mpb

Management Strategy Evaluation

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Introduction

`mpb` is an R package for conducting Management Strategy Evaluation (MSE) and simulating a variety of management procedures (MPs). An MP is the combination of pre-defined data, together with an algorithm to which the data are input to provide a value for a TAC or effort control measure. In this vignette the `FLife` package is used to condition an Operating Model (OM) using life history parameters and relationships. Both packages are part of `FLR` (Kell et al. (2007)).

FLife

The `FLife` package is used to create a stock. The first steps are to load the example `teleost` dataset and select the parameters for albacore.

```
data(teleost)

teleost
```

```
An object of class "FLPar"
iters:  145

params
                linf                    k                  t0
45.100000(28.02114)  0.246667( 0.17297) -0.143333( 0.13590)
                 l50                    a                   b
22.100000(11.71254)  0.011865( 0.00776)  3.010000( 0.15271)
units:  NA
```

```
alb=lhPar(teleost[,"Thunnus alalunga"])

alb
```

```
An object of class "FLPar"
params
      linf          k         t0          a          b      ato95
 131.81818    0.19182   -0.76909    0.01372    2.92800    1.00000
       a50       asym         bg         m1         m2         a1
   3.71080    1.00000    2.92800  375.41895   -1.61000    3.71080
        sl         sr          s          v        l50
   2.00000 5000.00000    0.90000 1000.00000   76.00000
units:  cm
```

The `lhPar` method is then used to derive the parameters for natural mortality-at=age, based on Gislason et al. (2008), and default parameters and relationships for selection pattern and stock recruitment.

The default parameters can be changed, e.g. by changing a parameter. `sl` is the standard deviation for the lefthand limb of the double normal selection pattern, here we change it from 2 to 1 to make it steeper.

```r
alb["sl"]=1
```

Equilibrium dynamics

The parameters are then used by `lhEql` to simulate the equilibrium dynamics by combining the spawner/yield per recruit relationships with a stock recruiment relationship.

```r
eql=lhEql(alb)
```

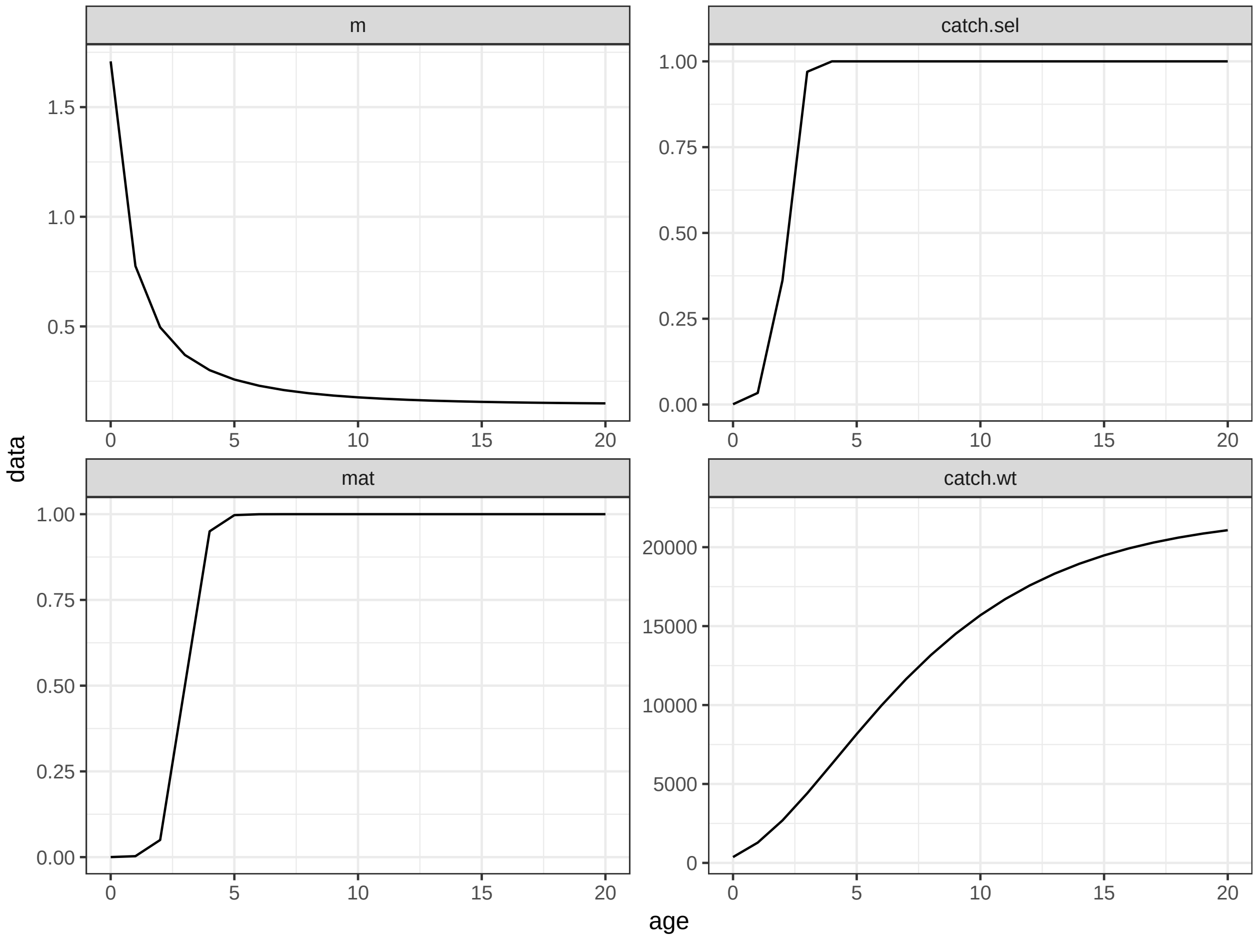


Figure 1 Vectors of m, selection pattern, maturity and weight-at-age.

Estimate equilibrium dynamics and reference points

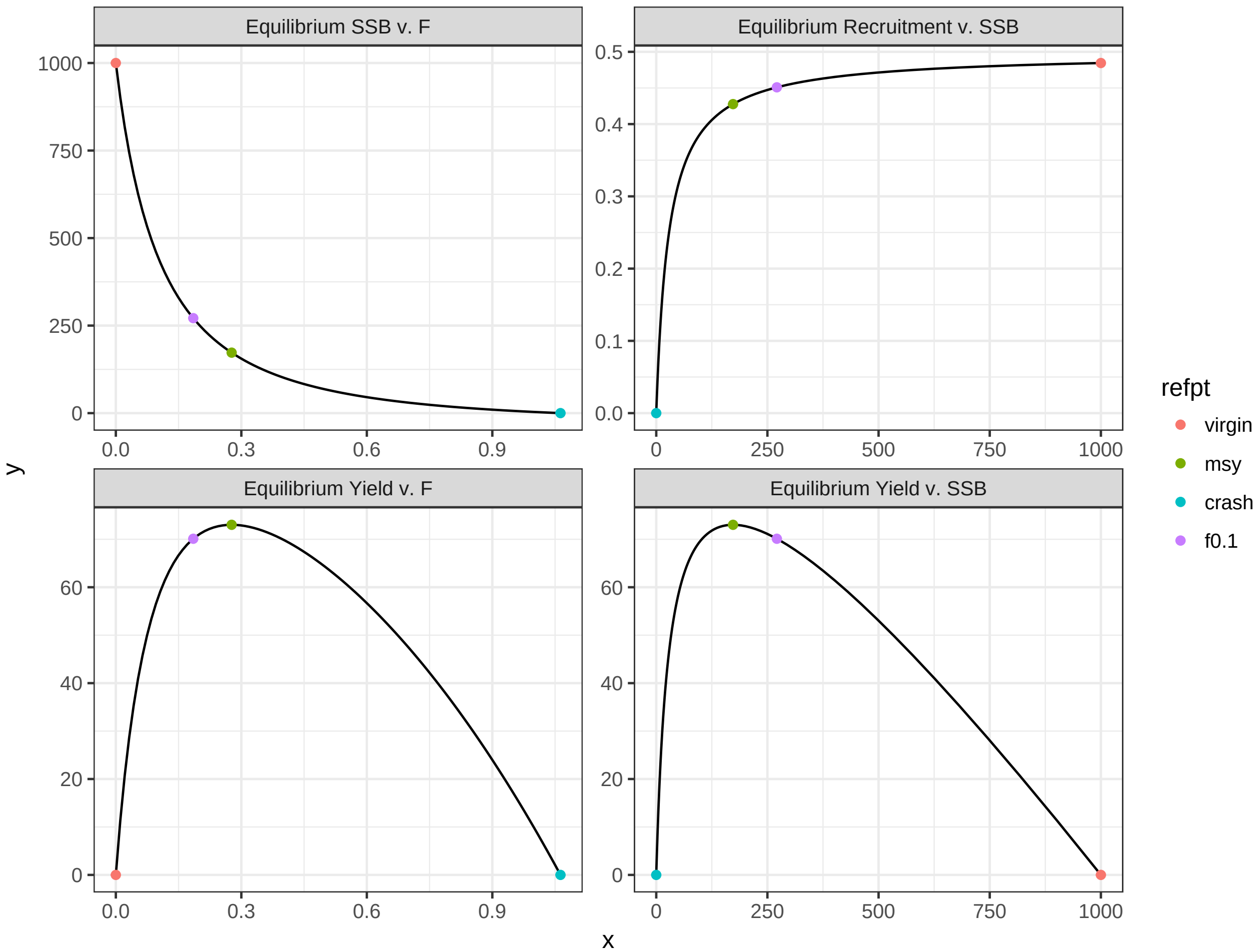


Figure 2 Expected, equilibrium, dynamics and reference points.

Time series

To go from equilibrium to time series dynamics the `FLBRP` object created by `lhEql` can be coerced to an `FLStock` object.

First change the F time series so that it represents a time series where the stock was origionally lightly exploited, F increased until the stock was overfished and then fishing pressure was reduced to ensure spawning stock biomass was greater than B_{MSY}.

```
fbar(eql)=FLBRP:::refpts(eql)["msy","harvest"]*FLQuant(c(rep(.1,19),
                                                           seq(.1,2,length.out=40),
                                                           seq(2,.7,length.out=11)[-1],
                                                           rep(.7,61)))[,1:105]
om=fwd(eql)
```

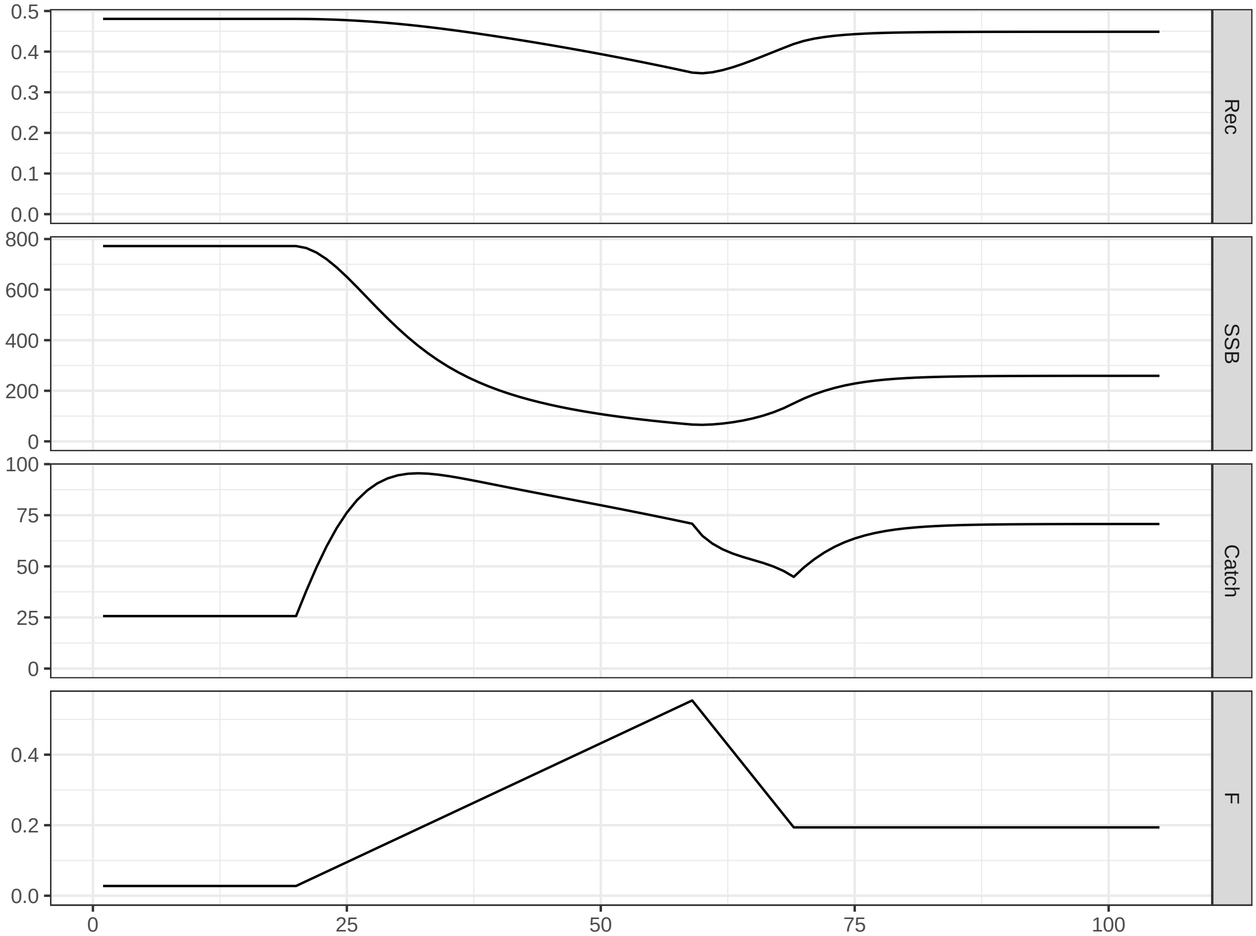


Figure 3 Time series of F, SSB, recruitment and yield

Stochastic dynamics

To simulation random variation in the time series, deviations around the stock recruitment relationship was modelled as a random variable.

```
nits=200

set.seed(1234)
srDev=FLife:::rlnoise(nits,fbar(eql)[,-1,,,,1]*0,.3,b=0.0)
```

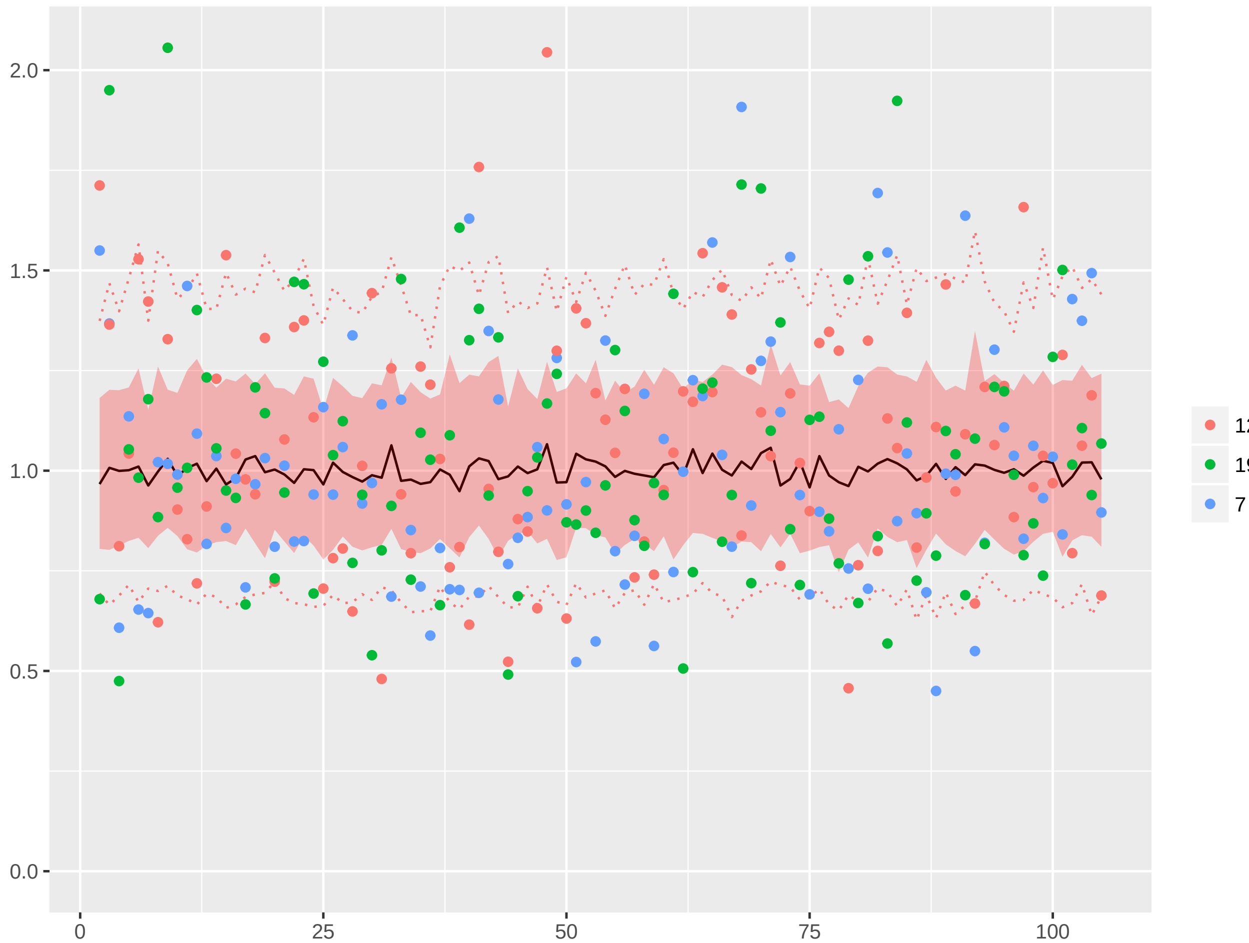


Figure 4 Time series of recruitment deviates

While to generate data for use in the MP, random measurement error was added to the simulated catch per unit effort (CPUE).

```
set.seed(3321)
uDev =rlnorm(nits,setPlusGroup(stock.n(eql),20)*0,.2)
```

These deviates were then used to create a stochastic time series by projecting the dynamics from year 1.

```
om =propagate(fwd(eql),nits)
oms=FLStocks("Projection"=fwd(om,f=fbar(om)[,-1],sr.residuals=rlnorm(nits,fbar(om)[,-1,,,,1]*0,.3),sr=eq
```

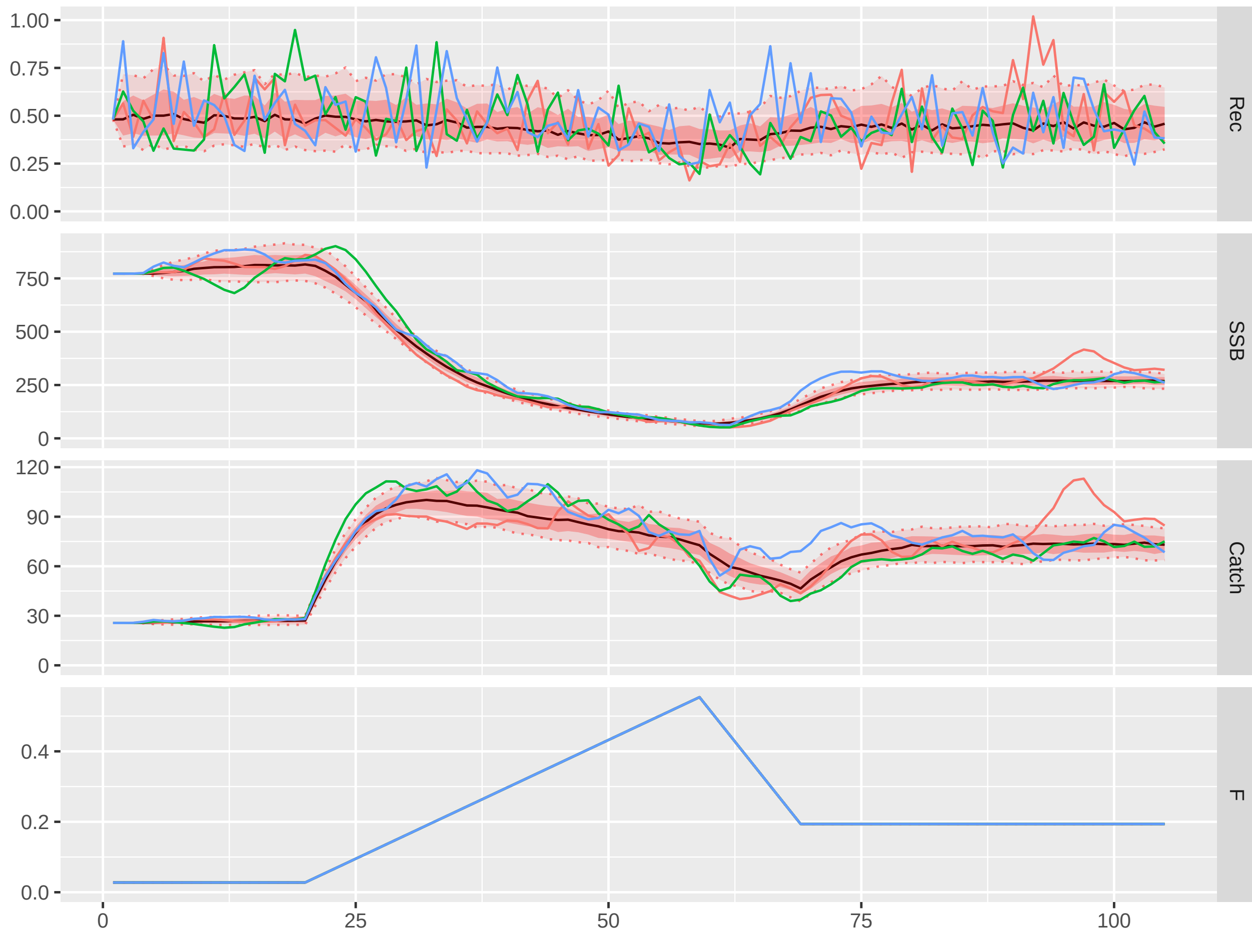


Figure 5 Stochastic Time series of F, SSB, recruitment and yield

Management Procedures

Feedback control

Management of a fish stocks is done using feedback control. The stock is assessed using historical data which is used estimate current stock status and then to project the stock forward under alternative management regulations for a variety of hypotheses and system dynamics. This procedure is then repeated in subsequent year to monitor and adjust the impact of management. MSE does this my simulating a MP. These can either be model based or empirical, i.e. based on a stock assessment or data alone.

In the `mpb` package there are a variety of MP, e.g. age, biomass and empirical based.

Harvest Control Rule

```
library(kobe)

hcr= data.frame(stock  =c(0.0 ,0.1 , 0.6,2.0),
                harvest=c(0.01,0.01, 0.7,0.7))
kobePhase()+
  geom_line(aes(stock,harvest),data=hcr,col="orange",size=2)
```

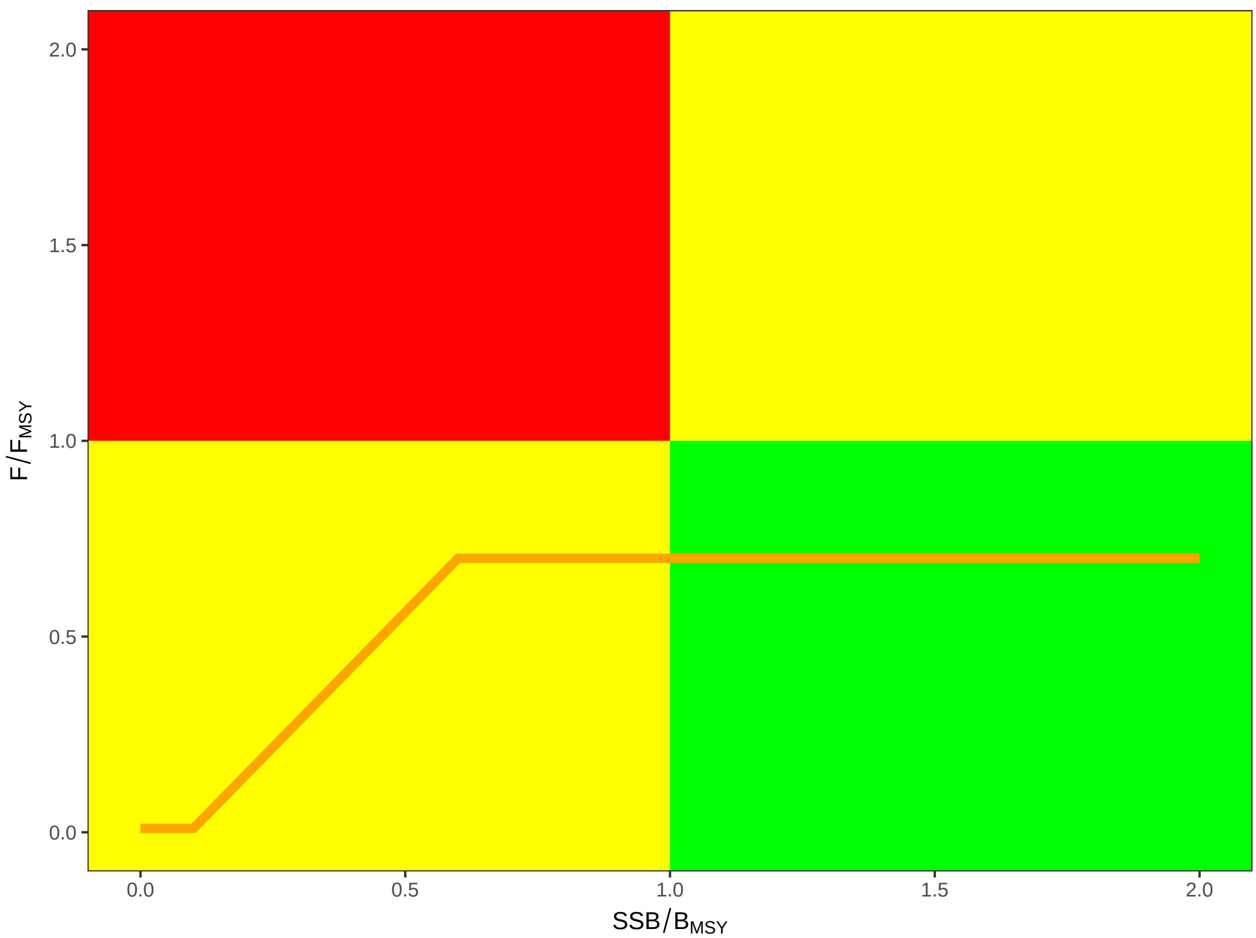


Figure 6 Hockey stick harvest control rule.

Age Based

In this example the MP is based on an Virtual Population Analysis (VPA).

First the control settings are checked by running `FLXSA` on data simulated by the OM without error and feedback. Ideally there should be no bias in the estimates from the stock assessment

```
mp=window(setPlusGroup(oms[["Projection"]],20),end=80)
```

```
[1] "maxfbar has been changed to accomodate new plusgroup"
```

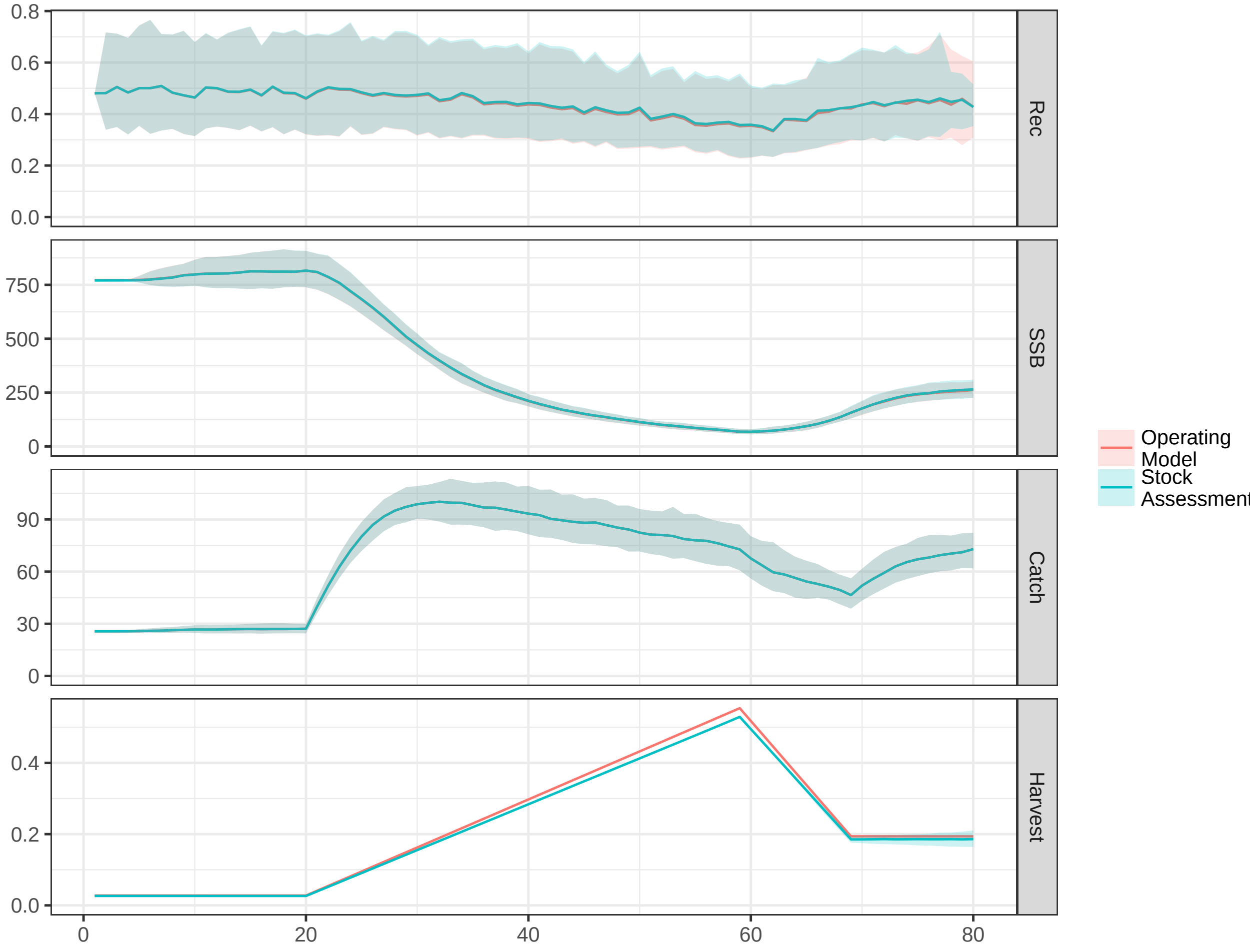
```
##Assessment
control=FLXSA.control(tol    =1e-16, maxit   =150,
                      min.nse=0.3,   fse     =0.5,
                      rage   =2,     qage    =10,
                      shk.n  =TRUE,  shk.f   =TRUE,
                      shk.yrs=10,    shk.ages=10,
                      window =10,    tsrange =10,
                      tspower=0,
                      vpa    =!TRUE)

idx=FLIndex(index=stock.n(mp)%*%uDev[,dimnames(stock.n(mp))$year])
range(idx)[c("plusgroup","startf","endf")]=c(NA,0.1,.2)

xsa=FLXSA(mp,idx,
          control=control,diag.flag=FALSE)
range(xsa)[c("min","max","plusgroup")]=range(mp)[c("min","max","plusgroup")]
mp=mp+xsa

sr=fmle(as.FLSR(mp,model="bevholt"),control=list(silent=TRUE))
rf=FLBRP(mp,sr)
```

```
plot(FLStocks("Stock\nAssessment"=mp,
              "Operating\nModel" =window(oms[["Projection"]],end=80)))
```



Before running the MSE, i.e. using XSA as part of a feedback control procedure, the current reference points need to be estimated.

Then the MSE can be run using the `mseXSA` function

```
source('~/Desktop/flr/FLBRP/R/fwd-setup.R')

oms[["Age"]]=mseXSA(oms[["Projection"]],eql, #OM
                    mp,control,rf=rf,         #MP
                    srDev=srDev,uDev=uDev,    #Random deviates for OM
                    start=75,end=103,maxF=1.0)        #year range
```

Figure 7 Time series from the MSE of F, SSB, recruitment and yield

Biomass Based

In `mpb` there is a biomass dynamic stock assessment, designed to be used as an MP.

First the control object has to be set, i.e. setting best guess, bounds and any priors for parameters.

```
mp        =as(window(oms[["Projection"]],start=20,end=75),"biodyn")
mp@indices=FLQuants("1"=(stock(oms[["Projection"]][,20:74])+
                         stock(oms[["Projection"]][,21:75]))/2.0)

params(    mp)["r"]=.25
```

```
mp=fwd(    mp,catch=catch(mp))
setParams( mp)=mp@indices[[1]]

setControl(mp)=params(mp)
control(   mp)["r",2:4]=c(.05,0.25,1.0)
control(   mp)["q1",]=c(-1,.1,1,10)
```

Then the assessment is run without feedback

```
mp=fit(mp)
```

and compared to the OM

Figure 8 Comparision of estimates and simulated time series of harvest rate and stock biomass.

```
source('~/Desktop/flr/mpb/R/hcr.R')

setControl(mp)=params(mp)

oms[["Biomass"]]=
  mseMPB(window(oms[["Projection"]],start=20,end=103),eql,mp,srDev=srDev,uDev=uDev,start=75,end=103)
```

```
75, 78, 81, 84, 87, 90, 93, 96, 99,
```

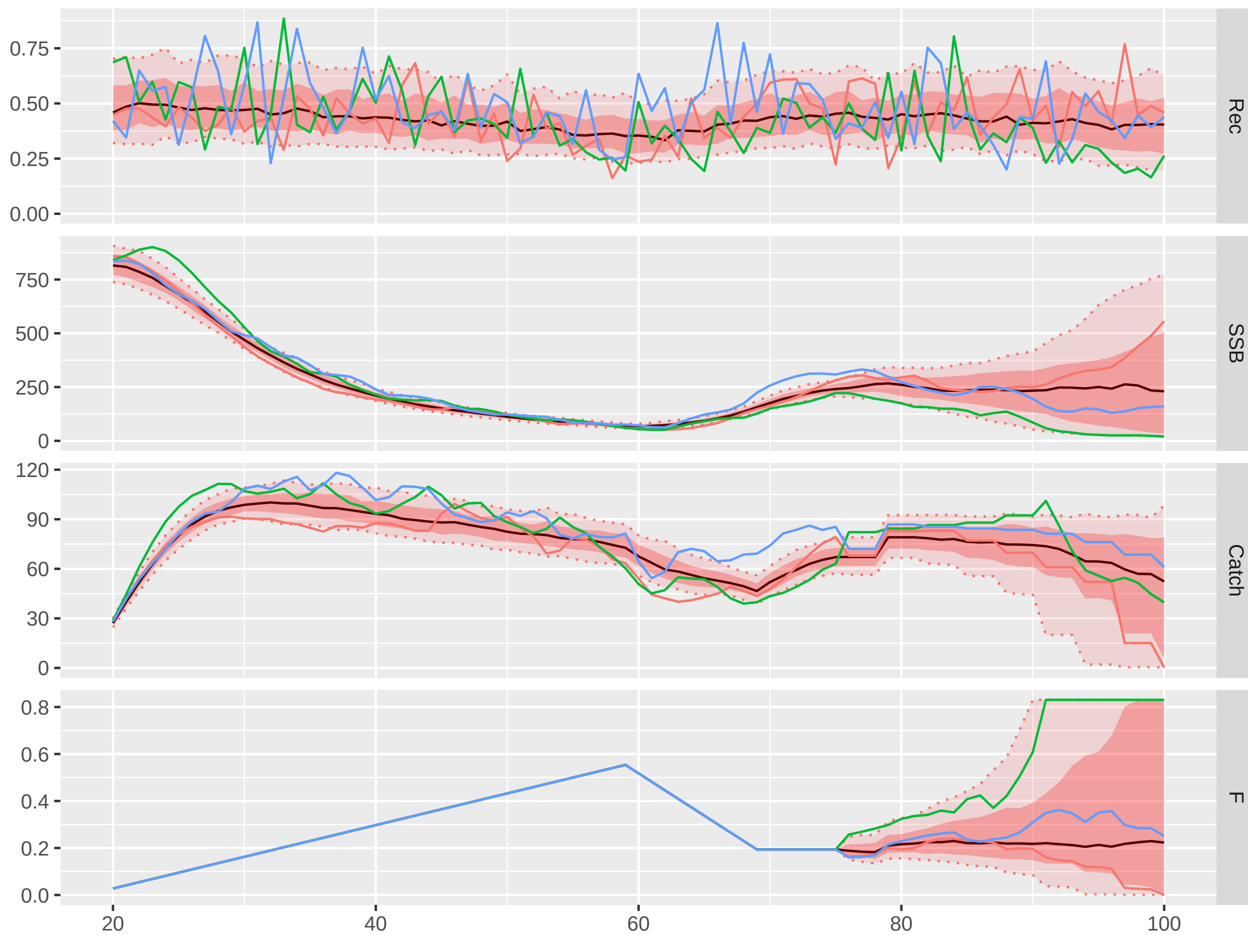


Figure 9 Time series from the MSE of F, SSB, recruitment and yield

```
oms[["Biomass2"]]=
  mseMPB(window(oms[["Projection"]],start=20,end=103),eql,mp,srDev=srDev,uDev=uDev,ftar=0.5,start=75,end
```

```
75, 78, 81, 84, 87, 90, 93, 96, 99,
```

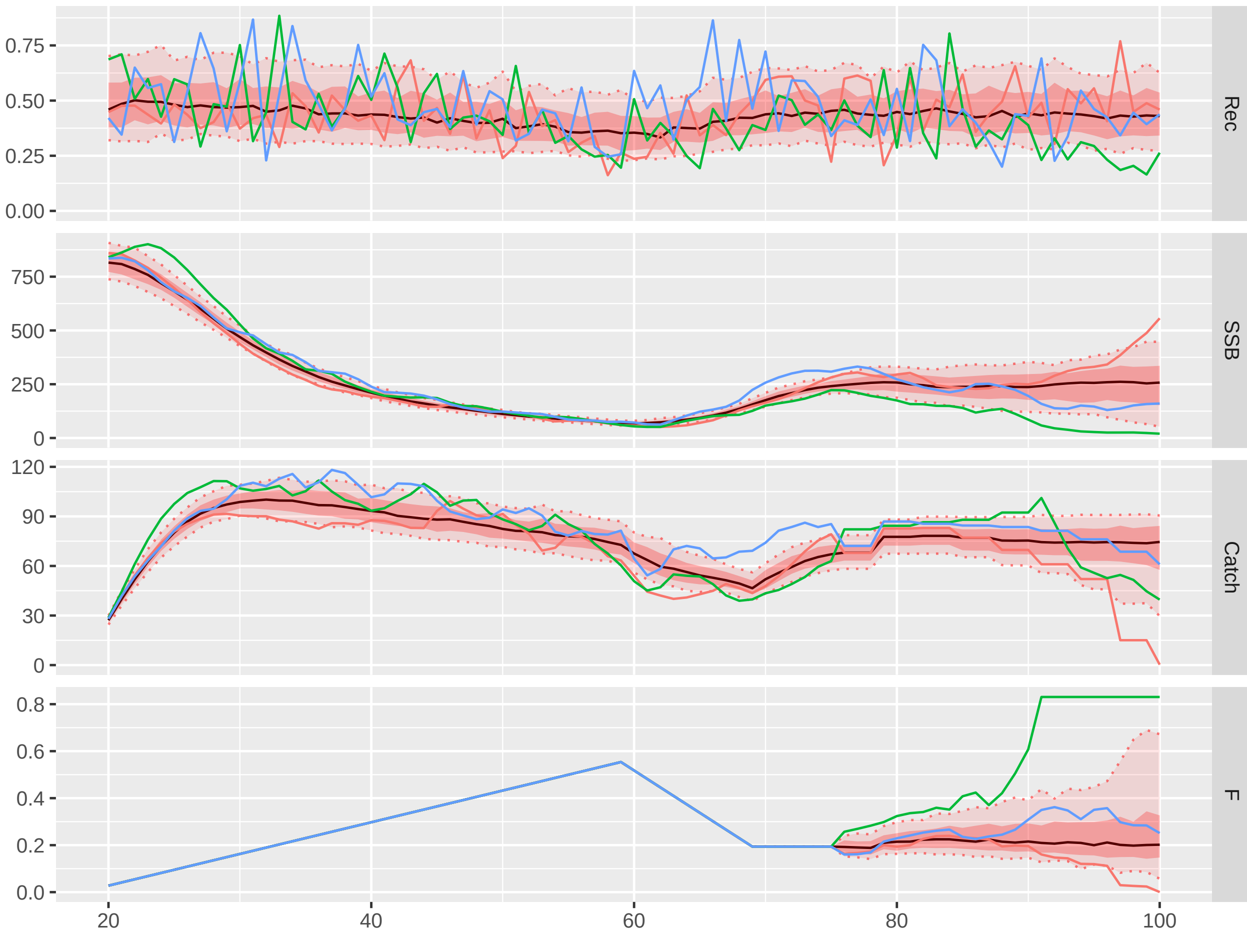


Figure 10 Time series from the MSE of F, SSB, recruitment and yield

Empirical

```
oms[["Emprirical"]]=mseEMP(oms[["Projection"]],eql,srDev=srDev,uDev=uDev,start=75,end=103)
```

```
==75, 78, 81, 84, 87, 90, 93, 96, 99, 102, ==
```

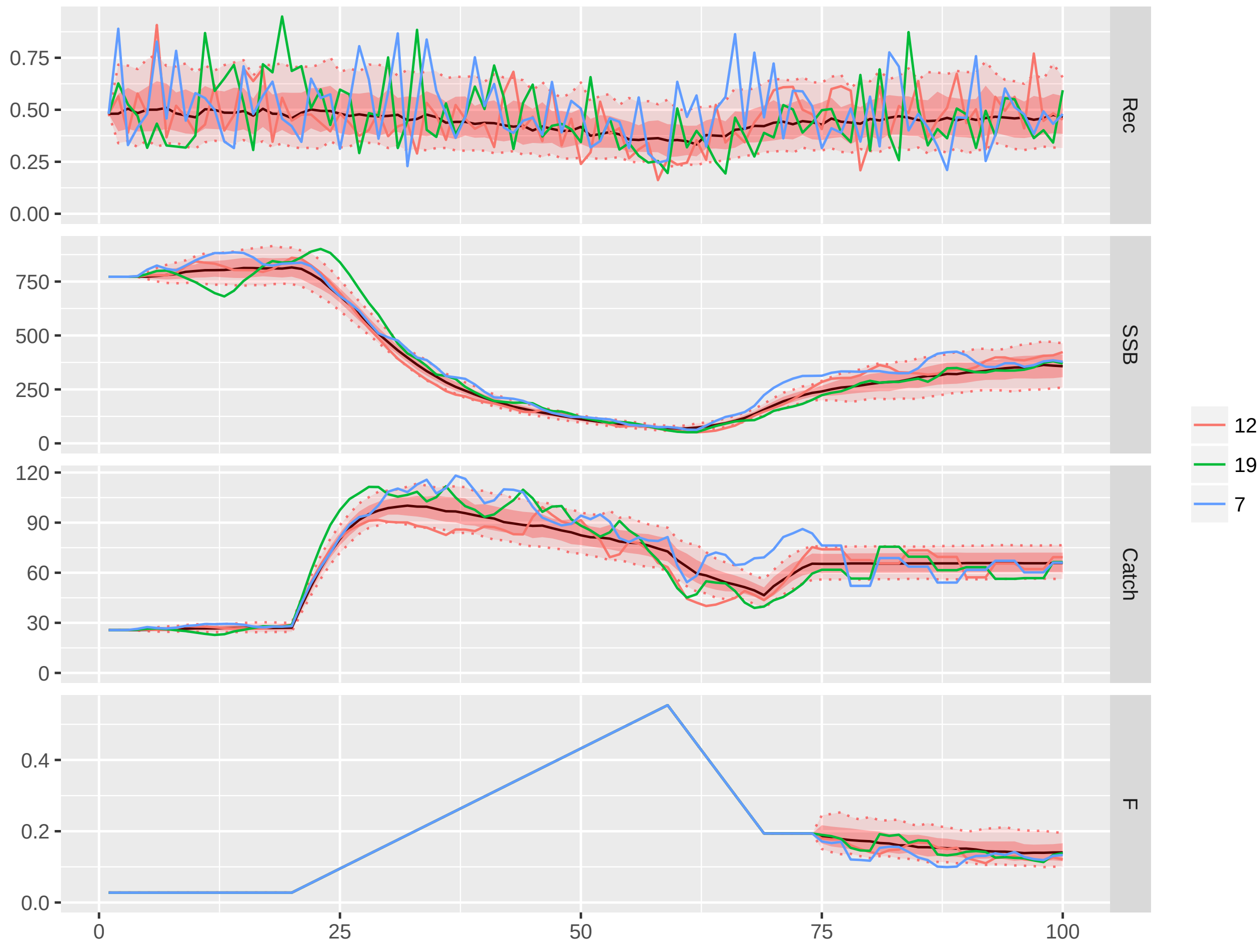


Figure 11 Time series from the MSE of F, SSB, recruitment and yield

Software Versions

- R version 3.4.1 (2017-06-30)
- FLCore: 2.6.5
- FLPKG:
- **Compiled**: Thu Sep 28 23:17:03 2017
- **Git Hash**: 0d70031

Author information

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References

Gislason, H., N. Daan, JC Rice, and JG Pope. 2008. "Does Natural Mortality Depend on Individual Size." *ICES*.

Kell, L.T., I. Mosqueira, P. Grosjean, J.M. Fromentin, D. Garcia, R. Hillary, E. Jardim, et al. 2007. "FLR: An Open-Source Framework for the Evaluation and Development of Management Strategies." *ICES J. Mar. Sci.* 64 (4): 640.