Short-Cut grid options

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Contents

Load packages

```
# Load
library(ggplot2)
library(FLCore)
library(ggplotFL)
library(mse)
library(FLRef)
library(ggpubr)
library(mseviz)
```

1 Short-Cut MSE grid

(1) F_{tgt} tuning as ratio of F_{eqsim}

(2) F_{Bx} tuning as a gradient of B/B_0 starting from B_{MSY}/B_0

1.1 Glossary

The following glossary summarizes key HCR parameters and associated target and limit reference points that are considered for tuning the candidate HCRs to optimise the trade-offs between maximizing fishing opportunity and risk:

- B_{lim}: a deterministic biomass limit reference point below which a stock is considered to have reduced reproductive capacity. Here B_{lim} was set to $0.25 B_{tgt}$

- F_{mmy}: Stochastic maximum median yield from EQSiM
- $F_{p0.5}$ F that leads to 5% probability that B is not exceeding B_{lim}
- F_{eqsim}: Outcome of $F_{eq} = min(F_{pa}, F_{mmy}$
- F_{MSYss}: "true" property of F_{MSY} in the OM, i.e. SS3 estimate
- B_{MSYss}: the average biomass around which the biomass fluctuated when fishing at F_{MSYss}
- F_{pa}: Robust $F_{p0.5}$ as conformined with feedback advice control (short-cut MSE)
- F_{msy}: $F_{MSY} = min(F_{eq}, F_{pa}$, which can be further optimised to improve catch performance, through $B_{trigger}$ tuning
- B_{pa}: a precautionary biomass reference point set with high probability that biomass is above B_{lim}, which acts as a safety margin below which the risk of reduced reproductive capacity is increasing. When the biomass is estimated to be above Bpa, the stock is considered to be within safe biological limits in terms of its reproductive capacity.
- C_{adv}: advised catch as output of the management procedure
- $B_{trigger}$: biomass trigger point of the HCR, specified as change point of biomass below which fishing mortality reduced relative to Ftgt. Specified

2 Build FLStock

SS3 outputs are loaded with the `readFLSss3()` into an `FLStock` object. The folder that contains the model outputs has to be specified.

In the following, the area outside is evaluated first.

```
run = "mon.27.8c9a"
stk = window(ss3om::readFLSss3(run, wtatage = TRUE))
   Warning: replacing previous import 'FLCore::profile' by 'r4ss::profile' when
   loading 'ss3om'
# Fill NAs
stk@m.spwn[] = 0
stk@harvest.spwn[] = 0
sr = ss3om::readFLSRss3(run)
stk@name = "mon.27.8c9a"
stk@desc = "2024, ICES, SS3"
out = ss3om::readOutputss3(run)

dir.create("rdata", showWarnings = F)
```

2.1 Consistency checks using backtesting

Set seed

```
set.seed(1507)
```

Get bias adjusted recruitment deviations from ss3 model

Simplify to annual sex-structured model

```
if (dims(stk)$season > 1) {
    stka = simplify(stk, "season", weighted = TRUE, harvest = TRUE)

    discards.wt(stka) = stock.wt(stka)
    stka@discards = computeDiscards(stka)
    # Make annual sra
    sra = sr
    params(sra) = FLPar(an(sr@params[, 1]), params = rownames(sr@params))
} else {
    sra = sr
    stka = stk

}
```

```
yrs = an(dimnames(stk)$year)
recruit = out$recruit[out$recruit$Yr %in% yrs, ]
dms <- list(year = yrs)
sigR = mean(an(out$sigma_R_info[1:2, "SD_of_devs_over_sigma_R"]))  # Realised sigR
residuals <- FLQuant(exp(recruit$dev - 0.5 * recruit$biasadjuster *
    sigR^2), dimnames = c(age = 0, dms), units = "")
recs = FLQuant(recruit$pred_recr, dimnames = c(age = 0,
    dms), units = "")


if (dims(stk)$unit == 2) recs <- expand(recs, unit = c("F",
    "M"))
```

```
testC = fwd(stka, sr = recs[, ac(1981:2023)], control = fwdControl(year = 1981:2023,
    value = (unitSums(catch(stka)[, ac(1981:2023)])), quant = "catch"))

testF = fwd(stka, sr = recs[, ac(1981:2023)], control = fwdControl(year = 1981:2023,
    value = unitMeans(fbar(stka)[, ac(1981:2023)]), quant = "fbar"))
```

```
plot(window(FLStocks(ss3om = stka, backtestC = testC, backtestF = testF))) +
    theme_bw() + facet_wrap(~qname, scale = "free_y")
```

Note that minor deviations are likely due to difficulties in precisely adjusting the rec devs with bias correction.

2.2 Estimate candidate reference points

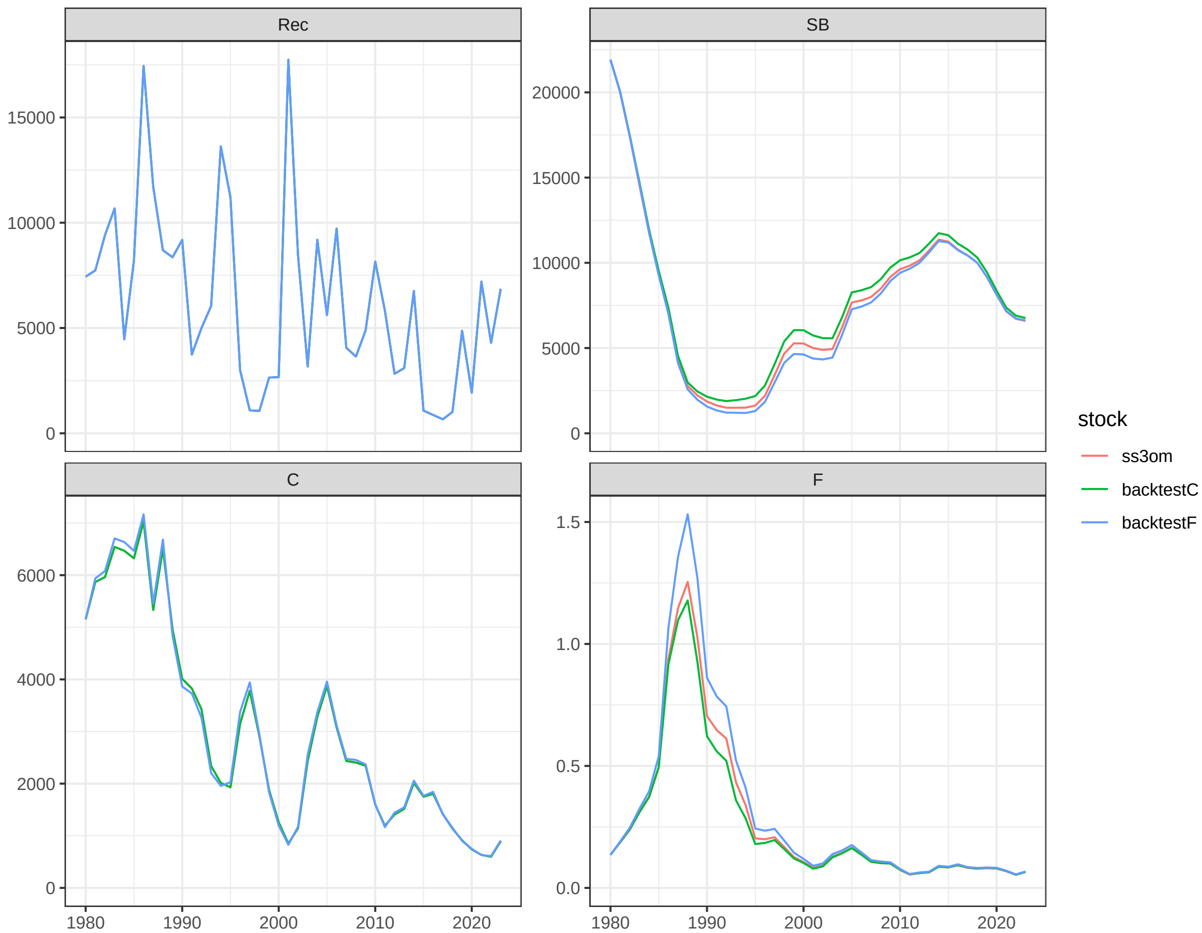

Figure 1: Comparison of stock trajectories from ss3om and a backtest under the same Fbar

```r
# Extract pars
s = params(sra)[[1]]
R0 = params(sra)[[2]]
B0 = params(sra)[[3]]
# Main recdevs
recyrs = recruit$Yr[recruit$era == "Main"]
maindevs = unitSums(residuals[, ac(recyrs)])
rho = cor(maindevs[, -1], maindevs[, -length(maindevs)])
sigmaR = out$sigma_R_in
rho
   [1] 0.4441913
sigmaR
   [1] 0.8

# MSY refpts
Bmsy <- out$derived_quants$Value[out$derived_quants$Label ==
    "SSB_MSY"]
Fmsy <- out$derived_quants$Value[out$derived_quants$Label ==
    "annF_MSY"]
MSY <- out$derived_quants$Value[out$derived_quants$Label ==
    "Dead_Catch_MSY"]

# Short cut devs
ay = out$endyr  # assessment year
SSBcv <- out$derived_quants$StdDev[out$derived_quants$Label ==
    paste0("SSB_", ay)]/out$derived_quants$Value[out$derived_quants$Label ==
    paste0("SSB_", ay)]

Fcv <- out$derived_quants$StdDev[out$derived_quants$Label ==
    paste0("F_", ay)]/out$derived_quants$Value[out$derived_quants$Label ==
    paste0("F_", ay)]
```

3 Reference point grid

Function to find B for F at equilibrium

```r
fwdB4F = function(stock, sr, Fs = 0.2, nfy = 200) {

    if (class(stock) == "FLStockR") {

        stock = as(stock, "FLStock")
    }
    fyrs = (dims(stock)$maxyear + 1):(dims(stock)$maxyear +
        nfy)
    nfy = length(fyrs)
    stkf = stf(stock, nfy)

    bx = do.call(c, lapply(an(Fs), function(x) {
        ictrl = fwdControl(data.frame(year = fyrs, quant = "fbar",
            value = x))
        out = fwd(stkf, sr = sr, control = ictrl)
```

```r
        an(tail(unitSums(ssb(out))))
    }))

    data.frame(F = an(Fs), B = bx)
}
```

Set B_{MSY} proxies as ratio of B_0

```r
BmsyB0 = Bmsy/B0

BmsyB0
   [1] 0.1978535

startB = ceiling(BmsyB0 * 20)/2 * 10
startB
   [1] 20
```

```r
Bfx = seq(startB, 40, 2.5)
Bx = FLPar(Bfx/100 * B0, params = paste0("B", Bfx))
```

Run

```r
Fbx = do.call(c, lapply(an(Bx), function(x) {
    fs = fwdF4B(stka, sra, btgt = x, nfy = 100, niy = 0,
        ftune = c(0.3 * Fmsy, 1.5 * Fmsy), tol = 0.001,
        verbose = F)
    an(tail(unitMeans(fbar(fs)), 1))
}))
```

Hypothetical F_{MSY} and $B_{trigger}$ from eqsim output

```r
Feq = Fmsy * 0.93
Btri.eq = 0.1 * B0 * 1.44
Beq = fwdB4F(stka, sra, Fs = Feq, nfy = 200)$B
```

Add EQSIM and "true" Fmsy

```r
Fb.tune = FLPar(c(Fmsy, Feq, Fbx, Bmsy, Beq, Bx), params = c("Fmsy",
    "Feq", paste0("Fb", Bfx), "Bmsy", "Beq", paste0("B",
        Bfx)))
```

```r
Fx = rev(seq(0.5, 0.95, 0.05))
Ftgt = FLPar(Fx * Feq, params = paste0(Fx, ".Fq"))
```

```r
Bftgt = fwdB4F(stka, sra, Fs = Ftgt, nfy = 200)

Bftgt
```

```r
Ftgt.tune = FLPar(c(Fmsy, Feq, Bftgt$F, Bmsy, Beq, Bftgt$B),
    params = c("Fmsy", "Feq", paste0(Fx, "Ftgt"), "Bmsy",
        "Fmsy", paste0(Fx, "Bftgt")))
```

```r
np = an(nrow(Fb.tune))

df1 = data.frame(Tune = rownames(Fb.tune)[1:(np/2)], Ftgt = round(an(Fb.tune)[1:(np/2)],
    3), Btri.eq = round(Btri.eq, 1), Btgt = round(an(Fb.tune)[(np/2 +
    1):np], 1), xB0 = round(an(Fb.tune)[(np/2 + 1):np]/B0,
    3))
```

```r
np = an(nrow(Ftgt.tune))

df2 = data.frame(Tune = rownames(Ftgt.tune)[1:(np/2)], Ftgt = round(an(Ftgt.tune)[1:(np/2)],
    3), Btri.eq = round(Btri.eq, 1), Btgt = round(an(Ftgt.tune)[(np/2 +
    1):np], 1), xB0 = round(an(Ftgt.tune)[(np/2 + 1):np]/B0,
    3))
```

```r
knitr::kable(df1, "pipe", align = "lccccc", caption = "Option 1: Initial tuning grid with EQSIM Btrigge
```

Table 1: Option 1: Initial tuning grid with EQSIM Btrigger based on Fbx.

Tune	Ftgt	Btri.eq	Btgt	xB0
Fmsy	0.182	4163.4	5720.5	0.198
Feq	0.169	4163.4	6681.3	0.231
Fb20	0.154	4163.4	5782.6	0.200
Fb22.5	0.142	4163.4	6505.4	0.225
Fb25	0.131	4163.4	7228.2	0.250
Fb27.5	0.122	4163.4	7951.0	0.275
Fb30	0.113	4163.4	8673.8	0.300
Fb32.5	0.105	4163.4	9396.7	0.325
Fb35	0.098	4163.4	10119.5	0.350
Fb37.5	0.091	4163.4	10842.3	0.375
Fb40	0.085	4163.4	11565.1	0.400

```r
knitr::kable(df2, "pipe", align = "lccccc", caption = "Option 2: Initial tuning grid with EQSIM Btrigge
```

Table 2: Option 2: Initial tuning grid with EQSIM Btrigger based on Feq tuning.

Tune	Ftgt	Btri.eq	Btgt	xB0
Fmsy	0.182	4163.4	5720.5	0.198
Feq	0.169	4163.4	6681.3	0.231
0.95Ftgt	0.161	4163.4	7196.2	0.249
0.9Ftgt	0.152	4163.4	7749.8	0.268
0.85Ftgt	0.144	4163.4	8345.0	0.289
0.8Ftgt	0.135	4163.4	8984.9	0.311
0.75Ftgt	0.127	4163.4	9672.8	0.335
0.7Ftgt	0.118	4163.4	10412.3	0.360
0.65Ftgt	0.110	4163.4	11207.3	0.388
0.6Ftgt	0.102	4163.4	12061.7	0.417
0.55Ftgt	0.093	4163.4	12980.1	0.449
0.5Ftgt	0.085	4163.4	13967.1	0.483

3.1 Stage 2

Tuning for range of Fs with Btrigger