Proxies for Fmsy ranges using predictive linear models. Notes

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Contents

1 Introduction

```
library(lattice)
library(MASS)
library(xtable)
library(ggplotFL)
FmsyRanges <- read.csv("FmsyRanges.csv")
FmsyWW <- read.csv("FmsyWW.csv")
load("cod55.mse2")
```

The objective of this analysis was to get provisional estimates of Fmsy ranges for the stocks harvested in the European Western Waters, which were included in the WW multi-annual plans analysis[1].

```
kable(FmsyWW)
```

MAP	stock	Fmsy
NWW	Cod CS	0.40
NWW	Haddock CS+WoS	0.33
NWW	Whiting CS	0.32
SWW	Hake (south)	0.24
SWW	Hake (north)	0.27
SWW	Horse Mackerel (South)	0.11
SWW	Megrim IB&BoB	0.17
SWW	Sole BoB	0.26
SWW	Blue whiting	0.30
SWW	4 Spot Megrim 8C9A	0.17
SWW	Horse Mackerel (Western)	0.13

2 ICES Fmsy estimates

The data provided by ICES in its report "EU request to ICES to provide FMSY ranges for selected North Sea and Baltic Sea stocks" formed the basis for the analysis presented here.

[1] Need to clarify which monkfish stocks are included

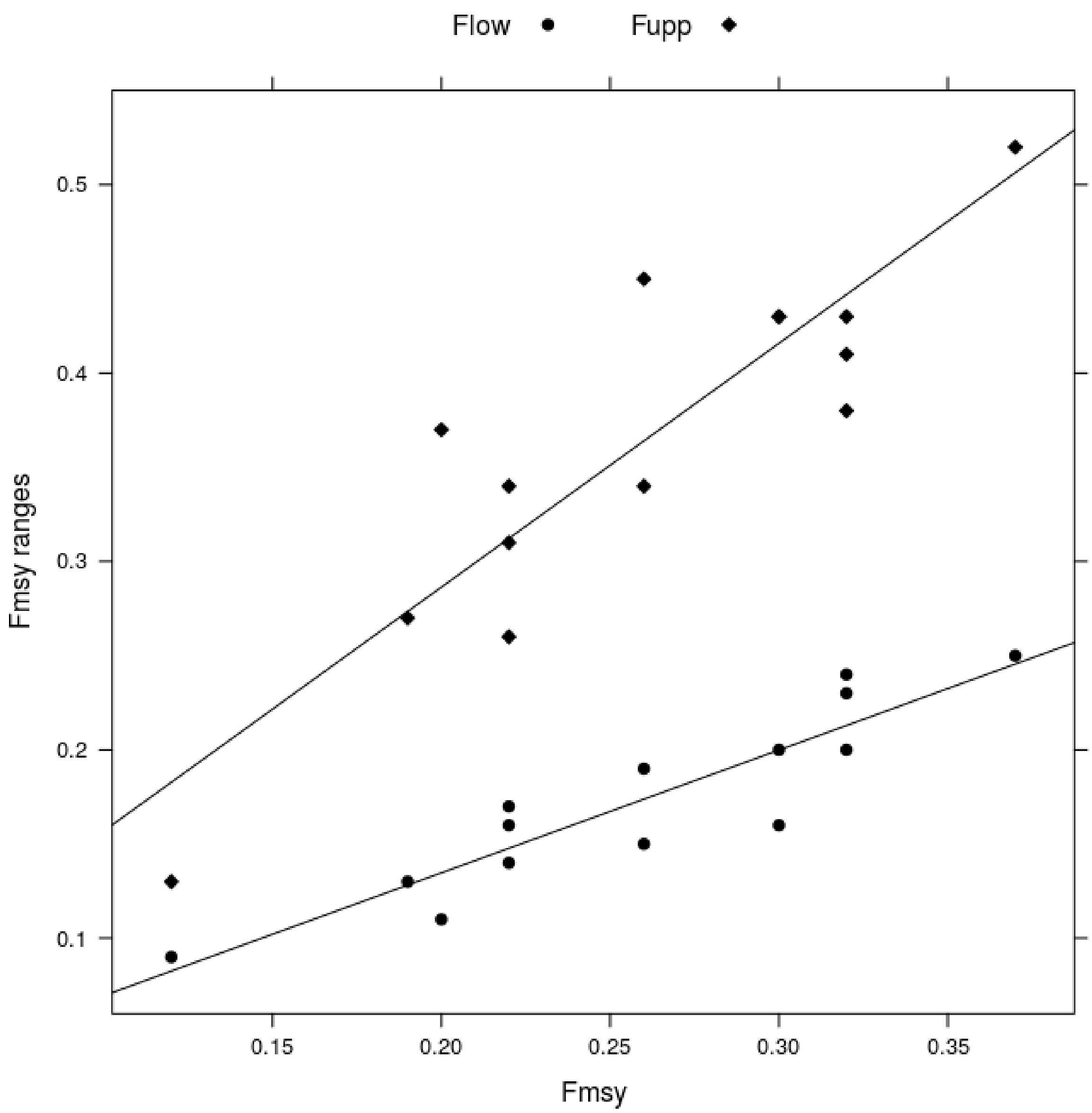
```r
kable(FmsyRanges)
```

stock	FP.05	FMSY	Flow	Fupp	FP.05AR	FuppnoAR	FuppAR
Cod in Subdivisions 22-24	0.57	0.26	0.15	0.45	0.66	0.45	0.45
Cod in Subarea IV (North Sea) Division IIIa (Skagerrak) and Division VIId	0.90	0.22	0.14	0.34	1.07	0.34	0.34
Haddock in Subarea IV and Divisions IIIa and VIa (Northern Shelf)	0.51	0.37	0.25	0.52	0.55	0.51	0.52
Herring in Subdivisions 25-29 and 32 (excluding Gulf of Riga herring)	0.22	0.22	0.16	0.31	0.28	0.22	0.28
Herring in Subdivision 28.1 (Gulf of Riga)	0.32	0.32	0.24	0.38	0.38	0.32	0.38
Herring in Subdivision 30 (Bothnian Sea)	0.12	0.12	0.09	0.13	0.13	0.12	0.13
Herring in Division IIIa and Subdivisions 22-24 (Western Baltic Spring Spawners)	0.46	0.32	0.23	0.41	0.52	0.41	0.41
Plaice in Subarea IV (North Sea)	0.48	0.19	0.13	0.27	0.56	0.27	0.27
Plaice in Division VIId	0.52	0.30	0.20	0.43	0.60	0.43	0.43
Saithe in Subarea IV and Divisions IIIaN and VIa	0.39	0.32	0.20	0.43	0.57	0.39	0.43
Sole in Division IIIa and Subdivisions 22-24 (Kattegat sole) [S-R short time-series: 1992-2013]	0.23	0.22	0.17	0.26	0.34	0.23	0.26
Sole in Subarea IV (North Sea)	0.38	0.20	0.11	0.37	0.42	0.37	0.37
Sole in Division VIId	0.39	0.30	0.16	0.43	0.41	0.39	0.41
Sprat in Subdivisions 22-32 (Baltic Sea) [S-R time-series: 1992–2013]	0.21	0.26	0.19	0.34	0.27	0.21	0.27

2.1 EDA

At a first glance the upper and lower boundaries of the Fmsy ranges seem to have a linear relation with the Fmsy estimates, where the upper limit has a steeper slope than the lower limit.

```
xyplot(Flow + Fupp ~ FMSY, data = FmsyRanges, auto.key = list(pch = 19,
    columns = 2), type = c("p", "r"), par.settings = list(superpose.symbol = list(pch = c(19,
    23), col = 1, fill = 1), superpose.line = list(col = 1)), xlab = "Fmsy",
    ylab = "Fmsy ranges")
```



Anyway there's a small number of points care must be taken.

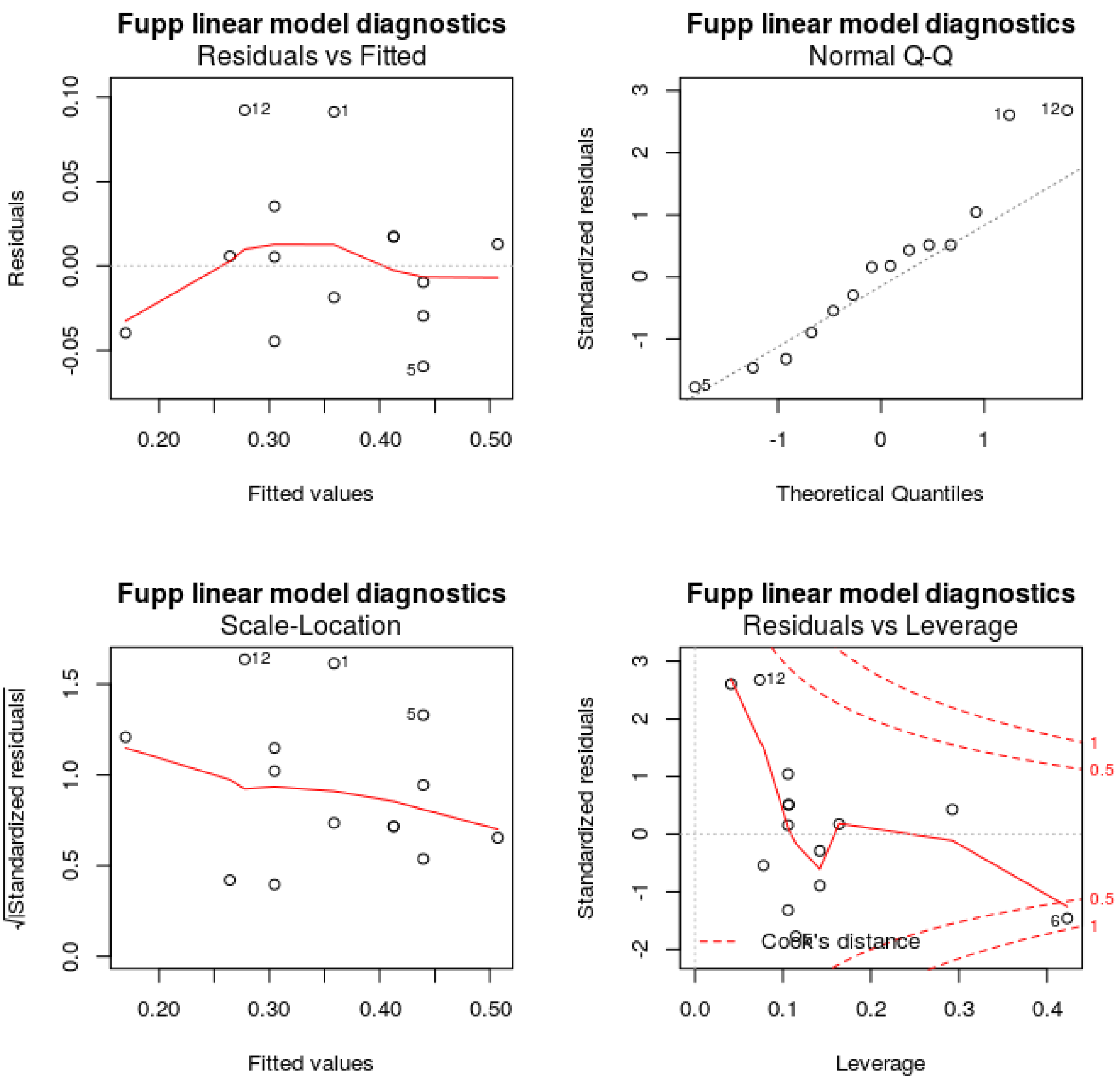
3 Proxies to Fmsy ranges

A robust linear model will be fitted to each limit and, using those models, will estimate the range's limits to the stocks that will be addressed by the EWG.

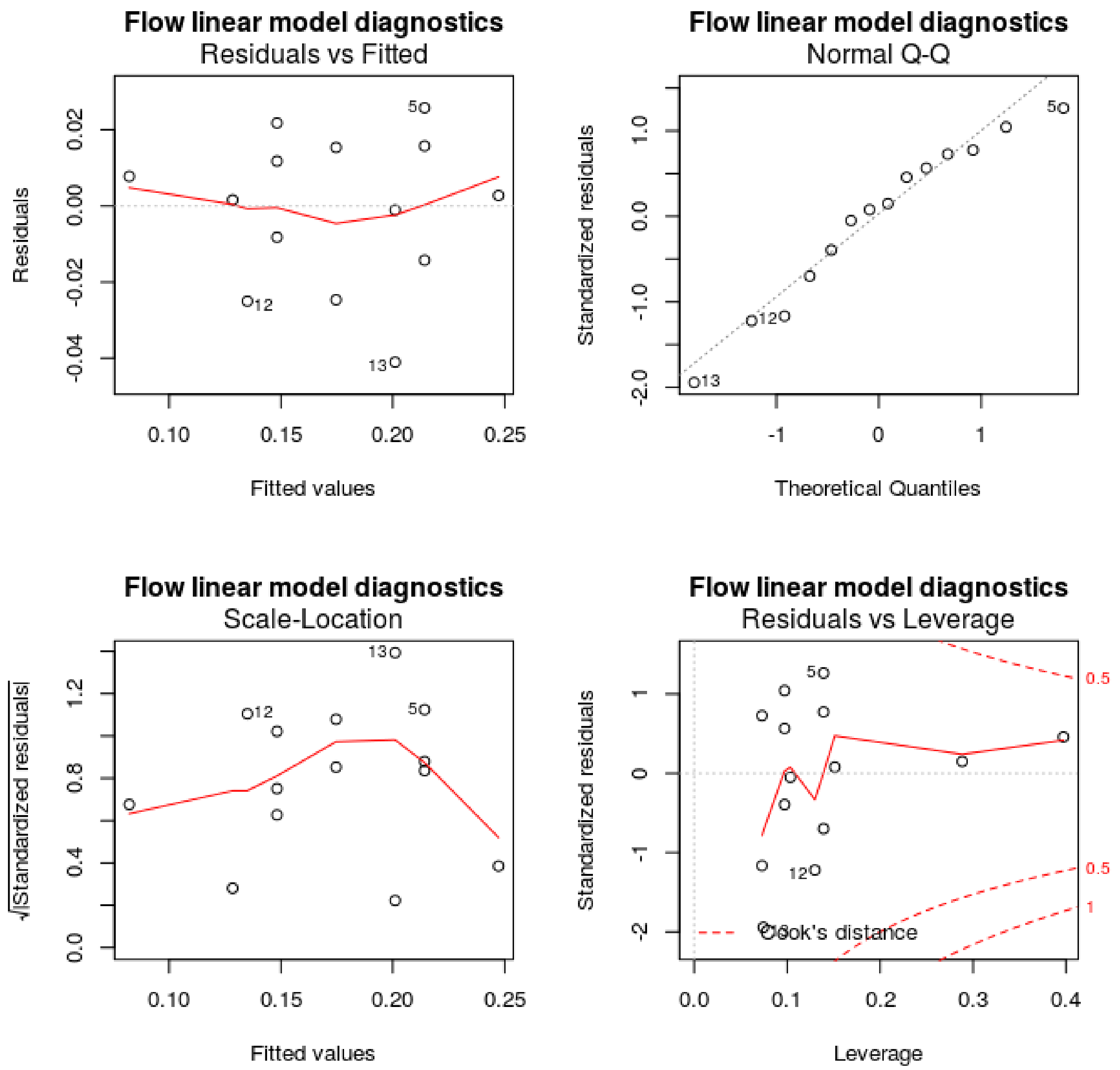
3.1 Model fit

```r
fupp.rlm <- rlm(Fupp ~ FMSY, data = FmsyRanges)
flow.rlm <- rlm(Flow ~ FMSY, data = FmsyRanges)
```

```r
par(mfrow = c(2, 2))
plot(fupp.rlm, main = "Fupp linear model diagnostics")
```




```r
plot(flow.rlm, main = "Flow linear model diagnostics")
```



3.2 WW estimates

```
FmsyWW$Fupp <- predict(fupp.rlm, newdata = data.frame(FMSY = FmsyWW$Fmsy))
FmsyWW$Flow <- predict(flow.rlm, newdata = data.frame(FMSY = FmsyWW$Fmsy))
```

```
kable(FmsyWW, digits = 2)
```

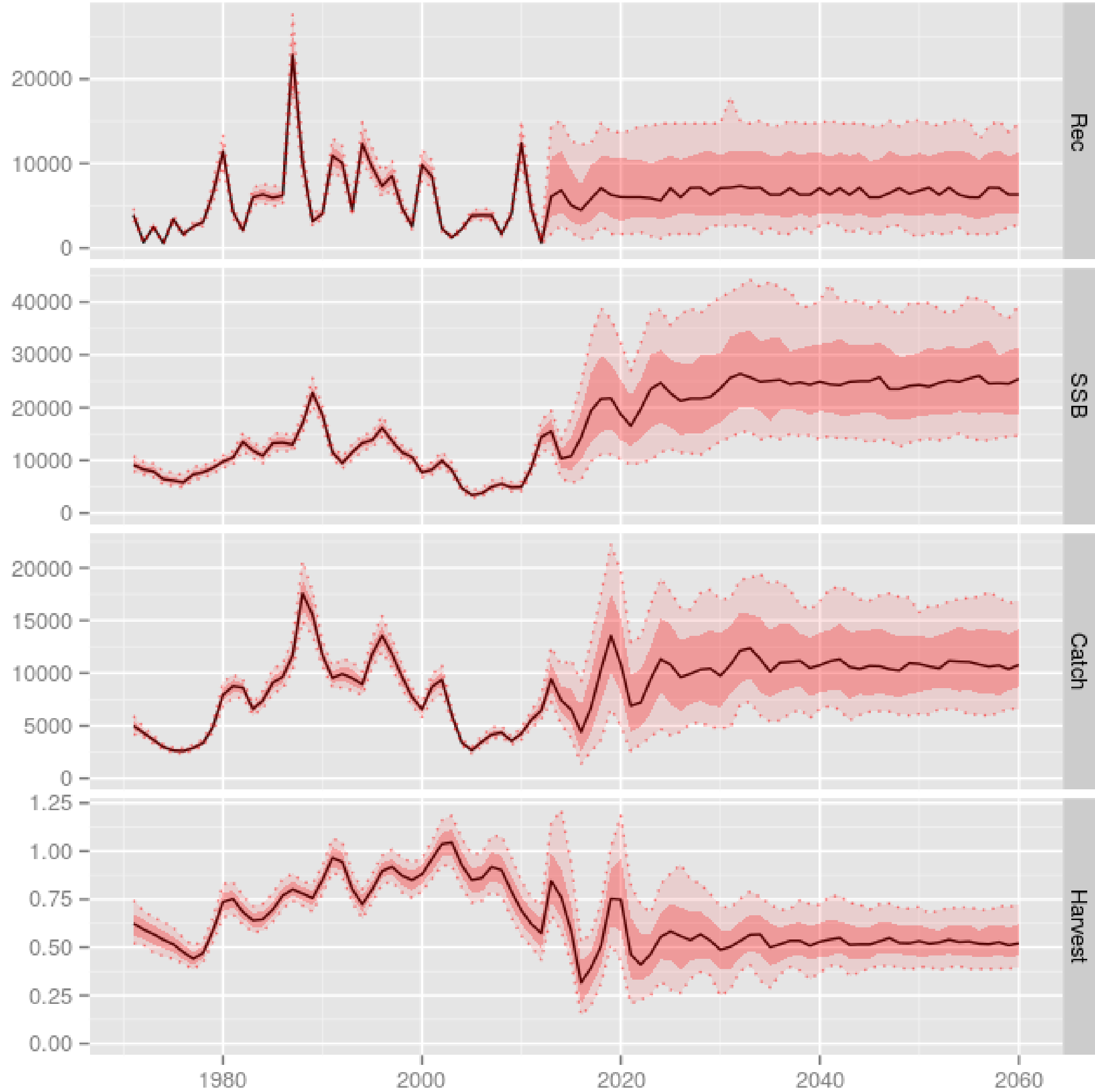
MAP	stock	Fmsy	Fupp	Flow
NWW	Cod CS	0.40	0.55	0.27
NWW	Haddock CS+WoS	0.33	0.45	0.22
NWW	Whiting CS	0.32	0.44	0.21
SWW	Hake (south)	0.24	0.33	0.16
SWW	Hake (north)	0.27	0.37	0.18
SWW	Horse Mackerel (South)	0.11	0.16	0.08
SWW	Megrim IB&BoB	0.17	0.24	0.12
SWW	Sole BoB	0.26	0.36	0.17
SWW	Blue whiting	0.30	0.41	0.20
SWW	4 Spot Megrim 8C9A	0.17	0.24	0.12
SWW	Horse Mackerel (Western)	0.13	0.18	0.09

4 Biological risk

The ranges must be tested for risk of collapse (probability of falling below Blim). A MSE was put together to test if the upper levels of the ranges are precautionary, which by ICES standards means that the risk of the SSB falling below Blim is less than 5%. The R/FLR/FLa4a code is in the annex.

4.1 Cod in the Celtic Sea

```
plot(window(cod55.mse2, end = 2060))
```



The biological risk was measured using the period when the stock stabilized, 2040-2060.

```
max(iterMeans(ssb(window(cod55.mse2, start = 2040, end = 2060)) < blim))

## [1] 0.02
```

5 Note of caution

These are provisional values based on the outputs available. ICES will go through the process of advising ranges later this year. Hopefully they won't be too different from the ones suggested here, but there's no guarantees of that.

Annex - MSE code

```r
###############################################################################
# EJ(20150519)
# Evaluate biological risk for Celtic Sea Cod of upper Fmsy range
###############################################################################

# ==============================================================================
# libraries and constants
# ==============================================================================
library(FLa4a)
library(FLash)
library(FLAssess)
library(ggplotFL)
source("funs.R")

# ==============================================================================
# Read data
# ==============================================================================

cod.idx <- readFLIndices("fleets-xsa-final.txt")
cod.idx[[1]] <- trim(cod.idx[[1]], age = 1:6)
cod.idx[[2]] <- trim(cod.idx[[2]], age = 1:4)
cod.idx <- rz(cod.idx)
load("COD.RData")
cod.stk <- stock

# ==============================================================================
# Fit a4a model to replicate official assessment as much as possible
# ==============================================================================

fmod <- ~I(age^2) + age + te(age, year, k = c(3, 10)) + s(year, k = 5)
cod.fit <- sca(cod.stk, cod.idx, fit = "assessment", fmodel = fmod)

plot(residuals(cod.fit, cod.stk, cod.idx))
wireframe(data ~ year + age, data = as.data.frame(FLQuants(a4a = harvest(cod.stk +
    cod.fit), orig = harvest(cod.stk))), groups = qname, main = "fishing mortality")
plot(FLStocks(orig = cod.stk, a4a = cod.stk + simulate(cod.fit, 250)))

cod <- cod.stk + cod.fit

# ==============================================================================
# Single species MSE to show example of envelope analysis
# ------------------------------------------------------------------------------
# Frange: 0.27-0.55 Btrig: 10300 Bpa: 10300 Blim: 7300 Fmsy: 0.4
# ==============================================================================

# stock
stk <- cod

# S/R
sr <- fmle(as.FLSR(stk, model = "segreg"))

# fixed variables
it <- 250
amx <- range(stk)["max"]
y0 <- range(stk)["minyear"]  # initial data year
```

```
ny <- 50  # number of years to project
dy <- 2011  # data year
ay <- 2012  # assessment year
iy <- 2012  # initial projections year (also intermediate)
fy <- iy + ny - 1  # final year
vy <- ac(iy:fy)
nsqy <- 3  # number of years to compute status quo metrics
mny <- 2015  # min year to get to trg
mxy <- 2015  # max year to get to trg

# management
flo <- 0.27
fup <- 0.55
bpa <- 10300
blim <- 7300

# fixed objects
TAC <- FLQuant(NA, dimnames = list(TAC = "all", year = vy, iter = 1:it))
BB <- FLQuant(0, dimnames = list(TAC = "all", year = vy, iter = 1:it))

# stock
sstk <- cod.stk + simulate(cod.fit, it)
pstk <- stf(sstk, ny, 5, 5)
landings.n(pstk) <- propagate(landings.n(pstk), it)
discards.n(pstk) <- propagate(discards.n(pstk), it)

# S/R residuals
sr.res <- window(rec(pstk), iy, fy)
sr.res[] <- sample(c(residuals(sr)), ny * it, replace = TRUE)

# index (pulled to 1st of January)
lst <- mcf(list(cod.idx[[1]]@index, stock.n(stk)))
idx.lq <- log(lst[[1]]/lst[[2]])
idx.qmu <- idx.qsig <- stock.n(iter(pstk, 1))
idx.qmu[] <- yearMeans(idx.lq)
idx.qsig[] <- log((sqrt(yearVars(idx.lq))/yearMeans(idx.lq))^2 + 1)  # check other methods
idx.q <- idx <- FLQuant(NA, dimnames = dimnames(stock.n(pstk)))
idx.q[, ac(y0:dy)] <- propagate(exp(idx.lq[, ac(y0:dy)]), it)
idx.q <- rlnorm(it, idx.qmu, idx.qsig)
idx <- idx.q * stock.n(pstk)
idx <- FLIndex(index = idx, index.q = idx.q)
range(idx)[c("startf", "endf")] <- c(0, 0)

# ------------------------------------------------------------------------------
# scenario up
# ------------------------------------------------------------------------------

ftrg <- fup

# go fish
for (i in vy[-length(vy)]) {
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay - y0)  # data years (positions vector)
    sqy <- (ay - y0 - nsqy + 1):(ay - y0)  # status quo years (positions vector)
    # oem
    stk0 <- pstk[, vy0]
```

```
    catch.n(stk0) <- catch.n(stk0) + 1  # avoid zeros
    idx0 <- idx[, vy0]
    index(idx)[, i] <- stock.n(pstk)[, i] * index.q(idx)[, i]
    # sa
    fit <- sca(stk0, FLIndices(idx0))
    stk0 <- stk0 + fit
    # mp
    fsq0 <- yearMeans(fbar(stk0)[, sqy])
    dnms <- list(iter = 1:it, year = c(ay, ay + 1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames = dnms, dim = unlist(lapply(dnms, length)))
    arr0[, , "val"] <- c(fsq0, rep(ftrg, it))
    arr0 <- aperm(arr0, c(2, 3, 1))
    ctrl <- fwdControl(data.frame(year = ay:(ay + 1), quantity = "f", val = NA))
    ctrl@trgtArray <- arr0
    stkTmp <- stf(stk0, 2)
    stkTmp <- fwd(stkTmp, ctrl = ctrl, sr = sr, sr.residuals = exp(sr.res[,
        ac(ay:(ay + 1))]), sr.residuals.mult = TRUE)
    TAC[, ac(ay + 1)] <- catch(stkTmp)[, ac(ay + 1)]
    # om
    ctrl@target <- ctrl@target[2, ]
    ctrl@target[, "quantity"] <- "catch"
    ctrl@trgtArray <- ctrl@trgtArray[2, , , drop = FALSE]
    ctrl@trgtArray[, "val", ] <- c(TAC[, ac(ay + 1)])  #+ BB[,ac(ay)])
    pstk <- fwd(pstk, ctrl = ctrl, sr = sr, sr.residuals = exp(sr.res[,
        ac(ay + 1)]), sr.residuals.mult = TRUE)
}
```