Loading your data into FLR

18 September, 2017

This tutorial details methods for reading data in various formats into R for generating objects of the FLStock, FLIndex and FLFleet classes.

Required packages

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

- CRAN: ggplot2
- FLR: FLCore; FLFleet; ggplotFL

You can do so as follows,

```
install.packages(c("ggplot2"))
install.packages(c("FLCore","ggplotFL"), repos="http://flr-project.org/R")
```

```
# Load all necessary packages, trim pkg messages
library(FLFleet)
library(ggplotFL)
```

Example data files

The data files used in this tutorial need to be available in R's working directory, and this code obtains them from the **FLR** website. Files will be downloaded to a temporary folder. If you want to keep a local copy, simply set a different value to the `dir` variable below.

```
dir <- tempdir()
download.file("http://flr-project.org/doc/src/loading_data.zip", file.path(dir, "loading_data.zip"))
unzip(file.path(dir, "loading_data.zip"), exdir=dir)
```

Reading files (csv, dat, . . .)

Fisheries data are generally stored in different formats (cvs, excel, SAS. . .). R provides tools to read and import data, from simple text files to more advanced SAS files or databases. Datacamp is a useful tutorial to quickly import data into R.

Your data are stored in a folder in your computer, or on a server. R requires a path to the data. You can check the working directory already active in your R session using the command `getwd()`. To set the working directory use `setwd("directory name")`. Case is important. Use '//' or " for separating folders and directories in Windows.

This tutorial will give some examples, but regardless of the format, the different steps are:

- Finding the right function to import data into R
- Reshaping the data as a matrix
- creating an FLQuant object

Importing files into R (example of csv file)

There are many ways of reading csv files. read.table with 'header', 'sep', 'dec' and 'row.names' options will allow you to read all .csv and .txt files.

The read.csv or read.csv2 functions are very useful for reading csv files.

```
catch.n <- read.csv(file.path(dir,"catch_numbers.csv"), row=1)
# We have read in the data as a data.frame
class(catch.n)
```

```
[1] "data.frame"
```

The data are now in your R environment. Before creating an **FLQuant** object, you need to make sure it is consistent with the type of object and formatting that is needed to run the FLQuant method. To get information on the structure and format needed, type ?FLQuant in your R Console.

Reshaping data as a matrix

FLQuant objects accept 'vector', 'array' or 'matrix'. We can convert the object *catch.n* to a matrix.

```
catch.n.matrix <- as.matrix(catch.n)
catch.n.matrix[,1:8]
```

X1957	X1958	X1959	X1960	X1961	X1962	X1963	X1964
0	100	1060	516	1768	259	132	88
7709	3349	7251	18221	7129	7170	6446	7030
9965	9410	3585	7373	14342	5535	5929	5903
1394	6130	8642	3551	6598	10427	2032	4048
6235	4065	3222	2284	2481	5235	3192	2195
2062	5584	1757	770	2392	3322	3541	3972
1720	6666	3699	1924	1659	7289	5889	9168

An FLQuant object is made of six dimensions. The name of the first dimension can be altered by the user from its default, 'quant'. This could typically be 'age' or 'length' for data related to natural populations. The only name not accepted is 'cohort', because data structured along cohort should be stored using the FLCohort class instead. Other dimensions are always named as follows: 'year' for the calendar year of the data point; 'unit' for any kind of division of the population, e.g. by sex; 'season' for any temporal strata shorter than year; 'area' for any kind of spatial stratification; and 'iter' for replicates obtained through bootstrap, simulation or Bayesian analysis.

When importing catch numbers, for example, the input object needs to be formatted as such: age or length in the first dimension and year in the second dimension. If the object is not formatted in the right way, you can use the `reshape` functions from the package reshape2.

Making an FLQuant object

We need to specify the dimnames

```
catch.n.flq <- FLQuant(catch.n.matrix, dimnames=list(age=1:7, year = 1957:2011))
catch.n.flq[,1:7]
```

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

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

   year
age 1957  1958  1959  1960  1961  1962  1963 
  1     0   100  1060   516  1768   259   132
  2  7709  3349  7251 18221  7129  7170  6446
  3  9965  9410  3585  7373 14342  5535  5929
  4  1394  6130  8642  3551  6598 10427  2032
  5  6235  4065  3222  2284  2481  5235  3192
  6  2062  5584  1757   770  2392  3322  3541
  7  1720  6666  3699  1924  1659  7289  5889

units:  NA
```

Reading common fisheries data formats

FLCore contains functions for reading in fish stock data in commonly used formats. To read a single variable (e.g. numbers-at-age, maturity-at-age) from the **Lowestoft VPA** format you use the `readVPA` function. The following example reads the catch numbers-at-age for herring:

```r
# Read from a VPA text file
catch.n <- readVPAFile(file.path(dir, "her-irlw","canum.txt"))
class(catch.n)
```

```
[1] "FLQuant"
attr(,"package")
[1] "FLCore"
```

This can be repeated for each of the data files. In addition, functions are available for Multifan-CL format `readMFCL`, and ADMB format `readADMB`.

Alternatively, if you have the full information for a stock in the **Lowestoft VPA**, **Adapt**, **CSA** or **ICA** format, you can read it all in together using the `readFLStock` function. Here, you point the function to the index file, with all other files in the same directory:

```r
# Read a collection of VPA files, pointing to the Index file:
# DELETE: her <- readFLStock('http://flr-project.org/doc/src/her-irlw/index.txt')
her <- readFLStock(file.path(dir, 'her-irlw', 'index.txt'))
class(her)
```

```
[1] "FLStock"
attr(,"package")
[1] "FLCore"
```

This correctly formats the data as an FLStock object. Note: the units for the slots have not been set. We will deal with this in the next section.

```r
summary(her)
```

```
An object of class "FLStock"

Name: Herring VIa(S) VIIbc 
Description: Imported from a VPA file. ( /tmp/RtmpW3Rc03/her-irlw/index.txt ).  Mo [...]
Quant: age 
Dims:  age  year    unit    season  area    iter
    7   55  1   1   1   1   
```

```
Range:  min max pgroup  minyear maxyear minfbar maxfbar
    1   7   NA  1957    2011    1   7

catch         : [ 1 55 1 1 1 1 ], units =  NA
catch.n       : [ 7 55 1 1 1 1 ], units =  NA
catch.wt      : [ 7 55 1 1 1 1 ], units =  NA
discards      : [ 1 55 1 1 1 1 ], units =  NA
discards.n    : [ 7 55 1 1 1 1 ], units =  NA
discards.wt   : [ 7 55 1 1 1 1 ], units =  NA
landings      : [ 1 55 1 1 1 1 ], units =  NA
landings.n    : [ 7 55 1 1 1 1 ], units =  NA
landings.wt   : [ 7 55 1 1 1 1 ], units =  NA
stock         : [ 1 55 1 1 1 1 ], units =  NA
stock.n       : [ 7 55 1 1 1 1 ], units =  NA
stock.wt      : [ 7 55 1 1 1 1 ], units =  NA
m             : [ 7 55 1 1 1 1 ], units =  NA
mat           : [ 7 55 1 1 1 1 ], units =  NA
harvest       : [ 7 55 1 1 1 1 ], units =  f
harvest.spwn  : [ 7 55 1 1 1 1 ], units =  NA
m.spwn        : [ 7 55 1 1 1 1 ], units =  NA
```

This object only contains the input data for the stock assessment, not any estimated values (e.g. harvest rates, stock abundances). You can add these to the object as follows:

```
stock.n(her) <- readVPAFile(file.path(dir, "her-irlw", "n.txt"))
print(stock.n(her)[,ac(2007:2011)]) # only print 2007:2011
```

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

   year
age 2007     2008     2009     2010     2011
  1 174571.1 282187.1 256537.9 500771.9 473853.8
  2 124606.8  64089.7 103602.4  94215.4 183911.3
  3 113657.7  75691.6  39075.8  65137.7  59210.2
  4  55794.7  60037.5  40312.1  22271.7  37090.3
  5  33210.4  28921.5  31447.1  23016.5  12700.7
  6  17193.0  16241.9  14308.2  17112.1  12507.7
  7   5355.8   9315.2   8255.6   9662.4  16579.1

units:  NA
```

```
harvest(her) <- readVPAFile(file.path(dir,"her-irlw", "f.txt"))
```

Now we have a fully filled FLStock object. But let's check the data are consistent.

```
# The sum of products (SOP)
apply(landings.n(her)*landings.wt(her), 2, sum)[,ac(2007:2011)]
```

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

     year
age   2007    2008    2009    2010    2011
  all 17790.6 13340.9 10482.3 10232.6  6921.2
```

```
units:  NA
```

```
# and the value read in from the VPA file
landings(her)[,ac(2007:2011)]
```

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

     year
age   2007  2008  2009  2010  2011
  all 17791 13340 10468 10241  6919

units:  NA
```

```
## They are not the same!!  We correct the landings to be the same as the SOP - there is a handy functi
landings(her) <- computeLandings(her)
# In addition, there is no discard information
discards.wt(her)[,ac(2005:2011)]
```

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

   year
age 2005 2006 2007 2008 2009 2010 2011
  1 NA   NA   NA   NA   NA   NA   NA
  2 NA   NA   NA   NA   NA   NA   NA
  3 NA   NA   NA   NA   NA   NA   NA
  4 NA   NA   NA   NA   NA   NA   NA
  5 NA   NA   NA   NA   NA   NA   NA
  6 NA   NA   NA   NA   NA   NA   NA
  7 NA   NA   NA   NA   NA   NA   NA

units:  NA
```

```
discards.n(her)[,ac(2005:2011)]
```

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

   year
age 2005 2006 2007 2008 2009 2010 2011
  1 NA   NA   NA   NA   NA   NA   NA
  2 NA   NA   NA   NA   NA   NA   NA
  3 NA   NA   NA   NA   NA   NA   NA
  4 NA   NA   NA   NA   NA   NA   NA
  5 NA   NA   NA   NA   NA   NA   NA
  6 NA   NA   NA   NA   NA   NA   NA
  7 NA   NA   NA   NA   NA   NA   NA

units:  NA
```

```
# Set up the discards and catches
discards.wt(her)  <- landings.wt(her)
discards.n(her)[] <- 0
```

```
discards(her)      <- computeDiscards(her)
catch(her)         <- landings(her)
catch.wt(her)      <- landings.wt(her)
catch.n(her)        <- landings.n(her)
```

Functions are available to computeLandings, computeDiscards, computeCatch and computeStock. These functions take the argument slot = 'catch', slot = 'wt' and slot = 'n' to compute the total weight, individual weight and numbers respectively, in addition to slot = 'all'.

Adding a description, units, ranges etc..

Before we are finished, we want to ensure the units and range references are correct. This is important as the derived calculations require the correct scaling (e.g. `fbar`, for the average fishing mortality range over the required age ranges).

First, let's ensure an appropriate name and description are assigned:

```
summary(her)
```

```
An object of class "FLStock"

Name: Herring VIa(S) VIIbc
Description: Imported from a VPA file. ( /tmp/RtmpW3Rc03/her-irlw/index.txt ).  Mo [...]
Quant: age
Dims:  age  year    unit    season  area    iter
    7   55  1   1   1   1

Range:  min max pgroup  minyear maxyear minfbar maxfbar
    1   7   NA  1957    2011    1   7

catch         : [ 1 55 1 1 1 1 ], units =  NA
catch.n       : [ 7 55 1 1 1 1 ], units =  NA
catch.wt      : [ 7 55 1 1 1 1 ], units =  NA
discards      : [ 1 55 1 1 1 1 ], units =  NA
discards.n    : [ 7 55 1 1 1 1 ], units =  NA
discards.wt   : [ 7 55 1 1 1 1 ], units =  NA
landings      : [ 1 55 1 1 1 1 ], units =  NA
landings.n    : [ 7 55 1 1 1 1 ], units =  NA
landings.wt   : [ 7 55 1 1 1 1 ], units =  NA
stock         : [ 1 55 1 1 1 1 ], units =  NA
stock.n       : [ 7 55 1 1 1 1 ], units =  NA
stock.wt      : [ 7 55 1 1 1 1 ], units =  NA
m             : [ 7 55 1 1 1 1 ], units =  NA
mat           : [ 7 55 1 1 1 1 ], units =  NA
harvest       : [ 7 55 1 1 1 1 ], units =  NA
harvest.spwn  : [ 7 55 1 1 1 1 ], units =  NA
m.spwn        : [ 7 55 1 1 1 1 ], units =  NA
```

```
#name and descriptions
name(her) # ok
```

```
[1] "Herring VIa(S) VIIbc "
```

```
desc(her) # ok
```

```
[1] "Imported from a VPA file. ( /tmp/RtmpW3Rc03/her-irlw/index.txt ).  Mon Sep 18 10:51:34 2017"
```

```
# Set the Fbar range for the stock
range(her)[c('minfbar','maxfbar')] # ok, but can be filled with  <- c(min,max)
```

```
minfbar maxfbar
      1       7
```

```
# set the plus group
range(her)['plusgroup']  <- 7 # final year is a plusgroup
## Units
units(catch(her)) <- units(discards(her)) <- units(landings(her)) <- units(stock(her)) <- 'tonnes'
units(catch.n(her)) <- units(discards.n(her)) <- units(landings.n(her)) <- units(stock.n(her)) <- '1000
units(catch.wt(her)) <- units(discards.wt(her)) <- units(landings.wt(her)) <- units(stock.wt(her)) <- '
units(harvest(her)) <- 'f'
```

This should now have the correct units defined:

```
summary(her)
```

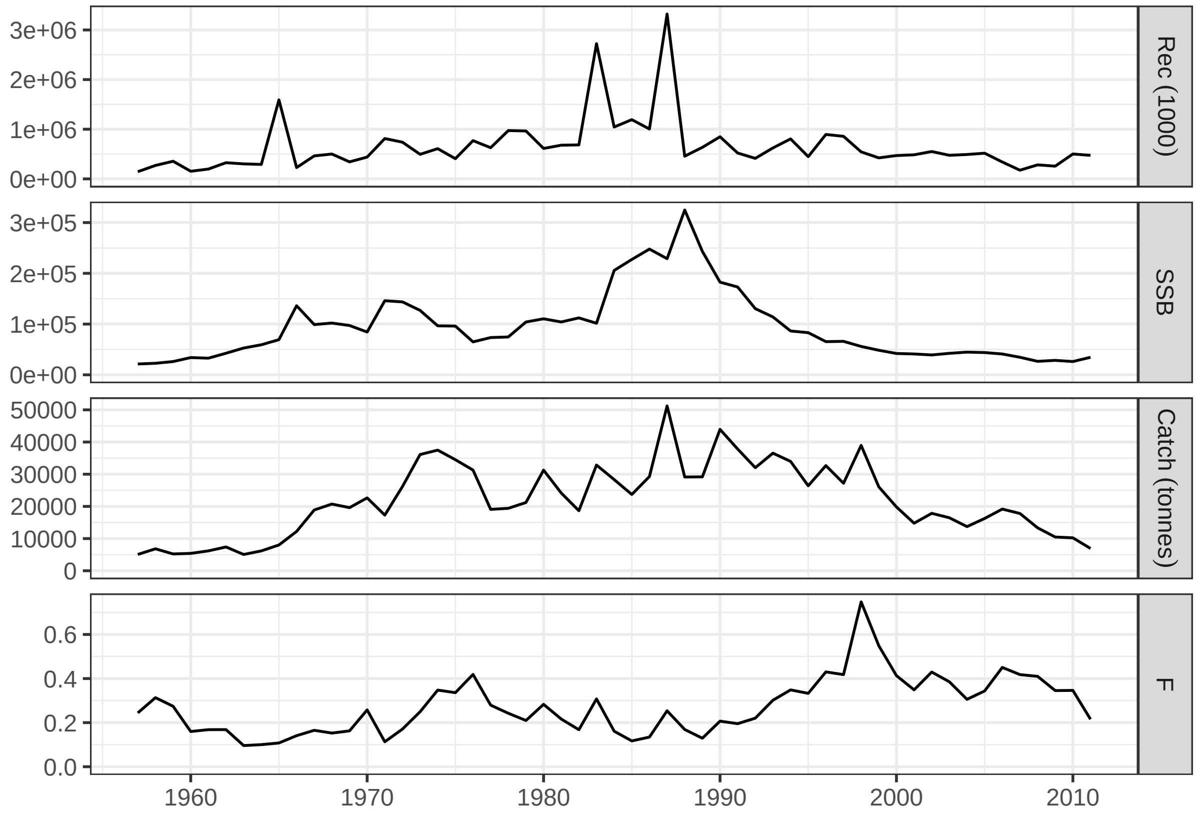
```
An object of class "FLStock"

Name: Herring VIa(S) VIIbc
Description: Imported from a VPA file. ( /tmp/RtmpW3Rc03/her-irlw/index.txt ).  Mo [...]
Quant: age
Dims:  age  year    unit    season  area    iter
    7   55  1   1   1   1

Range:  min max pgroup  minyear maxyear minfbar maxfbar
    1   7   7   1957    2011    1   7

catch         : [ 1 55 1 1 1 1 ], units =  tonnes
catch.n       : [ 7 55 1 1 1 1 ], units =  1000
catch.wt      : [ 7 55 1 1 1 1 ], units =  kg
discards      : [ 1 55 1 1 1 1 ], units =  tonnes
discards.n    : [ 7 55 1 1 1 1 ], units =  1000
discards.wt   : [ 7 55 1 1 1 1 ], units =  kg
landings      : [ 1 55 1 1 1 1 ], units =  tonnes
landings.n    : [ 7 55 1 1 1 1 ], units =  1000
landings.wt   : [ 7 55 1 1 1 1 ], units =  kg
stock         : [ 1 55 1 1 1 1 ], units =  tonnes
stock.n       : [ 7 55 1 1 1 1 ], units =  1000
stock.wt      : [ 7 55 1 1 1 1 ], units =  kg
m             : [ 7 55 1 1 1 1 ], units =  NA
mat           : [ 7 55 1 1 1 1 ], units =  NA
harvest       : [ 7 55 1 1 1 1 ], units =  f
harvest.spwn  : [ 7 55 1 1 1 1 ], units =  NA
m.spwn        : [ 7 55 1 1 1 1 ], units =  NA
```

```
plot(her) + theme_bw() # using the simple black and white theme
```



FLIndex objects

Two solutions can be used to read abundance indices into FLR.

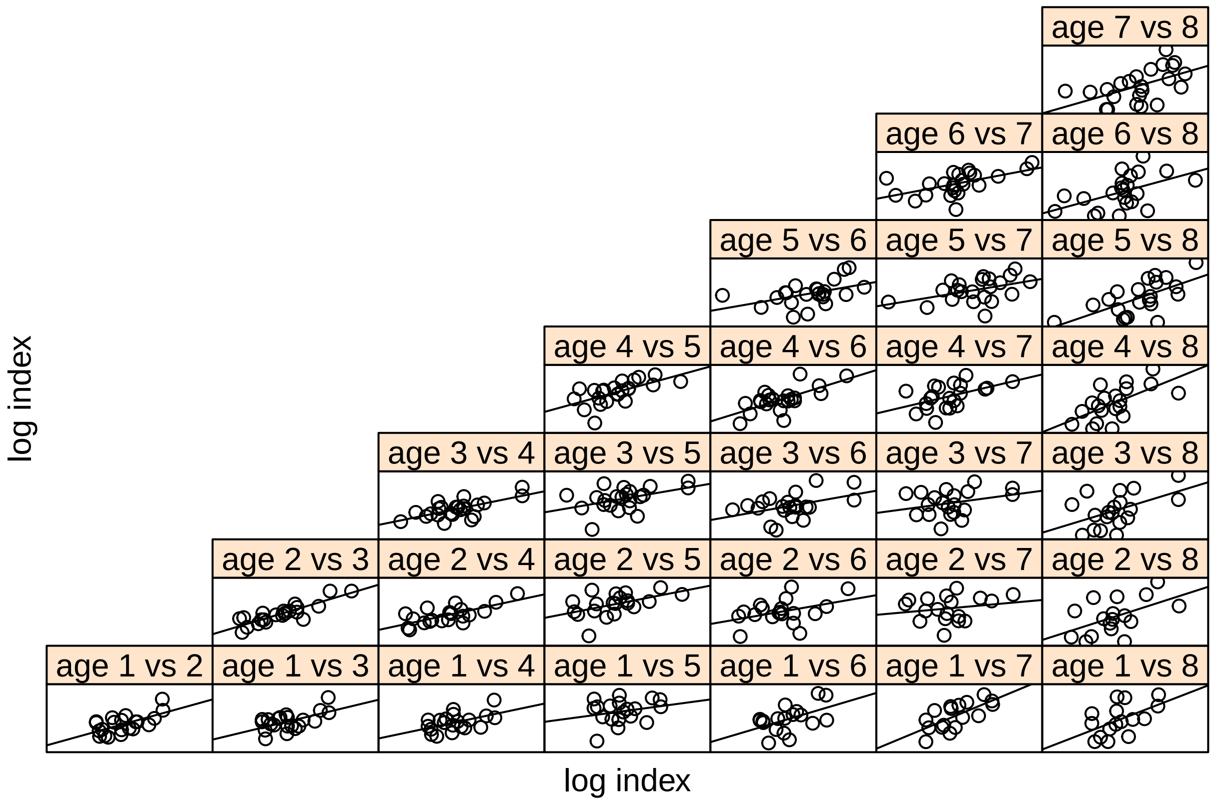
If your data are formatted in a **Lowestoft VPA** format, then FLCore contains functions for reading in indices. To read an abundance index, you use the `readFLIndices` function. The following example reads the index from the `ple4` example:

```
indices <- readFLIndices(file.path(dir, "ple4_ISIS.txt"))
```

Using this function, the 'names' and 'range' slots are already filled.

If your data are not formatted in a **Lowestoft VPA** format, then you and read them using read.table from base R, for example.

```
indices <- read.table(file.path(dir, "ple4Index1.txt"))
# transform into FLQuant
indices <- FLQuant(as.matrix(indices), dimnames=list(age=1:8, year = 1985:2008))
# and into FLIndex
indices <- FLIndex(index = indices)
# and then into FLIndices
indices <- FLIndices(indices)
plot(indices[[1]])
```



The ‘range’ slot needs to be filled with the end and start date of the tuning series

```
range(indices[[1]])[c('startf', 'endf')] <- c(0.66,0.75)
```

FLFleet objects

Reading data for fleets into an FLFleet object is complicated by the multi-layer structure of the object. The object is defined so that:

Level	Class	Contains
1	FLFleet	variables relating to vessel level activity
2	FLMetier(s)	variables relating to fishing level activity
3	FLCatch(es)	variables relating to stock catches

Here are the slots for each level:

```
# FLFleet level
summary(FLFleet())
```

```
An object of class "FLFleet"

Name:
Description:
Quant: quant
Dims:  quant    year    unit    season  area    iter
    1    1    1    1    1    1
```

```
Range:  min max minyear maxyear
    NA  NA  1   1

effort         : [ 1 1 1 1 1 1 ], units =  NA
fcost          : [ 1 1 1 1 1 1 ], units =  NA
capacity       : [ 1 1 1 1 1 1 ], units =  NA
crewshare      : [ 1 1 1 1 1 1 ], units =  NA

Metiers:
```

```r
# FLMetier level
summary(FLMetier())
```

```
An object of class "FLMetier"

Name:
Description:
Gear :  NA
Quant: quant
Dims:  quant    year    unit    season  area    iter
    1   1   1   1   1   1

Range:  min max minyear maxyear
    NA  NA  1   1

effshare       : [ 1 1 1 1 1 1 ], units =  NA
vcost          : [ 1 1 1 1 1 1 ], units =  NA

Catches:
     1 : [ 1 1 1 1 1 1 ]
```

```r
# FLCatch level
summary(FLCatch())
```

```
An object of class "FLCatch"

Name: NA
Description:
Quant: quant
Dims:  quant    year    unit    season  area    iter
    1   1   1   1   1   1

Range:  min max pgroup  minyear maxyear
    NA  NA  NA  1   1

landings       : [ 1 1 1 1 1 1 ], units =  NA
landings.n     : [ 1 1 1 1 1 1 ], units =  NA
landings.wt    : [ 1 1 1 1 1 1 ], units =  NA
landings.sel   : [ 1 1 1 1 1 1 ], units =  NA
discards       : [ 1 1 1 1 1 1 ], units =  NA
discards.n     : [ 1 1 1 1 1 1 ], units =  NA
discards.wt    : [ 1 1 1 1 1 1 ], units =  NA
discards.sel   : [ 1 1 1 1 1 1 ], units =  NA
catch.q        : [ 1 1 1 1 1 1 ], units =  NA
price          : [ 1 1 1 1 1 1 ], units =  NA
```

Due to the different levels, units and dimensions of the variables, and the potentially high number of combinations of fleets, métiers and stocks in a mixed fishery, getting the full data into an `FLFleets` object (which is a list of FLFleet objects) can be an onerous task.

A way of simplifying the generation of the fleet object is to ensure all the data are in a csv file with the following structure:

Fleet	Metier	Stock	type	age	year	unit	season	area	iter	data
Fleet1	Metier1	Stock1	landings.n	1	2011	1	all	unique	1	254.0
Fleet2	Metier1	Stock2	landings.wt	1	2011	1	all	unique	1	0.3

To generate the required structure, you can then read in the file and generate the object using an lapply function:

```
# Example of generating fleets
fl.nam <- unique(data$Fleet) # each of the fleets

yr.range <- 2005:2011 # year range of the data - must be same, even if filled with NAs or 0s

# empty FLQuant for filling with right dimensions
fq  <- FLQuant(dimnames = list(year = yr.range), quant = 'age')

### Fleet level slots ###
fleets <- FLFleet(lapply(fl.nam, function(Fl) {

# blank quants with the same dims
eff <- cap <- crw <- cos.fl <- fq

# fleet effort
eff[,ac(yr.range)] <- data$data[data$Fleet == Fl & data$type == 'effort']
units(eff) <- '000 kw days'

## Repeat for each fleet level variables (not shown) ##

### Metier level slots ###
met.nam  <- unique(data$Metier[data$Fleet == Fl]) # metiers for fleet
met.nam  <- met.nam[!is.na(met.nam)] # exclude the fleet level data

metiers  <- FLMetiers(lapply(met.nam, function(met) {

# blank quants
effmet <- cos.met <- fq

# effort share for metier
effmet[,ac(yr.range)] <- data$data[data$Fleet == Fl & data$Metier & data$type == 'effshare']
units(effmet)  <- NA

## Repeat for each metier level variables (not shown) ##


sp.nam <- unique(data$stock[data$Fleet == Fl & data$Metier == met]) # stocks caught by metier
sp.nam <- sp.nam[!is.na(sp.nam)] # exclude fleet and metier level data

catch <- FLCatches(lapply(sp.nam, function(S){
```

```
print(S)

# Quant dims may be specific per stock
la.age <- FLQuant(dimnames = list(age = 1:7, year = yr.range, quant = 'age'))
la.age[,ac(yr.range)] <- data$data[data$Fleet == Fl & data$Metier == met & data$Stock == S & data$type
units(la.age) <- '1000'

## Repeat for all stock level variables (not shown) ##

# Build F
res <- FLCatch(range = yr.range, name = S, landings.n = la.age,...)

## Compute any missing slots, e.g.
res@landings <- computeLandings(res)

return(res) # return filled FLCatch

})) # End of FLCatches

# Fill an FLMetier with all the stock catches
m <- FLMetier(catches = catch, name = met)
m@effshare  <- effmet
m@vcost <- vcost

         })) # end of FLMetiers

fl <- FLFleet(metiers = metiers, name = Fl, effort = ef,...) # fill with all variables
return(fl)

         }))

names(fleets) <- fl.nam
```

You should now have a multilevel object with `FLFleets` containing a list of FLFleet objects, each which in turn contain `FLMetiers` with a list of FLMetier objects for the fleet, and a list of `FLCatches` containing FLCatch objects for each stock caught by the métier.

References

None

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 web-page, http://flr-project.org.

Software Versions

- R version 3.4.1 (2017-06-30)
- FLCore: 2.6.5
- ggplotFL: 2.6.1
- ggplot2: 2.2.1
- **Compiled**: Mon Sep 18 10:51:38 2017

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