Written exam

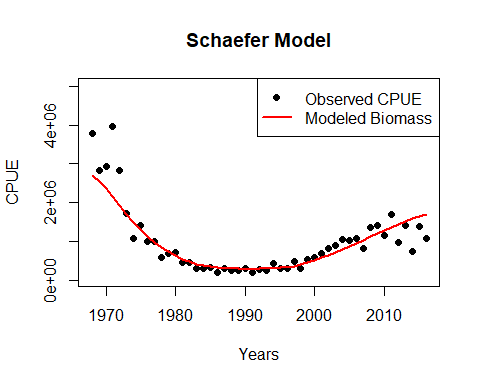
Patricia Faundez

April, 2018

# Data and vectors of Years, Catches, CPUE.obs and observation error  
Data <- read.csv("C:/Users/Patricia/Box Sync/2018\_Winter/Written\_exam/question\_2\_revised/data\_for\_question\_4.csv", stringsAsFactors = T)  
Years <- Data[,1]  
CPUE.obs <- Data[,2]  
Catches <- Data[,3]  
Error.ob <- Data[,4]

#Schaeffer Model  
  
model.pe <- function(r, K, q=1, year.start=1968, year.end=2016, catches, CPUE.obs){  
   
 #variables  
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Schaeffer model  
 Bt[1] <- K # biomass year 1 = carrying capacit  
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+Bt[i-1]\*r\*(1-Bt[i-1]/K)-catches[i-1])  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (49\*log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
   
   
 ## Return the results as a matrix of n columns  
 out <- cbind(CPUE.obs, catches, Bt, Residuals, Residuals2, sigma, NLL)  
 return(out)  
}  
  
# Exploring different values of r and K to get a feeling for what values will give reasonable fits to the data  
  
res.pe = model.pe(r=0.26 ,K=2692449, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs)  
#res.pe

#Plot Schaefer  
  
plot1 <- plot(Years, CPUE.obs, pch=16, ylim=c(50000,5000000),  
 main="Schaefer Model", ylab="CPUE")   
  
lines(Years, model.pe(r=0.26 ,K=2692449, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs)[,3], lwd=2, col="red")# using the r and K values from optimization  
  
legend("topright", legend=c("Observed CPUE", "Modeled Biomass"),  
 lty=c(NA, 1), col=c(1,2), pch=c(16, NA), lwd=2)



#model.pe(r=0.25 , K=2178306, q=1, year.start=1968, year.end=2016, sigma.obs=0.1, catches=Catches, CPUE.obs=CPUE.obs, sigma.w = 0.15, random.seed=4)

#Schaeffer  
  
minimize.NLL.pe <- function(par, q=1, year.start=1968, year.end=2016, catches, CPUE.obs){  
  
 ## r and K in one vector for optimization  
 r <- par[1]  
 K <- par[2]  
 #parlog <- log(par) # log-transformation  
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Schaeffer model  
 Bt[1] <- K   
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+Bt[i-1]\*r\*(1-Bt[i-1]/K)-catches[i-1])  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (49\*log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
   
 return(NLL)  
}  
  
#This verifies that the NLL as in the initial function (model.pred)  
minimize.NLL.pe(par=c(0.26 ,2692449), q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs)

## [1] -41.35341

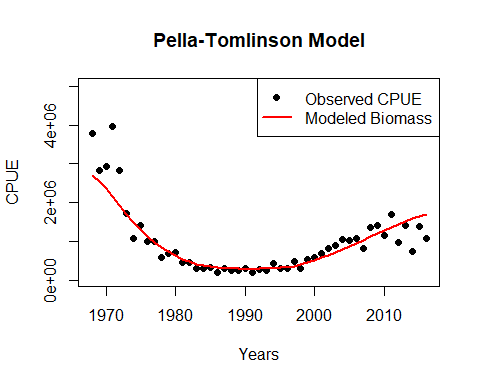
# OBSERVATION ERROR MODEL (Minimizing K)  
  
Rprofile.NLL.ob.K <- function(param.vector, K, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs){  
   
 r <- param.vector[1]  
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Schaeffer model  
 Bt[1] <- K # biomass year 1 = carrying capacit  
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+Bt[i-1]\*r\*(1-Bt[i-1]/K)-catches[i-1])  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (49\*log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
   
 return(NLL)  
}  
  
# The likelihood profile  
Rprofile.ob.K <- function(R.vec.ob.K, lower=10, upper=5000000) {  
 nR <- length(R.vec.ob.K)  
 saved.NLL <- saved.K <- vector(length=nR)  
   
 for (i in 1:nR) {  
 x <- optim(par=c(K=2778198),fn=Rprofile.NLL.ob.K, method="Brent",   
 param.vector=R.vec.ob.K[i], q=1, year.start=1968, year.end=2016,  
 catches=Catches, CPUE.obs=CPUE.obs,   
 lower=lower, upper=upper)  
 saved.NLL[i] <- x$value  
 saved.K[i] <- x$par  
 }  
 return(data.frame(ob.r = R.vec.ob.K, ob.K=saved.K, NLL.ob.K=saved.NLL))  
}  
# calculate the NLL for K  
R.vec.ob.K <- seq(0.1,0.9,0.01)  
  
values.ob <- Rprofile.ob.K(R.vec.ob.K=R.vec.ob.K, lower=10, upper=5000000)

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#values.ob

#Pella-Tomlinson Model, which has one additional parameter p  
  
model.pt <- function(r, K, p, q=1, year.start=1968, year.end=2016, catches, CPUE.obs){  
   
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Pella-Tomlinson  
 Bt[1] <- K # biomass year 1 = carrying capacit  
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+r/p\*Bt[i-1]\*(1-(Bt[i-1]/K)^p))- catches[i-1]  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (0.5\*log(2\*pi) + log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
   
 # Results   
 out <- cbind(CPUE.obs, catches, Bt, Residuals, Residuals2, sigma, NLL)  
 return(out)  
}  
  
res.pt = model.pt(r=0.26, K=2692449, p=1, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs)  
#res.pt

#Plot Pella-Tomlinson  
  
plot1 <- plot(Years, CPUE.obs, pch=16, ylim=c(50000,5000000),  
 main="Pella-Tomlinson Model", ylab="CPUE")   
  
lines(Years, model.pt(r=0.26, K=2692449, p=1, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs)[,3], lwd=2, col="red")  
  
legend("topright", legend=c("Observed CPUE", "Modeled Biomass"),  
 lty=c(NA, 1), col=c(1,2), pch=c(16, NA), lwd=2)



minimize.NLL.pt <- function(par, p=0.1, q=1, year.start=1968, year.end=2016, catches, CPUE.obs){  
  
 ## r and K in one vector for optimization  
 r <- par[1]  
 K <- par[2]  
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Pella-Tomlinson  
 Bt[1] <- K # biomass year 1 = carrying capacit  
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+r/p\*Bt[i-1]\*(1-(Bt[i-1]/K)^p))- catches[i-1]  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (0.5\*log(2\*pi) + log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
   
   
 return(NLL)  
}  
  
#This verifies that the NLL as in the initial function (model.pred)  
minimize.NLL.pt(par=c(0.26 ,2692449), p=0.1, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs)

## [1] 25.16164

# OBSERVATION ERROR MODEL (Minimizing K)  
  
Rprofile.NLL.pt <- function(param.vector, K, p, q=1, year.start=1968, year.end=2016, catches=Catches, CPUE.obs=CPUE.obs){  
   
 r <- param.vector[1]  
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Pella-Tomlinson  
 Bt[1] <- K # biomass year 1 = carrying capacit  
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+r/p\*Bt[i-1]\*(1-(Bt[i-1]/K)^p))- catches[i-1]  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (0.5\*log(2\*pi) + log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
   
 return(NLL)  
}  
  
# The likelihood profile  
Rprofile.ob.K <- function(R.vec.ob.K, lower=10, upper=5000000) {  
 nR <- length(R.vec.ob.K)  
 saved.NLL <- saved.K <- vector(length=nR)  
   
 for (i in 1:nR) {  
 x <- optim(par=c(K=2778198),fn=Rprofile.NLL.pt, method="Brent",   
 param.vector=R.vec.ob.K[i], p=1, q=1, year.start=1968, year.end=2016,  
 catches=Catches, CPUE.obs=CPUE.obs,   
 lower=lower, upper=upper)  
 saved.NLL[i] <- x$value  
 saved.K[i] <- x$par  
 }  
 return(data.frame(ob.r = R.vec.ob.K, ob.K=saved.K, NLL.ob.K=saved.NLL))  
}  
# calculate the NLL profile   
R.vec.ob.K <- seq(0.1,0.9,0.01)  
  
values.ob <- Rprofile.ob.K(R.vec.ob.K=R.vec.ob.K, lower=10, upper=5000000)

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#values.ob

#AIC model comparison   
  
#Schaefer Model  
  
param\_sch = 5 #r, K, q, sigma, B1968  
NLL\_sch= -41.35341  
  
# Pella-Tomlinson Model  
  
param\_pt = 6 #p, r, K, q, sigma, B1968  
NLL\_pt= 23.58520  
  
AIC\_sch = (2\*NLL\_sch)+(2\*param\_sch) #-72.71  
AIC\_pt = (2\*NLL\_pt)+(2\*param\_pt) #59.1704

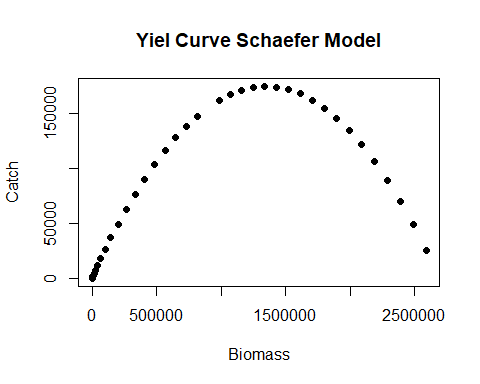
#Simulate a population dynamics model, simulate catches and biomass for different fishing effort with optimum values of r and K, calculated from Schaefer Model   
  
#Fstart = fishing mortality rate, must be >0 not equal to 0  
#Bstart = starting biomass  
#nyears = number of years to simulate  
  
logistic.effort <- function(r, K, Bstart, Fstart, nyears,   
 nruns) {  
 Bmat <- matrix(nrow=nruns, ncol=nyears,   
 dimnames=list(paste("Run",1:nruns), paste("Year",1:nyears)))  
   
 Cmat <- matrix(nrow=nruns, ncol=nyears,   
 dimnames=list(paste("Run",1:nruns), paste("Year",1:nyears)))  
 Bmat[,1] <- Bstart   
 umsy <- r/2 #umsy = 1-exp(-Fmsy)  
 for (i in 1:nruns) {  
 for (yr in 1:(nyears-1)) {  
 Cmat[i,yr] <- Bmat[i,yr]\*(1-exp(-Fstart))  
 Bmat[i,yr+1] <- Bmat[i,yr] + r\*Bmat[i,yr]\*(1-Bmat[i,yr]/K) - Cmat[i,yr]  
 } #end of loop over years  
 } #end of loop for nruns  
   
 invisible(list(Bmat=Bmat, Cmat=Cmat))  
}  
#long 100-yr run  
temp <- logistic.effort(r=0.26, K=2692449, Bstart=2692449, Fstart=0.01, # I change Fstart to get catch and biomass at each fishing effort value, I recorded manually and generate a .csv file. I have to learn how to generate the whole data set in R  
 nyears=101, nruns=1) # Here I put nyears=101 because I get an NA in the last year  
  
#temp #100 years of simulation  
  
# Catch and Biomass by setting Fstart=0.01   
Catch <- temp$Cmat[,100]   
Biomass <- temp$Bmat[,100]  
  
Catch

## [1] 25765.05

Biomass

## [1] 2589409

#Plot Yield curve for Schaefer model   
  
Catch\_Biomass <- read.csv("C:/Users/Patricia/Box Sync/2018\_Winter/Written\_exam/question\_2\_revised/Catch\_Biomass.csv")  
C <- Catch\_Biomass[,2]  
B <- Catch\_Biomass[,3]  
  
plot1 <- plot(B, C, pch=16,  
 main="Yiel Curve Schaefer Model", ylab="Catch", xlab="Biomass")



#This code is to show my attemp to log transform the parameters r and K before to enter the optimization. This is the shaefer model  
  
minimize.NLL.pe <- function(par, q=1, year.start=1968, year.end=2016, sigma.obs=0.1, catches=Catches, CPUE.obs=CPUE.obs, sigma.w = 0.15, random.seed=4){  
  
 ## r and K in one vector for optimization  
 r <- par[1]  
 K <- par[2]  
 par <- log(par) # log-transformation  
 model.pe <- function(r, K, q=1, year.start=1968, year.end=2016, catches, CPUE.obs){  
   
 #variables  
 years <- year.start:year.end   
 num.years <- length(years)   
 Bt <- rep(NA, num.years)   
   
 # predicted population with Schaeffer model  
 Bt[1] <- K # biomass year 1 = carrying capacit  
 for(i in 2:num.years){  
 Bt[i] <- max(0,Bt[i-1]+Bt[i-1]\*r\*(1-Bt[i-1]/K)-catches[i-1])  
 }  
   
 # calculating residuals and sigma  
 Residuals <- (log(CPUE.obs)-log(Bt))   
 Residuals2 <- ((log(CPUE.obs)-log(Bt))^2)   
 sigma <- sqrt(sum(Residuals2)/(num.years-1))  
   
 # calculating NLL  
 NLL <- (49\*log(sigma)) + sum(((log(CPUE.obs)-log(Bt))^2) / (2\*sigma^2))  
 }  
 return(NLL)  
}