Estimation of constant stock-recruitment parameters for mixed fisheries Management Strategy Evaluation

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FishKOSM Project

FishKOSM Project

Mixed fisheries, MSY ranges and Management Strategy Evaluation

Investigate the performance of MSY reference values and ranges to provide practical and operational advice on the management of mixed demersal fisheries.

FishKOSM Project

FLBEIA toolbox which facilitates the development of bio-economic impact assessments of fisheries management strategies.

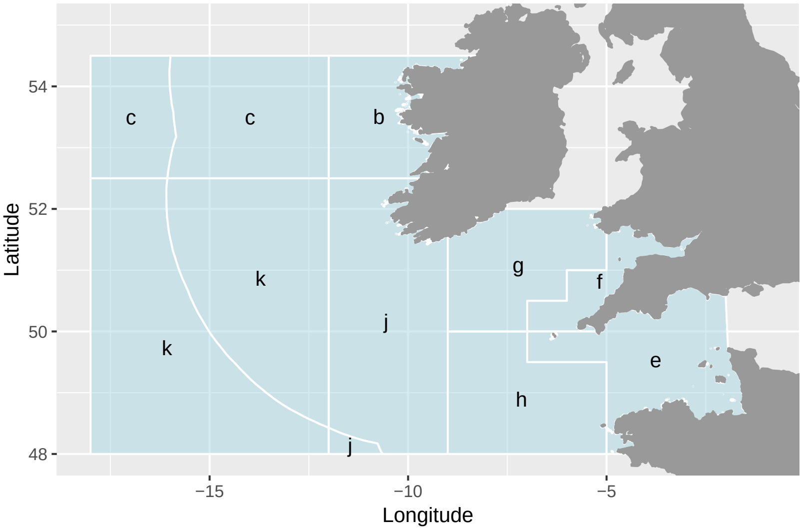
The simulation is divided in two worlds:

- the operating model (OM, the real world)
- the management procedure model (MPM, the perceived world)

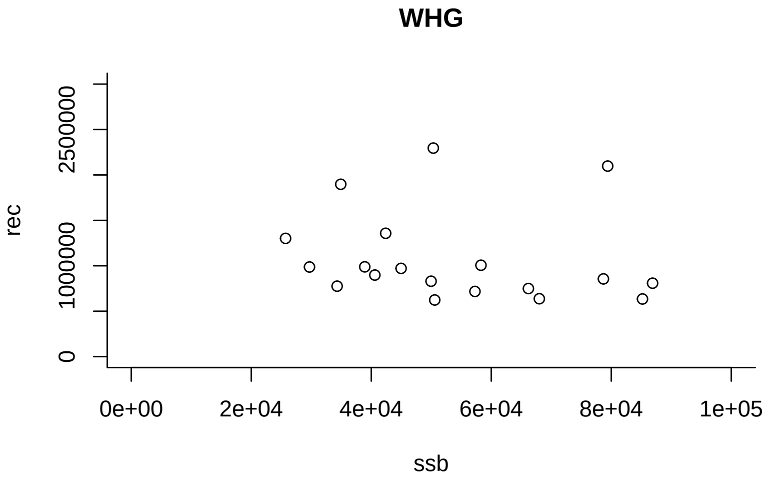
Estimation of S-R parameters

Study area

Divisions 7.e-k (Eastern English Channel and Southern Celtic Seas)



Data



[0]Data from the ICES Stock Assessment Graphs database <http://sg.ices.dk> for the period (1999 - 2017)

Standard estimation of the S-R parameters

The Beverton and Holt stock recruitment relationship

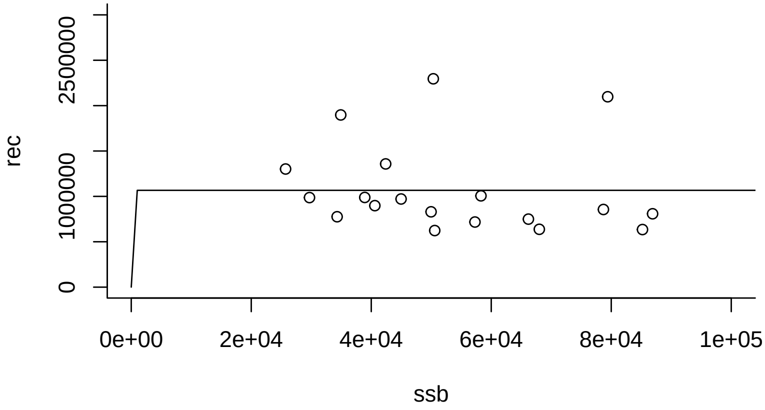
$$R = \frac{\alpha B}{\beta + B}$$

Where

- R : the recruitment
- B : the spawing stock biomass
- α : the maximum rectruitment
- β : the spawing stock biomass needed to produce $\alpha/2$

Standard estimation of the S-R parameters

Direct estimation of α and β using a likelihood function



Estimation of the S-R parameters using **the steepness h**

The Beverton and Holt stock recruitment relationship

$$R = \frac{B}{\alpha + \beta B}$$

Where

- R : the recruitement
- B : the spawing stock biomass
- α : the inverse of the initial slope of the curve
- β : the inverse of asymptotic recruitment

Estimation of the S-R parameters using **the steepness h**

α and β parameters

$$\alpha = \frac{S_0}{R_0}\frac{1-h}{4h}$$

$$\beta = \frac{5h-1}{4hR_0}$$

Where

- R_0 : the recruitment when $F = 0$
- h : the steepness parameter defined as the proportion of unfished recruitment R_0 produced by 20% of unfished population (spawning biomass S_0)
- S_0 : the spawing stock biomass when at $F = 0$

[0]from Mangel et al. 2009

Estimation of the S-R parameters using **the steepness h**

The Beverton-Holt spawner-recruit function expressed with steepness parameter

$$R = \frac{0.8 R_0 h S}{0.2 S_0 (1-h) + (h-0.2) S}$$

Where

- R : the recruitement
- R_0 : the unfished recruitment
- h : the steepness parameter defined as the proportion of unfished recruitment R_0 produced by 20% of unfished population (spawning biomass S_0)
- S : the spawing stock biomass

[0] from Mace and Doonan 1988

Estimation of the S-R parameters using **the steepness h**

Etimation of N by age when $F = 0$

$$N_{a+1} = N_a e^{-M_a}$$

- N : Abundance of Whiting
- M_a : Natural mortality
- a : age

[0] data from ICES WGCSE REPORT 2017

Estimation of the S-R parameters using **the steepness h**

Etimation of S by age when $F = 0$

$$S_0 = \sum_{a=0}^{T} N_a W_a Mat_a$$

Where

- S_0 : the unfished spawing biomass
- N_a : the number at age
- W_a : the weight at age
- Mat_a : the maturity at age

[0] data from ICES WGCSE REPORT 2017

Estimation of the S-R parameters using **the steepness h**

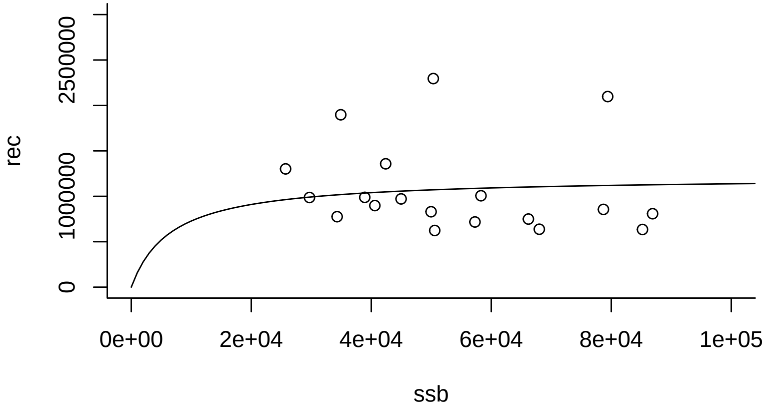
Using a fixed value for the steepness parameter

- Estimation of α and β using a likelihood function
- $h = 0.81$

[0] from Myers et al. 1999

Estimation of the S-R parameters using **the steepness h**

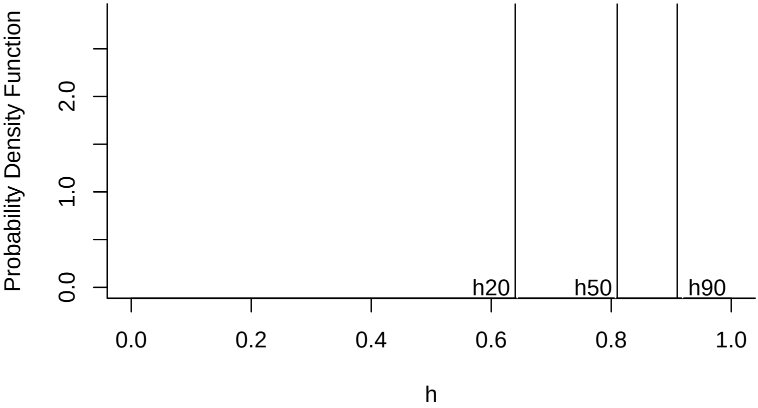
Using a fixed value for the steepness parameter



Estimation of the S-R parameters using **the steepness h**

Adding a prior on the steepness parameter

Estimated from (*Myers et al. 1999*)



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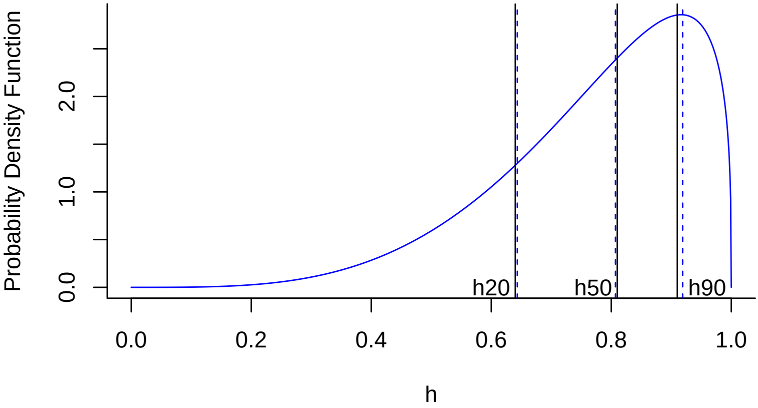

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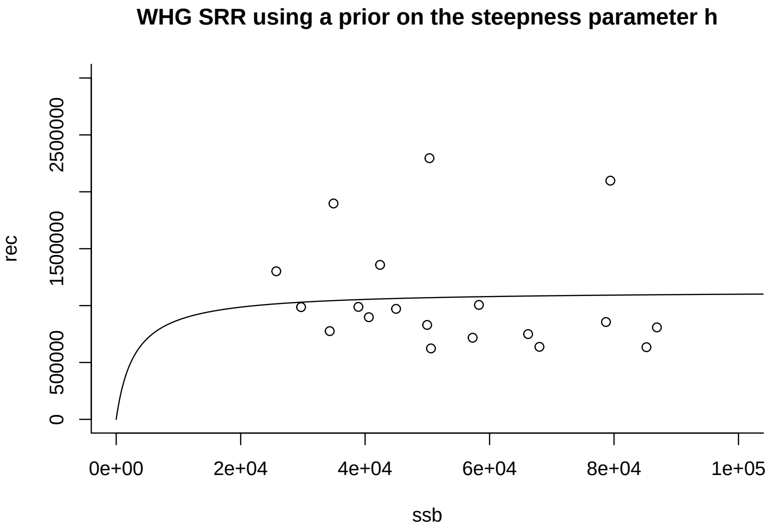
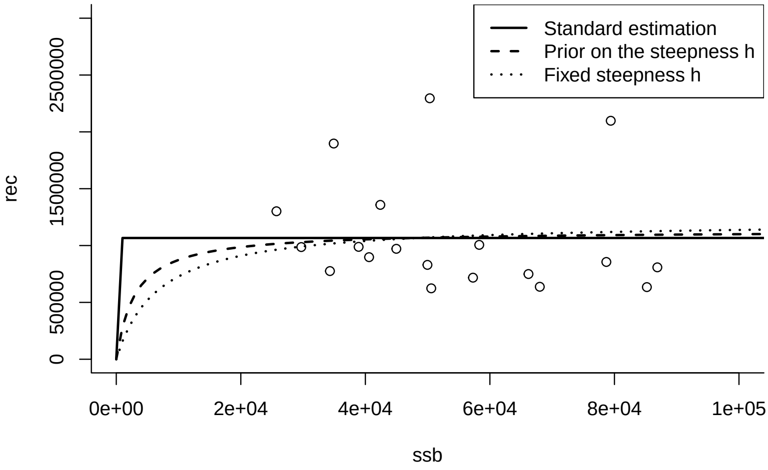


Estimation of the S-R parameters



R Code

Standard estimation of the S-R parameters

Direct estimation of α and β using a likelihood function

```
LL <- function(par){
  a <- exp(par[1])
  b <- exp(par[2])
  c <- exp(par[3])

  R <- a*ssb / (b+ssb)

  ll = dlnorm(rec, meanlog = log(R)-(c^2)/2, sdlog = c, log = T)
  -sum(ll)
}

LL_opt_WHG <- optim(par = log(c(15e3, 1e4, 2)),  fn = LL)
```

Estimation of the S-R parameters using **the steepness h**

Using a fixed value for the steepness parameter

```
## likelihood function
LL <- function(par) {

  R0 <- exp(par[1])
  c <- exp(par[2])

  M <- M # vector of natural mortality by age
  N <- rep(NA, 7)
  N[1] <- R0
  for (i in 1:6) {
    N[i+1] <- N[i]*exp(-M[i])
  }

  data$N <-N
  S <- apply(data, 1, function(x) x[2]*x[3]*x[4])
  S0 <- sum(S)

  R <- 0.8*R0*h*ssb / (0.2*S0*(1-h) + ssb*(h-0.2))

  ll = dlnorm(rec, meanlog = log(R)-(c^2)/2, sdlog = c, log = T)
  -sum(ll)
}

LL_opt <- nlminb(start = log(c(10000, 0.2)),  objective = LL)
```

Estimation of the S-R parameters using **the steepness h**

Adding a prior on the steepness parameter

Estimation of the distribution of the prior

```
#  adding a prior for the steepness parameter
zmed <- 0.81
z20 <- 0.64
z80 <- 0.91

## sum of square of the difference at z20 and z80
ssq <- function(alpha){
  beta <- (alpha - 1/3) / zmed - alpha + 2/3
  z20.pred <- qbeta(p = 0.2, shape1 = alpha, shape2 = beta)
  z80.pred <- qbeta(p = 0.8, shape1 = alpha, shape2 = beta)
  return((z20.pred-z20)^2 + (z80.pred-z80)^2)
}

fit <- optim(par = 2, fn = ssq, method = "Brent", lower = 1, upper = 50)

alpha.hat <- fit$par
beta.hat <- (alpha.hat - 1/3) / zmed - alpha.hat + 2/3
```

Estimation of the S-R parameters using **the steepness h**

Adding a prior on the steepness parameter

```
# Likelihood function : Estimation of R0 using a prior en h
LL <- function(par) {

  # parameters to estimate
  R0 <- exp(par[1])
  sdev <- exp(par[2])
  h <- exp(par[3])

  # abundance by age class
  N <- rep(NA, 8)
  N[1] <- R0
  for (i in 1:7) {
    N[i+1] <- N[i]*exp(-M[i])
  }

  # S0
  data$N <- N
  S <- apply(data, 1, function(x) x[2]*x[3]*x[4])
  S0 <- sum(S)

  R <- 0.8*R0*h*ssb / (0.2*S0*(1-h) + ssb*(h-0.2))

  ll = dlnorm(rec, meanlog = log(R)-(sdev^2)/2, sdlog = sdev, log = T)
  llp <- ll + dbeta(h, shape1 = alpha.hat, shape2 = beta.hat) # adding the prior

  -sum(llp)
}

LL_opt <- nlminb(start = log(c(10000, 0.2, 0.8)),  objective = LL)

R0.hat <- exp(LL_opt$par[1])
```