Método de Zhou 2013

PCOM Posterior-focused catch-only method S. Zhou, Modificado por Elson Leal y María José Zúñiga para sardina austral Aysen, CBA 2021

This method requires time series of catch data only. However, some life history parameters, M, Linf, k, T_max, T_maturation, will improve the performance. Also, a rough guess of maximum depletion level D = B_end/K will be helpful. This example is for single catch series

Modelo

```r
library(knitr) # para generar reporte Rmarkdown
library(stringr)
library(reshape)
library(dplyr)
library(ggplot2)
library(ggthemes) # para ggplot
library(patchwork) # para unir gráficos de ggplot
library(strucchange) # libreria utilizada para análisis de quiebres

getwd()
```

```
## [1] "/Users/mariajosezunigabasualto/MJZ/CTP2021/SARDINA_AUSTRAL AYSEN/INFORME _FINAL"
```

```r
##############################################################################
# model
##############################################################################
BDM=function(K,dep,b,C,r){   ### biomass dynamics model
 B=err.B=rep(NA,length(C))
 B[1]=b*K;b1=B[1]
 for(i in 2:length(B)){
  B[i]=max(min(B[i-1]+r*B[i-1]*(1-B[i-1]/K)-C[i-1],K),0)
#  err.B[i]=ifelse(!is.na(U[i-1]&U[i]) & B[i]>0,(B[i-1]/B[i]-U[i-1]/U[i]^2,NA)
 }
 if(all(B>C) & all(B<=K)){
  abs(B[length(B)]-dep*K)
# if(any(U>0)){((B[length(B)]-dep*K)/K)^2 +sum(err.B,na.rm=T)} else ((B[length(B)]-dep*K)/K)^2
 } else {10^5}
}
```

Simulación

```
################################################################################
# simulation
################################################################################
sim1=function(k25=k25,k75=k75,r25=r25,r75=r75,yr=yr,C=C,nsim=nsim,msy=NULL){
 Bend.keep=K.keep=r.keep=dep.keep=d.keep=vector()
 nyr=length(yr)
 B=F2Fmsy=B2Bmsy=matrix(NA,nyr,nsim)
 K=r=vector()
 plot(0,0,type="n",xlim=c(min(yr),max(yr)),ylim=c(-1,round(k75,0)*1.15),
 xlab="", ylab="",yaxt="n",xaxt="n")
 for(j in 1:nsim){
   K[1]=runif(1,k25,k75)
   r[1]=runif(1,r25,r75)
   B[1,j]=K[1]
   for(i in 2:(nyr)){
     r[i]=runif(1,r25,r75)
     K[i]=runif(1,k25,k75)
     B[i,j]=B[i-1,j]+r[i]*B[i-1,j]*(1-B[i-1,j]/K[i])-C[i-1]
     F2Fmsy[i,j]=(C[i]/B[i,j])/(r[i]/2)
     B2Bmsy[i,j]=B[i,j]/(K[i]/2)
   }
   cols<-rgb(runif(1,0,j)/nsim,(nsim-runif(1,0,j))/nsim,(1)/(nsim+100),
   alpha=0.6)
   lines(yr,B[,j],col=cols)
   K.keep[j]=mean(K)
   r.keep[j]=mean(r)
   F2Fmsy[,j]=(C/B[,j])/(mean(r)/2)
   B2Bmsy[,j]=B[,j]/(mean(K)/2)
 }
 Bend.keep=B[nyr,]
 d.keep=B[nyr,]/mean(K)
 lines(yr,apply(B,1,median),lty=1,lwd=3)
 lines(yr,C,lwd=2,col="#363636",lty=2)
 points(yr,C,pch=21,col=4,bg=4,cex=1.3)
 y1<-seq(0,round(k75,0)*1.1,le=5);
 x1<-seq(1,length(yr),by=1)
 axis(1,at=yr[x1],labels=yr[x1],las=1,cex.axis=1)
 axis(2,at=y1,labels=format(round(y1/1000,0),3),las=2,cex.axis=1)
 legend(yr[nyr-4],max(y1)*1.05,c("Biomasa","Captura","RMS"),lty=c(1,2,2),
 col=c(1,"#363636",2),pch=c(NA,21,NA),lwd=c(2,2,2),pt.bg=c(NA,4,NA),cex=1.3,bty="n")
 BC<-expression(paste('Biomasa (%*%'1000 ton) y Captura (ton)',sep=""))
 mtext(BC,side=2,line=4.0,cex=1)
 mtext("Años",side=1,line=3.5,cex=1)
 if(is.null(msy)){} else {abline(h=msy,lty=2,col=2,lwd=2)}
 msy=K.keep*r.keep/4
 return(list(K.keep,r.keep,msy,Bend.keep,d.keep,B,r,F2Fmsy,B2Bmsy))
}
```

Ingresa datos de captura

```
#
#######################################################################
# input catch data and r range for sautral XI stock
#######################################################################
C=c(4033,5318,4163,7547,5097,3853,653,1352,1839)
yr=seq(2012,2020)
r.lci=0.85;
r.uci=1.2
#######################################################################
# search through K grids, with specific range for K1 follow
#######################################################################
N1=100
K1=exp(seq(log(max(C)),log(max(C)*50),l=N1))
#######################################################################
# genera los valores de la deplecion
#######################################################################
dep=round(seq(0.1,0.8,0.05),2)
nd=length(dep)
r1=obj1=matrix(0,N1,nd)  #matriz que almacena los output de las funciones
b=1#Si (C[1]/max(C)<0.5, (0.5+0.9)/2 (0.3+0.6)/2);b=0.5
# ciclo
for(j in 1:nd){
  for(i in 1:N1){
    out=optimize(BDM,K=K1[i],b=b,C=C,dep=dep[j],
    interval=c(r.lci-.05,r.uci+.05))
    r1[i,j]=out$min
    obj1[i,j]=out$obj
  }
}


#######################################################################
#
#vLinf=58.95;vk=0.28;Tmax=10;Tmat=NA;T=17
#M=vector()
#M[1]=exp(1.44-0.982*log(Tmax))
#M[2]=1.65/Tmat
#M[3]=exp(1.2-0.17*log(vLinf)+log(vk))
#M[4]=1.82*vk
#M[5]=exp(-0.0152-0.279*log(vLinf)+0.6543*log(vk)+0.463*log(T))
#w=0.87 #para teleost y w=0.41 para chondrithys
#r.mean=2*mean(M,na.rm=T)*w
#r.sd=sd(M,na.rm=T)
#r.backup=r
#r[r > r.mean+2*r.sd | r < r.mean-2*r.sd]=NA

############################
r1.backup=r1  ;# r1=r1.backup
r1[obj1 > K1*0.01]=NA
r1[r1 > r.uci | r1 < r.lci]=NA
############################
kr=as.data.frame(cbind(K1,r1))
colnames(kr)=c('k',dep)
```

```r
all=cbind(K1,stack(kr[,2:nd+1]))#antes nd+1
colnames(all)=c("k","r","ind")

all$d=as.numeric(as.character(all$ind))
all=all[,c(1,2,4)]
all=all[!is.na(all[,2]),]
all$msy=all[,1]*all[,2]/4


############################
# estimate reference points
############################
#cutoff=ifelse(tail(C,1)/max(C)<=0.5,0.5,0.8)
all2     =all[!is.na(all$r) & all$d <= 0.45,]#cutoff,assume upper depeltion=0.45
quan1    =apply(all2,2,quantile)
k25      =quan1[,1][2]
k75      =quan1[,1][4]
r25      =quan1[,2][2]
r75      =quan1[,2][4]
msy.media=quan1[,4][3]
all3     =all2[all2$k>k25 & all2$k<k75 & all2$r>r25 & all2$r<r75,]
para     =list(k25=k25,k75=k75,r25=r25,r75=r75)
```
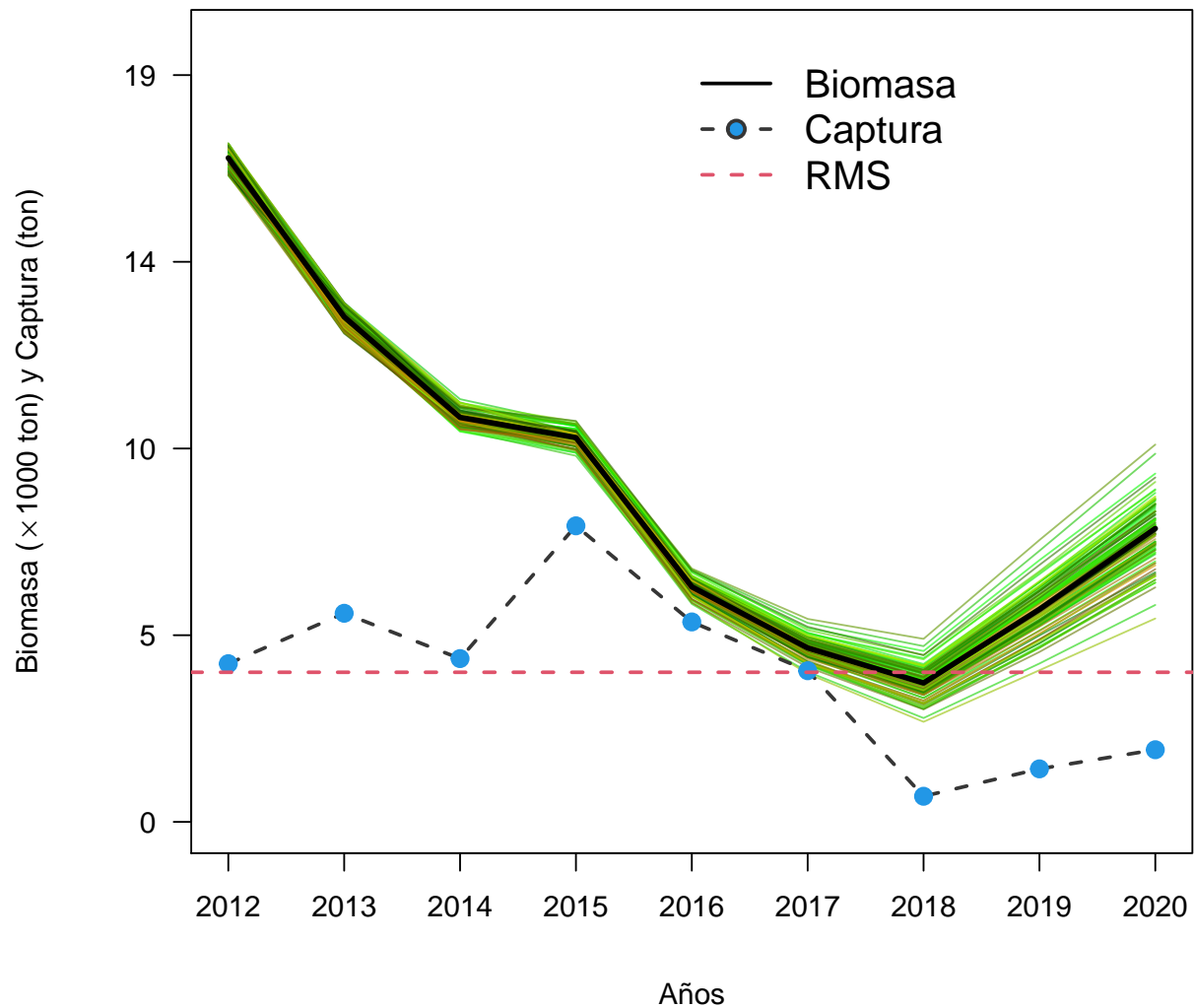
Figura biomasa

```
################################################################################
nsim=100
#GRAFICA LA BIOMASA
par(mar=c(5,5.5,1,1),cex.axis=1.3,cex.lab=1.3)
out1=sim1(k25=k25,k75=k75,r25=r25,r75=r75,C=C,yr=yr,nsim=nsim,msy=msy.media)
```



```
################################################################################
#EXTRAE DATOS DE INTERES PARA LA INCERTIDUMBRE
################################################################################
F2Fmsy   =as.data.frame(out1[8]);
B2Bmsy   =as.data.frame(out1[9])
quant    =function(x)quantile(x,c(0.2,0.8))

dat.out =data.frame(year=yr,
                    B2Bmsy.med=apply(B2Bmsy,1,median),
                    quan1.B=apply(B2Bmsy,1,quant)[1,],
                    quan3.B=apply(B2Bmsy,1,quant)[2,],
```

```
                    F2Fmsy.med=apply(F2Fmsy,1,median),
                    quan1.F=apply(F2Fmsy,1,quant)[1,],
                    quan3.F=apply(F2Fmsy,1,quant)[2,])

BF2msy.end = data.frame(t(rbind(B2Bmsy[length(yr),],F2Fmsy[length(yr),])))
colnames(BF2msy.end)=c("B2Bmsy","F2Fmsy")
#kable(BF2msy.end)
#
out1.backup=out1 #out1=out1.backup
sp=out1[1:5]
sp=as.data.frame(sp)    # summary(sp)
colnames(sp)=c("k","r","msy","Bend","Depletion")
BendD=apply(sp,2,quantile)
###############################################################
#FINAL RESULT
################################################################
tabla<-cbind(quan1[,c(1,2,4)],BendD[,4:5])
write.csv2(tabla,"tabla1.csv",row.names=FALSE)
kable(tabla)
```

	k	r	msy	Bend	Depletion
0%	15989.66	0.8508866	3681.066	5184.100	0.3081813
25%	16473.03	0.8752486	3765.170	6954.839	0.4134472
50%	16634.15	0.9136759	3813.748	7478.541	0.4445799
75%	17304.61	0.9444092	3887.964	7917.629	0.4706826
100%	17304.61	0.9902422	3958.410	9618.272	0.5717814

```
Bioma <-apply(out1.backup[[6]],1,quantile)
#note: Bmsy = k/2, Blim = k/4
B.sim =data.frame(out1[6])
BF    =t(apply(B.sim,1,quantile))
BF    =cbind(BF,C/BF)
BRP   =c(quan1[3,1]/2,quan1[3,2]/2)
fs    =data.frame(cbind(BF[,c(8,3)],yr)) # F y Biomasa media
#GRAFICA BIOMASA V/S CPUE
#plot(yr,BF[,3],type="b",ylab="Biomasa and CPUE")
#par(new=T)
#plot(yr,U,type="b",col=2,axes=F,xlab="",ylab="")
#
```

Sensibilidad

```r
#########################################################
#  sensitivity to assumed upper depletion (if needed) #
#########################################################
med.out=low.out=up.out=matrix(NA,nrow=4,ncol=6)
d.l=c(0.45,0.6,0.7,0.8)  # assumed upper depletion levels
layout(matrix(1:4,ncol=2,byrow=T),widths=c(1,1),heights=c(1,1))
for(i in 1:4){
  all2=all[!is.na(all$r) & all$d <= d.l[i],]
  quan1=apply(all2,2,quantile)
  k25=quan1[,1][2]
  k75=quan1[,1][4]
  r25=quan1[,2][2]
  r75=quan1[,2][4]
  msy.median=quan1[,4][3]
  nsim=100
  ##############################################################################
  #Figura
  par(mar=c(5,5.5,1,1),cex.axis=1.3)
  out1=sim1(k25=k25,k75=k75,r25=r25,r75=r75,C=C,yr=yr,nsim=nsim,msy=msy.media)
  tex=paste("reducción=",d.l[i],sep="")
  text(2015,round(para$k25,0)*0.26,tex,cex=1.2,xpd=T)
  ##############################################################################
  # Tablas
  sp  = out1[1:5]
  sp  = as.data.frame(sp)    # summary(sp)
  colnames(sp)= c('k','r','msy','Bend','D')
  BendD = apply(sp,2,quantile)

  med.out[i,] =(c(quan1[3,],BendD[3,4:5]))
  low.out[i,] =(c(quan1[2,],BendD[1,4:5]))
  up.out[i,]  =(c(quan1[4,],BendD[5,4:5]))

  med.out[,3] =t(d.l)
  low.out[,3] =t(d.l)
  up.out[,3]  =t(d.l)

  colnames(med.out)=c("k","r","d.upper","msy","Bend","D")
  colnames(low.out)=c("k","r","d.upper","msy","Bend","D")
  colnames(up.out)=c("k","r","d.upper","msy","Bend","D")

  kable(med.out)
  kable(low.out)
  kable(up.out)
  ##############################################################################
}
```
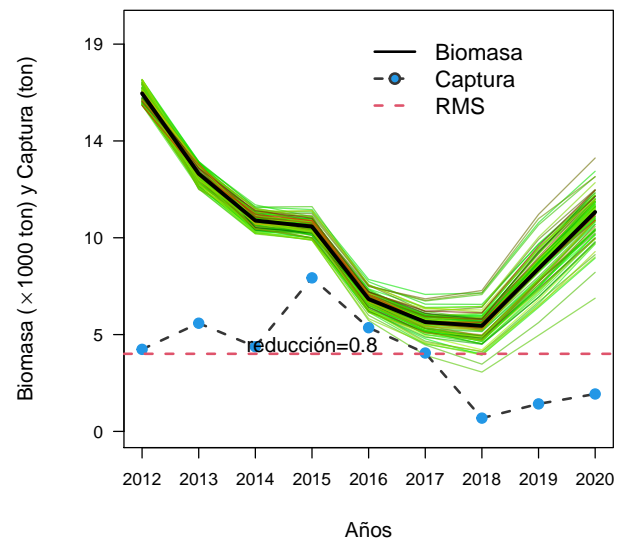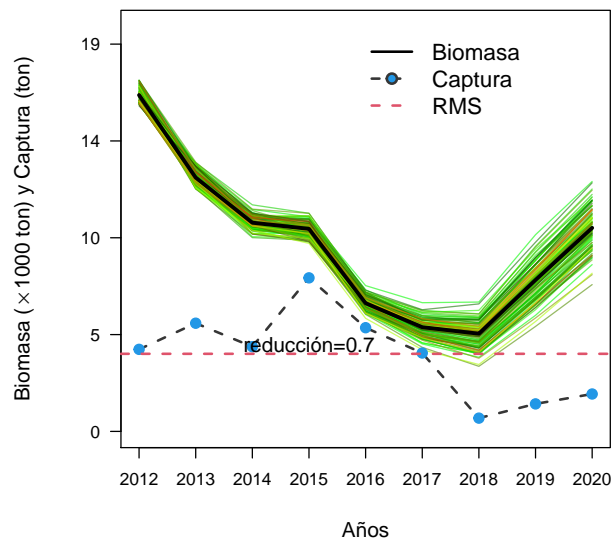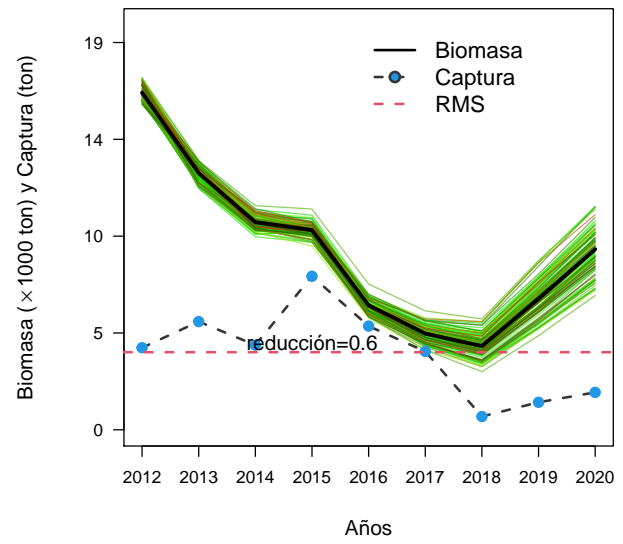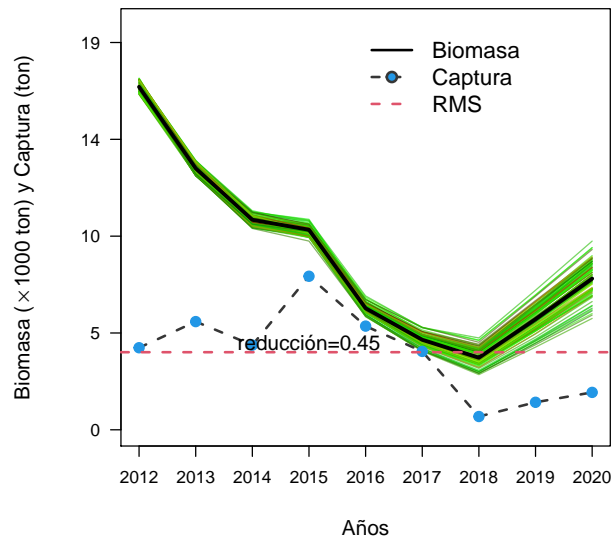
```
########################################################################################
# parameters as a function of assumed upper depletion level
########################################################################################
#name3<-paste(getwd(),"/Figuras/Fig3_Zhou2013_sensitivity.png",sep="")
#png(file=name3,width=900,height=1000)
layout(matrix(1:4,ncol=2,byrow=T),widths=c(1,1),heights=c(1,1))
par(mar=c(5.6,6.7,4,4),cex.axis=1.4)

plot(med.out[,3],med.out[,1]/1000,ylim=c(0,max(med.out[,1]/1000*1.3)),type='l',lwd=2,xlab='',ylab='',la
lines(low.out[,3],low.out[,1]/1000,lty=2);lines(up.out[,3],up.out[,1]/1000,lty=2)
mtext(expression(paste('K ('%*%'1000 ton)')),side=2,line=3.8,cex=1.4)
mtext("Reducción superior",side=1,line=3.6,cex=1.4)

plot(med.out[,3],med.out[,2],ylim=c(0,max(med.out[,2]*1.3)),type='l',lwd=2,xlab='',ylab='',las=1)
mtext('r',side=2,line=3.8,cex=1.4)
mtext("Reducción superior",side=1,line=3.6,cex=1.4)
lines(low.out[,3],low.out[,2],lty=2);lines(up.out[,3],up.out[,2],lty=2)

plot(med.out[,3],med.out[,4]/1000,ylim=c(0,max(med.out[,4]/1000*1.3)),type='l',lwd=2,xlab='',ylab='',la
lines(low.out[,3],low.out[,4]/1000,lty=2);lines(up.out[,3],up.out[,4]/1000,lty=2)
mtext(expression(paste('RMS ('%*%'1000 ton)')),side=2,line=3.8,cex=1.4)
mtext("Reducción superior",side=1,line=3.6,cex=1.4)

plot(med.out[,3],med.out[,6],ylim=c(0,max(med.out[,6]*1.5)),type='l',lwd=2,xlab='',ylab='',las=1)
lines(low.out[,3],low.out[,6],lty=2);lines(up.out[,3],up.out[,6],lty=2)
mtext("Reducción",side=2,line=3.8,cex=1.4)
mtext("Reducción superior",side=1,line=3.6,cex=1.4)
```
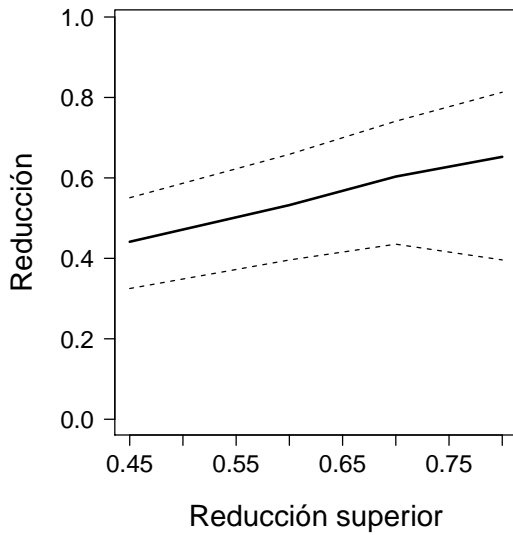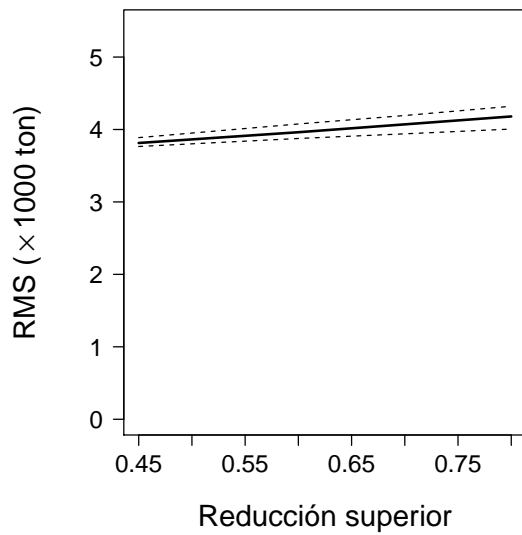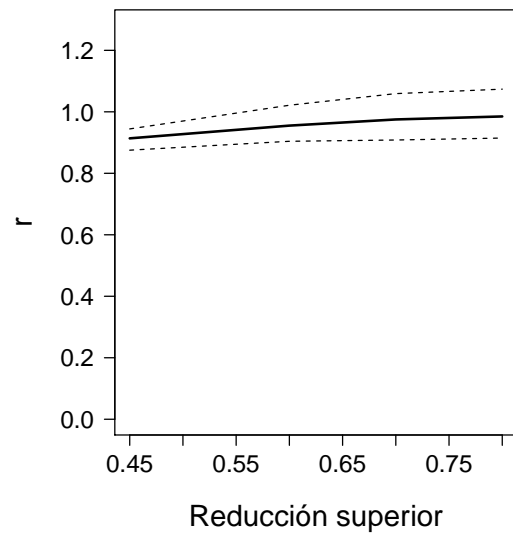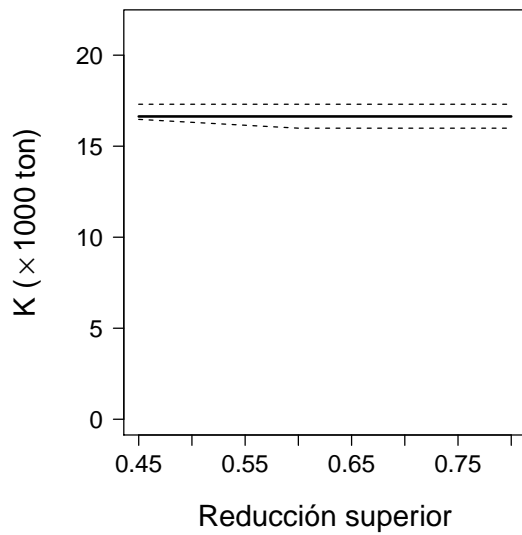
```
#dev.off()

#############################################################################
# GRAFICA DIAGRAMA DE FASE
#############################################################################
library(MASS)

K       <- med.out[1,1]
mc.dat  <-BF2msy.end
Bmrs    <-tabla[3,1]/2 #BMRS
Fmrs    <-tabla[3,2]/2 #FMRS
Fest    <-C/Bioma[3,] #F anual
Y1      <-Fest/Fmrs;
X1      <-Bioma[3,]/Bmrs
```

```r
Z1      <-Bioma[3,]/K
#h=rep(0.13,4)
z<-kde2d(mc.dat[,1],mc.dat[,2],n=100,
lims=c(range(c(0,max(X1))),range(c(0,max(Y1)*1.7))))
est<-z$z/max(z$z);z$z<-est
#Bmrs=43590;Fmrs=0.3515;Fest=C/Bioma[3,]
#Y1<-Fest/Fmrs;X1<-Bioma[2,]/Bmrs
#
soli<-cbind(yr,round(Bioma[3,],0),round(Fest,2),round(Z1,2),round(X1,2),round(Y1,2))
colnames(soli)<-c("year","BT","Fest","B_Bo","Brel","Frel")


kable(soli)
```

year	BT	Fest	B_Bo	Brel	Frel
2012	16925	0.24	1.02	2.04	0.52
2013	12871	0.41	0.77	1.55	0.90
2014	10310	0.40	0.62	1.24	0.88
2015	9795	0.77	0.59	1.18	1.69
2016	5991	0.85	0.36	0.72	1.86
2017	4434	0.87	0.27	0.53	1.90
2018	3540	0.18	0.21	0.43	0.40
2019	5418	0.25	0.33	0.65	0.55
2020	7479	0.25	0.45	0.90	0.54

```r
kable(rbind(Bmrs,Fmrs))
```

Bmrs	8317.0750007
Fmrs	0.4568379

```r
#library(rJava)                                      ## PROBLEMAS CON ESTO
#library(xlsx)
write.csv2(soli,"tabla2.csv",row.names=FALSE)
#DEFINE LAS AREAS DE LOS POLIGONOS
cols<-c("#696969","#A8A8A8","#DEDEDE")
ini<-c(-0.09);
xmax<-max(X1)*1.35;
ymax<-max(Y1)*1.22;
xmin<-(0.08)
pol1<-matrix(c(0.9,ini,0.9,1.1,xmax,1.1,xmax,0.75,1.25,0.75,1.25,ini),
ncol=2,byrow=T)
pol2<-matrix(c(1.25,ini,1.25,0.75,xmax,0.75,xmax,ini),ncol=2,byrow=T)
pol3<-matrix(c(xmax,1.1,xmax,ymax,0.9,ymax,0.9,1.1),ncol=2,byrow=T)
pol4<-matrix(c(0.5,ini,0.9,ini,0.9,ymax,0.5,ymax),ncol=2,byrow=T)
pol5<-matrix(c(-0.07,ini,0.5,ini,0.5,ymax,-0.07,ymax),ncol=2,byrow=T)

#name4<-paste(getwd(),"/Figuras/Fig4_Zhou2013_fase.png",sep="")
#png(file=name4,width=1200,height=1000)
par(mar=c(6.1,6.5,4.8,4.8),cex.axis=1,cex.lab=1)
plot(X1,Y1,col=0,xlab="",ylab="",yaxt="n",xlim=c(xmin,max(X1)*1.1),
ylim=c(0.09,max(Y1)*1.17))
axis(2,las=1)
```

```r
polygon(pol5,col=cols[1],border=1);polygon(pol4,col=cols[2],border=1)
polygon(pol3,col=cols[3],border=1);polygon(pol2,col=cols[3],border=1)
polygon(pol1,col="white",border="black")
#points(mc.dat[,1],mc.dat[,2],pch=21,bg="#B5B5B5",cex=0.9,col=1)
lines(X1,Y1,lty=2,col=1,lwd=2)
lines(X1,Y1,type="p",bg=2,pch=21,cex=1,lwd=2)
abline(v=1,lty=2,col=8,lwd=2);abline(h=1,lty=2,col=8,lwd=2)
abline(v=0.5,lty=2,col=8,lwd=2)
contour(z,drawlabels=FALSE,levels=c(0.1,0.25,0.5,0.75),add=TRUE)
text(0.5,max(Y1)*1.29,expression(PBR[paste("agotamiento")]),cex=1.1,
pos=1,xpd=T)
text(1,max(Y1)*1.29,expression(B[paste("RMS")]),cex=1.1,pos=1,xpd=T)
text(max(X1)*1.19,1.11,expression(F[paste("RMS")]),cex=1.1,pos=1,xpd=T)
mtext(expression(paste("Biomasa total relativa a ",B[paste("RMS")],sep="")),
side=1,line=4.2,cex=1.2)
mtext(expression(paste("Mortalidad por pesca relativa a ",F[paste("RMS")],
sep="")),side=2,line=3.8,cex=1.2)
#a2<-which(yr%in%seq(2015,1994,by=-2)==TRUE)
a2<-c(1,2,3,4,5,6,7,8,9)
text(X1[a2],Y1[a2]*1.06,yr[a2],cex=1,pos=4,col=4)
#text(1.10,0.83,"Plena Explotación",cex=1.6,pos=4,col=1,lwd=2)
#text(1.56,0.31,"Sub Explotación",cex=1.6,pos=4,col=1,lwd=2)
#text(1.33,1.51,"Sobrepesca",cex=1.6,pos=4,col=1,lwd=2)
#text(0.58,0.67,"Sobre",cex=1.6,pos=4,col=1,lwd=2)
#text(0.52,0.51,"Explotación",cex=1.6,pos=4,col=1,lwd=2)
#text(0.68,1.18,"Sobre-explotación y Sobrepesca",cex=1.6,pos=4,lwd=2,srt=90)
#text(0.23,1.18,"Colapso y/o Agotamiento",cex=1.6,pos=4,lwd=2,srt=90)
box()
```
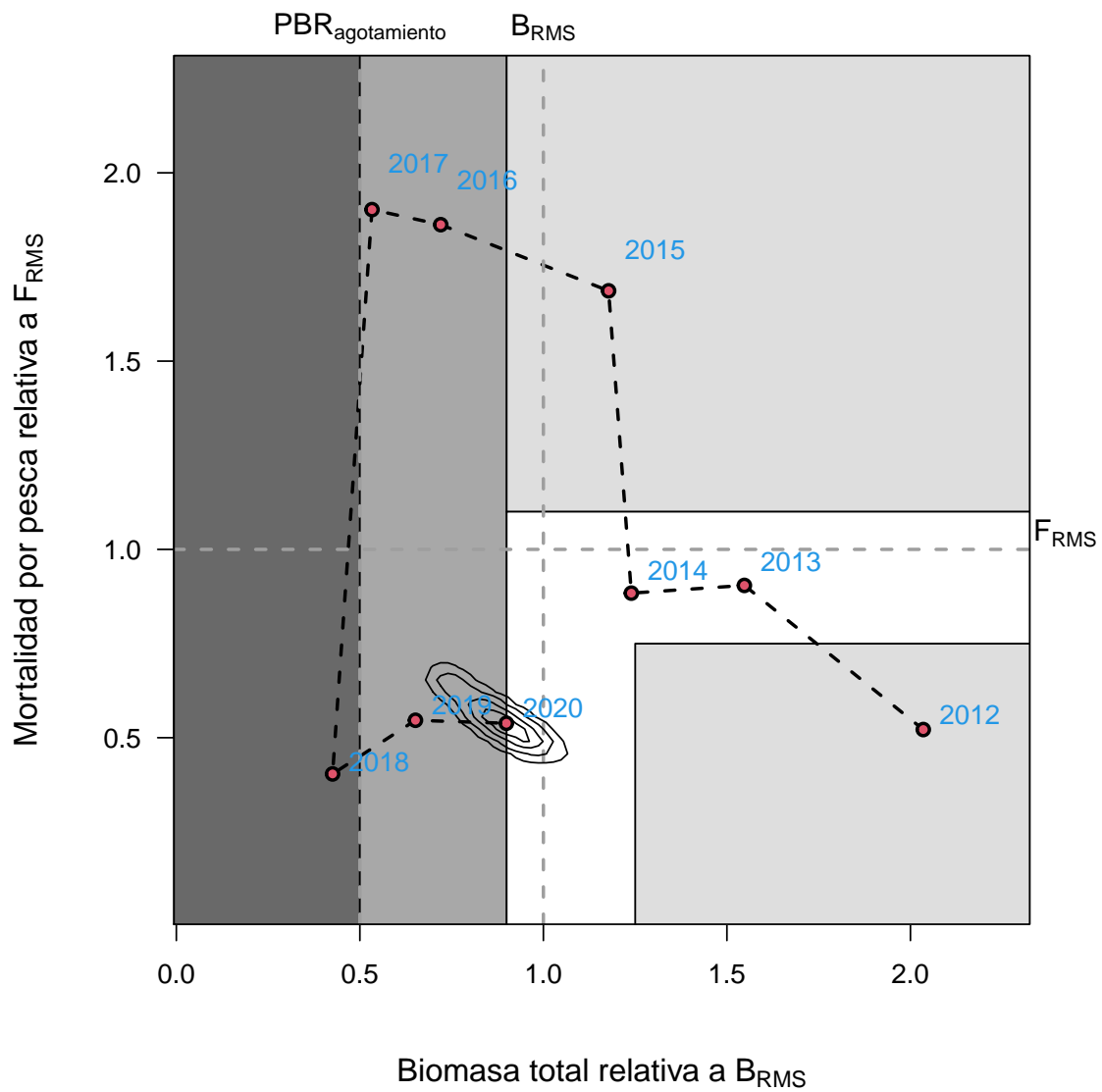
```
#dev.off()
```

Cálculo de CBA

```r
################################################################################
#CALCULO DE LA CBA  PARA SARDINA AUSTRAL XI
################################################################################
mata <-out1.backup[1:5];
mm   <-length(mata)
mato <-vector()

for(p in 1:mm){
  mato <-cbind(mato,mata[[p]])}
  mate <-as.data.frame(mato)
  colnames(mate)<-c("k","r","msy","Bend","Depletion")

yy      <-length(yr)
prob    <-c(0.6666667,1.00,1.25) # pnderadores de Frms
ss      <-dim(sp)
yrs_pro <-seq(yr[yy],yr[yy]+11,by=1) # años de proyección
yyp     <-length(yrs_pro)

BT=CT=array(NA,c(length(prob),ss[1],length(yrs_pro)))

BT[,,1] <-Bioma[3,yy]
CT[,,1] <-C[yy]
Fi      <-Fmrs*prob

# y = Frms ponderados
# n = número de simulaciones
# m = años de proyección

for(y in 1:length(Fi)){
 for(n in 1:ss[1]){
  ki=sp$k[n] # parámetro K simulado
  ri=sp$r[n] # parámetro r simulado
  for(m in 1:(yyp-1)){ # PROYECCIÓN
   if(m==1){
     CT[y,,1]=C[yy]} # igual a la captura del último año
    else {
      CT[y,n,m]=BT[y,n,m]*Fi[y]} # captura proyectada
      BT[y,n,m+1]=BT[y,n,m]+ri*BT[y,n,m]*(1-BT[y,n,m]/ki)-CT[y,n,m] # biomasa total proyectada
    if(m==(yyp-1)){
      CT[y,n,m+1]=BT[y,n,m+1]*Fi[y]}
  }
 }
}

################################################################################
# GRAFICA LA CBA 2 PARA sardina austral
################################################################################
FF   <-formatC(Fi,format="f",digits=2)
BB   <-expression(paste("Biomasa (mil t)",sep=""))
Binf <-tabla[2,1]/2
Bsup <-tabla[4,1]/2
rng1 <-range(BT[,,],na.rm=T)
```
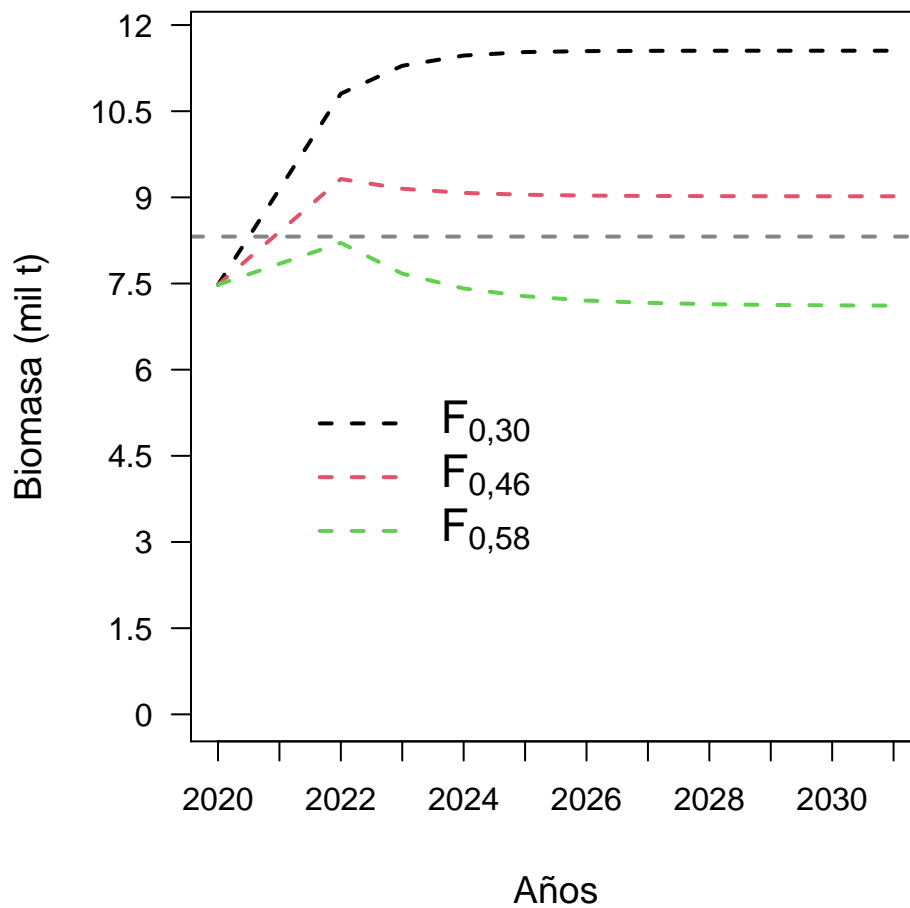
14

```
ax2  <-seq(0,rng1[2]*1.15,by=1500)
cols <-"#858585"
y1   <-length(yrs_pro)
xxxx<-matrix(ncol=3,nrow=11)

par(mar=c(5,5,1,1),cex.axis=1,cex.lab=1)
plot(yrs_pro[-2],seq(0,rng1[2]*1.15,le=(y1-1)),col=0,type="o",xlab="",ylab="",yaxt="n",ylim=c(0,rng1[2]*

for(x in 1:length(Fi)){
  xxxx[,x]<-apply(BT[x,,],2,quantile)[3,-2]
 lines(yrs_pro[-2],xxxx[,x],col=x,lty=2,lwd=2)
}
abline(h=Bmrs,lty=2,lwd=2,col=cols)
axis(2,at=ax2,labels=ax2/1000,las=1,cex=1)
mtext(BB,side=2,line=3.5,cex=1.2)
mtext("Años",side=1,line=3.4,cex=1.2)
legend(2021,rng1[2]*0.5,c(expression(F[paste("0,30")]),expression(F[paste("0,46")]),
expression(F[paste("0,58")])),lty=c(2,2,2,2,2),lwd=c(2,2,2,2,2),cex=1.4,
col=c(1,2,3),bty="n")
```



```
################################################################################
# GRAFICA LA CAPTURA
################################################################################
```

```
CC    <-expression(paste("Captura (mil t )",sep=""))
MRS   <-tabla[3,3] #50%
rng2 <-range(CT[,,],na.rm=T)
ax3   <-seq(0,rng2[2]*1.15,by=1000)

xxxx<-matrix(ncol=3,nrow=11)

par(mar=c(5,5,1,1),cex.axis=1,cex.lab=1)
plot(yrs_pro[-2],seq(0,rng2[2]*1.15,le=11),col=0,type="o",xlab="",ylab="",yaxt="n",ylim=c(0,rng2[2]*0.95

for(x in 1:length(Fi)){
  xxxx[,x]<-apply(CT[x,,],2,quantile)[3,-2]
 lines(yrs_pro[-2],xxxx[,x],col=x,lty=2,lwd=2)
}
abline(h=MRS,lty=2,lwd=2,col=cols)
axis(2,at=ax3,labels=sprintf("%0.0f",ax3/1000),las=1,cex=1.4)
mtext(CC,side=2,line=3.5,cex=1.2)
mtext("Años",side=1,line=3.4,cex=1.2)
legend(2021,rng2[2]*0.5,c(expression(F[paste("0,30")]),expression(F[paste("0,46")]),
expression(F[paste("0,58")])),lty=c(2,2,2,2,2),lwd=c(2,2,2,2,2),cex=1.4,
col=c(1,2,3),bty="n")
```
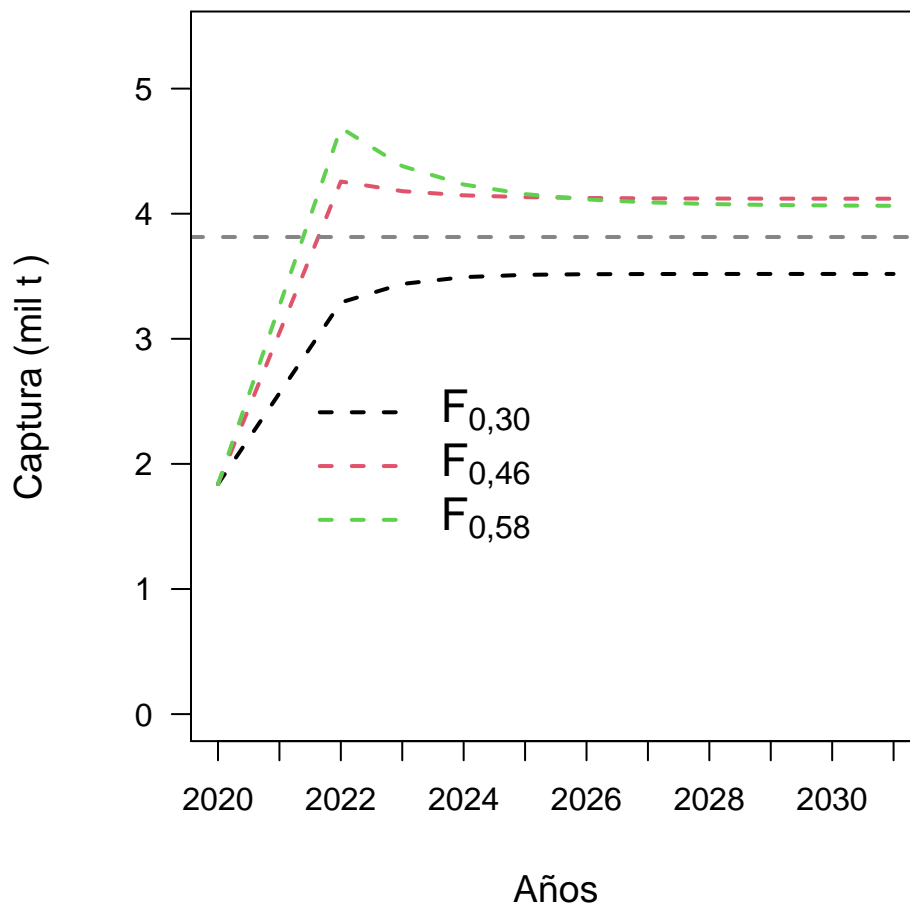
```
######################################################################################
# TABLA DE RESULTADOS CAPTURA 2021
######################################################################################
ct<-matrix(NA,length(Fi),5)
for(i in 1:length(Fi)){
 ct[i,]<-as.numeric(quantile(CT[i,,2],probs=c(.1,.2,.3,.4,.5)))  # CT[i,,2] (el 2 representa 1 año de p
}
colnames(ct)<-c("10%","20%","30%","40%","50%")
rownames(ct)<-formatC(Fi,format="f",digits=2)
cat("\n")

print(ct)
```

```
##           10%      20%      30%      40%      50%
## 0.30 2944.677 2949.502 2955.280 2963.020 2967.849
## 0.46 4417.015 4424.252 4432.919 4444.530 4451.773
## 0.57 5521.269 5530.316 5541.149 5555.662 5564.716
```

```
######################################################################################
# TABLA DE RESULTADOS biomasa 2021
######################################################################################
bt<-matrix(NA,length(Fi),5)
for(i in 1:length(Fi)){
 bt[i,]<-as.numeric(quantile(BT[i,,2],probs=c(.1,.2,.3,.4,.5)))  # CT[i,,2] (el 2 representa 1 año de p
}
colnames(bt)<-c("10%","20%","30%","40%","50%")
rownames(bt)<-formatC(Fi,format="f",digits=2)
cat("\n")

print(bt)
```

```
##          10%      20%      30%      40%      50%
## 0.30 9668.67 9684.512 9703.483 9728.898 9744.753
## 0.46 9668.67 9684.512 9703.483 9728.898 9744.753
## 0.57 9668.67 9684.512 9703.483 9728.898 9744.753
```

```
year<-seq(2012,2021)
bioHil<-c(NA,17712,12394,11186,6911,5161,4212,6108,7933,8592)

par(mar=c(5,5,1,1),cex.axis=1,cex.lab=1)
plot(year,c(soli[,2],bt[2,5]),type="o",pch=19,ylim=c(0,20000), xaxp=c(2012,2022,10),ylab="Biomasa total
lines(year,bioHil,type="o",col=2,pch=19)
legend(2017,16000,c("Hilborn y Mangel 1997","Zhou 2013"),
       bty="n",lwd=1,pch=19,col=c(2,1), title="Método de estimación")
```
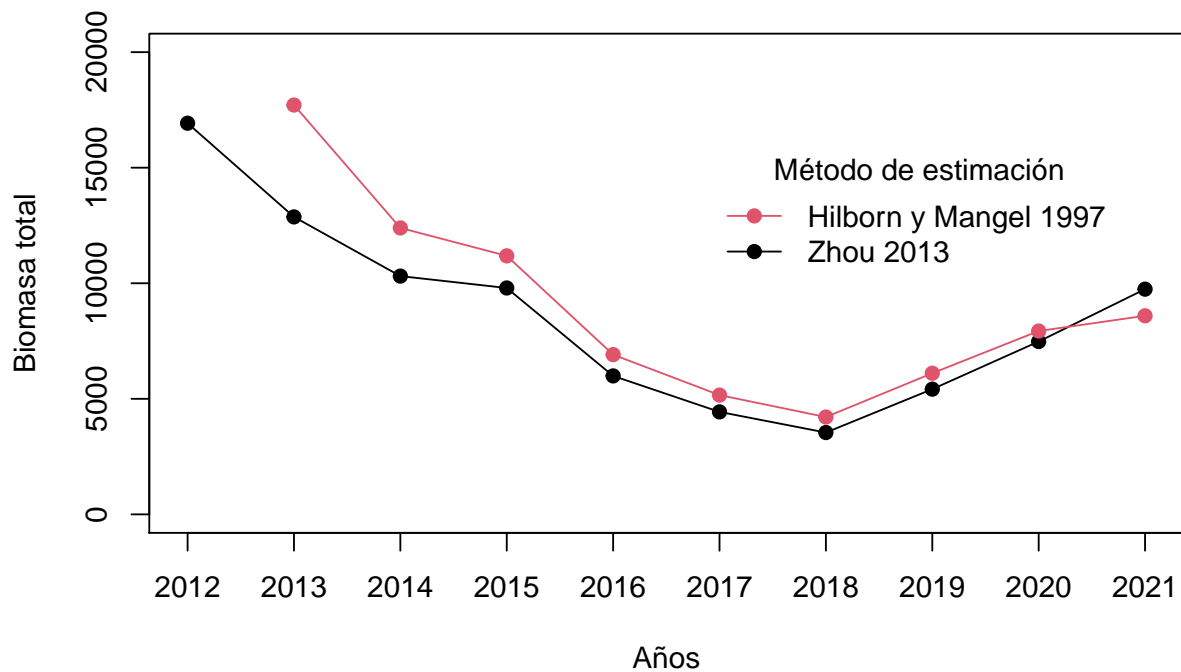
```
###############################################################################
# RANGO CBA PARA PBR Al MRS (2) y EL 2021(2)
###############################################################################
rango<-quantile(CT[2,,2],prob=c(0.025,0.25,0.50,0.75,0.975))

kable(rango)
```

	x
2.5%	4403.471
25%	4428.872
50%	4451.773
75%	4473.140
97.5%	4514.643

```
#
#FIN
```