

Short Term Forecasting for advice using FLaSh

08 March, 2017

Short term forecasts help projecting the stock to forecast the implications of different management choices over a limited number of years. There are three necessary ingredients when projecting in FLR: a stock object - that you will forecast and about which you have made some assumptions about what will happen in the future, a stock-recruitment relationship, a projection control - specify what targets and when to hit them.

In FLR, the method for short term forecasts is called `fwd()`, which takes an `FLStock`, `FLSR`, and `fwdControl`.

Required packages

To follow this tutorial you should have installed the following packages:

- CRAN: `ggplot2`
- FLR: `FLCore`, `FLaSh`, `FLAssess`, `FLBRP`, `ggplotFL`

if you are using Windows, please use 32-bit R version
You can do so as follows,

```
install.packages(c("FLAssess", "FLBRP", "ggplotFL"),  
  repos = "http://flr-project.org/R")
```

The example used here is for the `ple4` data that is available in FLR. This needs to be loaded first

```
library(FLAssess)  
library(FLaSh)  
library(ggplotFL)  
library(FLBRP)  
data(ple4)  
summary(ple4)
```

An object of class "FLStock"

Name: Plaice in IV

Description: Imported from a VPA file. (N:\Projecte [...]

Quant: age

| Dims: | age | year | unit | season | area | iter |
|-------|-----|------|------|--------|------|------|
| | 10 | 52 | 1 | 1 | 1 | 1 |

| Range: | min | max | pgroup | minyear | maxyear | minfbar | maxfbar |
|--------|-----|-----|--------|---------|---------|---------|---------|
| | 1 | 10 | 10 | 1957 | 2008 | 2 | 6 |

```

catch      : [ 1 52 1 1 1 1 ], units = t
catch.n    : [ 10 52 1 1 1 1 ], units = 10^3
catch.wt   : [ 10 52 1 1 1 1 ], units = kg
discards   : [ 1 52 1 1 1 1 ], units = t
discards.n : [ 10 52 1 1 1 1 ], units = 10^3
discards.wt : [ 10 52 1 1 1 1 ], units = kg
landings   : [ 1 52 1 1 1 1 ], units = t
landings.n : [ 10 52 1 1 1 1 ], units = 10^3
landings.wt : [ 10 52 1 1 1 1 ], units = kg
stock      : [ 1 52 1 1 1 1 ], units = t
stock.n    : [ 10 52 1 1 1 1 ], units = 10^3
stock.wt   : [ 10 52 1 1 1 1 ], units = kg
m          : [ 10 52 1 1 1 1 ], units = m
mat        : [ 10 52 1 1 1 1 ], units = NA
harvest    : [ 10 52 1 1 1 1 ], units = f
harvest.spwn : [ 10 52 1 1 1 1 ], units = NA
m.spwn     : [ 10 52 1 1 1 1 ], units = NA

```

Extending the stock object for the projections

Our ple4 stock goes up to 2008, and in this example we want to make a 3 year projection, so we need to extend the stock by 3 years (nyears).

The projection will predict abundances in the future, but what will the future stock weights, maturity, natural mortality, etc. be like? The assumptions on those will affect the outcome of the projection. Rather than using `window()` or `trim()` that makes all future data NA, we use the `stf()` function (short term forecast) that has several options that allow to control the assumptions about the future stock parameters.

These assumptions specify how many years you want to average over to set future values. For example, `wts.nyears` is the number of years over which to calculate the `*.wt`, `*.spwn`, `mat` and `m` slots. By default this is set to 3 years. This is a fairly standard assumption for STFs, i.e. the future mean weights at age will be the same as the mean of the last 3 years. Hence, What is going to happen in the next few years is probably similar to what happened in the last few years.

A simple 3 year forecast for the weights, natural mortality, etc. assuming these are equal to their averages over the last 3 years is done by

```

ple4_stf <- stf(ple4, nyears = 3, wts.nyears = 3,
na.rm = TRUE)

```

Previously, the stock went up to 2008. Now the stock goes up to 2011 and the future weights are equal to the means of the last three observed years, as can be observed from the last six years of the stock weights of the `ple4_stf` object.

```
maxyr_stk <- range(ple4)[["maxyear"]]
```

```
range(ple4_stf)
```

| min | max | plusgroup | minyear |
|---------|---------|-----------|---------|
| 1 | 10 | 10 | 1957 |
| maxyear | minfbar | maxfbar | |
| 2011 | 2 | 6 | |

```
maxyr_stf <- range(ple4_stf)[["maxyear"]]
```

```
stock.wt(ple4_stf)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

| | year | | | |
|-----|----------|----------|----------|----------|
| age | 2006 | 2007 | 2008 | 2009 |
| 1 | 0.053000 | 0.048000 | 0.050000 | 0.050333 |
| 2 | 0.129000 | 0.093000 | 0.114000 | 0.112000 |
| 3 | 0.195000 | 0.239000 | 0.200000 | 0.211333 |
| 4 | 0.321000 | 0.241000 | 0.278000 | 0.280000 |
| 5 | 0.354000 | 0.337000 | 0.355000 | 0.348667 |
| 6 | 0.424000 | 0.394000 | 0.429000 | 0.415667 |
| 7 | 0.439000 | 0.458000 | 0.484000 | 0.460333 |
| 8 | 0.506000 | 0.412000 | 0.627000 | 0.515000 |
| 9 | 0.583000 | 0.526000 | 0.598000 | 0.569000 |
| 10 | 0.730673 | 0.548489 | 0.730672 | 0.669945 |

| | year | |
|-----|----------|----------|
| age | 2010 | 2011 |
| 1 | 0.050333 | 0.050333 |
| 2 | 0.112000 | 0.112000 |
| 3 | 0.211333 | 0.211333 |
| 4 | 0.280000 | 0.280000 |
| 5 | 0.348667 | 0.348667 |
| 6 | 0.415667 | 0.415667 |
| 7 | 0.460333 | 0.460333 |
| 8 | 0.515000 | 0.515000 |
| 9 | 0.569000 | 0.569000 |
| 10 | 0.669945 | 0.669945 |

units: kg

For maturity the same assumption (of the future being the same as the average as the last 3 years) holds, but those maturities were assumed constant already.

```
mat(ple4_stf)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

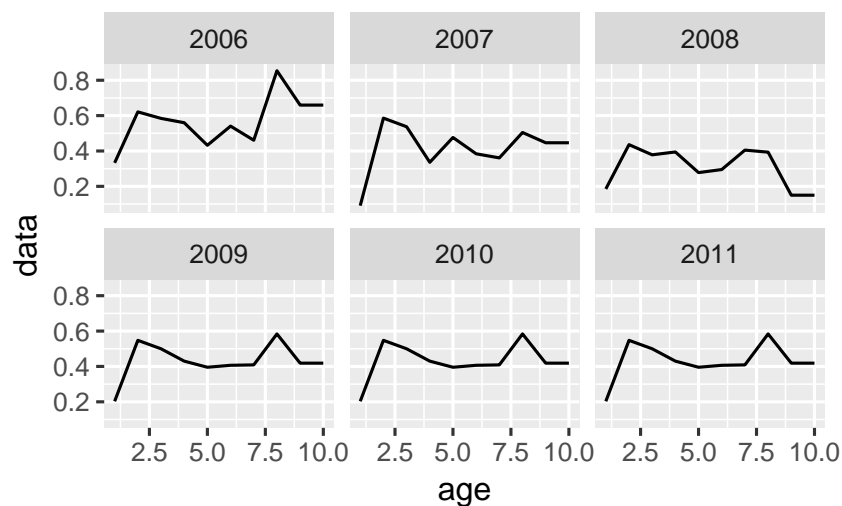
, , unit = unique, season = all, area = unique

| | year |
|-----|-------------------------------|
| age | 2006 2007 2008 2009 2010 2011 |
| 1 | 0.0 0.0 0.0 0.0 0.0 0.0 |
| 2 | 0.5 0.5 0.5 0.5 0.5 0.5 |
| 3 | 0.5 0.5 0.5 0.5 0.5 0.5 |
| 4 | 1.0 1.0 1.0 1.0 1.0 1.0 |
| 5 | 1.0 1.0 1.0 1.0 1.0 1.0 |
| 6 | 1.0 1.0 1.0 1.0 1.0 1.0 |
| 7 | 1.0 1.0 1.0 1.0 1.0 1.0 |
| 8 | 1.0 1.0 1.0 1.0 1.0 1.0 |
| 9 | 1.0 1.0 1.0 1.0 1.0 1.0 |
| 10 | 1.0 1.0 1.0 1.0 1.0 1.0 |

units: NA

Notice that the future fishing mortality has also been set (mean of the last 3 years, by default).

```
ggplot(harvest(ple4_stf)[, ac((maxyr_stf - 5):maxyr_stf)]) +  
  geom_line(aes(x = age, y = data)) + facet_wrap(~year)
```



The stock numbers at age and the catch numbers at age are not forecasted yet: this is what the `fwd()` function will perform later.

```
stock.n(ple4_stf)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

| | year | | | |
|-----|----------|----------|----------|------|
| age | 2006 | 2007 | 2008 | 2009 |
| 1 | 820006.3 | 949341.2 | 844041.2 | NA |
| 2 | 554592.5 | 531914.3 | 784234.7 | NA |
| 3 | 422068.8 | 269655.1 | 267892.4 | NA |
| 4 | 88052.9 | 212889.2 | 142573.0 | NA |
| 5 | 136368.1 | 45514.9 | 137660.4 | NA |
| 6 | 17534.5 | 80086.2 | 25575.8 | NA |
| 7 | 16289.7 | 9240.6 | 49356.8 | NA |
| 8 | 4114.0 | 9297.5 | 5828.1 | NA |
| 9 | 2688.5 | 1585.1 | 5078.7 | NA |
| 10 | 2854.5 | 3660.1 | 6750.3 | NA |

| | year | |
|-----|------|------|
| age | 2010 | 2011 |
| 1 | NA | NA |
| 2 | NA | NA |
| 3 | NA | NA |
| 4 | NA | NA |
| 5 | NA | NA |
| 6 | NA | NA |
| 7 | NA | NA |
| 8 | NA | NA |
| 9 | NA | NA |
| 10 | NA | NA |

units: 10³

Meanwhile, the landings and discards are forecasted ratios of what is discarded and what is landed over the last 3 years of data.

```
landings.n(ple4_stf)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

year

| age | 2006 | 2007 | 2008 |
|-----|------------|------------|------------|
| 1 | 3.5500e+02 | 1.2860e+03 | 3.8000e+02 |
| 2 | 1.8987e+04 | 1.9205e+04 | 1.0970e+04 |
| 3 | 6.7465e+04 | 3.7309e+04 | 4.2865e+04 |
| 4 | 2.5254e+04 | 4.7053e+04 | 3.7970e+04 |
| 5 | 4.2525e+04 | 1.4971e+04 | 2.9476e+04 |
| 6 | 6.5550e+03 | 1.7142e+04 | 5.7000e+03 |
| 7 | 4.9670e+03 | 2.4590e+03 | 6.7520e+03 |
| 8 | 2.0530e+03 | 1.8560e+03 | 9.1200e+02 |
| 9 | 1.2350e+03 | 5.4300e+02 | 6.7300e+02 |
| 10 | 1.3190e+03 | 1.2590e+03 | 8.9600e+02 |

year

| age | 2009 | 2010 | 2011 |
|-----|------------|------------|------------|
| 1 | 6.9226e-03 | 6.9226e-03 | 6.9226e-03 |
| 2 | 6.8339e-02 | 6.8339e-02 | 6.8339e-02 |
| 3 | 4.2124e-01 | 4.2124e-01 | 4.2124e-01 |
| 4 | 7.9214e-01 | 7.9214e-01 | 7.9214e-01 |
| 5 | 9.2489e-01 | 9.2489e-01 | 9.2489e-01 |
| 6 | 8.5454e-01 | 8.5454e-01 | 8.5454e-01 |
| 7 | 7.4116e-01 | 7.4116e-01 | 7.4116e-01 |
| 8 | 6.4967e-01 | 6.4967e-01 | 6.4967e-01 |
| 9 | 1.0000e+00 | 1.0000e+00 | 1.0000e+00 |
| 10 | 1.0000e+00 | 1.0000e+00 | 1.0000e+00 |

units: 10³

```
discards.n(ple4_stf)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

year

| age | 2006 | 2007 | 2008 |
|-----|------------|------------|------------|
| 1 | 2.2047e+05 | 7.7312e+04 | 1.3541e+05 |
| 2 | 2.2508e+05 | 2.0514e+05 | 2.5263e+05 |
| 3 | 1.1022e+05 | 6.9312e+04 | 3.7393e+04 |
| 4 | 1.0656e+04 | 1.0735e+04 | 6.2370e+03 |
| 5 | 3.0000e+03 | 1.4370e+03 | 2.2820e+03 |
| 6 | 4.1000e+02 | 7.1510e+03 | 5.1700e+02 |
| 7 | 7.5400e+02 | 2.0400e+02 | 8.8820e+03 |
| 8 | 1.9400e+02 | 1.6490e+03 | 8.9100e+02 |
| 9 | 0.0000e+00 | 0.0000e+00 | 0.0000e+00 |
| 10 | 0.0000e+00 | 0.0000e+00 | 0.0000e+00 |

year

| age | 2009 | 2010 | 2011 |
|-----|------------|------------|------------|
| 1 | 9.9308e-01 | 9.9308e-01 | 9.9308e-01 |
| 2 | 9.3166e-01 | 9.3166e-01 | 9.3166e-01 |
| 3 | 5.7876e-01 | 5.7876e-01 | 5.7876e-01 |
| 4 | 2.0786e-01 | 2.0786e-01 | 2.0786e-01 |
| 5 | 7.5111e-02 | 7.5111e-02 | 7.5111e-02 |
| 6 | 1.4546e-01 | 1.4546e-01 | 1.4546e-01 |
| 7 | 2.5884e-01 | 2.5884e-01 | 2.5884e-01 |
| 8 | 3.5033e-01 | 3.5033e-01 | 3.5033e-01 |
| 9 | 0.0000e+00 | 0.0000e+00 | 0.0000e+00 |
| 10 | 0.0000e+00 | 0.0000e+00 | 0.0000e+00 |

units: 10³

The stock-recruitment relationship (SRR)

A short term forecast does not use a SRR, instead it generally assumes that recruitment in the future is the mean of the historic recruitments. However, we still need to have a SRR that contains the mean value, which is what we mimic for this example. First we estimate the geometric mean recruitment, that we then add to an SRR object

```
mean_rec <- mean(rec(ple4))
```

```
ple4_sr <- as.FLSR(ple4, model = "geomean")
params(ple4_sr)["a", ] <- mean_rec
params(ple4_sr)
```

An object of class "FLPar"

params

a

1039494

units: NA

The control object

The final thing we need to set up is the control object. This tells the projection what to do, i.e. what level of fishing mortality to use

A standard scenario for a STF is the 'status quo' scenario, assuming that the future mean fishing mortality will be the same as the mean of the last X years (X depends on the stock). We will set up this scenario as a simple example using the F_{bar} in the last year (2008), being 0.356 per year.

```
round(fbar(ple4), 3)
```

An object of class "FLQuant"

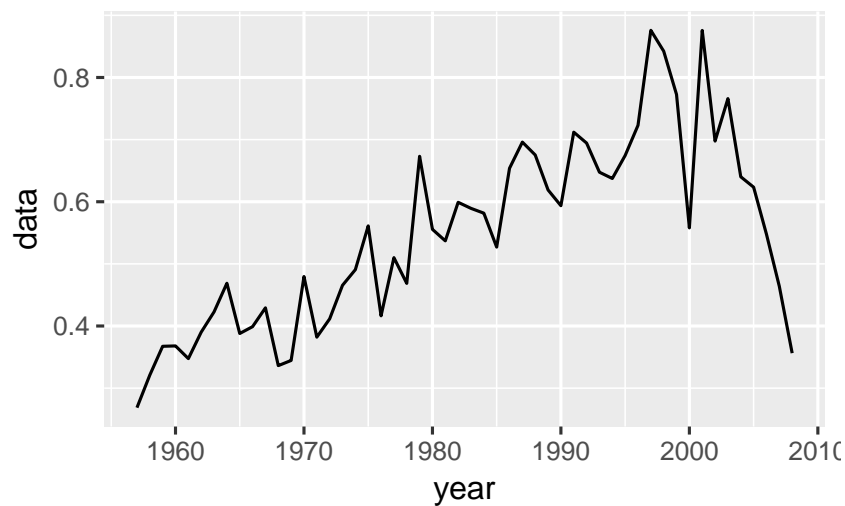
```
, , unit = unique, season = all, area = unique
```

```
year
age  1957  1958  1959  1960  1961
all  0.269  0.321  0.367  0.368  0.348
```

```
[ ... 42 years]
```

```
year
age  2004  2005  2006  2007  2008
all  0.640  0.623  0.548  0.464  0.356
```

```
ggplot(fbar(ple4), aes(x = year, y = data)) +
  geom_line()
```



Below we define the last year of the stock and the status quo Fbar
fbar_SQ.

```
fbar_SQ <- mean(fbar(ple4)[, as.character(maxyr_stk)])
```

Now we introduce the control object: `fwdControl()`. This takes 1
argument - a data.frame that sets:

- The quantity (or type) of the target (we are using Fbar but can also set catch etc. see MTF)
- The value of the target, here status quo F
- The year the target is to be hit
- Some other things that we will ignore for now

Let's make the data.frame

```
ctrl_target <- data.frame(year = 2009:2011, quantity = "f",
  val = fbar_SQ)
# Set the control object - year, quantity and
# value for the moment
ctrl_f <- fwdControl(ctrl_target)
ctrl_f
```

Target

| | year | quantity | min | val | max |
|---|------|----------|-----|--------|-----|
| 1 | 2009 | f | NA | 0.3563 | NA |
| 2 | 2010 | f | NA | 0.3563 | NA |
| 3 | 2011 | f | NA | 0.3563 | NA |

| | min | val | max |
|---|-----|---------|-----|
| 1 | NA | 0.35631 | NA |
| 2 | NA | 0.35631 | NA |
| 3 | NA | 0.35631 | NA |

We see that we have what looks like our `ctrl_target`, but now it has two more columns (min and max). There is another table underneath which is for uncertainty but that we ignore in *STF*.

Running the STF

Below we run a simple STF with 'status quo' future fishing mortality. Remember we had to make assumptions about the future (weights, selection pattern, discard ratio etc.).

This is done using `fwd()`, which takes three objects: the stock, the control object, the SRR. It returns an updated `FLStock` object. This updated has forecasted stock numbers, based on the recruitment assumptions, the fishing mortality, and the natural mortality. Because we now have stock numbers, we can calculate forecasted `ssb`.

```
ple4_sq <- fwd(ple4_stf, ctrl = ctrl_f, sr = ple4_sr)
```

Below, we check if the recruitment in the forecasted stock indeed corresponds to the mean recruitment

```
mean_rec
```

```
[1] 1039494
```

```
rec(ple4_sq)[, ac((maxyr_stf - 5):maxyr_stf)]
```

```
An object of class "FLQuant"
An object of class "FLQuant"
, , unit = unique, season = all, area = unique
```

```
      year
age 2006    2007    2008    2009    2010
  1 820006  949341  844041 1039494 1039494
      year
age 2011
  1 1039494
```

```
units: NA
```

Similarly, we check if the fbar in the forecasted stock indeed corresponds to the status quo fishing mortality.

```
round(fbar_sq, 3)

[1] 0.356

round(fbar(ple4_sq)[, ac((maxyr_stf - 5):maxyr_stf)],
      3)
```

```
An object of class "FLQuant"
An object of class "FLQuant"
, , unit = unique, season = all, area = unique
```

```
      year
age  2006  2007  2008  2009  2010  2011
all 0.548 0.464 0.356 0.356 0.356 0.356
```

```
units: f
```

The stock numbers are calculated using the recruitment and the future mortality

```
stock.n(ple4_sq)[, ac((maxyr_stf - 5):maxyr_stf)]
```

```
An object of class "FLQuant"
An object of class "FLQuant"
, , unit = unique, season = all, area = unique
```

```
      year
age 2006    2007    2008    2009
  1 820006.3 949341.2 844041.2 1039494.2
  2 554592.5 531914.3 784234.7 634556.4
  3 422068.8 269655.1 267892.4 458861.8
```

| | | | | |
|----|----------|----------|----------|----------|
| 4 | 88052.9 | 212889.2 | 142573.0 | 166055.3 |
| 5 | 136368.1 | 45514.9 | 137660.4 | 86954.4 |
| 6 | 17534.5 | 80086.2 | 25575.8 | 94351.2 |
| 7 | 16289.7 | 9240.6 | 49356.8 | 17228.2 |
| 8 | 4114.0 | 9297.5 | 5828.1 | 29788.4 |
| 9 | 2688.5 | 1585.1 | 5078.7 | 3558.4 |
| 10 | 2854.5 | 3660.1 | 6750.3 | 9212.2 |

year

| age | 2010 | 2011 |
|-----|-----------|-----------|
| 1 | 1039494.2 | 1039494.2 |
| 2 | 802562.9 | 802562.9 |
| 3 | 374263.6 | 473354.4 |
| 4 | 280909.2 | 229119.3 |
| 5 | 107361.5 | 181619.3 |
| 6 | 57762.5 | 71318.6 |
| 7 | 62135.0 | 38039.5 |
| 8 | 11325.1 | 40844.9 |
| 9 | 17078.0 | 6492.8 |
| 10 | 8330.8 | 16575.1 |

units: NA

Note that the future harvest slot is different from the harvest from the one we set up, but that the selection pattern is the same: F at age has been multiplied by the same value to give us the target Fbar value

```
round(harvest(ple4_stf)[, ac((maxyr_stf - 2):maxyr_stf)],
      3)
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

| | year | | |
|-----|-------|-------|-------|
| age | 2009 | 2010 | 2011 |
| 1 | 0.203 | 0.203 | 0.203 |
| 2 | 0.548 | 0.548 | 0.548 |
| 3 | 0.500 | 0.500 | 0.500 |
| 4 | 0.430 | 0.430 | 0.430 |
| 5 | 0.395 | 0.395 | 0.395 |
| 6 | 0.407 | 0.407 | 0.407 |
| 7 | 0.409 | 0.409 | 0.409 |
| 8 | 0.584 | 0.584 | 0.584 |
| 9 | 0.419 | 0.419 | 0.419 |

```
10 0.419 0.419 0.419
```

```
units: f
```

```
round(harvest(ple4_sq)[, ac((maxyr_stf - 2):maxyr_stf)],
      3)
```

```
An object of class "FLQuant"
```

```
An object of class "FLQuant"
```

```
, , unit = unique, season = all, area = unique
```

```
      year
age 2009 2010 2011
 1  0.159 0.159 0.159
 2  0.428 0.428 0.428
 3  0.391 0.391 0.391
 4  0.336 0.336 0.336
 5  0.309 0.309 0.309
 6  0.318 0.318 0.318
 7  0.320 0.320 0.320
 8  0.456 0.456 0.456
 9  0.327 0.327 0.327
10  0.327 0.327 0.327
```

```
units: f
```

```
harvest(ple4_stf)[, ac((maxyr_stf - 2):maxyr_stf)]/harvest(ple4_sq)[,
  ac((maxyr_stf - 2):maxyr_stf)]
```

```
An object of class "FLQuant"
```

```
An object of class "FLQuant"
```

```
, , unit = unique, season = all, area = unique
```

```
      year
age 2009 2010 2011
 1  1.2797 1.2797 1.2797
 2  1.2797 1.2797 1.2797
 3  1.2797 1.2797 1.2797
 4  1.2797 1.2797 1.2797
 5  1.2797 1.2797 1.2797
 6  1.2797 1.2797 1.2797
 7  1.2797 1.2797 1.2797
 8  1.2797 1.2797 1.2797
 9  1.2797 1.2797 1.2797
10  1.2797 1.2797 1.2797
```

units: f

The catch numbers come from the predicted abundance and harvest rates using the Baranov equation. The catches are then split into landings and discards using the ratios computed by `stf()`.

```
landings.n(ple4_sq)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

| | year | | | |
|-----|----------|----------|----------|----------|
| age | 2006 | 2007 | 2008 | 2009 |
| 1 | 355.00 | 1286.00 | 380.00 | 1006.12 |
| 2 | 18987.00 | 19205.00 | 10970.00 | 14418.91 |
| 3 | 67465.00 | 37309.00 | 42865.00 | 59684.58 |
| 4 | 25254.00 | 47053.00 | 37970.00 | 35832.72 |
| 5 | 42525.00 | 14971.00 | 29476.00 | 20398.74 |
| 6 | 6555.00 | 17142.00 | 5700.00 | 20939.33 |
| 7 | 4967.00 | 2459.00 | 6752.00 | 3332.27 |
| 8 | 2053.00 | 1856.00 | 912.00 | 6773.26 |
| 9 | 1235.00 | 543.00 | 673.00 | 947.53 |
| 10 | 1319.00 | 1259.00 | 896.00 | 2453.01 |

| | year | |
|-----|----------|----------|
| age | 2010 | 2011 |
| 1 | 1006.12 | 1006.12 |
| 2 | 18236.48 | 18236.48 |
| 3 | 48680.81 | 61569.64 |
| 4 | 60616.80 | 49441.17 |
| 5 | 25186.06 | 42606.28 |
| 6 | 12819.21 | 15827.72 |
| 7 | 12018.13 | 7357.58 |
| 8 | 2575.09 | 9287.29 |
| 9 | 4547.50 | 1728.89 |
| 10 | 2218.31 | 4413.60 |

units: NA

```
discards.n(ple4_sq)[, ac((maxyr_stf - 5):maxyr_stf)]
```

An object of class "FLQuant"

An object of class "FLQuant"

, , unit = unique, season = all, area = unique

year

| age | 2006 | 2007 | 2008 | 2009 |
|-----|----------|----------|----------|----------|
| 1 | 220473.0 | 77312.0 | 135406.0 | 144332.6 |
| 2 | 225077.0 | 205140.0 | 252629.0 | 196572.8 |
| 3 | 110215.0 | 69312.0 | 37393.0 | 82004.2 |
| 4 | 10656.0 | 10735.0 | 6237.0 | 9402.9 |
| 5 | 3000.0 | 1437.0 | 2282.0 | 1656.6 |
| 6 | 410.0 | 7151.0 | 517.0 | 3564.4 |
| 7 | 754.0 | 204.0 | 8882.0 | 1163.8 |
| 8 | 194.0 | 1649.0 | 891.0 | 3652.4 |
| 9 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10 | 0.0 | 0.0 | 0.0 | 0.0 |

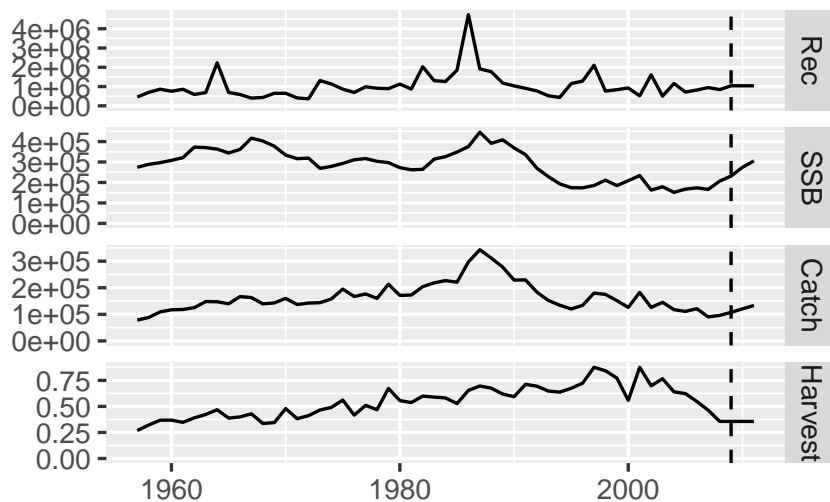
year

| age | 2010 | 2011 |
|-----|----------|----------|
| 1 | 144332.6 | 144332.6 |
| 2 | 248617.9 | 248617.9 |
| 3 | 66885.5 | 84594.2 |
| 4 | 15906.5 | 12973.9 |
| 5 | 2045.4 | 3460.1 |
| 6 | 2182.1 | 2694.3 |
| 7 | 4197.2 | 2569.5 |
| 8 | 1388.6 | 5008.1 |
| 9 | 0.0 | 0.0 |
| 10 | 0.0 | 0.0 |

units: NA

We can see the projection using a plot here

```
plot(ple4_sq) + geom_vline(lty = 2, xintercept = an(ISOdate(maxyr_stk +
  1, 1, 1)))
```



Short term forecast with many F scenarios

Typically when running STF you explore several different future F scenarios. The scenarios are based on 'F status quo', which we calculated above as the mean F of the last X years.

For a 3 year STF the F pattern is:

- year 1: fbar_status_quo
- year 2: $\text{fbar_status_quo} * \text{fbar_multiplier}$
- year 3: $\text{fbar_status_quo} * \text{fbar_multiplier}$

Note that the fbar_multiplier is the same for years 2 and 3

We are going to run several STFs with different values for the fbar_multiplier

```
fbar_multiplier <- seq(from = 0, to = 2, by = 0.2)
```

Next we are going to build a data.frame that builds these scenarios. Each column in the dataframe is a year, each row is a scenario. Note that if you project for more than 3 years you will need to add more columns / years to the matrix

```
fbar_scenarios <- cbind(rep(fbar_SQ, length(fbar_multiplier)),
  fbar_multiplier * fbar_SQ, fbar_multiplier *
  fbar_SQ)
```

Another scenario we are interested in is $F_{0.1}$. We can calculate this using FLBRP (or maybe you already have a value).

```
f01 <- c(refpts(brp(FLBRP(ple4)))["f0.1", "harvest"])
```

```
# Add the F0.1 scenario as a final scenario
```

```
fbar_scenarios <- rbind(fbar_scenarios, c(fbar_SQ,
  f01, f01))
```

```
# Add some names
```

```
colnames(fbar_scenarios) <- c("2009", "2010",
  "2011")
```

```
rownames(fbar_scenarios) <- c(fbar_multiplier,
  "f01")
```

```
fbar_scenarios
```

| | 2009 | 2010 | 2011 |
|-----|--------|--------|--------|
| 0 | 0.3563 | 0.0000 | 0.0000 |
| 0.2 | 0.3563 | 0.0713 | 0.0713 |
| 0.4 | 0.3563 | 0.1425 | 0.1425 |

| | 2009 | 2010 | 2011 |
|-----|--------|--------|--------|
| 0.6 | 0.3563 | 0.2138 | 0.2138 |
| 0.8 | 0.3563 | 0.2850 | 0.2850 |
| 1 | 0.3563 | 0.3563 | 0.3563 |
| 1.2 | 0.3563 | 0.4276 | 0.4276 |
| 1.4 | 0.3563 | 0.4988 | 0.4988 |
| 1.6 | 0.3563 | 0.5701 | 0.5701 |
| 1.8 | 0.3563 | 0.6414 | 0.6414 |
| 2 | 0.3563 | 0.7126 | 0.7126 |
| f01 | 0.3563 | 0.0876 | 0.0876 |

There are various results we want to extract from the STF, like predicted Catch, SSB and the relative change in these. First make an empty matrix in which to store the results

```
stf_results <- matrix(NA, nrow = nrow(fbar_scenarios),
  ncol = 8)
# Set some column names
colnames(stf_results) <- c("Fbar", paste0("Catch",
  maxyr_stk + 1), paste0("Catch", maxyr_stk +
  2), paste0("Catch", maxyr_stk + 3), paste0("SSB",
  maxyr_stk + 2), paste0("SSB", maxyr_stk +
  3), paste0("SSB_change_", maxyr_stk + 2, "- ",
  maxyr_stk + 3, "(%)"), paste0("Catch_change_",
  maxyr_stk, "- ", maxyr_stk + 2, "(%)"))

# Store the resulting FLStock each time
stk_stf <- FLStocks()
# Loop over the scenarios (each row in the
# fbar_scenarios table)
for (scenario in 1:nrow(fbar_scenarios)) {
  cat("Scenario: ", scenario, "\n")
  # Make a target object with F values for that
  # scenario
  ctrl_target <- data.frame(year = (maxyr_stf -
    2):maxyr_stf, quantity = "f", val = fbar_scenarios[scenario,
    ])
  # Set the control object - year, quantity and
  # value for the moment
  ctrl_f <- fwdControl(ctrl_target)
  # ctrl_target Run the forward projection. We
  # include an additional argument, maxF. By
  # default the value of maxF is 2.0 Here we
  # increase it to 10.0 so that F is not limited
```



```

ple4_fwd <- fwd(ple4_stf, ctrl = ctrl_f, sr = ple4_sr) #, maxF = 10.0)
## Check it has worked - uncomment out to check
## scenario by scenario
## plot(ple4_fwd[,ac(2001:2011)]) Store the
## result - if you want to, comment out if
## unnecessary
stk_stf[[as.character(scenario)]] <- ple4_fwd

# Fill results table
stf_results[scenario, 1] <- round(fbar(ple4_fwd)[,
  ac(2011)], 3) # final stf year
stf_results[scenario, 2] <- catch(ple4_fwd)[,
  ac(maxyr_stk + 1)] # 1st stf year
stf_results[scenario, 3] <- catch(ple4_fwd)[,
  ac(maxyr_stk + 2)] # 2nd stf year
stf_results[scenario, 4] <- catch(ple4_fwd)[,
  ac(maxyr_stk + 3)] # final stf year
stf_results[scenario, 5] <- ssb(ple4_fwd)[,
  ac(maxyr_stk + 2)] # 2nd stf year
stf_results[scenario, 6] <- ssb(ple4_fwd)[,
  ac(maxyr_stk + 3)] # final stf year

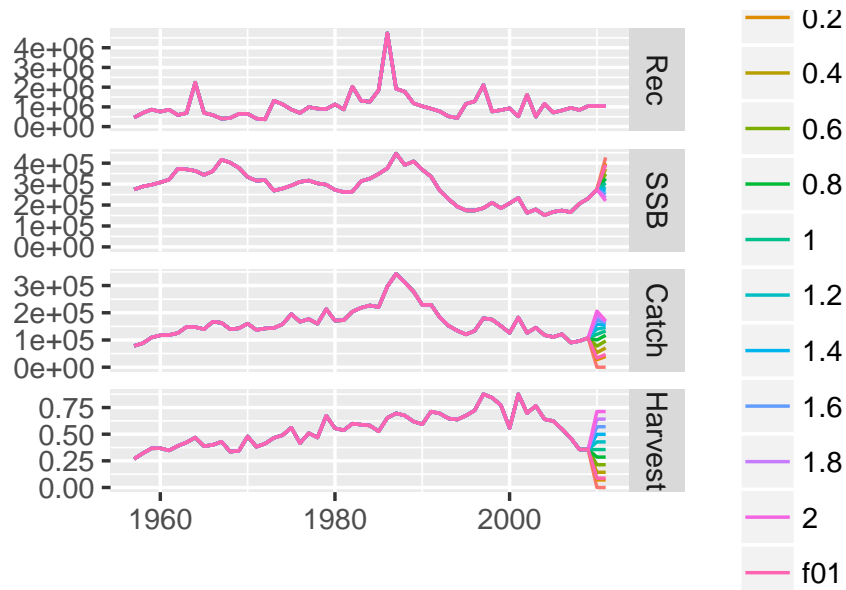
# change in ssb in last two stf years
stf_results[scenario, 7] <- round((ssb(ple4_fwd)[,
  ac(maxyr_stk + 3)] - ssb(ple4_fwd)[, ac(maxyr_stk +
  2)])/ssb(ple4_fwd)[, ac(maxyr_stk + 2)] *
  100, 1)

# change in catch from true year, to 2nd to
# last stf year
stf_results[scenario, 8] <- round((catch(ple4_fwd)[,
  ac(maxyr_stk + 2)] - catch(ple4_fwd)[,
  ac(maxyr_stk)])/catch(ple4_fwd)[, ac(maxyr_stk)] *
  100, 1)
}

# Give the FLStocks object some names
names(stk_stf) <- rownames(fbar_scenarios)

# Plotting
plot(stk_stf)

```



The different scenarios are plotted above. The table of results is given below.

stf_results

| Fbar | Catch2009 | Catch2010 | Catch2011 | SSB2010 | SSB2011 | SSB_change_2010-2011(%) | Catch_change_2008-2010 |
|-------|-----------|-----------|-----------|---------|---------|-------------------------|------------------------|
| 0.000 | 107543 | 0 | 0 | 274322 | 427478 | 55.8 | -10 |
| 0.071 | 107543 | 27670 | 39016 | 274322 | 399470 | 45.6 | -7 |
| 0.143 | 107543 | 53457 | 70819 | 274322 | 373394 | 36.1 | -2 |
| 0.214 | 107543 | 77495 | 96520 | 274322 | 349112 | 27.3 | -1 |
| 0.285 | 107543 | 99907 | 117069 | 274322 | 326496 | 19.0 | 0 |
| 0.356 | 107543 | 120809 | 133278 | 274322 | 305429 | 11.3 | 2 |
| 0.428 | 107543 | 140308 | 145840 | 274322 | 285800 | 4.2 | 4 |
| 0.499 | 107543 | 158502 | 155345 | 274322 | 267507 | -2.5 | 6 |
| 0.570 | 107543 | 175484 | 162298 | 274322 | 250458 | -8.7 | 8 |
| 0.641 | 107543 | 191338 | 167127 | 274322 | 234562 | -14.5 | 9 |
| 0.713 | 107543 | 206143 | 170197 | 274322 | 219741 | -19.9 | 11 |
| 0.088 | 107543 | 33744 | 46903 | 274322 | 393326 | 43.4 | -0 |

More information

- You can submit bug reports, questions or suggestions on this tutorial at <https://github.com/flr/doc/issues>.
- Or send a pull request to <https://github.com/flr/doc/>
- For more information on the FLR Project for Quantitative Fisheries Science in R, visit the FLR webpage, <http://flr-project.org>.

Software Versions

- R version 3.3.2 (2016-10-31)
- FLCore: 2.6.0.20170228
- FLAssess: 2.5.20150717
- FLash: 2.5.7
- ggplotFL: 2.5.9.9000
- ggplot2: 2.2.1
- FLBRP: 2.5.20170228
- **Compiled:** Wed Mar 8 13:54:50 2017

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