Recruitment Bias Adjustment in Ricker Model

## 1. Ricker model in BAM, SS, and AMAK and the conversion function

### 1.1 BAM method

E1:

E2:

Here, virgin recruitment and steepness are median values, and

### 1.2 SS method

E3:

E4:

Here, virgin recruitment and steepness are mean values, and

### 1.3 AMAK method (To be compared...)

E5:

E6:

### 1.4 Compare BAM and SS estimates following Erik's method

## True\_Median\_R0=1e+06  
## True\_Median\_h=0.75  
## BAM\_Median\_R0=1000000.0000007  
## BAM\_Median\_h=0.751697762807624  
## SS\_Mean\_R0=1242388.30382867  
## SS\_Mean\_h=0.930889947871603

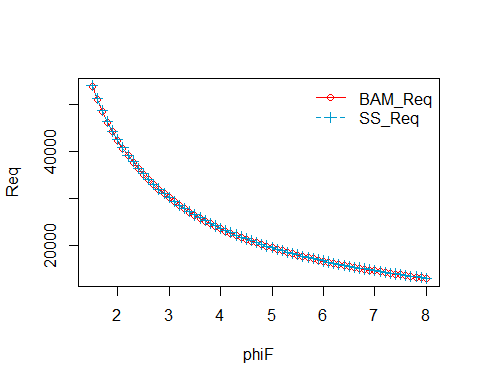


Figure 1. Equilibrium R over phiF from BAM (red solid line) and SS (blue dash line). **It demonstrates that with correct conversion from median to mean values, BAM and SS should produce almost identical estimates.**

### 1.5 Conversion function

#### 1.5.1 The conversion function following Chris's method

convertSRparms <- function(R0, h, phi, sigmaR, mean2med){  
 BC <- ifelse(mean2med == TRUE, exp(-0.5 \* sigmaR^2), exp(0.5 \* sigmaR^2))  
 S0BC <- R0 \* phi \* (1 + log(BC) / h)  
 R0BC <- S0BC / phi  
 Rnew <- BC \* 0.2 \*S0BC / phi \* exp(h \* (1 - 0.2 \* S0BC/ (R0 \* phi)))  
 hBC <- Rnew /R0BC  
 return(list(S0BC = S0BC, R0BC = R0BC, hBC = hBC))  
}

#### 1.5.2 Inputs (Median R0, median h, phi, sigmaR, mean2med) and outputs (Mean R0BC and mean hBC)

## R0=1e+06  
## h=0.75  
## phi=0.01025625  
## sigmaR=0.6  
## mean2med=FALSE  
## R0BC=1240000  
## hBC=0.420867209283096

**The converted mean steepness (hBC) is different compared to the SS\_Mean\_h from section 1.4.**

#### 1.5.3 Validation check

BC <- ifelse(mean2med == TRUE, exp(-0.5 \* sigmaR^2), exp(0.5 \* sigmaR^2))  
S.vec <- seq(0, R0 \* phi, length.out = 1000)  
R.vec <- S.vec / phi \* exp(h \* (1 - S.vec/ (R0 \* phi)))  
R.vecBC <- R.vec \* BC  
R.calc <- S.vec / phi \* exp(p$hBC \* (1 - S.vec / (p$R0BC \* phi)))  
diff <- R.calc - R.vecBC  
range(diff)

## [1] -228384.5 0.0

plot(S.vec, R.vecBC, col="red", xlab="SSB", ylab="R", type="l", lty=1)  
lines(S.vec, R.calc, col="deepskyblue3", lty=2)  
legend("topleft",   
 legend=c("BAM\_R", "SS\_R"),   
 col=c("red", "deepskyblue3"),   
 lty=c(1,2),  
 bty="n")

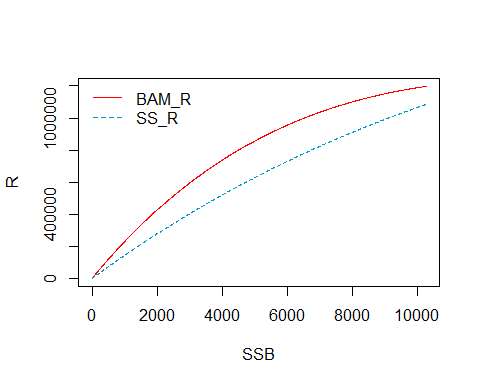


Figure 2. Mean recruitment over SSB from BAM (red solid line) and SS (blue dash line). **The estimates from BAM and SS are not identical like the results from section 1.4. The conversion of steepness needs to be checked, so I read Dorn 2002 paper to seek a solution.**

## 2. Ricker model from Dorn 2002 and the conversion function

### 2.1 Curvature parameter and steepness from Dorn 2002

The Ricker curve with paramters median virgin recruitment and curvature parameter is

E7:

The steepness from Dorn 2002 is

E8:

E9:

E10:

The curvature parameter from Dorn 2002 is

E11:

The euqations were derived following [Mangel et al. 2009](https://www.researchgate.net/publication/267878032_Estimating_stock-recruitment_steepness_from_life_history_information_A_case_study_of_north_Pacific_bluefin_tuna_Thunnus_orientalis) and [Sampson 2008](http://oregonstate.edu/instruct/fw431/sampson/LectureNotes/15-Recruitment3.pdf).

The from Dorn 2002 is equivalent to the steepness in BAM and SS (E1-E4).

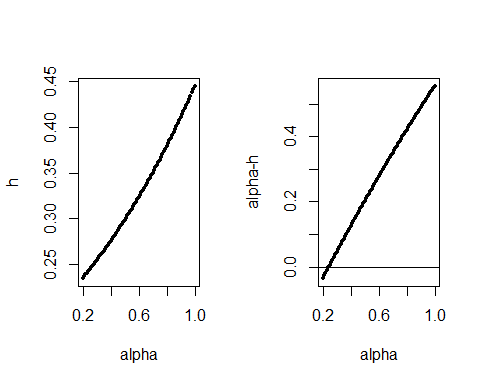


Figure 3. The difference between and steepness in Ricker model from Dorn 2002.

### 2.2 The final conversion function with consideration of conversion between and true steepness in Dorn 2002:

**hBC <- 1.25*log(5*Rnew /R0BC)**

convertSRparms <- function(R0, h, phi, sigmaR, mean2med){  
 BC <- ifelse(mean2med == TRUE, exp(-0.5 \* sigmaR^2), exp(0.5 \* sigmaR^2))  
 S0BC <- R0 \* phi \* (1 + log(BC) / h)  
 R0BC <- S0BC / phi  
 Rnew <- BC \* 0.2 \*S0BC / phi \* exp(h \* (1 - 0.2 \* S0BC/ (R0 \* phi)))  
 hBC <- 1.25\*log(5\*Rnew /R0BC)  
 return(list(S0BC = S0BC, R0BC = R0BC, hBC = hBC))  
}

### 2.3 Inputs (Median R0, median h, phi, sigmaR, mean2med) and outputs (Mean R0BC and mean hBC)

## R0=1e+06  
## h=0.75  
## phi=0.01025625  
## sigmaR=0.6  
## mean2med=FALSE  
## R0BC=1240000  
## hBC=0.93

**The converted mean steepness (hBC) is the same compared to the SS\_Mean\_h from section 1.4.**

### 2.4 Validation check

BC <- ifelse(mean2med == TRUE, exp(-0.5 \* sigmaR^2), exp(0.5 \* sigmaR^2))  
S.vec <- seq(0, R0 \* phi, length.out = 1000)  
R.vec <- S.vec / phi \* exp(h \* (1 - S.vec/ (R0 \* phi)))  
R.vecBC <- R.vec \* BC  
R.calc <- S.vec / phi \* exp(p$hBC \* (1 - S.vec / (p$R0BC \* phi)))  
diff <- R.calc - R.vecBC  
range(diff)

## [1] -2.328306e-10 4.656613e-10

plot(S.vec, R.vecBC, col="red", xlab="SSB", ylab="R", type="l", lty=1)  
lines(S.vec, R.calc, col="deepskyblue3", lty=2)  
legend("topleft",   
 legend=c("BAM\_R", "SS\_R"),   
 col=c("red", "deepskyblue3"),   
 lty=c(1,2),  
 bty="n")

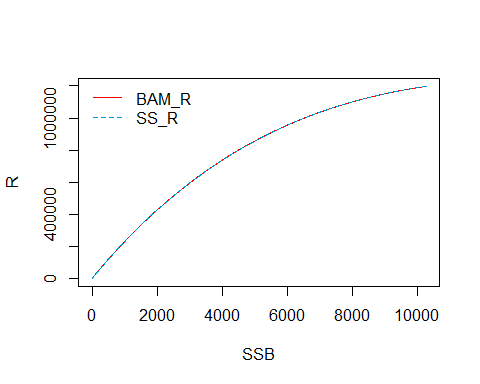


Figure 4. Mean recruitment over SSB from BAM (red solid line) and SS (blue dash line). **The estimates from BAM and SS are identical, like the results from section 1.4. The final conversion function is correct.**

### 2.5. Median and mean virgin recruitment and steepness over a range of steepness and sigmaR

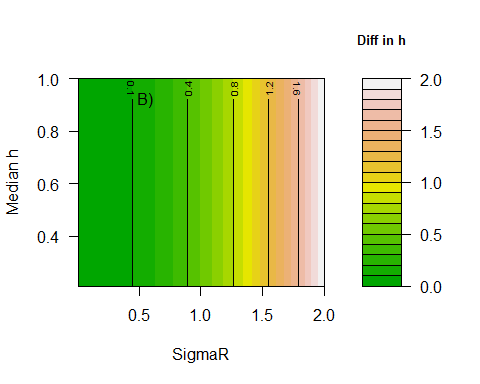
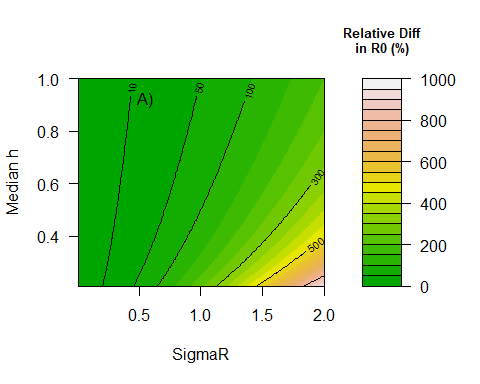


Figure 5. A) Relative difference in virgin recruitment (%; ) over possible combination of median steepness and standard deviation of recruitment using the stock-recruitment parameters conversion function. B) Difference in steepness () over possible combination of median steepness and standard deviation of recruitment using the stock-recruitment parameters conversion function.