Reference Points with FLBRP, Summer School in Quantative Fisheries Stock Assessment, Capo Granitola

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July 13th, 2017

```
# load the library
library(FLBRP)
```

```
## Loading required package: FLCore
## Loading required package: MASS
## Loading required package: lattice
## FLCore (Version 2.6.3, packaged: 2017-07-05 12:26:15 UTC)
## Loading required package: FLash
## Loading required package: ggplotFL
## Loading required package: ggplot2
##
## Attaching package: 'ggplot2'
## The following object is masked from 'package:FLCore':
##
##     %+%
## Warning: replacing previous import 'ggplot2::%+%' by 'FLCore::%+%' when
## loading 'ggplotFL'
```

```
# Load the example FLStock object from FLCore
# we are going to use one of the stock objects from the HKE_09_10_11 stock assessment
load("HKEFbar0_3.RData")
hke<-HKE.new_xsa

# Create the corresponding FLBRP object
hkebrp <- FLBRP(hke)

summary(hkebrp)
```

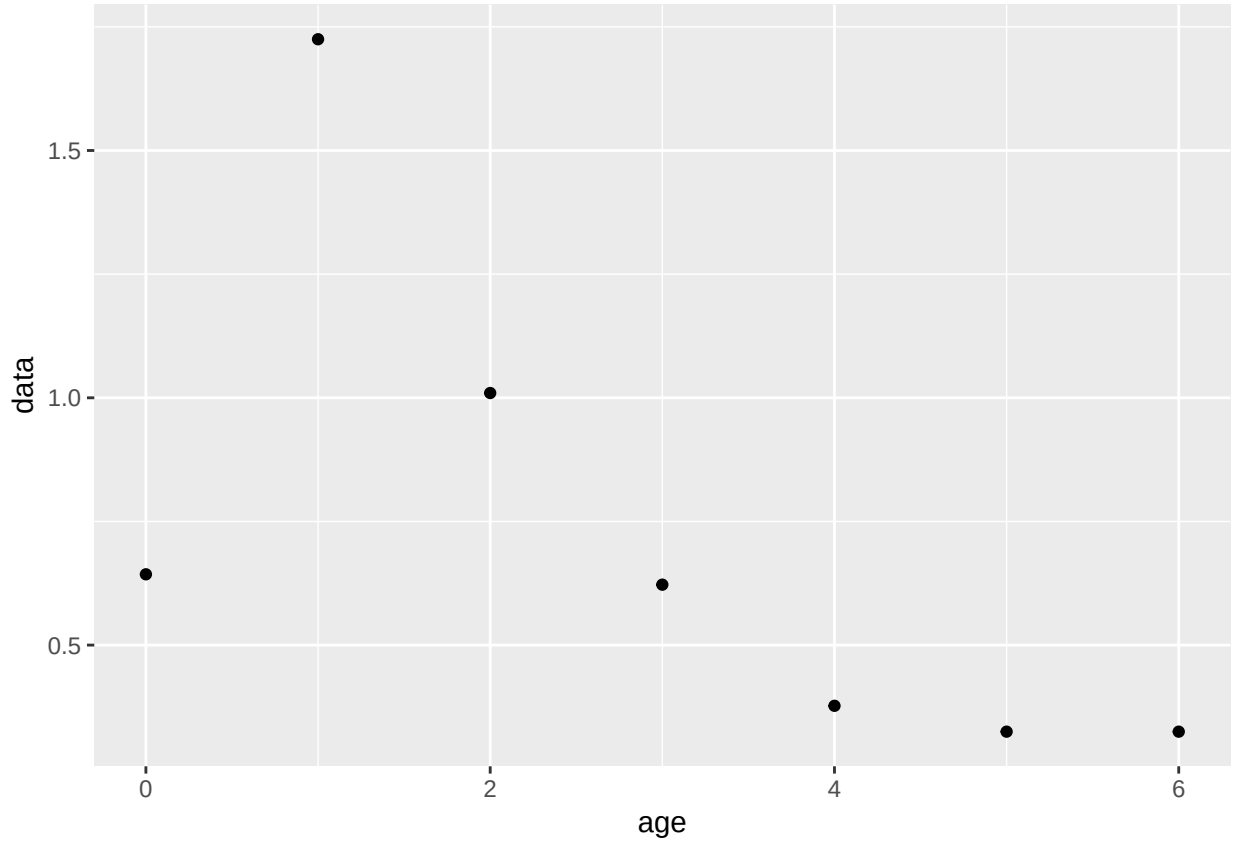
```
## An object of class "FLBRP"
##
## Name:
## Description:
## Quant: age
## Dims:  age   year    unit    season  area    iter
##  7   101 1   1   1   1
##
## Range:  min  max pgroup  minfbar maxfbar
##  0   6   6   0   3
##
## fbar          : [ 1 101 1 1 1 1 ], units =  f
## fbar.obs      : [ 1 9 1 1 1 1 ], units =  f
```

```
## landings.obs  : [ 1 9 1 1 1 1 ], units =  t
## discards.obs  : [ 1 9 1 1 1 1 ], units =  NA
## rec.obs       : [ 1 9 1 1 1 1 ], units =  NA
## ssb.obs       : [ 1 9 1 1 1 1 ], units =  kg
## stock.obs     : [ 1 9 1 1 1 1 ], units =  kg
## profit.obs    : [ 1 9 1 1 1 1 ], units =  NA
## landings.sel  : [ 7 1 1 1 1 1 ], units =  f
## discards.sel  : [ 7 1 1 1 1 1 ], units =  f
## bycatch.harv  : [ 7 1 1 1 1 1 ], units =  f
## stock.wt      : [ 7 1 1 1 1 1 ], units =  kg
## landings.wt   : [ 7 1 1 1 1 1 ], units =  NA
## discards.wt   : [ 7 1 1 1 1 1 ], units =  NA
## bycatch.wt    : [ 7 1 1 1 1 1 ], units =  NA
## m             : [ 7 1 1 1 1 1 ], units =  NA
## mat           : [ 7 1 1 1 1 1 ], units =  NA
## harvest.spwn  : [ 7 1 1 1 1 1 ], units =  NA
## m.spwn        : [ 7 1 1 1 1 1 ], units =  NA
## availability  : [ 7 1 1 1 1 1 ], units =  NA
## price         : [ 7 1 1 1 1 1 ], units =  NA
## vcost         : [ 1 1 1 1 1 1 ], units =  NA
## fcost         : [ 1 1 1 1 1 1 ], units =  NA
```

```
# The FLBRP class has information on:

# selection Patterns
catch.sel(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1
##   0 0.64312
##   1 1.72500
##   2 1.00969
##   3 0.62219
##   4 0.37727
##   5 0.32497
##   6 0.32497
##
## units:  f
```

```
# discards.sel(hkebrp)

ggplot(catch.sel(hkebrp), aes( age, data))+geom_point()
```




```
# ggplot(discards.sel(hkebrp), aes( age, data))+geom_point()


# mass-at-age
stock.wt(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1
##   0 0.010913
##   1 0.147273
##   2 0.504652
##   3 1.145925
##   4 1.871101
##   5 2.691069
##   6 4.024266
##
## units:  kg
```

```
catch.wt(hkebrp)
```

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

```
## age 1
##   0 0.010913
##   1 0.147273
##   2 0.504652
##   3 1.145925
##   4 1.871101
##   5 2.691069
##   6 4.024266
##
## units:  NA
```

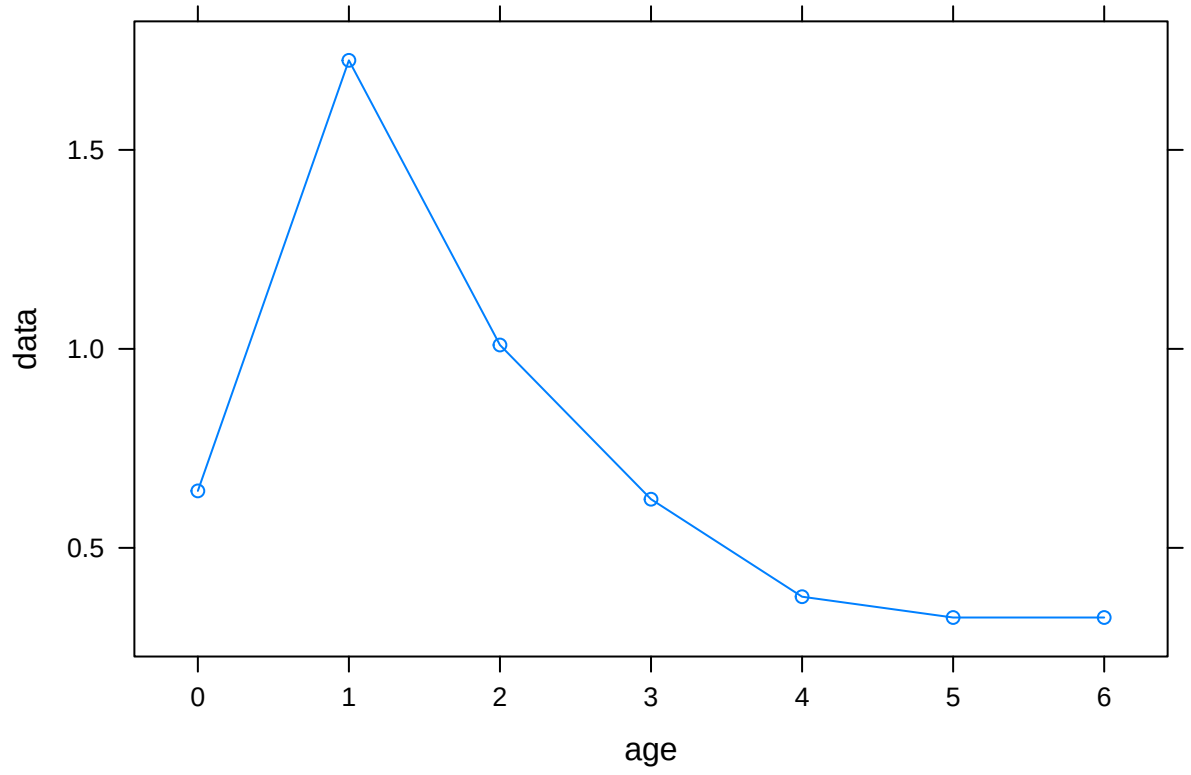
```
# discards.wt(hkebrp)

# biological parameters
m(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1
##   0 1.18108
##   1 0.57816
##   2 0.42077
##   3 0.36116
##   4 0.32880
##   5 0.31803
##   6 0.29796
##
## units:  NA
```

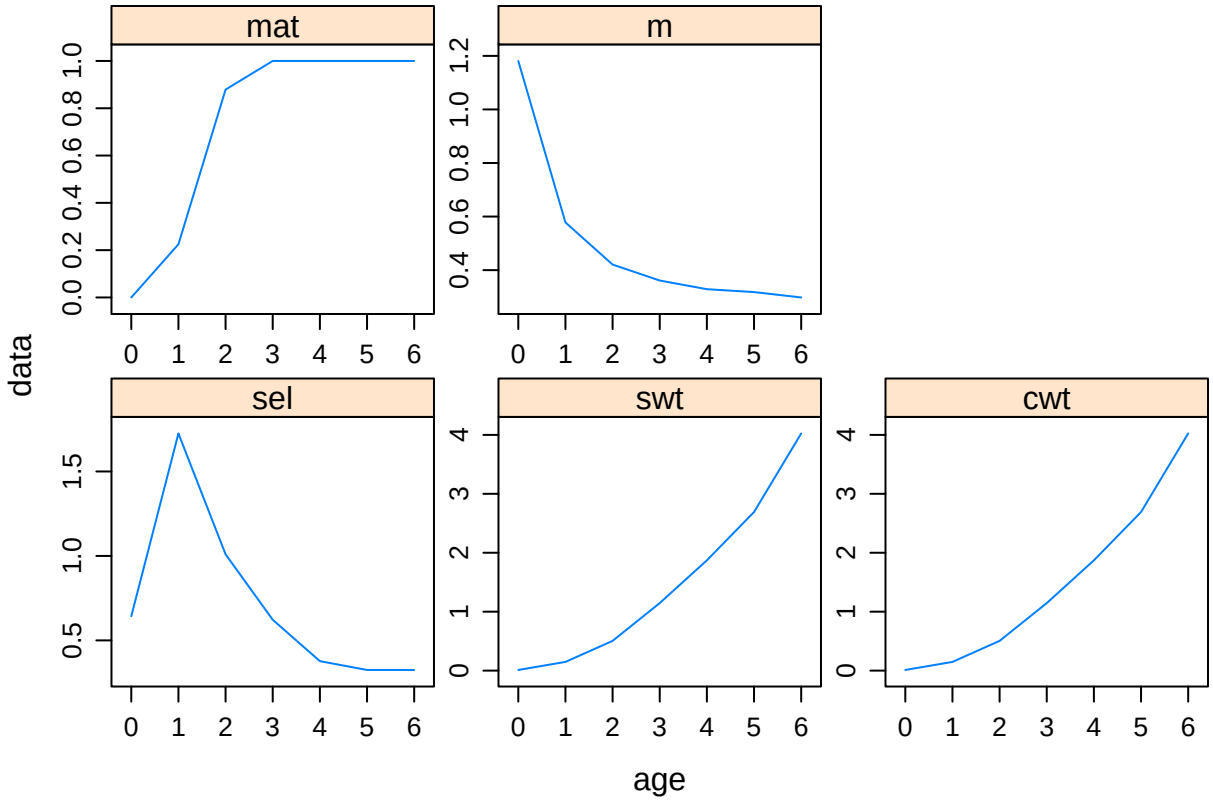
```
mat(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1
##   0 0.00000
##   1 0.22468
##   2 0.87888
##   3 1.00000
##   4 1.00000
##   5 1.00000
##   6 1.00000
##
## units:  NA
```

```
# selectivity
xyplot(data~age,data=catch.sel(hkebrp),type=c('l', 'p'))
```




```
# and other quantities by age
xyplot(data~age|qname, data=FLQuants(sel=catch.sel(hkebrp),
                                     swt=stock.wt(hkebrp),
                                     cwt =catch.wt(hkebrp), mat= mat(hkebrp), m = m(hkebrp)),
       type="l",scale="free")
```




```
# we have not provided a SR relationship yet
# so analyses wll be per-recruit


# All *.obs slots hold the observations from FLStock
fbar.obs(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##      year
## age   2006    2007    2008    2009    2010    2011    2012    2013
##   all 1.32180 1.16916 1.10318 1.04618 1.05383 1.24175 0.99996 0.91843
##      year
## age   2014
##   all 1.16887
##
## units:  f
```

```
# Once an FLBRP object has been created then equilibrium
# quantities can be estimated

# we estimate equilibrium quantities
hkebrp <- brp(hkebrp)

# and a set of equilibirum quantities for a range of F values
```

```
# fishing mortality
fbar(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##      year
## age   1    2    3    4    5    6    7    8    9    10   11   12   13
##   all 0.00 0.04 0.08 0.12 0.16 0.20 0.24 0.28 0.32 0.36 0.40 0.44 0.48
##      year
## age   14   15   16   17   18   19   20   21   22   23   24   25   26
##   all 0.52 0.56 0.60 0.64 0.68 0.72 0.76 0.80 0.84 0.88 0.92 0.96 1.00
##      year
## age   27   28   29   30   31   32   33   34   35   36   37   38   39
##   all 1.04 1.08 1.12 1.16 1.20 1.24 1.28 1.32 1.36 1.40 1.44 1.48 1.52
##      year
## age   40   41   42   43   44   45   46   47   48   49   50   51   52
##   all 1.56 1.60 1.64 1.68 1.72 1.76 1.80 1.84 1.88 1.92 1.96 2.00 2.04
##      year
## age   53   54   55   56   57   58   59   60   61   62   63   64   65
##   all 2.08 2.12 2.16 2.20 2.24 2.28 2.32 2.36 2.40 2.44 2.48 2.52 2.56
##      year
## age   66   67   68   69   70   71   72   73   74   75   76   77   78
##   all 2.60 2.64 2.68 2.72 2.76 2.80 2.84 2.88 2.92 2.96 3.00 3.04 3.08
##      year
## age   79   80   81   82   83   84   85   86   87   88   89   90   91
##   all 3.12 3.16 3.20 3.24 3.28 3.32 3.36 3.40 3.44 3.48 3.52 3.56 3.60
##      year
## age   92   93   94   95   96   97   98   99   100  101
##   all 3.64 3.68 3.72 3.76 3.80 3.84 3.88 3.92 3.96 4.00
##
## units:  f
```

```
harvest(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1        2        3        4        5        6        7
##   0 0.000000 0.025725 0.051450 0.077175 0.102900 0.128625 0.154350
##   1 0.000000 0.069000 0.138000 0.207000 0.276000 0.345000 0.413999
##   2 0.000000 0.040388 0.080775 0.121163 0.161550 0.201938 0.242325
##   3 0.000000 0.024888 0.049775 0.074663 0.099550 0.124438 0.149326
##   4 0.000000 0.015091 0.030181 0.045272 0.060363 0.075453 0.090544
##   5 0.000000 0.012999 0.025998 0.038997 0.051996 0.064995 0.077994
##   6 0.000000 0.012999 0.025998 0.038997 0.051996 0.064995 0.077994
##    year
## age 8        9        10       11       12       13       14
##   0 0.180074 0.205799 0.231524 0.257249 0.282974 0.308699 0.334424
##   1 0.482999 0.551999 0.620999 0.689999 0.758999 0.827999 0.896999
##   2 0.282713 0.323100 0.363488 0.403875 0.444263 0.484651 0.525038
##   3 0.174213 0.199101 0.223989 0.248876 0.273764 0.298651 0.323539
##   4 0.105635 0.120725 0.135816 0.150907 0.165997 0.181088 0.196178
```

```
##   5 0.090993 0.103992 0.116990 0.129989 0.142988 0.155987 0.168986
##   6 0.090993 0.103992 0.116990 0.129989 0.142988 0.155987 0.168986
##    year
## age 15       16       17       18       19       20       21
##   0 0.360149 0.385874 0.411599 0.437324 0.463049 0.488774 0.514498
##   1 0.965999 1.034999 1.103999 1.172999 1.241998 1.310998 1.379998
##   2 0.565426 0.605813 0.646201 0.686588 0.726976 0.767363 0.807751
##   3 0.348427 0.373314 0.398202 0.423089 0.447977 0.472865 0.497752
##   4 0.211269 0.226360 0.241450 0.256541 0.271632 0.286722 0.301813
##   5 0.181985 0.194984 0.207983 0.220982 0.233981 0.246980 0.259979
##   6 0.181985 0.194984 0.207983 0.220982 0.233981 0.246980 0.259979
##    year
## age 22       23       24       25       26       27       28
##   0 0.540223 0.565948 0.591673 0.617398 0.643123 0.668848 0.694573
##   1 1.448998 1.517998 1.586998 1.655998 1.724998 1.793998 1.862998
##   2 0.848138 0.888526 0.928914 0.969301 1.009689 1.050076 1.090464
##   3 0.522640 0.547528 0.572415 0.597303 0.622190 0.647078 0.671966
##   4 0.316904 0.331994 0.347085 0.362176 0.377266 0.392357 0.407448
##   5 0.272978 0.285977 0.298976 0.311975 0.324974 0.337972 0.350971
##   6 0.272978 0.285977 0.298976 0.311975 0.324974 0.337972 0.350971
##    year
## age 29       30       31       32       33       34       35
##   0 0.720298 0.746023 0.771748 0.797473 0.823198 0.848923 0.874647
##   1 1.931998 2.000997 2.069997 2.138997 2.207997 2.276997 2.345997
##   2 1.130851 1.171239 1.211626 1.252014 1.292401 1.332789 1.373177
##   3 0.696853 0.721741 0.746629 0.771516 0.796404 0.821291 0.846179
##   4 0.422538 0.437629 0.452720 0.467810 0.482901 0.497992 0.513082
##   5 0.363970 0.376969 0.389968 0.402967 0.415966 0.428965 0.441964
##   6 0.363970 0.376969 0.389968 0.402967 0.415966 0.428965 0.441964
##    year
## age 36       37       38       39       40       41       42
##   0 0.900372 0.926097 0.951822 0.977547 1.003272 1.028997 1.054722
##   1 2.414997 2.483997 2.552997 2.621997 2.690997 2.759997 2.828996
##   2 1.413564 1.453952 1.494339 1.534727 1.575114 1.615502 1.655889
##   3 0.871067 0.895954 0.920842 0.945729 0.970617 0.995505 1.020392
##   4 0.528173 0.543264 0.558354 0.573445 0.588535 0.603626 0.618717
##   5 0.454963 0.467962 0.480961 0.493960 0.506959 0.519958 0.532957
##   6 0.454963 0.467962 0.480961 0.493960 0.506959 0.519958 0.532957
##    year
## age 43       44       45       46       47       48       49
##   0 1.080447 1.106172 1.131897 1.157622 1.183347 1.209071 1.234796
##   1 2.897996 2.966996 3.035996 3.104996 3.173996 3.242996 3.311996
##   2 1.696277 1.736664 1.777052 1.817440 1.857827 1.898215 1.938602
##   3 1.045280 1.070168 1.095055 1.119943 1.144830 1.169718 1.194606
##   4 0.633807 0.648898 0.663989 0.679079 0.694170 0.709261 0.724351
##   5 0.545956 0.558955 0.571953 0.584952 0.597951 0.610950 0.623949
##   6 0.545956 0.558955 0.571953 0.584952 0.597951 0.610950 0.623949
##    year
## age 50       51       52       53       54       55       56
##   0 1.260521 1.286246 1.311971 1.337696 1.363421 1.389146 1.414871
##   1 3.380996 3.449996 3.518996 3.587995 3.656995 3.725995 3.794995
##   2 1.978990 2.019377 2.059765 2.100152 2.140540 2.180927 2.221315
##   3 1.219493 1.244381 1.269268 1.294156 1.319044 1.343931 1.368819
##   4 0.739442 0.754533 0.769623 0.784714 0.799805 0.814895 0.829986
```

```
##   5 0.636948 0.649947 0.662946 0.675945 0.688944 0.701943 0.714942
##   6 0.636948 0.649947 0.662946 0.675945 0.688944 0.701943 0.714942
##    year
## age 57       58       59       60       61       62       63
##   0 1.440596 1.466321 1.492046 1.517771 1.543495 1.569220 1.594945
##   1 3.863995 3.932995 4.001995 4.070995 4.139995 4.208995 4.277995
##   2 2.261703 2.302090 2.342478 2.382865 2.423253 2.463640 2.504028
##   3 1.393707 1.418594 1.443482 1.468369 1.493257 1.518145 1.543032
##   4 0.845077 0.860167 0.875258 0.890349 0.905439 0.920530 0.935621
##   5 0.727941 0.740940 0.753939 0.766938 0.779937 0.792935 0.805934
##   6 0.727941 0.740940 0.753939 0.766938 0.779937 0.792935 0.805934
##    year
## age 64       65       66       67       68       69       70
##   0 1.620670 1.646395 1.672120 1.697845 1.723570 1.749295 1.775020
##   1 4.346994 4.415994 4.484994 4.553994 4.622994 4.691994 4.760994
##   2 2.544415 2.584803 2.625190 2.665578 2.705966 2.746353 2.786741
##   3 1.567920 1.592808 1.617695 1.642583 1.667470 1.692358 1.717246
##   4 0.950711 0.965802 0.980892 0.995983 1.011074 1.026164 1.041255
##   5 0.818933 0.831932 0.844931 0.857930 0.870929 0.883928 0.896927
##   6 0.818933 0.831932 0.844931 0.857930 0.870929 0.883928 0.896927
##    year
## age 71       72       73       74       75       76       77
##   0 1.800745 1.826470 1.852195 1.877920 1.903644 1.929369 1.955094
##   1 4.829994 4.898994 4.967994 5.036994 5.105994 5.174993 5.243993
##   2 2.827128 2.867516 2.907903 2.948291 2.988678 3.029066 3.069453
##   3 1.742133 1.767021 1.791908 1.816796 1.841684 1.866571 1.891459
##   4 1.056346 1.071436 1.086527 1.101618 1.116708 1.131799 1.146890
##   5 0.909926 0.922925 0.935924 0.948923 0.961922 0.974921 0.987920
##   6 0.909926 0.922925 0.935924 0.948923 0.961922 0.974921 0.987920
##    year
## age 78       79       80       81       82       83       84
##   0 1.980819 2.006544 2.032269 2.057994 2.083719 2.109444 2.135169
##   1 5.312993 5.381993 5.450993 5.519993 5.588993 5.657993 5.726993
##   2 3.109841 3.150229 3.190616 3.231004 3.271391 3.311779 3.352166
##   3 1.916347 1.941234 1.966122 1.991009 2.015897 2.040785 2.065672
##   4 1.161980 1.177071 1.192162 1.207252 1.222343 1.237434 1.252524
##   5 1.000919 1.013917 1.026916 1.039915 1.052914 1.065913 1.078912
##   6 1.000919 1.013917 1.026916 1.039915 1.052914 1.065913 1.078912
##    year
## age 85       86       87       88       89       90       91
##   0 2.160894 2.186619 2.212344 2.238068 2.263793 2.289518 2.315243
##   1 5.795993 5.864993 5.933992 6.002992 6.071992 6.140992 6.209992
##   2 3.392554 3.432941 3.473329 3.513716 3.554104 3.594492 3.634879
##   3 2.090560 2.115447 2.140335 2.165223 2.190110 2.214998 2.239886
##   4 1.267615 1.282706 1.297796 1.312887 1.327978 1.343068 1.358159
##   5 1.091911 1.104910 1.117909 1.130908 1.143907 1.156906 1.169905
##   6 1.091911 1.104910 1.117909 1.130908 1.143907 1.156906 1.169905
##    year
## age 92       93       94       95       96       97       98
##   0 2.340968 2.366693 2.392418 2.418143 2.443868 2.469593 2.495318
##   1 6.278992 6.347992 6.416992 6.485992 6.554992 6.623992 6.692992
##   2 3.675267 3.715654 3.756042 3.796429 3.836817 3.877204 3.917592
##   3 2.264773 2.289661 2.314548 2.339436 2.364324 2.389211 2.414099
##   4 1.373249 1.388340 1.403431 1.418521 1.433612 1.448703 1.463793
```

```
##   5 1.182904 1.195903 1.208902 1.221901 1.234900 1.247898 1.260897
##   6 1.182904 1.195903 1.208902 1.221901 1.234900 1.247898 1.260897
##    year
## age 99       100      101
##   0 2.521043 2.546768 2.572492
##   1 6.761991 6.830991 6.899991
##   2 3.957979 3.998367 4.038755
##   3 2.438986 2.463874 2.488762
##   4 1.478884 1.493975 1.509065
##   5 1.273896 1.286895 1.299894
##   6 1.273896 1.286895 1.299894
##
## units:  f
```

```
# abundance-at-age
stock.n(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1          2          3          4          5          6
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 3.0695e-01 2.9915e-01 2.9155e-01 2.8415e-01 2.7693e-01 2.6990e-01
##   2 1.7217e-01 1.5661e-01 1.4246e-01 1.2958e-01 1.1787e-01 1.0722e-01
##   3 1.1304e-01 9.8754e-02 8.6273e-02 7.5370e-02 6.5844e-02 5.7523e-02
##   4 7.8774e-02 6.7127e-02 5.7202e-02 4.8744e-02 4.1537e-02 3.5395e-02
##   5 5.6701e-02 4.7593e-02 3.9949e-02 3.3532e-02 2.8146e-02 2.3626e-02
##   6 1.6010e-01 1.2789e-01 1.0234e-01 8.2026e-02 6.5840e-02 5.2920e-02
##    year
## age 7          8          9          10         11         12
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 2.6304e-01 2.5636e-01 2.4985e-01 2.4351e-01 2.3732e-01 2.3130e-01
##   2 9.7530e-02 8.8716e-02 8.0698e-02 7.3405e-02 6.6771e-02 6.0736e-02
##   3 5.0253e-02 4.3902e-02 3.8353e-02 3.3506e-02 2.9272e-02 2.5572e-02
##   4 3.0162e-02 2.5702e-02 2.1902e-02 1.8664e-02 1.5904e-02 1.3553e-02
##   5 1.9831e-02 1.6646e-02 1.3972e-02 1.1728e-02 9.8442e-03 8.2630e-03
##   6 4.2589e-02 3.4316e-02 2.7680e-02 2.2351e-02 1.8065e-02 1.4614e-02
##    year
## age 13         14         15         16         17         18
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 2.2542e-01 2.1970e-01 2.1412e-01 2.0868e-01 2.0338e-01 1.9821e-01
##   2 5.5247e-02 5.0254e-02 4.5712e-02 4.1581e-02 3.7823e-02 3.4405e-02
##   3 2.2340e-02 1.9517e-02 1.7050e-02 1.4895e-02 1.3013e-02 1.1368e-02
##   4 1.1549e-02 9.8413e-03 8.3862e-03 7.1462e-03 6.0896e-03 5.1892e-03
##   5 6.9358e-03 5.8218e-03 4.8867e-03 4.1018e-03 3.4430e-03 2.8900e-03
##   6 1.1833e-02 9.5882e-03 7.7755e-03 6.3100e-03 5.1242e-03 4.1640e-03
##    year
## age 19         20         21         22         23         24
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 1.9318e-01 1.8827e-01 1.8349e-01 1.7883e-01 1.7429e-01 1.6986e-01
##   2 3.1295e-02 2.8467e-02 2.5894e-02 2.3554e-02 2.1425e-02 1.9489e-02
##   3 9.9316e-03 8.6764e-03 7.5799e-03 6.6219e-03 5.7850e-03 5.0539e-03
##   4 4.4220e-03 3.7681e-03 3.2110e-03 2.7362e-03 2.3317e-03 1.9869e-03
##   5 2.4258e-03 2.0362e-03 1.7091e-03 1.4346e-03 1.2042e-03 1.0108e-03
```

```
##   6 3.3857e-03 2.7546e-03 2.2423e-03 1.8263e-03 1.4882e-03 1.2132e-03
##    year
## age 25         26         27         28         29         30
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 1.6555e-01 1.6135e-01 1.5725e-01 1.5325e-01 1.4936e-01 1.4557e-01
##   2 1.7727e-02 1.6125e-02 1.4668e-02 1.3342e-02 1.2136e-02 1.1040e-02
##   3 4.4152e-03 3.8572e-03 3.3697e-03 2.9438e-03 2.5718e-03 2.2467e-03
##   4 1.6931e-03 1.4428e-03 1.2295e-03 1.0477e-03 8.9278e-04 7.6078e-04
##   5 8.4841e-04 7.1214e-04 5.9776e-04 5.0175e-04 4.2116e-04 3.5351e-04
##   6 9.8958e-04 8.0749e-04 6.5919e-04 5.3834e-04 4.3982e-04 3.5946e-04
##    year
## age 31         32         33         34         35         36
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 1.4187e-01 1.3827e-01 1.3476e-01 1.3133e-01 1.2800e-01 1.2475e-01
##   2 1.0042e-02 9.1343e-03 8.3088e-03 7.5579e-03 6.8748e-03 6.2535e-03
##   3 1.9628e-03 1.7147e-03 1.4980e-03 1.3087e-03 1.1433e-03 9.9881e-04
##   4 6.4829e-04 5.5244e-04 4.7076e-04 4.0115e-04 3.4184e-04 2.9130e-04
##   5 2.9673e-04 2.4907e-04 2.0906e-04 1.7548e-04 1.4730e-04 1.2364e-04
##   6 2.9389e-04 2.4036e-04 1.9665e-04 1.6094e-04 1.3175e-04 1.0789e-04
##    year
## age 37         38         39         40         41         42
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 1.2158e-01 1.1849e-01 1.1548e-01 1.1255e-01 1.0969e-01 1.0691e-01
##   2 5.6883e-03 5.1742e-03 4.7066e-03 4.2812e-03 3.8943e-03 3.5424e-03
##   3 8.7258e-04 7.6230e-04 6.6596e-04 5.8179e-04 5.0827e-04 4.4403e-04
##   4 2.4823e-04 2.1152e-04 1.8025e-04 1.5360e-04 1.3089e-04 1.1153e-04
##   5 1.0378e-04 8.7111e-05 7.3119e-05 6.1375e-05 5.1517e-05 4.3242e-05
##   6 8.8375e-05 7.2410e-05 5.9345e-05 4.8649e-05 3.9891e-05 3.2718e-05
##    year
## age 43         44         45         46         47         48
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 1.0419e-01 1.0154e-01 9.8966e-02 9.6452e-02 9.4003e-02 9.1615e-02
##   2 3.2222e-03 2.9310e-03 2.6661e-03 2.4251e-03 2.2060e-03 2.0066e-03
##   3 3.8791e-04 3.3889e-04 2.9606e-04 2.5864e-04 2.2595e-04 1.9740e-04
##   4 9.5044e-05 8.0991e-05 6.9016e-05 5.8812e-05 5.0116e-05 4.2706e-05
##   5 3.6297e-05 3.0467e-05 2.5573e-05 2.1466e-05 1.8018e-05 1.5124e-05
##   6 2.6840e-05 2.2024e-05 1.8075e-05 1.4838e-05 1.2183e-05 1.0005e-05
##    year
## age 49         50         51         52         53         54
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 8.9289e-02 8.7021e-02 8.4811e-02 8.2657e-02 8.0558e-02 7.8512e-02
##   2 1.8253e-03 1.6603e-03 1.5102e-03 1.3737e-03 1.2496e-03 1.1367e-03
##   3 1.7245e-04 1.5065e-04 1.3161e-04 1.1498e-04 1.0045e-04 8.7754e-05
##   4 3.6392e-05 3.1011e-05 2.6426e-05 2.2519e-05 1.9189e-05 1.6352e-05
##   5 1.2695e-05 1.0656e-05 8.9442e-06 7.5076e-06 6.3017e-06 5.2896e-06
##   6 8.2178e-06 6.7512e-06 5.5473e-06 4.5589e-06 3.7473e-06 3.0806e-06
##    year
## age 55         56         57         58         59         60
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 7.6518e-02 7.4575e-02 7.2681e-02 7.0835e-02 6.9036e-02 6.7283e-02
##   2 1.0339e-03 9.4049e-04 8.5549e-04 7.7817e-04 7.0784e-04 6.4387e-04
##   3 7.6664e-05 6.6975e-05 5.8510e-05 5.1116e-05 4.4656e-05 3.9012e-05
##   4 1.3934e-05 1.1874e-05 1.0118e-05 8.6222e-06 7.3473e-06 6.2610e-06
##   5 4.4400e-06 3.7268e-06 3.1282e-06 2.6258e-06 2.2040e-06 1.8500e-06
```

```
##   6 2.5330e-06 2.0830e-06 1.7133e-06 1.4093e-06 1.1595e-06 9.5407e-07
##    year
## age 61         62         63         64         65         66
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 6.5574e-02 6.3908e-02 6.2285e-02 6.0703e-02 5.9162e-02 5.7659e-02
##   2 5.8568e-04 5.3275e-04 4.8460e-04 4.4080e-04 4.0097e-04 3.6473e-04
##   3 3.4082e-05 2.9774e-05 2.6011e-05 2.2724e-05 1.9852e-05 1.7343e-05
##   4 5.3353e-06 4.5464e-06 3.8742e-06 3.3014e-06 2.8132e-06 2.3973e-06
##   5 1.5529e-06 1.3034e-06 1.0941e-06 9.1835e-07 7.7085e-07 6.4704e-07
##   6 7.8515e-07 6.4622e-07 5.3195e-07 4.3793e-07 3.6058e-07 2.9693e-07
##    year
## age 67         68         69         70         71         72
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 5.6195e-02 5.4768e-02 5.3377e-02 5.2021e-02 5.0700e-02 4.9412e-02
##   2 3.3176e-04 3.0178e-04 2.7451e-04 2.4970e-04 2.2713e-04 2.0660e-04
##   3 1.5151e-05 1.3236e-05 1.1564e-05 1.0102e-05 8.8254e-06 7.7100e-06
##   4 2.0428e-06 1.7408e-06 1.4834e-06 1.2641e-06 1.0772e-06 9.1790e-07
##   5 5.4311e-07 4.5588e-07 3.8265e-07 3.2119e-07 2.6960e-07 2.2630e-07
##   6 2.4454e-07 2.0141e-07 1.6591e-07 1.3668e-07 1.1262e-07 9.2797e-08
##    year
## age 73         74         75         76         77         78
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 4.8157e-02 4.6934e-02 4.5742e-02 4.4581e-02 4.3449e-02 4.2345e-02
##   2 1.8793e-04 1.7095e-04 1.5550e-04 1.4144e-04 1.2866e-04 1.1703e-04
##   3 6.7356e-06 5.8843e-06 5.1407e-06 4.4910e-06 3.9234e-06 3.4275e-06
##   4 7.8219e-07 6.6654e-07 5.6798e-07 4.8400e-07 4.1244e-07 3.5146e-07
##   5 1.8995e-07 1.5944e-07 1.3383e-07 1.1234e-07 9.4293e-08 7.9148e-08
##   6 7.6473e-08 6.3027e-08 5.1950e-08 4.2823e-08 3.5304e-08 2.9107e-08
##    year
## age 79         80         81         82         83         84
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 4.1270e-02 4.0222e-02 3.9200e-02 3.8204e-02 3.7234e-02 3.6289e-02
##   2 1.0646e-04 9.6834e-05 8.8083e-05 8.0122e-05 7.2881e-05 6.6294e-05
##   3 2.9944e-06 2.6159e-06 2.2853e-06 1.9965e-06 1.7442e-06 1.5237e-06
##   4 2.9949e-07 2.5521e-07 2.1748e-07 1.8532e-07 1.5792e-07 1.3457e-07
##   5 6.6435e-08 5.5764e-08 4.6807e-08 3.9289e-08 3.2979e-08 2.7682e-08
##   6 2.4000e-08 1.9791e-08 1.6321e-08 1.3461e-08 1.1103e-08 9.1584e-09
##    year
## age 85         86         87         88         89         90
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 3.5367e-02 3.4469e-02 3.3593e-02 3.2740e-02 3.1909e-02 3.1098e-02
##   2 6.0303e-05 5.4853e-05 4.9895e-05 4.5386e-05 4.1284e-05 3.7553e-05
##   3 1.3312e-06 1.1629e-06 1.0160e-06 8.8756e-07 7.7539e-07 6.7739e-07
##   4 1.1467e-07 9.7719e-08 8.3270e-08 7.0958e-08 6.0467e-08 5.1526e-08
##   5 2.3235e-08 1.9503e-08 1.6371e-08 1.3741e-08 1.1534e-08 9.6816e-09
##   6 7.5552e-09 6.2331e-09 5.1427e-09 4.2434e-09 3.5015e-09 2.8896e-09
##    year
## age 91         92         93         94         95         96
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 3.0308e-02 2.9539e-02 2.8789e-02 2.8057e-02 2.7345e-02 2.6650e-02
##   2 3.4159e-05 3.1072e-05 2.8264e-05 2.5709e-05 2.3386e-05 2.1272e-05
##   3 5.9178e-07 5.1699e-07 4.5165e-07 3.9457e-07 3.4471e-07 3.0114e-07
##   4 4.3908e-08 3.7416e-08 3.1884e-08 2.7169e-08 2.3152e-08 1.9729e-08
##   5 8.1265e-09 6.8213e-09 5.7256e-09 4.8060e-09 4.0341e-09 3.3861e-09
```

```
##   6 2.3848e-09 1.9683e-09 1.6246e-09 1.3411e-09 1.1070e-09 9.1393e-10
##    year
## age 97         98         99         100        101
##   0 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00 1.0000e+00
##   1 2.5974e-02 2.5314e-02 2.4671e-02 2.4044e-02 2.3434e-02
##   2 1.9350e-05 1.7601e-05 1.6010e-05 1.4563e-05 1.3247e-05
##   3 2.6308e-07 2.2983e-07 2.0079e-07 1.7541e-07 1.5324e-07
##   4 1.6812e-08 1.4326e-08 1.2208e-08 1.0403e-08 8.8648e-09
##   5 2.8422e-09 2.3857e-09 2.0025e-09 1.6809e-09 1.4109e-09
##   6 7.5454e-10 6.2299e-10 5.1440e-10 4.2476e-10 3.5077e-10
##
## units:  NA
```

```
# catch-at-age
catch.n(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1          2          3          4          5          6
##   0 0.0000e+00 1.4940e-02 2.9573e-02 4.3906e-02 5.7947e-02 7.1702e-02
##   1 0.0000e+00 1.5197e-02 2.8729e-02 4.0749e-02 5.1396e-02 6.0795e-02
##   2 0.0000e+00 5.0674e-03 9.0491e-03 1.2121e-02 1.4434e-02 1.6116e-02
##   3 0.0000e+00 2.0389e-03 3.5213e-03 4.5614e-03 5.2524e-03 5.6703e-03
##   4 0.0000e+00 8.5717e-04 1.4505e-03 1.8410e-03 2.0770e-03 2.1968e-03
##   5 0.0000e+00 5.2669e-04 8.7878e-04 1.0997e-03 1.2233e-03 1.2757e-03
##   6 0.0000e+00 1.4288e-03 2.2727e-03 2.7156e-03 2.8885e-03 2.8844e-03
##    year
## age 7          8          9          10         11         12
##   0 8.5177e-02 9.8379e-02 1.1131e-01 1.2399e-01 1.3641e-01 1.4858e-01
##   1 6.9064e-02 7.6307e-02 8.2620e-02 8.8090e-02 9.2797e-02 9.6813e-02
##   2 1.7277e-02 1.8010e-02 1.8392e-02 1.8492e-02 1.8365e-02 1.8059e-02
##   3 5.8769e-03 5.9222e-03 5.8463e-03 5.6815e-03 5.4535e-03 5.1825e-03
##   4 2.2307e-03 2.2022e-03 2.1297e-03 2.0275e-03 1.9064e-03 1.7746e-03
##   5 1.2771e-03 1.2431e-03 1.1853e-03 1.1126e-03 1.0314e-03 9.4660e-04
##   6 2.7687e-03 2.5869e-03 2.3703e-03 2.1402e-03 1.9104e-03 1.6898e-03
##    year
## age 13         14         15         16         17         18
##   0 1.6050e-01 1.7219e-01 1.8364e-01 1.9487e-01 2.0587e-01 2.1666e-01
##   1 1.0021e-01 1.0303e-01 1.0535e-01 1.0721e-01 1.0865e-01 1.0973e-01
##   2 1.7614e-02 1.7063e-02 1.6433e-02 1.5748e-02 1.5026e-02 1.4283e-02
##   3 4.8846e-03 4.5720e-03 4.2543e-03 3.9387e-03 3.6305e-03 3.3335e-03
##   4 1.6383e-03 1.5020e-03 1.3690e-03 1.2413e-03 1.1206e-03 1.0077e-03
##   5 8.6161e-04 7.7882e-04 6.9982e-04 6.2564e-04 5.5684e-04 4.9368e-04
##   6 1.4836e-03 1.2946e-03 1.1238e-03 9.7135e-04 8.3640e-04 7.1786e-04
##    year
## age 19         20         21         22         23         24
##   0 2.2723e-01 2.3760e-01 2.4776e-01 2.5772e-01 2.6749e-01 2.7707e-01
##   1 1.1046e-01 1.1090e-01 1.1107e-01 1.1099e-01 1.1070e-01 1.1022e-01
##   2 1.3532e-02 1.2782e-02 1.2042e-02 1.1317e-02 1.0614e-02 9.9348e-03
##   3 3.0504e-03 2.7828e-03 2.5318e-03 2.2978e-03 2.0808e-03 1.8805e-03
##   4 9.0306e-04 8.0680e-04 7.1881e-04 6.3883e-04 5.6647e-04 5.0128e-04
##   5 4.3618e-04 3.8419e-04 3.3746e-04 2.9568e-04 2.5849e-04 2.2551e-04
##   6 6.1437e-04 5.2450e-04 4.4678e-04 3.7983e-04 3.2236e-04 2.7314e-04
```

```
##    year
## age 25          26          27          28          29          30
##   0 2.8646e-01 2.9567e-01 3.0470e-01 3.1356e-01 3.2225e-01 3.3077e-01
##   1 1.0957e-01 1.0877e-01 1.0783e-01 1.0678e-01 1.0562e-01 1.0437e-01
##   2 9.2827e-03 8.6595e-03 8.0661e-03 7.5033e-03 6.9709e-03 6.4689e-03
##   3 1.6963e-03 1.5276e-03 1.3736e-03 1.2333e-03 1.1059e-03 9.9038e-04
##   4 4.4277e-04 3.9041e-04 3.4369e-04 3.0213e-04 2.6523e-04 2.3255e-04
##   5 1.9637e-04 1.7070e-04 1.4815e-04 1.2840e-04 1.1112e-04 9.6050e-05
##   6 2.3112e-04 1.9531e-04 1.6485e-04 1.3900e-04 1.1709e-04 9.8540e-05
##    year
## age 31          32          33          34          35          36
##   0 3.3913e-01 3.4733e-01 3.5537e-01 3.6326e-01 3.7101e-01 3.7861e-01
##   1 1.0305e-01 1.0166e-01 1.0021e-01 9.8712e-02 9.7176e-02 9.5606e-02
##   2 5.9966e-03 5.5533e-03 5.1380e-03 4.7497e-03 4.3872e-03 4.0493e-03
##   3 8.8595e-04 7.9169e-04 7.0676e-04 6.3035e-04 5.6172e-04 5.0015e-04
##   4 2.0365e-04 1.7815e-04 1.5569e-04 1.3592e-04 1.1856e-04 1.0333e-04
##   5 8.2925e-05 7.1514e-05 6.1611e-05 5.3028e-05 4.5599e-05 3.9178e-05
##   6 8.2864e-05 6.9629e-05 5.8467e-05 4.9063e-05 4.1147e-05 3.4488e-05
##    year
## age 37          38          39          40          41          42
##   0 3.8606e-01 3.9338e-01 4.0056e-01 4.0760e-01 4.1452e-01 4.2131e-01
##   1 9.4010e-02 9.2394e-02 9.0763e-02 8.9121e-02 8.7474e-02 8.5824e-02
##   2 3.7349e-03 3.4426e-03 3.1712e-03 2.9195e-03 2.6864e-03 2.4706e-03
##   3 4.4498e-04 3.9561e-04 3.5148e-04 3.1207e-04 2.7692e-04 2.4557e-04
##   4 8.9984e-05 7.8303e-05 6.8089e-05 5.9168e-05 5.1382e-05 4.4594e-05
##   5 3.3633e-05 2.8852e-05 2.4733e-05 2.1187e-05 1.8138e-05 1.5518e-05
##   6 2.8893e-05 2.4193e-05 2.0249e-05 1.6940e-05 1.4167e-05 1.1843e-05
##    year
## age 43          44          45          46          47          48
##   0 4.2797e-01 4.3451e-01 4.4094e-01 4.4724e-01 4.5343e-01 4.5951e-01
##   1 8.4175e-02 8.2531e-02 8.0895e-02 7.9267e-02 7.7652e-02 7.6051e-02
##   2 2.2710e-03 2.0866e-03 1.9163e-03 1.7592e-03 1.6144e-03 1.4809e-03
##   3 2.1766e-04 1.9282e-04 1.7073e-04 1.5110e-04 1.3367e-04 1.1820e-04
##   4 3.8681e-05 3.3533e-05 2.9055e-05 2.5163e-05 2.1781e-05 1.8846e-05
##   5 1.3269e-05 1.1340e-05 9.6857e-06 8.2688e-06 7.0558e-06 6.0180e-06
##   6 9.8970e-06 8.2679e-06 6.9049e-06 5.7649e-06 4.8117e-06 4.0151e-06
##    year
## age 49          50          51          52          53          54
##   0 4.6548e-01 4.7134e-01 4.7710e-01 4.8275e-01 4.8831e-01 4.9376e-01
##   1 7.4464e-02 7.2895e-02 7.1345e-02 6.9813e-02 6.8302e-02 6.6812e-02
##   2 1.3580e-03 1.2449e-03 1.1409e-03 1.0452e-03 9.5734e-04 8.7659e-04
##   3 1.0447e-04 9.2307e-05 8.1527e-05 7.1981e-05 6.3531e-05 5.6055e-05
##   4 1.6299e-05 1.4090e-05 1.2176e-05 1.0518e-05 9.0819e-06 7.8395e-06
##   5 5.1306e-06 4.3722e-06 3.7244e-06 3.1713e-06 2.6994e-06 2.2969e-06
##   6 3.3496e-06 2.7937e-06 2.3295e-06 1.9421e-06 1.6187e-06 1.3490e-06
##    year
## age 55          56          57          58          59          60
##   0 4.9912e-01 5.0438e-01 5.0956e-01 5.1464e-01 5.1963e-01 5.2454e-01
##   1 6.5345e-02 6.3899e-02 6.2477e-02 6.1078e-02 5.9703e-02 5.8352e-02
##   2 8.0245e-04 7.3440e-04 6.7197e-04 6.1470e-04 5.6220e-04 5.1408e-04
##   3 4.9443e-05 4.3598e-05 3.8433e-05 3.3870e-05 2.9842e-05 2.6286e-05
##   4 6.7647e-06 5.8354e-06 5.0321e-06 4.3382e-06 3.7388e-06 3.2214e-06
##   5 1.9537e-06 1.6613e-06 1.4122e-06 1.2000e-06 1.0195e-06 8.6583e-07
##   6 1.1240e-06 9.3633e-07 7.7988e-07 6.4947e-07 5.4079e-07 4.5023e-07
```

```
##    year
## age 61          62          63          64          65          66
##   0 5.2936e-01 5.3410e-01 5.3876e-01 5.4333e-01 5.4783e-01 5.5226e-01
##   1 5.7024e-02 5.5722e-02 5.4443e-02 5.3188e-02 5.1958e-02 5.0752e-02
##   2 4.6999e-04 4.2960e-04 3.9262e-04 3.5875e-04 3.2776e-04 2.9940e-04
##   3 2.3148e-05 2.0380e-05 1.7938e-05 1.5786e-05 1.3889e-05 1.2218e-05
##   4 2.7748e-06 2.3895e-06 2.0572e-06 1.7706e-06 1.5237e-06 1.3109e-06
##   5 7.3514e-07 6.2402e-07 5.2955e-07 4.4928e-07 3.8108e-07 3.2316e-07
##   6 3.7478e-07 3.1193e-07 2.5959e-07 2.1601e-07 1.7972e-07 1.4951e-07
##    year
## age 67          68          69          70          71          72
##   0 5.5661e-01 5.6088e-01 5.6509e-01 5.6922e-01 5.7329e-01 5.7729e-01
##   1 4.9570e-02 4.8412e-02 4.7277e-02 4.6165e-02 4.5077e-02 4.4012e-02
##   2 2.7345e-04 2.4971e-04 2.2801e-04 2.0817e-04 1.9002e-04 1.7344e-04
##   3 1.0746e-05 9.4490e-06 8.3073e-06 7.3023e-06 6.4177e-06 5.6395e-06
##   4 1.1275e-06 9.6960e-07 8.3364e-07 7.1660e-07 6.1587e-07 5.2920e-07
##   5 2.7398e-07 2.3224e-07 1.9681e-07 1.6676e-07 1.4126e-07 1.1965e-07
##   6 1.2437e-07 1.0344e-07 8.6029e-08 7.1540e-08 5.9485e-08 4.9458e-08
##    year
## age 73          74          75          76          77          78
##   0 5.8122e-01 5.8509e-01 5.8889e-01 5.9263e-01 5.9631e-01 5.9994e-01
##   1 4.2969e-02 4.1949e-02 4.0950e-02 3.9973e-02 3.9018e-02 3.8084e-02
##   2 1.5829e-04 1.4445e-04 1.3180e-04 1.2025e-04 1.0970e-04 1.0007e-04
##   3 4.9548e-06 4.3526e-06 3.8230e-06 3.3574e-06 2.9480e-06 2.5883e-06
##   4 4.5465e-07 3.9053e-07 3.3540e-07 2.8800e-07 2.4726e-07 2.1225e-07
##   5 1.0132e-07 8.5780e-08 7.2613e-08 6.1457e-08 5.2006e-08 4.4001e-08
##   6 4.1117e-08 3.4180e-08 2.8412e-08 2.3615e-08 1.9626e-08 1.6310e-08
##    year
## age 79          80          81          82          83          84
##   0 6.0350e-01 6.0701e-01 6.1046e-01 6.1385e-01 6.1720e-01 6.2049e-01
##   1 3.7170e-02 3.6277e-02 3.5404e-02 3.4550e-02 3.3716e-02 3.2901e-02
##   2 9.1271e-05 8.3241e-05 7.5912e-05 6.9222e-05 6.3118e-05 5.7547e-05
##   3 2.2721e-06 1.9944e-06 1.7503e-06 1.5360e-06 1.3477e-06 1.1824e-06
##   4 1.8217e-07 1.5633e-07 1.3414e-07 1.1508e-07 9.8713e-08 8.4664e-08
##   5 3.7223e-08 3.1484e-08 2.6626e-08 2.2515e-08 1.9035e-08 1.6091e-08
##   6 1.3553e-08 1.1262e-08 9.3573e-09 7.7743e-09 6.4587e-09 5.3654e-09
##    year
## age 85          86          87          88          89          90
##   0 6.2372e-01 6.2691e-01 6.3005e-01 6.3314e-01 6.3618e-01 6.3917e-01
##   1 3.2104e-02 3.1326e-02 3.0565e-02 2.9823e-02 2.9097e-02 2.8388e-02
##   2 5.2465e-05 4.7828e-05 4.3598e-05 3.9740e-05 3.6221e-05 3.3011e-05
##   3 1.0373e-06 9.0988e-07 7.9803e-07 6.9986e-07 6.1372e-07 5.3812e-07
##   4 7.2606e-08 6.2257e-08 5.3377e-08 4.5758e-08 3.9222e-08 3.3615e-08
##   5 1.3601e-08 1.1495e-08 9.7131e-09 8.2067e-09 6.9332e-09 5.8566e-09
##   6 4.4569e-09 3.7021e-09 3.0749e-09 2.5539e-09 2.1210e-09 1.7614e-09
##    year
## age 91          92          93          94          95          96
##   0 6.4212e-01 6.4503e-01 6.4789e-01 6.5070e-01 6.5348e-01 6.5621e-01
##   1 2.7696e-02 2.7020e-02 2.6360e-02 2.5715e-02 2.5085e-02 2.4471e-02
##   2 3.0085e-05 2.7416e-05 2.4983e-05 2.2765e-05 2.0742e-05 1.8899e-05
##   3 4.7180e-07 4.1362e-07 3.6258e-07 3.1781e-07 2.7855e-07 2.4412e-07
##   4 2.8807e-08 2.4684e-08 2.1149e-08 1.8119e-08 1.5521e-08 1.3294e-08
##   5 4.9466e-09 4.1775e-09 3.5276e-09 2.9786e-09 2.5147e-09 2.1228e-09
##   6 1.4627e-09 1.2147e-09 1.0086e-09 8.3746e-10 6.9533e-10 5.7730e-10
```

```
##    year
## age 97         98         99         100        101
##   0 6.5890e-01 6.6156e-01 6.6417e-01 6.6675e-01 6.6928e-01
##   1 2.3871e-02 2.3285e-02 2.2713e-02 2.2155e-02 2.1610e-02
##   2 1.7218e-05 1.5686e-05 1.4290e-05 1.3018e-05 1.1858e-05
##   3 2.1393e-07 1.8746e-07 1.6426e-07 1.4391e-07 1.2608e-07
##   4 1.1386e-08 9.7504e-09 8.3492e-09 7.1488e-09 6.1204e-09
##   5 1.7919e-09 1.5123e-09 1.2763e-09 1.0770e-09 9.0877e-10
##   6 4.7929e-10 3.9790e-10 3.3032e-10 2.7421e-10 2.2762e-10
##
## units:  NA
```

```
# plus some age-aggregated values
yield.hat(hkebrp)
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##      year
## age   1        2        3        4        5        6        7
##   all 0.000000 0.016066 0.027381 0.035157 0.040307 0.043518 0.045307
##      year
## age   8        9        10       11       12       13       14
##   all 0.046063 0.046077 0.045569 0.044703 0.043600 0.042350 0.041019
##      year
## age   15       16       17       18       19       20       21
##   all 0.039655 0.038292 0.036953 0.035655 0.034408 0.033219 0.032090
##      year
## age   22       23       24       25       26       27       28
##   all 0.031023 0.030016 0.029069 0.028178 0.027341 0.026555 0.025817
##      year
## age   29       30       31       32       33       34       35
##   all 0.025123 0.024471 0.023856 0.023278 0.022732 0.022216 0.021728
##      year
## age   36       37       38       39       40       41       42
##   all 0.021266 0.020828 0.020412 0.020017 0.019640 0.019281 0.018939
##      year
## age   43       44       45       46       47       48       49
##   all 0.018611 0.018297 0.017997 0.017708 0.017432 0.017165 0.016909
##      year
## age   50       51       52       53       54       55       56
##   all 0.016663 0.016425 0.016196 0.015975 0.015761 0.015555 0.015355
##      year
## age   57       58       59       60       61       62       63
##   all 0.015162 0.014975 0.014793 0.014618 0.014448 0.014283 0.014123
##      year
## age   64       65       66       67       68       69       70
##   all 0.013967 0.013817 0.013670 0.013528 0.013391 0.013257 0.013127
##      year
## age   71       72       73       74       75       76       77
##   all 0.013000 0.012877 0.012758 0.012642 0.012529 0.012420 0.012314
##      year
## age   78       79       80       81       82       83       84
##   all 0.012210 0.012110 0.012012 0.011917 0.011825 0.011735 0.011648
##      year
```

```
## age   85       86       87       88       89       90       91
##   all 0.011563 0.011481 0.011401 0.011323 0.011247 0.011174 0.011102
##      year
## age   92       93       94       95       96       97       98
##   all 0.011033 0.010966 0.010900 0.010837 0.010775 0.010715 0.010657
##      year
## age   99       100      101
##   all 0.010601 0.010546 0.010493
##
## units:  NA
```

```
# mean recruitment
rec.hat(hkebrp)
```

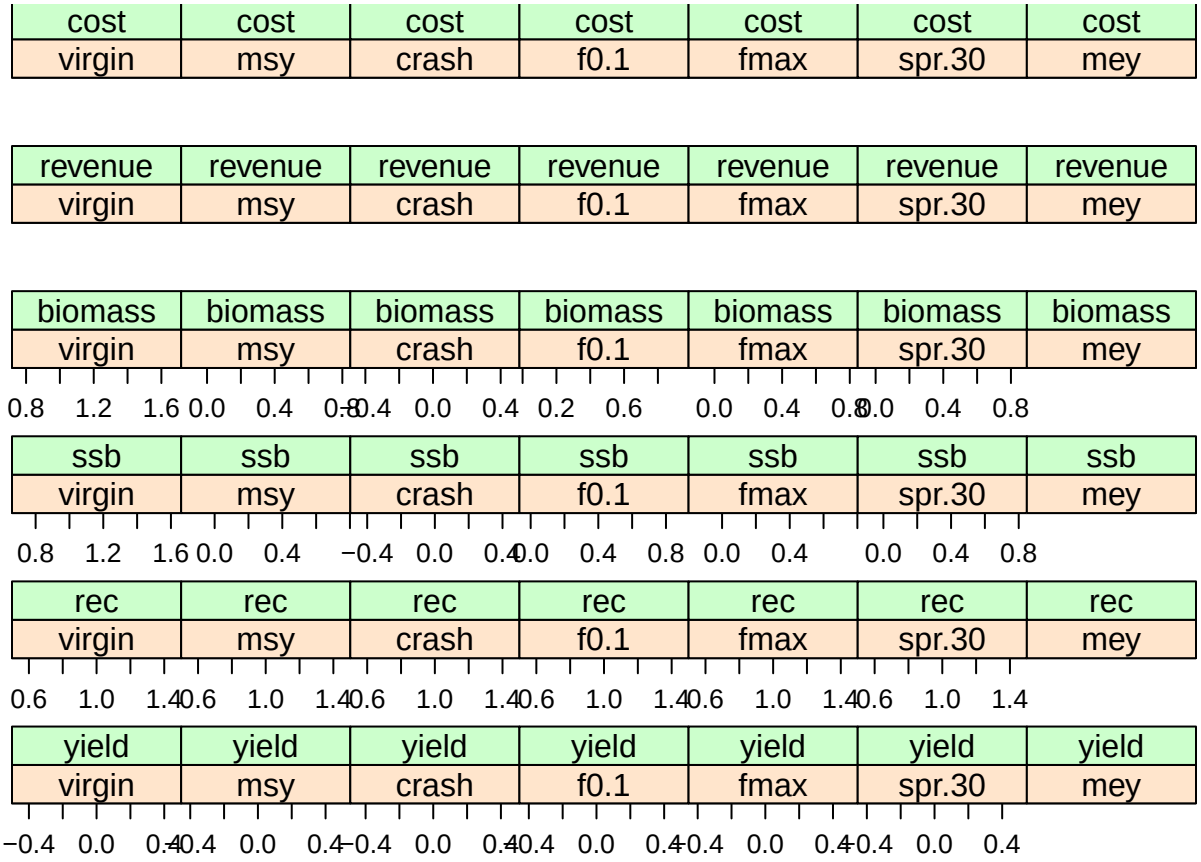
```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##    year
## age 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
##   0 1 1 1 1 1 1 1 1 1 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##    year
## age 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
##   0 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##    year
## age 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72
##   0 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##    year
## age 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
##   0 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##    year
## age 96 97 98 99 100 101
##   0 1  1  1  1  1   1
##
## units:  NA
```

```
# and we get a table of reference points
refpts(hkebrp)
```

```
## An object of class "FLPar"
##         quantity
## refpt    harvest    yield      rec        ssb        biomass    revenue
##   virgin 0.0000e+00 0.0000e+00 1.0000e+00 1.1603e+00 1.2168e+00         NA
##   msy    3.0035e-01 4.6147e-02 1.0000e+00 3.0193e-01 3.4690e-01         NA
##   crash  1.2052e+01 9.4880e-03 1.0000e+00 4.3705e-06 1.0933e-02         NA
##   f0.1   2.1604e-01 4.4382e-02 1.0000e+00 4.3362e-01 4.8134e-01         NA
##   fmax   3.0035e-01 4.6147e-02 1.0000e+00 3.0193e-01 3.4690e-01         NA
##   spr.30 2.6686e-01 4.5909e-02 1.0000e+00 3.4810e-01 3.9413e-01         NA
##   mey            NA         NA         NA         NA         NA         NA
##         quantity
## refpt    cost       profit
##   virgin         NA         NA
##   msy            NA         NA
##   crash          NA         NA
##   f0.1           NA         NA
##   fmax           NA         NA
##   spr.30         NA         NA
```

```
##   mey            NA          NA
## units:  NA
```

```
plot(refpts(hkebrp))
```




```
# In this case, Fmsy is the same as Fmax, since the assumed stock recruitment
# relationship is mean recruitment


refpts(hkebrp)[c('msy', ('fmax')), ]
```

```
## An object of class "FLPar"
##       quantity
## refpt  harvest  yield    rec      ssb      biomass  revenue  cost
##   msy  0.300346 0.046147 1.000000 0.301927 0.346900       NA       NA
##   fmax 0.300346 0.046147 1.000000 0.301927 0.346900       NA       NA
##       quantity
## refpt  profit
##   msy        NA
##   fmax       NA
## units:  NA
```

```
# Thus plotting the reference points ans expected quantities
plot(hkebrp)
```

```
## Warning in .local(x, i, j, ...): using a local copy of '[[' which will be
## removed in later versions of FLCore
```

```
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```
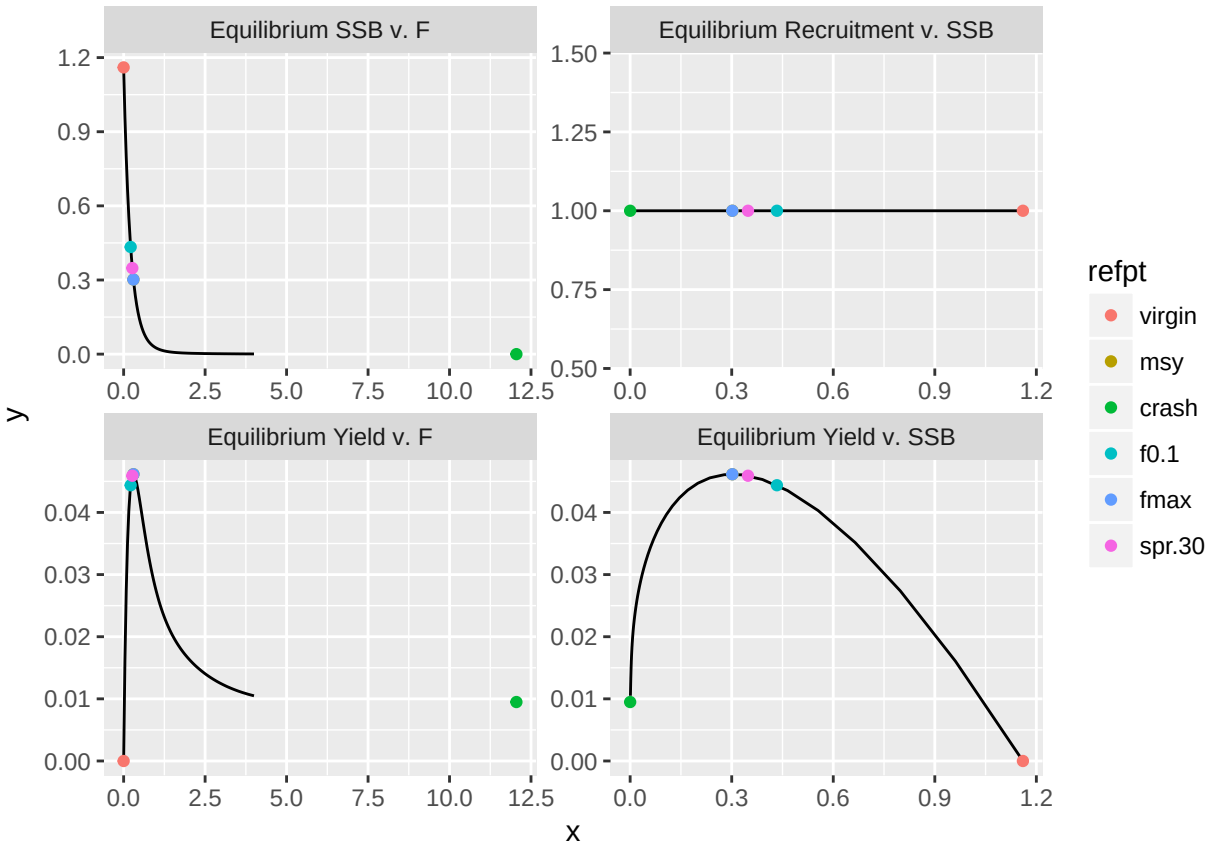




```
# The derived reference points would be used to compare the fishing mortality (from Fbar) with the
# reference point of choice.
fbar(hke)[,"2014"]
```

```
## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##      year
## age   2014
##   all 1.1689
##
## units:  f
```

```
refpts(hkebrp)['f0.1','harvest']
```

```
## An object of class "FLPar"
##       quantity
## refpt  harvest
##   f0.1 0.21604
## units:  NA
```

```
# F/F0.1 ?
fbar(hke)[,"2014"]  / refpts(hkebrp)['f0.1','harvest']
```

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

```
## age   2014
##   all 5.4104
##
## units:  f
```

```
# SR

# Now we provide a stock-recruit relationship

model = "geomean"
srr <- fmle(as.FLSR(hke, model = model))
```

```
## Warning in optim(par = structure(160879.071868521, .Names = "a"), fn = function (par) : one-dimensio
## use "Brent" or optimize() directly
```

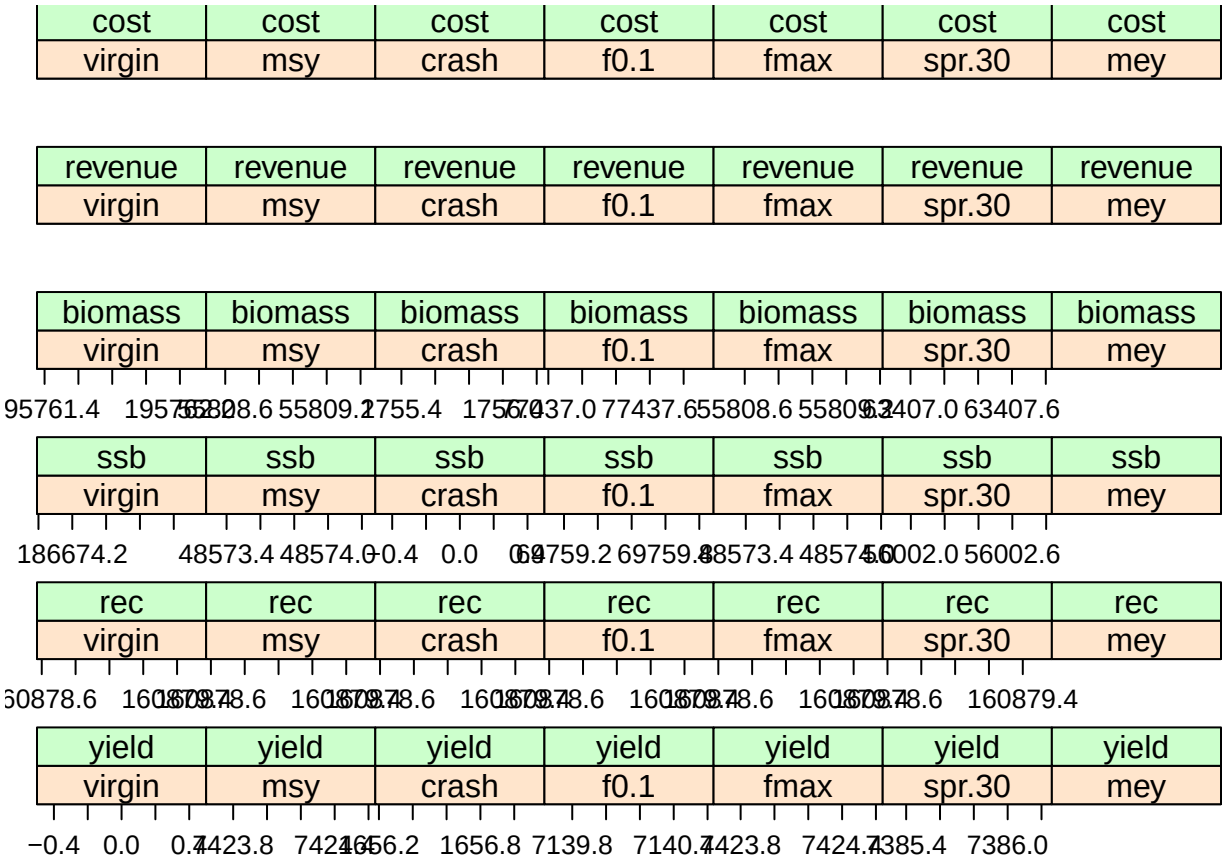
```
##   Nelder-Mead direct search function minimizer
## function value for initial parameters = -9.129982
##   Scaled convergence tolerance is 1.36047e-07
## Stepsize computed as 16087.907187
## BUILD              2 -8.541476 -9.129982
## HI-REDUCTION       4 -8.968169 -9.129982
## HI-REDUCTION       6 -9.087978 -9.129982
## HI-REDUCTION       8 -9.119314 -9.129982
## HI-REDUCTION      10 -9.127296 -9.129982
## HI-REDUCTION      12 -9.129308 -9.129982
## HI-REDUCTION      14 -9.129813 -9.129982
## HI-REDUCTION      16 -9.129940 -9.129982
## HI-REDUCTION      18 -9.129971 -9.129982
## HI-REDUCTION      20 -9.129979 -9.129982
## HI-REDUCTION      22 -9.129981 -9.129982
## HI-REDUCTION      24 -9.129982 -9.129982
## Exiting from Nelder Mead minimizer
##     26 function evaluations used
```

```
#Reference points
hkebrpgm <- brp(FLBRP(hke, sr = srr))
ref_points<- refpts(hkebrpgm)
ref_points
```

```
## An object of class "FLPar"
##         quantity
## refpt    harvest    yield      rec        ssb        biomass    revenue
##   virgin 0.0000e+00 0.0000e+00 1.6088e+05 1.8667e+05 1.9576e+05         NA
##   msy    3.0035e-01 7.4241e+03 1.6088e+05 4.8574e+04 5.5809e+04         NA
##   crash  3.0711e+01 1.6567e+03 1.6088e+05 4.3202e-06 1.7557e+03         NA
##   f0.1   2.1604e-01 7.1401e+03 1.6088e+05 6.9760e+04 7.7437e+04         NA
##   fmax   3.0035e-01 7.4241e+03 1.6088e+05 4.8574e+04 5.5809e+04         NA
##   spr.30 2.6686e-01 7.3858e+03 1.6088e+05 5.6002e+04 6.3407e+04         NA
##   mey            NA         NA         NA         NA         NA         NA
##         quantity
## refpt    cost       profit
##   virgin         NA         NA
##   msy            NA         NA
##   crash          NA         NA
##   f0.1           NA         NA
##   fmax           NA         NA
```

```
##   spr.30          NA          NA
##   mey             NA          NA
## units:  NA
```

```
plot(refpts(hkebrpgm))
```




```
plot(hkebrpgm)
```

```
## Warning in .local(x, i, j, ...): using a local copy of '[[' which will be
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```
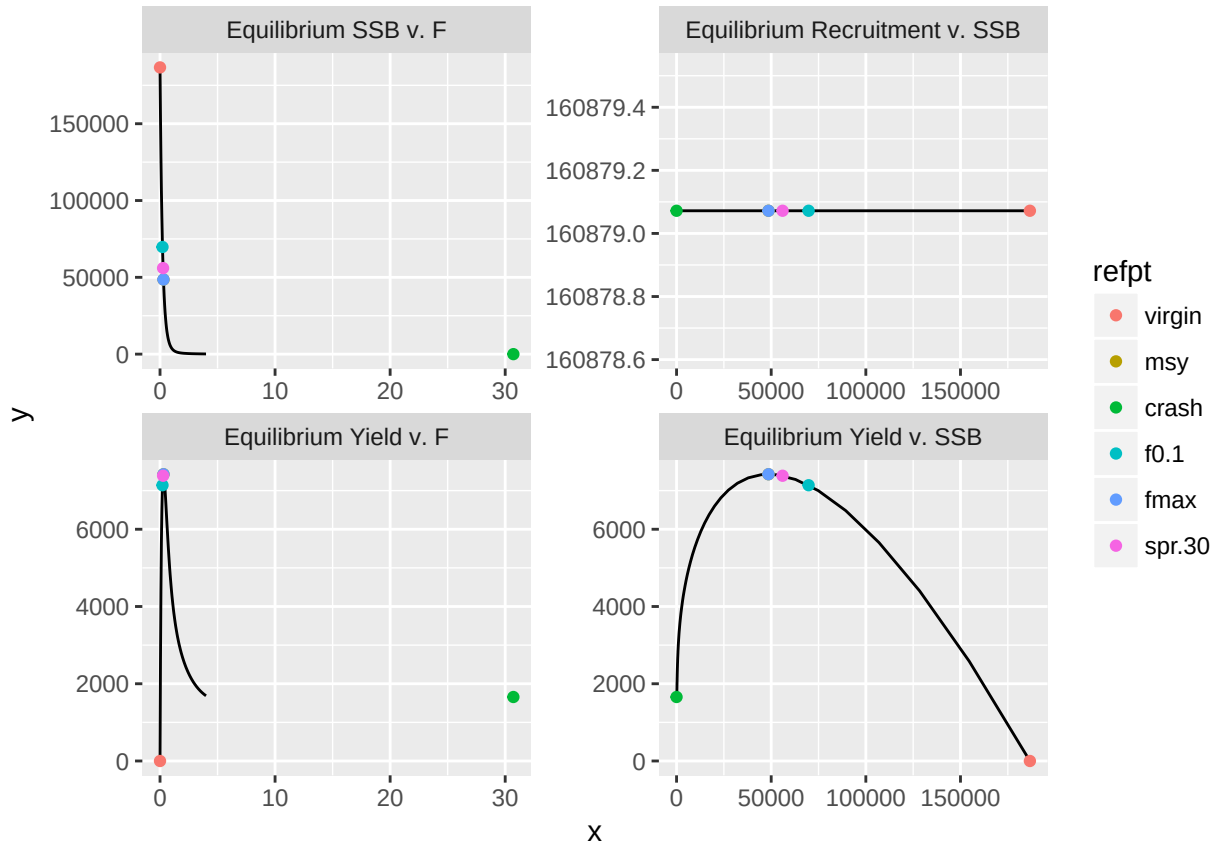
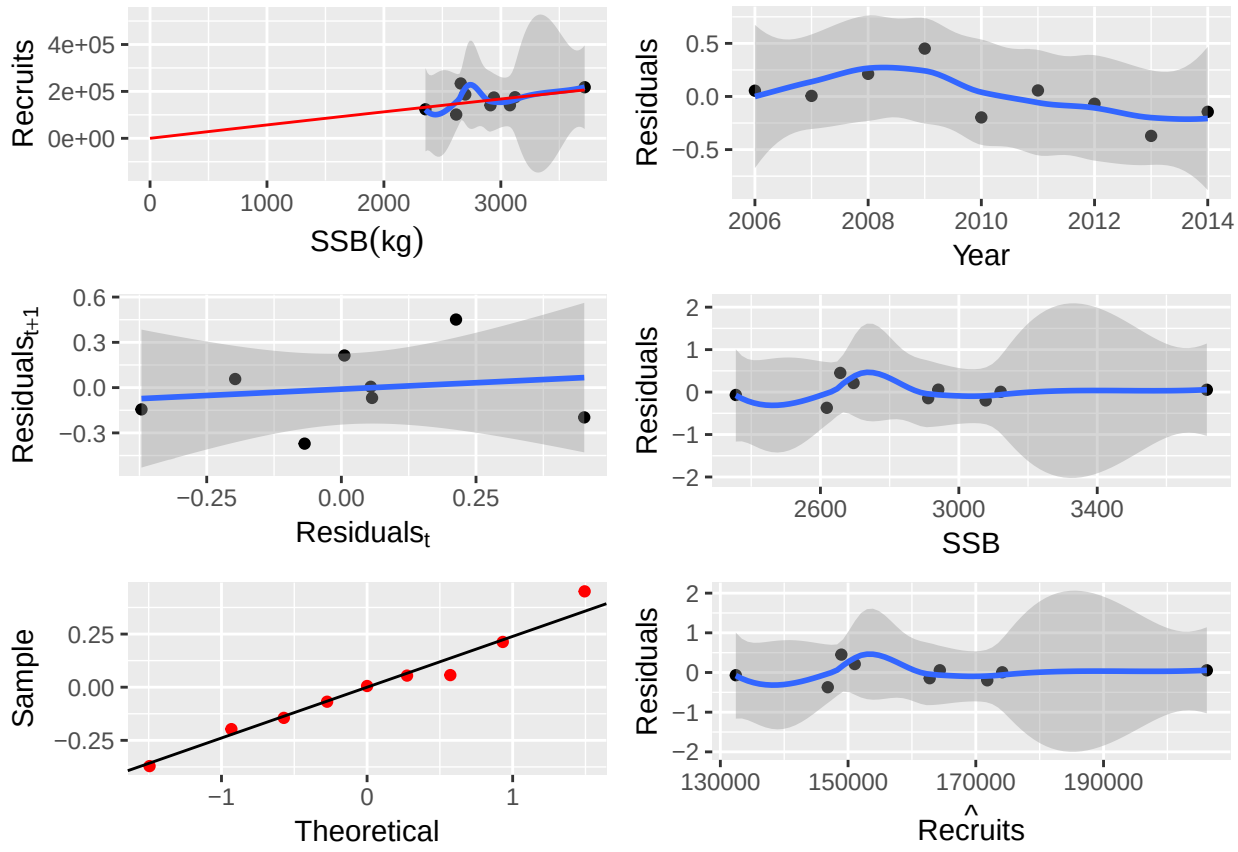




```
rp_table = data.frame(ref_points@.Data)[,1:5]
temp <- rownames(rp_table)
rp_table = data.frame(rp_table, row.names = NULL)
rp_table <- cbind(temp, rp_table)
colnames(rp_table) =c("", "F","Total Yield","Recruitment","SSB","Biomass")

write.table(rp_table,file="Ref_points_HKE.csv",sep=";",row.names=FALSE, col.names=T)

################################################

# we can add a SR fitted model

hkesr <- as.FLSR(hke, model=bevholt)
hkesr <- fmle(hkesr)
```

```
##   Nelder-Mead direct search function minimizer
## function value for initial parameters = -2.355174
##   Scaled convergence tolerance is 3.50948e-08
## Stepsize computed as 18687.676922
## BUILD              3 9.363309 -3.874934
## Warning in log(x@.Data, ...): NaNs produced
## HI-REDUCTION       5 6.700774 -3.874934
## Warning in log(x@.Data, ...): NaNs produced
## HI-REDUCTION       7 3.988498 -3.874934
```

```
## HI-REDUCTION       9 1.545284 -3.874934
## REFLECTION        11 -2.355174 -8.205219
## LO-REDUCTION      13 -3.874934 -9.524250
## HI-REDUCTION      15 -7.518147 -9.524250
## HI-REDUCTION      17 -8.205219 -9.524250
## HI-REDUCTION      19 -9.244832 -9.524250
## HI-REDUCTION      21 -9.292561 -9.524250
## LO-REDUCTION      23 -9.517158 -9.529330
## REFLECTION        25 -9.524250 -9.570396
## LO-REDUCTION      27 -9.529330 -9.570396
## REFLECTION        29 -9.562661 -9.577835
## HI-REDUCTION      31 -9.570396 -9.586610
## EXTENSION         33 -9.577835 -9.615444
## LO-REDUCTION      35 -9.586610 -9.615444
## EXTENSION         37 -9.596039 -9.640606
## EXTENSION         39 -9.615444 -9.688921
## EXTENSION         41 -9.640606 -9.744801
## EXTENSION         43 -9.688921 -9.842045
## EXTENSION         45 -9.744801 -9.926103
## EXTENSION         47 -9.842045 -10.049477
## EXTENSION         49 -9.926103 -10.109394
## EXTENSION         51 -10.049477 -10.189164
## EXTENSION         53 -10.109394 -10.199520
## EXTENSION         55 -10.189164 -10.229756
## LO-REDUCTION      57 -10.199520 -10.229756
## EXTENSION         59 -10.222950 -10.236260
## EXTENSION         61 -10.229756 -10.241241
## LO-REDUCTION      63 -10.236260 -10.241241
## REFLECTION        65 -10.240839 -10.241797
## HI-REDUCTION      67 -10.241241 -10.241797
## LO-REDUCTION      69 -10.241464 -10.241802
## LO-REDUCTION      71 -10.241748 -10.241802
## LO-REDUCTION      73 -10.241797 -10.241806
## HI-REDUCTION      75 -10.241802 -10.241820
## LO-REDUCTION      77 -10.241806 -10.241820
## LO-REDUCTION      79 -10.241817 -10.241820
## HI-REDUCTION      81 -10.241818 -10.241820
## HI-REDUCTION      83 -10.241819 -10.241820
## REFLECTION        85 -10.241820 -10.241820
## HI-REDUCTION      87 -10.241820 -10.241820
## HI-REDUCTION      89 -10.241820 -10.241820
## HI-REDUCTION      91 -10.241820 -10.241820
## Exiting from Nelder Mead minimizer
##     93 function evaluations used
```

```
plot(hkesr)
```




```
# and provide it when constructing FLBRP
hkebrp <- FLBRP(hke, sr=hkesr)

# let's have a look at the formula
model(hkebrp)
```

```
## rec ~ a * ssb/(b + ssb)
## <environment: 0x10538814>
```

```
# and parameters a and b
params(hkebrp)
```

```
## An object of class "FLPar"
## params
##       a       b
## 5677840   98637
## units:  NA
```

```
# and we refit FLBRP
hkebrp <- brp(hkebrp)


# and see the difference in RPs
refpts(hkebrp)
```

```
## An object of class "FLPar"
##          quantity
## refpt     harvest    yield      rec        ssb        biomass    revenue
```

```
##   virgin 0.0000e+00 0.0000e+00 5.5928e+06 6.4896e+06 6.8055e+06         NA
##   msy    2.7544e-01 2.4776e+05 5.3839e+06 1.8067e+06 2.0530e+06         NA
##   crash  1.1304e+00 3.7645e-06 1.5088e-04 2.6212e-06 6.9331e-06         NA
##   f0.1   2.1604e-01 2.4190e+05 5.4504e+06 2.3634e+06 2.6235e+06         NA
##   fmax   3.0035e-01 2.4694e+05 5.3511e+06 1.6157e+06 1.8563e+06         NA
##   spr.30 2.6686e-01 2.4765e+05 5.3945e+06 1.8778e+06 2.1261e+06         NA
##   mey            NA         NA         NA         NA         NA         NA
##         quantity
## refpt    cost       profit
##   virgin         NA         NA
##   msy            NA         NA
##   crash          NA         NA
##   f0.1           NA         NA
##   fmax           NA         NA
##   spr.30         NA         NA
##   mey            NA         NA
## units:  NA
```

```r
# and relationships
plot(hkebrp)
```

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