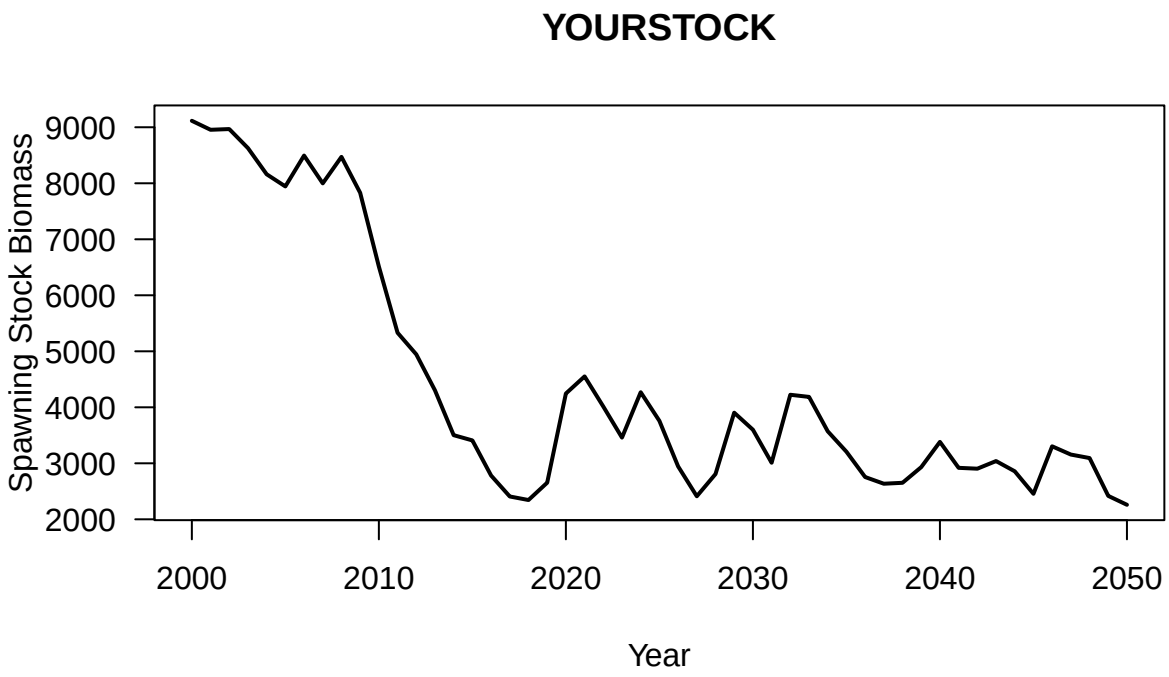
Maturity and Selectivity (2 points)

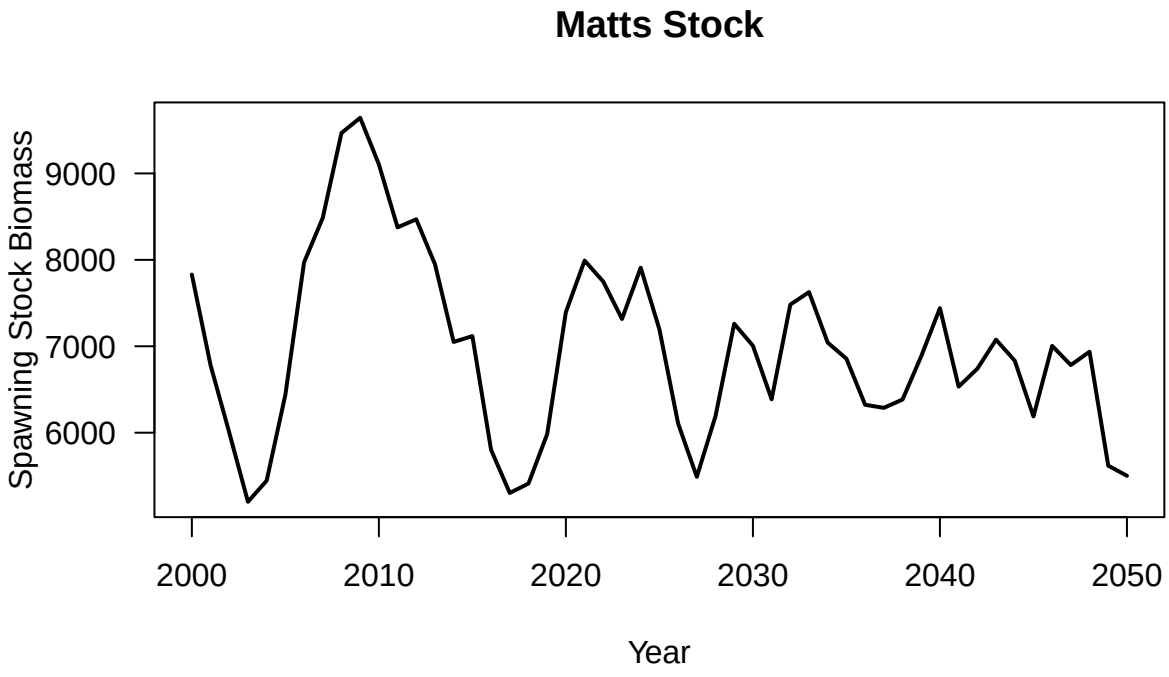
Examine your maturity and fishery selectivity plots. Which age or size classes are most vulnerable to the fishery (1 pt)? Right now, the fishery only targets mature fish, how would decreasing the targeted length or age of harvested fish modify your SSB trend (1 pt)?

SSB and Age Structure (2 points)

Compare your SSB and abundance-at-age plots to mine. How does the age structure and growth pattern of your stock influence its sensitivity to the fishery compared to mine (1 pt)? Which age classes act as a buffer against declines in SSB, and why (1 pt)?"

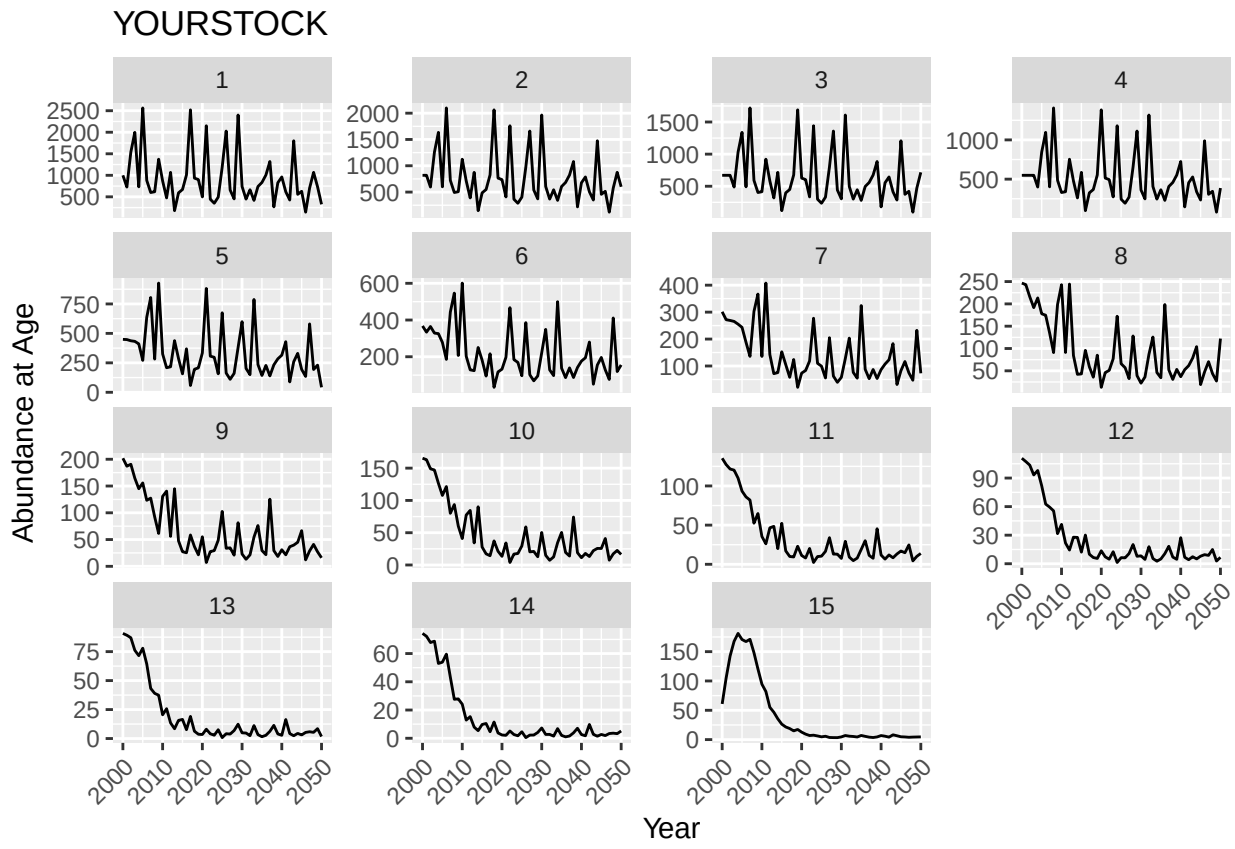
```
par(mfrow=c(2,1))
plot(SSB~yrs, type="l", xlab="Year", ylab="Spawning Stock Biomass",
     las=1, lwd=2, main=stock)
plot(sim_pop_dy$SSB~yrs, type="l", xlab="Year", ylab="Spawning Stock Biomass",
     las=1, lwd=2, main="Matts Stock")
```



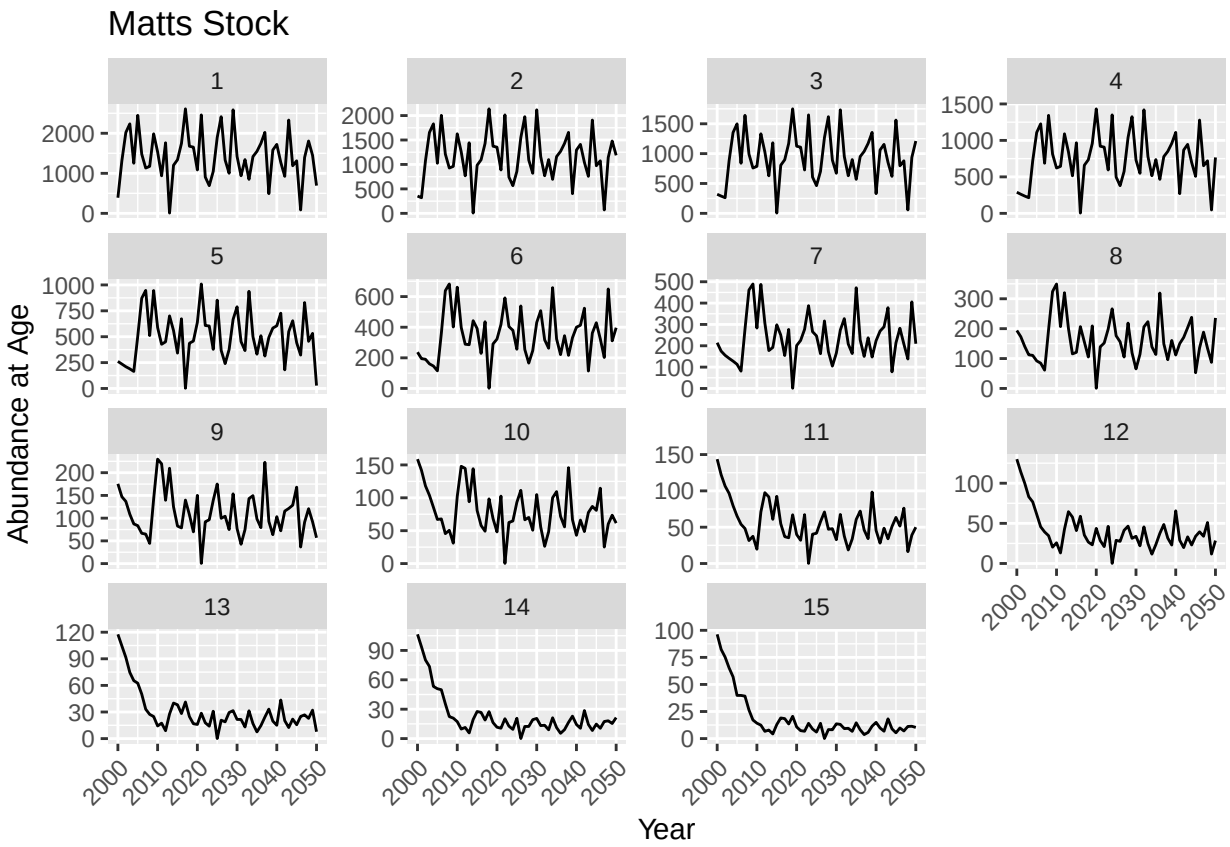



```
N_df<-data.frame(N=c(N),year=rep(yrs, nages), age=(rep(seq(from=1, to=nages),
                                                       each=51)))

ggplot(data=N_df, aes(x=year, y=N))+xlab("Year")+ylab("Abundance at Age")+
```

```
  geom_line()+ggtitle(stock)+
  facet_wrap(~age, scales = "free_y")+
  theme(axis.text.x = element_text(angle = 45, hjust=1))
```




```
N_df<-data.frame(N=c(sim_pop_dy$N),year=rep(yrs, sim_pop_dy$nages),
                 age=(rep(seq(from=1, to=sim_pop_dy$nages), each=51)))

ggplot(data=N_df, aes(x=year, y=N))+xlab("Year")+ylab("Abundance at Age")+
  geom_line()+ggtitle("Matts Stock")+
  facet_wrap(~age, scales = "free_y")+
  theme(axis.text.x = element_text(angle = 45, hjust=1))
```

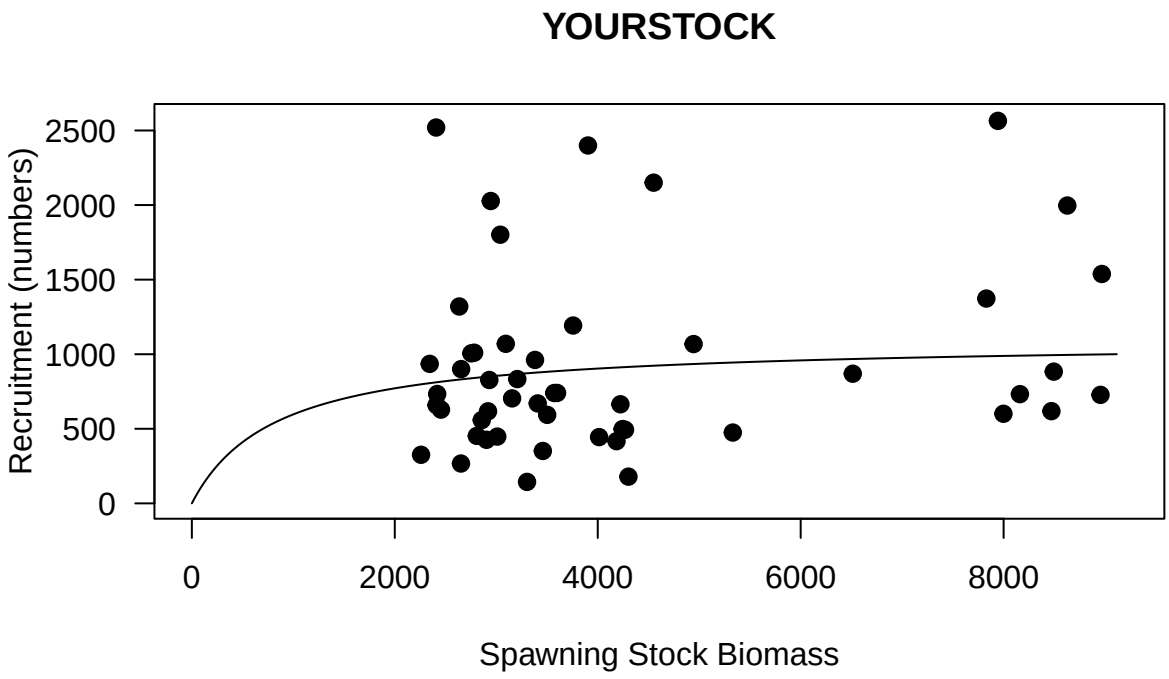


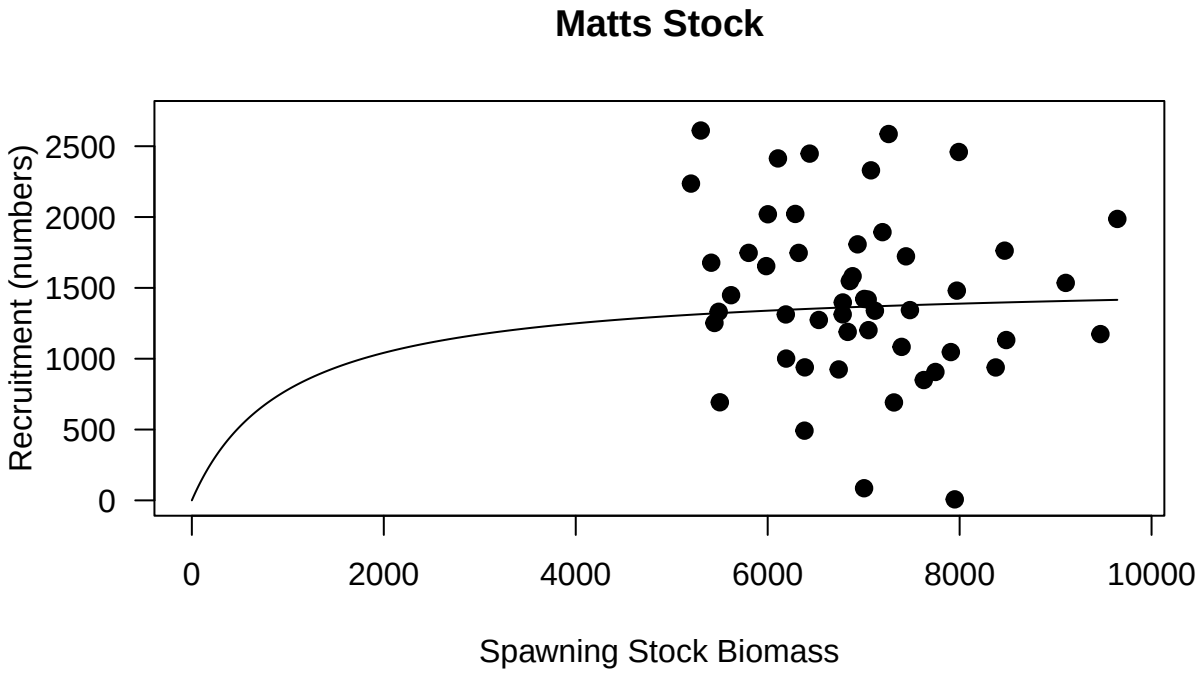
Recruitment (2 points)

Please describe any differences that you see between your stock-recruitment curve and mine (1 point). What implications do these differences have for the population dynamics of your stock relative to mine (1 point)?

```
sim_ssb<-seq(from=0, to=max(SSB), by=1)
sim_rec<-bev_holt(sim_ssb, R0, SSB0, h)

par(mfrow=c(2,1))
plot(R~SSB, xlab="Spawning Stock Biomass", ylab="Recruitment (numbers)",
     las=1, lwd=2, pch=19, xlim=c(0,max(SSB)+100),
     ylim=c(0, max(R[2:nyears])+10), main=stock)
lines(sim_ssb, sim_rec)

sim_ssb<-seq(from=0, to=max(sim_pop_dy$SSB), by=1)
plot(sim_pop_dy$R~sim_pop_dy$SSB, xlab="Spawning Stock Biomass",
     ylab="Recruitment (numbers)", las=1, lwd=2, pch=19,
     xlim=c(0,max(sim_pop_dy$SSB)+100),
     ylim=c(0, max(sim_pop_dy$R[2:nyears])+100), main="Matts Stock")
```

```
lines(sim_ssb,
      (10/mean(sim_pop_dy$maa*sim_pop_dy$waa)*sim_ssb)/(1+0.001*sim_ssb))
```

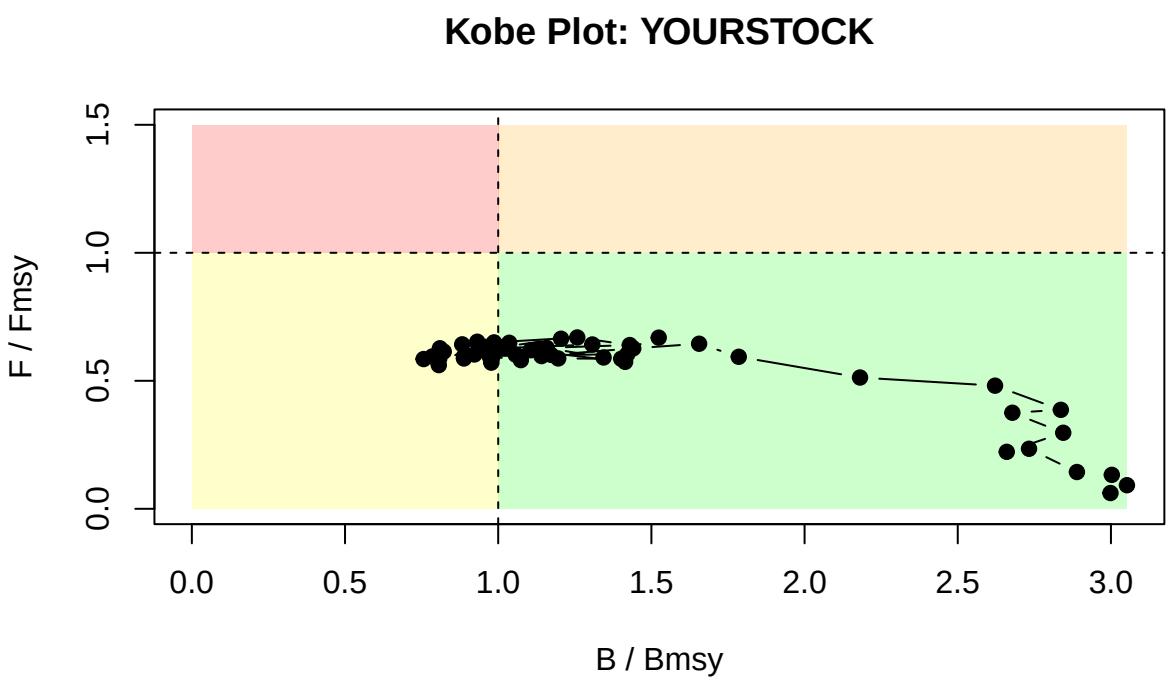




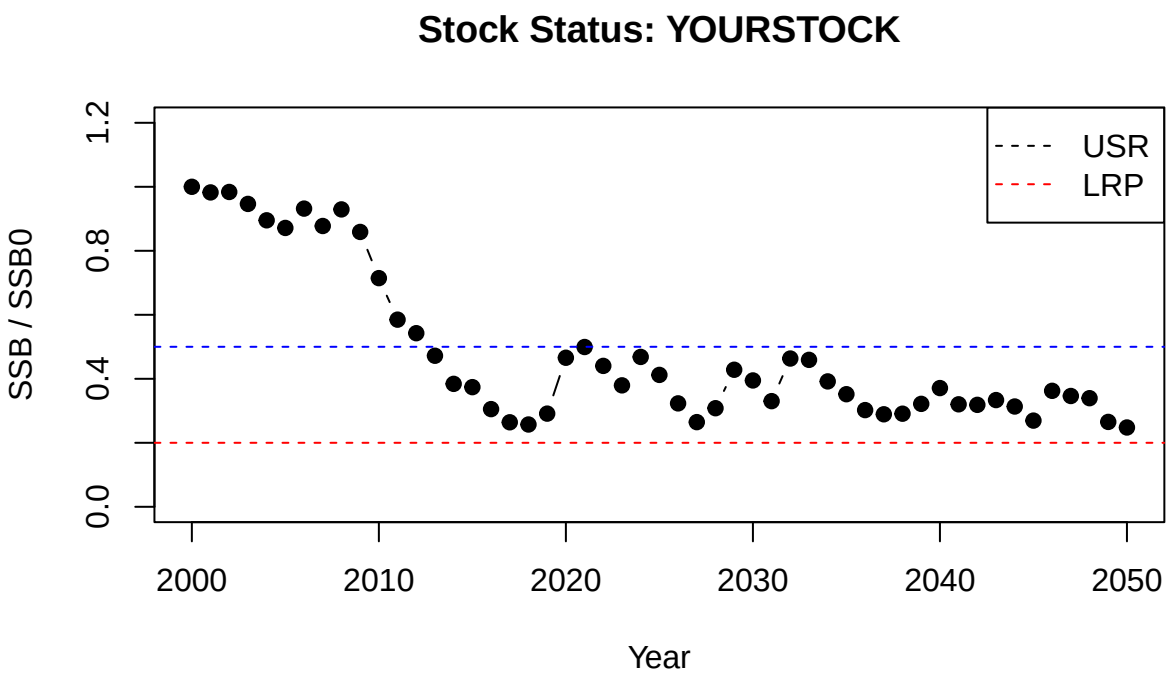
Sustainability (2 points)

Below I create a Kobe plot (using B/Bmsy vs F/Fmsy) and a USR/LRP plot (using SSB/SSB0). What do these plots indicate about the sustainability of the fishery on your stock?

```
B_ratio <- SSB / Bmsy
F_ratio <- rowMeans(F) / Fmsy

xmax <- max(1.5, max(B_ratio))
ymax <- max(1.5, max(F_ratio))

plot(B_ratio, F_ratio, type="n",
     xlab="B / Bmsy", ylab="F / Fmsy",
     main=paste("Kobe Plot:", stock),
     xlim=c(0, xmax), ylim=c(0, ymax))

rect(xleft=1, ybottom=0, xright=xmax, ytop=1, col=adjustcolor("green", alpha.f=0.2), bor
rect(xleft=0, ybottom=0, xright=1, ytop=1, col=adjustcolor("yellow", alpha.f=0.2), borde
rect(xleft=1, ybottom=1, xright=xmax, ytop=ymax, col=adjustcolor("orange", alpha.f=0.2),
rect(xleft=0, ybottom=1, xright=1, ytop=ymax, col=adjustcolor("red", alpha.f=0.2), borde

abline(v=1, h=1, lty=2)

lines(B_ratio, F_ratio, type="b", pch=19, col="black")
```




```
ssb_ratio <- SSB / SSB0

plot(yrs, ssb_ratio, type="b", pch=19,
     xlab="Year", ylab="SSB / SSB0",
     main=paste("Stock Status:", stock),
     ylim=c(0, max(1.2, ssb_ratio)))

abline(h=USR/SSB0, col="blue", lty=2)  # USR
abline(h=LRP/SSB0, col="red", lty=2)   # LRP

legend("topright",
       legend=c("USR", "LRP"),
       col=c("black","red"),
       lty=c(2,2),
       pch=c(NA,NA))
```


Stock Status: YOURSTOCK
SSB / SSB0
0.0
0.4
0.8
1.2
2000
2010
2020
2030
2040
2050
Year
USR
LRP