Smart Conditioning II

27 febrero, 2020

```
## Warning: package 'knitr' was built under R version
## 3.5.3
```

Aim

FLBEIA (Garcia et al. 2017) provides a battery of tutorials for learning how to use this software. This is the fifth tutorial of **FLBEIA** and it is a practical guide about the conditioning **FLBEIA** using the functions available in the 'Smart Update II' module. It is divided in the following sections:

- Conditioning of the model
  - The FLBiols object.
  - The FLFleets object.
  - The rest of data objects.
  - The control objects.
- The validation of the conditioning.
- The scenarios.
- The advice.

At the end of the tutorial some exercises are proposed.

Required packages to run this tutorial

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

- CRAN: ggplot2 XLConnect XLConnectJars
- FLR: FLCore, FLAssess, FLash, FLBEIA, FLFleet

If you are using Windows, please use 64-bit R version because some of the packages (mainly FLash) do not work in 32-bit.

```
install.packages( c("ggplot2", "XLConnect", "XLConnectJars"))
install.packages( c("FLCore", "FLFleet", "FLBEIA",
                    "FLash", "FLAssess", "FLXSA"),
                  repos="http://flr-project.org/R")
```

It has to be noted that packages `FLCore`, `FLFleets` and `FLBEIA` have to be installed in this exact order, as alternative orders can cause some problems.

Load all the necessary packages.

```
library(FLBEIA)
library(XLConnect)
```

```
library(XLConnectJars)
library(plyr)
```

Conditioning of the model

The most difficult part in the generation of the mixed-fisheries advice is the compilation of the data. There are two main sources of data:

- The biological data that comes from the stocks assessment working groups.
- the catch and effort data at fleet and metier level.

The biological data is easy to get and it is not problematic because the data has been already used by the stock assessment working groups and it is free of errors. However, although the catch data at fleet and metier level forms the basis for the catch data in the assessment working groups there are usually many issues that make the process of data compilation long and tedious. The effort data is reported by the member states to the working groups and the catch data is either reported by the member states to the working groups or extracted from Intercatch www.intercatch.dk. The data reported by the member states contains the length of the vessel that is missing in intercatch. Once you have the data, the first two steps in the generation of the advice are ensuring that:

- Total catch provided at metier level for each stock match exactly the catch data used in the stock assesment working groups.
- The metier and fleet code names used in the different data files match exactly.

In this tutorial we will obviate these two steps, because they do not contribute to the objective, and will use data files that have already been checked and corrected.

The functions presented in this tutorial are part of the 'Smart Conditioning II' module of FLBEIA. They provide functions to create the FLBiols, the FLFleets and covars object, for the rest of the objects the functions available in FLCore or the 'Smart Conditioning I' modules should be used.

The data used in the tutorial corresponds with the Demersal fishery operating in Iberian Coast. The fishery is formed by two countries, Spain and Portugal, and several fleets operating with different gears. An squeme of the case sutdy is shown below

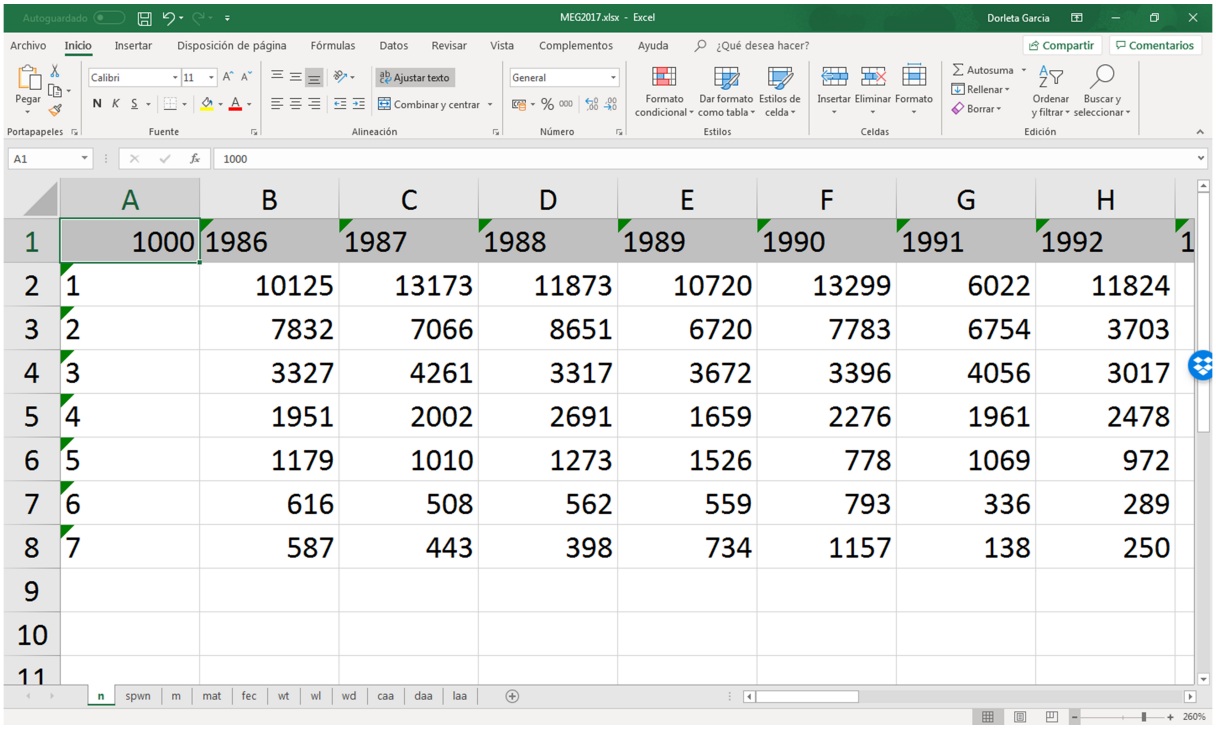
- Stocks:
  - Hake: 16 age classes and caught by most of the fleets, catches around 13000 tons. the status of the stocks was bad in the last years and it is the most restrictive stocks.
  - Monkfish: 30 age classes and caught by most of the fleets, catches around 2500 tons.
  - Four Spot Megrim: 8 age classes and caught by the trawlers, catches around 2500 tons.
  - Megrim: 7 age classes and caught by trawlers along with the other megrim, catches around 500 tons.
- Fleets:
  - SP_GNS: Spanish Gillnetters.
    - DEF_100_0_0"
    - "DEF_60_79_0_0"
    - "DEF_80_99_0_0"
  - PT_GNS: Portuguese Gillnetters.
    - DEF_0_0_0
  - PT_GTR: Portuguese Trammel Nets.
    - DEF_0_0_0
  - SP_GTR: Spanish Trammel Nets.
    - DEF_0_0_0
  - SP_LLS: Spanish Longliners
    - DEF_0_0_0

- PT_MIS: Portuguese miscelaneous.
  - MIS_0_0_0_HC
- SP_MIS: Spanish miscelaneous.
  - MIS_0_0_0_HC
- PT_OTB: Portuguese Bottom Otter Trawl.
  - CRU_55_0_0
  - DEF_65_0_0
- SP_OTB: Spanish Bottom Otter Trawl.
  - DEF_65_0_0
  - MPD_55_0_0
- SP_OTB_24m: Spanish Bottom Otter Trawlers smaller than 24 m.
  - MCD_55_0_0
- OTH_OTH: A fleet that accounts for the catch not included in the rest of the fleets.
  - OTH
- SP_PTB: Spanish pair trawlers.
  - MPD_55_0_0

The FLBiols object in this tutorial is created using the 'Smart Update II' functions available in FLBEIA. These functions are an alternative to the 'Smart Update I' function presented in the tutorial XXX. The functions have been coded to be able to build the FLBiols and FLFleets objects based on the data used by the ICES assessment working groups and Mixed-Fisheries advice working groups as directly as possible.

The FLBiols object.

The biological data needed to build the FLBiols objects is taken from and excel file. The data corresponding to each of input factor (number at age, natural mortality,...) is given in a separate sheet in a matrix form. Each sheet contains a matrix with age in rows and year in columns. Data for all the quantities needs to be reported for the whole data series. If some data is not available NA should be used instead. Units (if available) must be stored in the first line and column (A1).



	A	B	C	D	E	F	G	H
1	1000	1986	1987	1988	1989	1990	1991	1992
2	1	10125	13173	11873	10720	13299	6022	11824
3	2	7832	7066	8651	6720	7783	6754	3703
4	3	3327	4261	3317	3672	3396	4056	3017
5	4	1951	2002	2691	1659	2276	1961	2478
6	5	1179	1010	1273	1526	778	1069	972
7	6	616	508	562	559	793	336	289
8	7	587	443	398	734	1157	138	250
9								
10								
11								

Figure 1: Excel file with the data needed to condition the FLBiol object

The data stored in each fleet is explained in the table below. Each row corresponds with one sheet in the excel file:

sheet	description	mandatory	If not provided
n	Abundance at 1st January	TRUE	-
wt	mean weight at age	TRUE	-
mat	maturity	TRUE	-
fec	fecundity	FALSE	fecundity equal to 1
m	natural mortality	TRUE	-
spwn	moment of the year when spawning occurs (in percentage)	TRUE	-
f	fishing mortality at age	TRUE	-
caa	catch at age	TRUE	-
laa	landings at age	FALSE	catch equal to landings
daa	discards at age	FALSE	discards equal to 0
wc	weight at age of catches	FALSE	weighted mean of the weights of the landings and discards
wl	weight at age of landings	FALSE	weight of the landings equal to that in the population
wd	weight at age of discards	FALSE	weight of the discards equal to that in the population

Figure 2: List of data needed to condition the FLBiol Object. Each row corresponds with onesheet in the excel file.

Firts we download the data from the FLR we page using R commands

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

Once the data is prepared in excel format it is imported into an FLBiol object using the create.biol.arrays function. The function is applied in an stock-by-stock basis and then the objects are joing in a single FLBiols object using the function with the same name. In the process of conditioning the model it is extremely important to be consistent in the name used along the whole process. This is why we recommend using names as standard as possible. For stock for example the use of the FAO codes with three letters is highly recommended.

```
stknms <- c('HKE', 'LDB', 'MEG', 'MON')

hke <- create.biol.arrays(file.path(tdir,'stocks/HKE2017.xlsx'), name = 'HKE',
                  ages = 0:15, hist.yrs = 1982:2017 , sim.yrs = 2018:2025,
                  fbar = c(1,3), mean.yrs = 2015:2017, excel = TRUE)

mon <- create.biol.arrays(file.path(tdir,'stocks/MON2017.xlsx'), name = 'MON',
                          ages = 0:30, hist.yrs = 1980:2017 , sim.yrs = 2018:2025,
                           fbar = c(1,8), mean.yrs = 2015:2017,  excel = TRUE)
ldb <- create.biol.arrays(file.path(tdir,'stocks/LDB2017.xlsx'), name = 'LDB',
```

```
                            ages = 0:7, hist.yrs = 1986:2017 , sim.yrs = 2018:2025,
                            fbar = c(2,4), mean.yrs = 2015:2017, excel = TRUE)

meg <- create.biol.arrays(file.path(tdir,'stocks/MEG2017.xlsx'), name = 'MEG',
                            ages = 1:7, hist.yrs = 1986:2017 , sim.yrs = 2018:2025,
                            fbar = c(2,4),mean.yrs = 2015:2017, excel = TRUE)
```

We join all the objects in a sigle FLBiols and we extend it until 2025 applying the window function at FLBiol object level.

```
biols <- list(HKE = hke, MON = mon, LDB = ldb, MEG = meg)

biols <- FLBiols(lapply(biols, function(x) window(x, 2000,2025)))
```

For some stocks we change the weight in the projection to use the one used by the assessment working group to generate the single stock TAC advice.

```
biols$HKE@wt[, ac(2018:2020)] <- c(0.00, 0.05, 0.30, 0.87, 1.71, 2.72, 3.81, 4.93, 6.04,
                                   7.11, 8.15, 9.13, 10.02, 10.82, 11.51, 12.39)
biols$LDB@wt[,ac(2018:2020)]  <- c(0.004,   0.024,  0.044,  0.071,  0.1,    0.131,  0.162,
                                   0.218)
biols$MEG@wt[,ac(2018:2020)]  <- c(0.038, 0.089, 0.134, 0.180, 0.222, 0.2840, 0.396)
```

Stock assessments with iterations

Stocks assessed for example with Bayesian models do not only provide point estimates of the parameters but also their join probability distribution in the form of multiple iterations. If an stock is assessed with a bayesian model FLBEIA should be conditioned using a big enough number of iterations to represent the inherent uncertainty properly. In this case, instead of using an excel file with different sheets we can use a R list with 13 arrays. Each array corresponds with the sheets in the excel file ("n", "wt", "mat", "fec", "m", "spwn", "f", "caa", "laa", "daa", "wl" and "wd"). Each of these arrays must have dimension [na,ny,ni] where 'na' corresponds with the number of ages, 'ny' with the number of years and 'ni' with the number of iterations. In the call to the 'create.biol.arrays' the name of the workspace where the data is stored is used and the name of the list must be called 'data'.

The FLFleets object

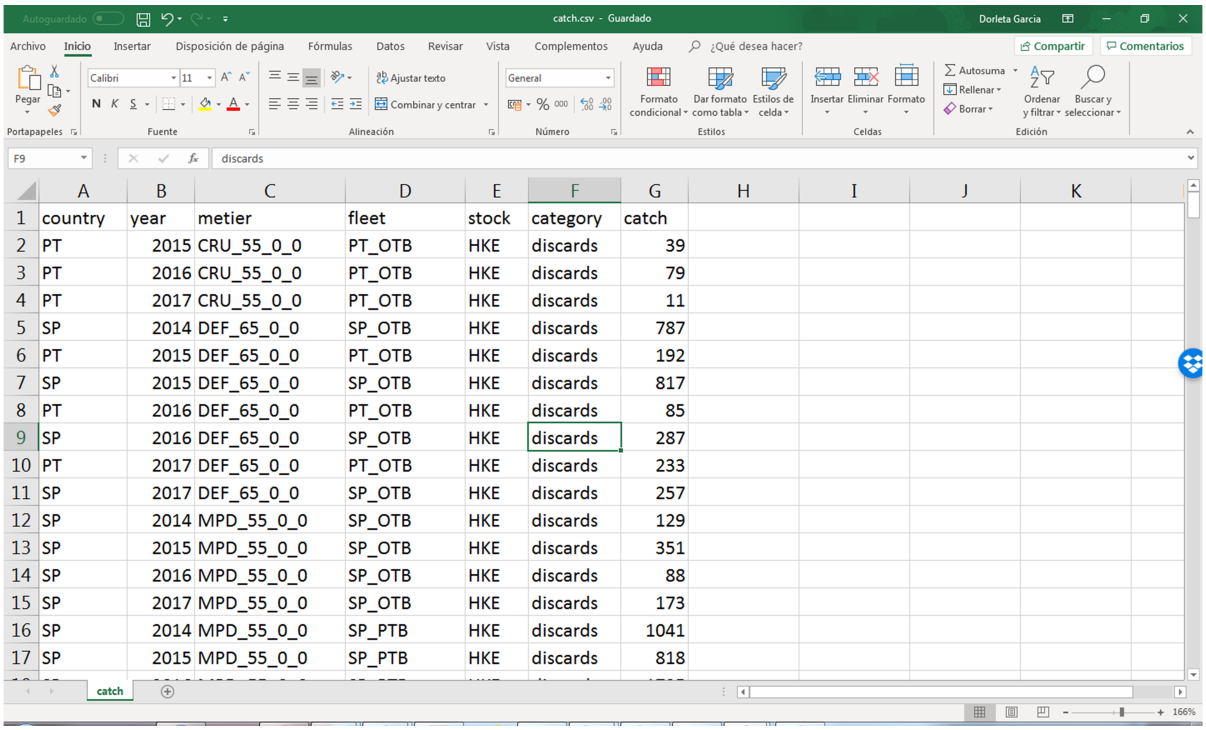
To create the fleets, we will use the 'create.fleets.arrays' function. The R help page for this function provides some useful information.

```
?create.fleets.arrays
```

The function uses catch and effort data in the same format used in the WKMIXFISH as shown in Figures **??** and **??**. The fleets and metiers names used in both files must match. The country column is not mandatory but the rest are. Aa the metier column is mandatory, the case where a fleet does not have metiers corresponds with a fleet with a single metier case, in this case the same name can be used for the metier and the fleet. The landings and discards are given in total weight. Any unit can be used for the landings and discards but the units used must be coherent along all the objects used. For example, the units of the product of numbers at age and weight at age in the 'FLBiols' object must be the same as the units of the catch and landings in the catch data file. In the case of effort, for example, the units used are free, but the units used in all the indicator related with effort, variable cost for instance, must be coherent.

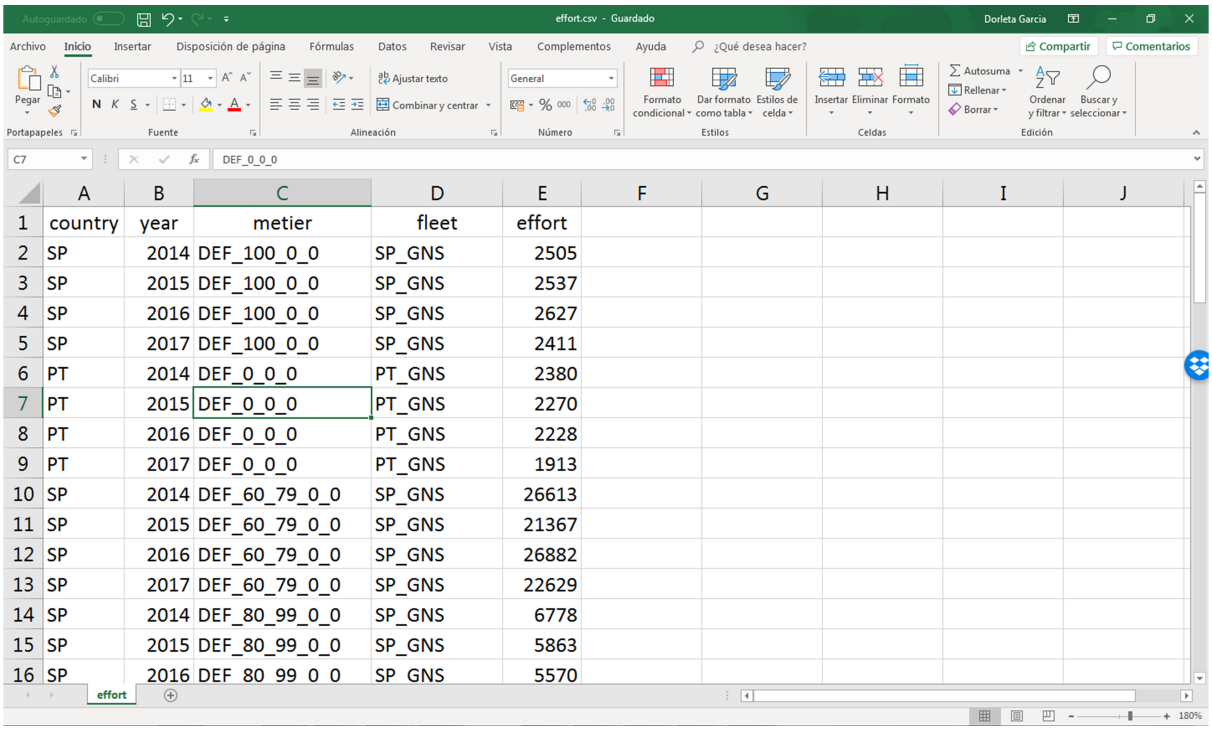
The arguments 'flnms', 'flt_mt_nms' and 'flt_mt_stk_nms' are used to let R know which is the structure of the fleet. As they are bit long we build them outside the function.

```
# fleet names
flnms <-  c('SP_GNS', 'PT_GNS', 'PT_GTR', 'SP_GTR', 'SP_LLS', 'PT_MIS', 'SP_MIS',
```



	A	B	C	D	E	F	G
1	country	year	metier	fleet	stock	category	catch
2	PT	2015	CRU_55_0_0	PT_OTB	HKE	discards	39
3	PT	2016	CRU_55_0_0	PT_OTB	HKE	discards	79
4	PT	2017	CRU_55_0_0	PT_OTB	HKE	discards	11
5	SP	2014	DEF_65_0_0	SP_OTB	HKE	discards	787
6	PT	2015	DEF_65_0_0	PT_OTB	HKE	discards	192
7	SP	2015	DEF_65_0_0	SP_OTB	HKE	discards	817
8	PT	2016	DEF_65_0_0	PT_OTB	HKE	discards	85
9	SP	2016	DEF_65_0_0	SP_OTB	HKE	discards	287
10	PT	2017	DEF_65_0_0	PT_OTB	HKE	discards	233
11	SP	2017	DEF_65_0_0	SP_OTB	HKE	discards	257
12	SP	2014	MPD_55_0_0	SP_OTB	HKE	discards	129
13	SP	2015	MPD_55_0_0	SP_OTB	HKE	discards	351
14	SP	2016	MPD_55_0_0	SP_OTB	HKE	discards	88
15	SP	2017	MPD_55_0_0	SP_OTB	HKE	discards	173
16	SP	2014	MPD_55_0_0	SP_PTB	HKE	discards	1041
17	SP	2015	MPD_55_0_0	SP_PTB	HKE	discards	818

Figure 3: Catch data file.



	A	B	C	D	E
1	country	year	metier	fleet	effort
2	SP	2014	DEF_100_0_0	SP_GNS	2505
3	SP	2015	DEF_100_0_0	SP_GNS	2537
4	SP	2016	DEF_100_0_0	SP_GNS	2627
5	SP	2017	DEF_100_0_0	SP_GNS	2411
6	PT	2014	DEF_0_0_0	PT_GNS	2380
7	PT	2015	DEF_0_0_0	PT_GNS	2270
8	PT	2016	DEF_0_0_0	PT_GNS	2228
9	PT	2017	DEF_0_0_0	PT_GNS	1913
10	SP	2014	DEF_60_79_0_0	SP_GNS	26613
11	SP	2015	DEF_60_79_0_0	SP_GNS	21367
12	SP	2016	DEF_60_79_0_0	SP_GNS	26882
13	SP	2017	DEF_60_79_0_0	SP_GNS	22629
14	SP	2014	DEF_80_99_0_0	SP_GNS	6778
15	SP	2015	DEF_80_99_0_0	SP_GNS	5863
16	SP	2016	DEF_80_99_0_0	SP_GNS	5570

Figure 4: Effort data file.

```
            'PT_OTB', 'SP_OTB', 'SP_OTB_24m', 'OTH_OTH', 'SP_PTB')

# List with the metiers for each fleet
flt_mt_nms <- list(SP_GNS = c("DEF_100_0_0", "DEF_60_79_0_0", "DEF_80_99_0_0"),
                   PT_GNS = "DEF_0_0_0",
                   PT_GTR = "DEF_0_0_0",
                   SP_GTR = "DEF_60_79_0_0",
                   SP_LLS = "DEF_0_0_0",
                   PT_MIS = "MIS_0_0_0_HC",
                   SP_MIS = "MIS_0_0_0_HC",
                   PT_OTB = c("CRU_55_0_0", "DEF_65_0_0"),
                   SP_OTB = c("DEF_65_0_0", "MPD_55_0_0"),
                   SP_OTB_24m = "MCD_55_0_0",
                   OTH_OTH = "OTH",
                   SP_PTB = "MPD_55_0_0")

# List of list with the stocks caugth by each metier for each fleet
flt_mt_stk_nms <- list(SP_GNS = list(DEF_100_0_0 = c("HKE", "LDB", "MEG", "MON"),
                                     DEF_60_79_0_0 = c("HKE", "LDB", "MEG", "MON"),
                                     DEF_80_99_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       PT_GNS = list(DEF_0_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       PT_GTR = list(DEF_0_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       SP_GTR = list(DEF_60_79_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       SP_LLS = list(DEF_0_0_0 = c("HKE", "LDB",  "MON")),
                       PT_MIS = list(MIS_0_0_0_HC = c("HKE", "LDB", "MEG", "MON")),
                       SP_MIS = list(MIS_0_0_0_HC = c("HKE", "LDB", "MEG", "MON")),
                       PT_OTB = list(CRU_55_0_0 = c("HKE", "LDB", "MEG", "MON"),
                                     DEF_65_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       SP_OTB = list(DEF_65_0_0 = c("HKE", "LDB", "MEG", "MON"),
                                     MPD_55_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       SP_OTB_24m = list(MCD_55_0_0 = c("HKE", "LDB", "MEG", "MON")),
                       OTH_OTH = list(OTH = c("HKE", "LDB", "MEG", "MON")),
                       SP_PTB = list(MPD_55_0_0 = c("HKE", "LDB", "MEG", "MON")))
```

Stock data files are used to fill the 'landings.wt' and 'discards.wt' slots in the FLCatch slots of the FLFleet object.

```
# stock data file  names
stk_objs <- c(file.path(tdir,"stocks/HKE2017.xlsx"), file.path(tdir,"stocks/LDB2017.xlsx"),
              file.path(tdir,"stocks/MEG2017.xlsx"), file.path(tdir,"stocks/MON2017.xlsx") )
names(stk_objs) <- c('HKE', 'LDB', 'MEG', 'MON')
stk_objs
```

```
##                                                                                HK
## "C:\\Users\\ssanchez\\AppData\\Local\\Temp\\RtmpCE2wcS/flbeia_data_smart_cond_II/stocks/HKE2017.xlsx
##                                                                                LD
## "C:\\Users\\ssanchez\\AppData\\Local\\Temp\\RtmpCE2wcS/flbeia_data_smart_cond_II/stocks/LDB2017.xlsx
##                                                                                ME
## "C:\\Users\\ssanchez\\AppData\\Local\\Temp\\RtmpCE2wcS/flbeia_data_smart_cond_II/stocks/MEG2017.xlsx
##                                                                                MO
## "C:\\Users\\ssanchez\\AppData\\Local\\Temp\\RtmpCE2wcS/flbeia_data_smart_cond_II/stocks/MON2017.xlsx
```

To call the function 'create.fleets.arrays' to create the FLFleets object we have to decide how to condition the catch at age at metier level. There are 4 different ways of conditioning the landings and discards at age, depenending on data availability. The options are stock dependent so we can use different options for each

stock. In the options one to three is extremely important that the sum of the catch at ages provided are equal to the overall catch at age.

- Catch at age data is available at m?tier level for all the m?tiers included in the CS.
- Catch at age data is only available at fleet level.
- Catch at age data is disaggregated but the segments dot not correspond exactly with the m?tiers/fleets considered in the case study.
- Catch at age data is only available at stock level.

In each case the excel files must be named differently. In the first option, the most complete one, we need to provide an excel file for each fleet, and within the file there must be a sheet for each of the metiers as shown in Figure 5. The file name must be equal to 'CAA_' followed by the name of the fleet and with the '.xlsx' suffix. In turn, the sheets of the excel file must match exactly the name fo the metiers.

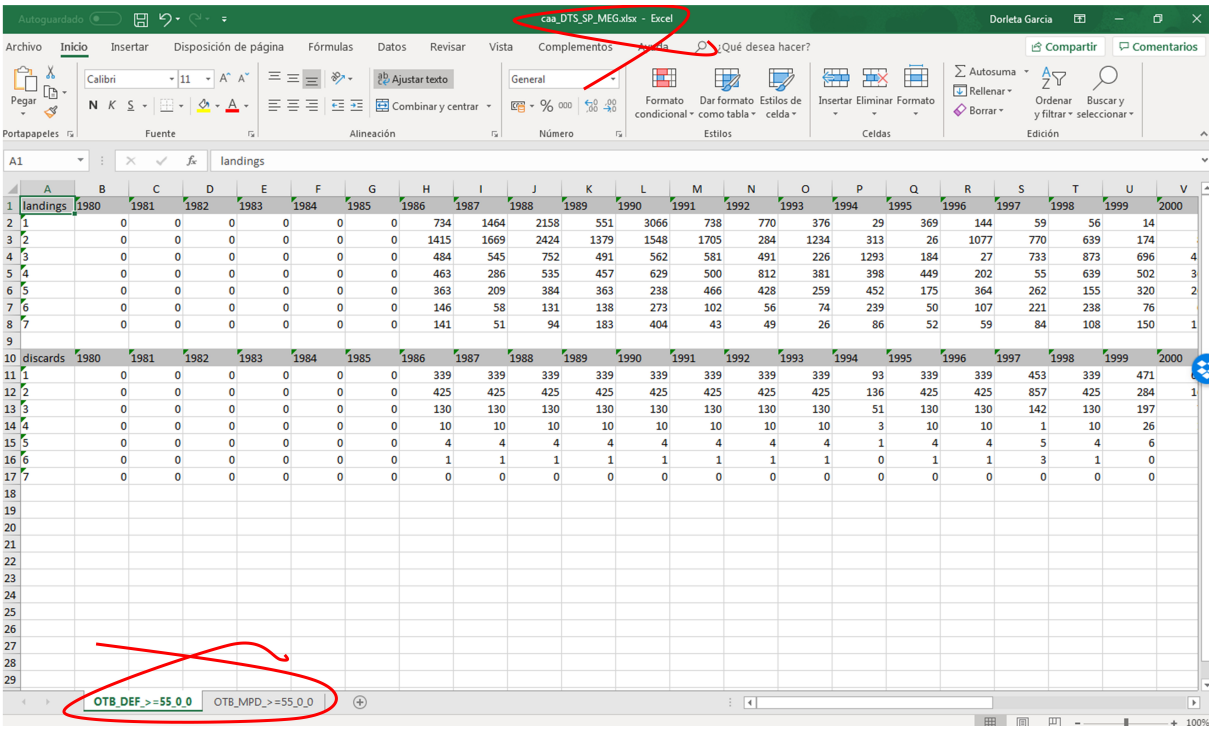


Figure 5: Catch at age data file for option 1, catch at age provided at metier level.

In the second option the catch at age data is provided at fleet level. As in option one the file name must be equal to 'CAA_' followed by the name of the fleet and with the '.xlsx' suffix. In this case the file must have only one sheet with the name of the fleet (Figure 6). The partial catches at metier level, (metier catch divided by the fleet catch), are used to divided the overal catch at age by metier

The third option is quite useful because usually the catch at age data is available at different level. In this case only one file per stock is provided. The file name must be equal to 'CAA_' followed by the name of the *stock* and with the '.xlsx' suffix. Within the file each fleet must be named with the name of the fleet segment it represents (Figure 7). Then, it is neccesary to inform R about the correspondence of the segments with the metiers in the FLFleet object as shown in Figure 8. Then, the partial catches at metier level are used to divided the overal catch at age by metier. Sometimes, in this case it is not easy to ensure that the catch at age obtained summing up the catch at age at fleet level corresponds exactly with the overall catch at age. Hence, there will be differences in the selection pattern of the fleet and the fishing mortality,

Option 4 is the most basic option. The catch at age is provided at overall level and then it is divided among metiers assuming the same distribution by age. The partial catches at metier level are used to divided the

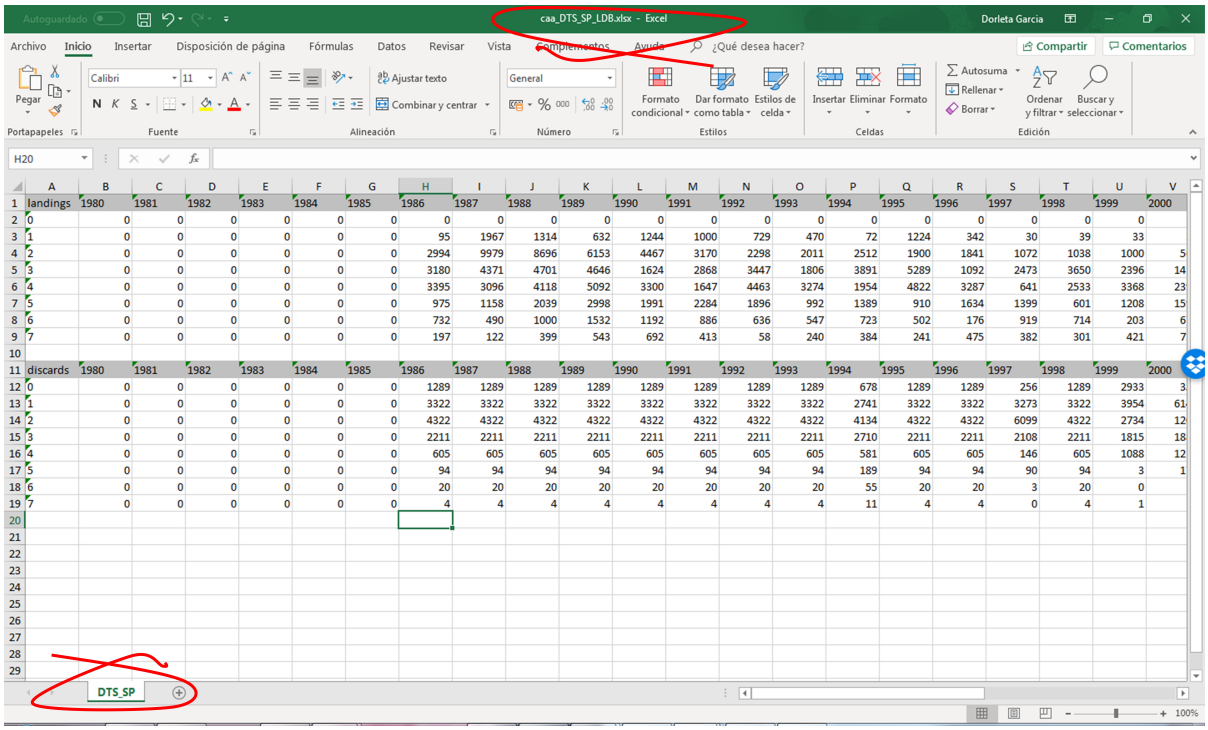


Figure 6: Catch at age data file for option 2, catch at age provided at fleet level.

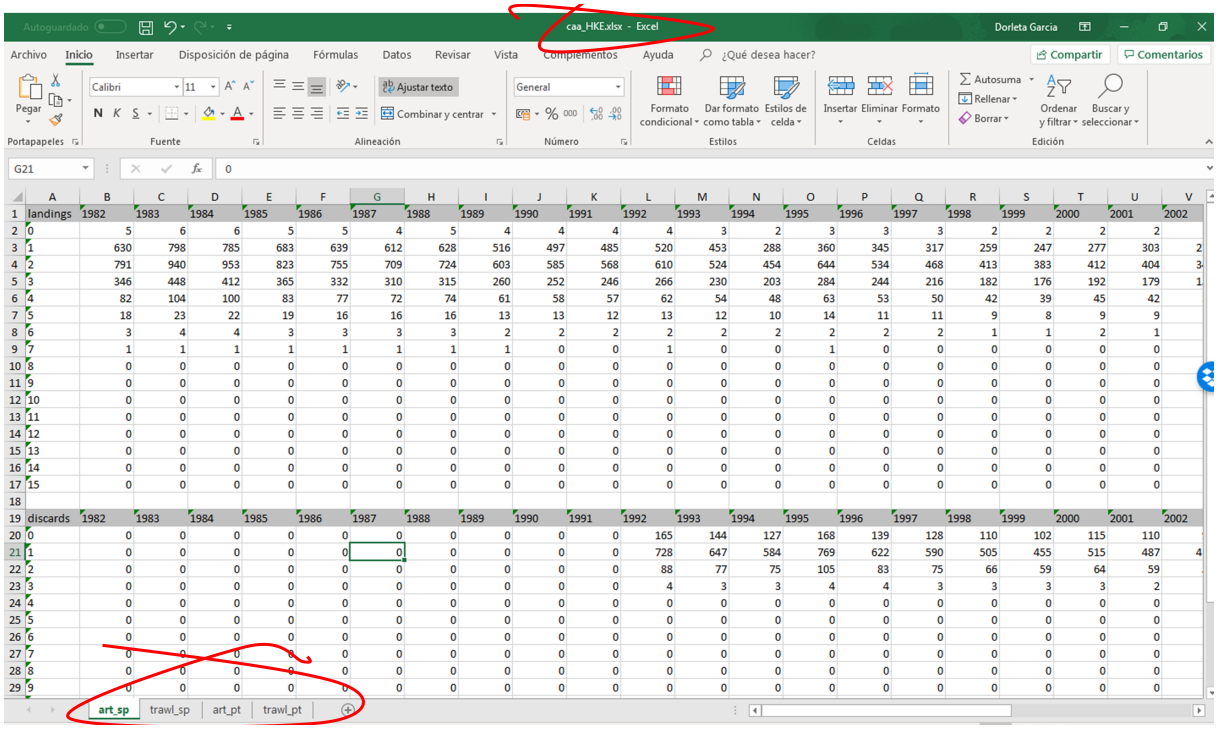
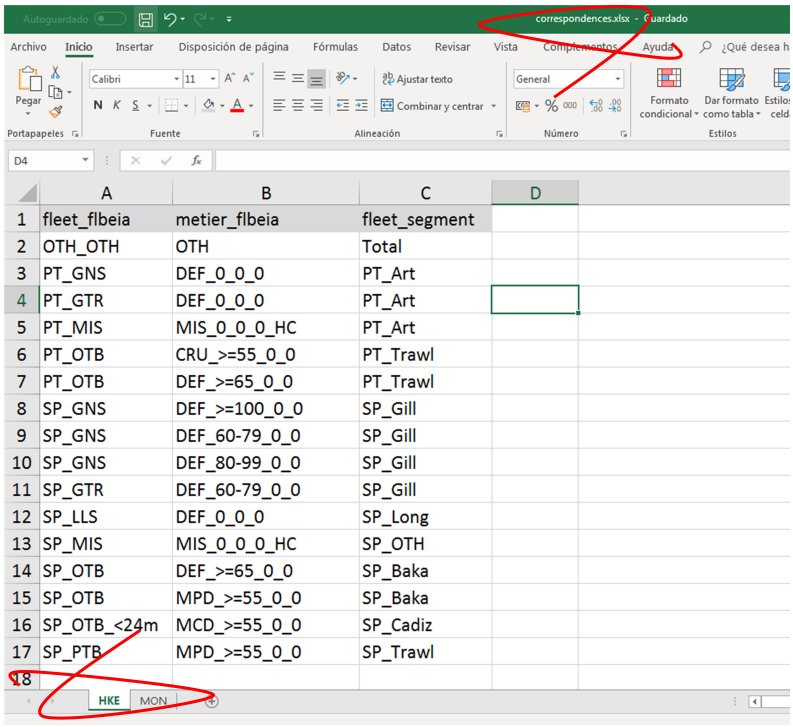


Figure 7: Catch at age data file for option 3, catch at age provided at segment level level.



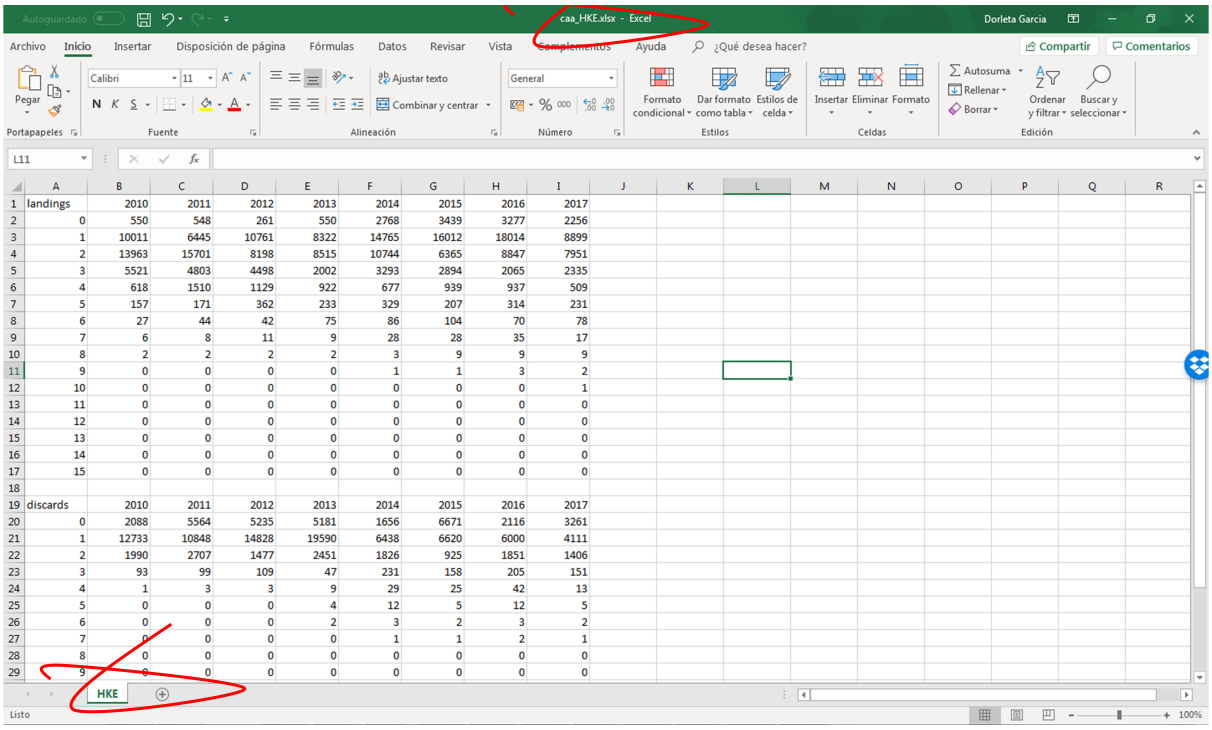
	A	B	C	D
1	fleet_flbeia	metier_flbeia	fleet_segment	
2	OTH_OTH	OTH	Total	
3	PT_GNS	DEF_0_0_0	PT_Art	
4	PT_GTR	DEF_0_0_0	PT_Art	
5	PT_MIS	MIS_0_0_0_HC	PT_Art	
6	PT_OTB	CRU_>=55_0_0	PT_Trawl	
7	PT_OTB	DEF_>=65_0_0	PT_Trawl	
8	SP_GNS	DEF_>=100_0_0	SP_Gill	
9	SP_GNS	DEF_60-79_0_0	SP_Gill	
10	SP_GNS	DEF_80-99_0_0	SP_Gill	
11	SP_GTR	DEF_60-79_0_0	SP_Gill	
12	SP_LLS	DEF_0_0_0	SP_Long	
13	SP_MIS	MIS_0_0_0_HC	SP_OTH	
14	SP_OTB	DEF_>=65_0_0	SP_Baka	
15	SP_OTB	MPD_>=55_0_0	SP_Baka	
16	SP_OTB_<24m	MCD_>=55_0_0	SP_Cadiz	
17	SP_PTB	MPD_>=55_0_0	SP_Trawl	
18				

Figure 8: Table with the correspondences between the fleet segments used to provide the catch at age data and the metiers in the fleet data.

overal catch at age by metier. The file name must be equal to 'CAA_' followed by the name of the *stock* and with the '.xlsx' suffix

In all the cases each excel sheet has two matrices with the number of columns equal to the number of historical years and the number of rows equal to the number of age groups. The first matrix corresponds with the landings at age and the second matrix,both *separated by a single row*, with the discards at age.

In this call to the 'create.fleets.arrays' function we will not condition the price, only the effort and the catches.



	A	B	C	D	E	F	G	H	I
1	landings	2010	2011	2012	2013	2014	2015	2016	2017
2	0	550	548	261	550	2768	3439	3277	2256
3	1	10011	6445	10761	8322	14765	16012	18014	8899
4	2	13963	15701	8198	8515	10744	6365	8847	7951
5	3	5521	4803	4498	2002	3293	2894	2065	2335
6	4	618	1510	1129	922	677	939	937	509
7	5	157	171	362	233	329	207	314	231
8	6	27	44	42	75	86	104	70	78
9	7	6	8	11	9	28	28	35	17
10	8	2	2	2	2	3	9	9	9
11	9	0	0	0	0	1	1	3	2
12	10	0	0	0	0	0	0	0	1
13	11	0	0	0	0	0	0	0	0
14	12	0	0	0	0	0	0	0	0
15	13	0	0	0	0	0	0	0	0
16	14	0	0	0	0	0	0	0	0
17	15	0	0	0	0	0	0	0	0
18									
19	discards	2010	2011	2012	2013	2014	2015	2016	2017
20	0	2088	5564	5235	5181	1656	6671	2116	3261
21	1	12733	10848	14828	19590	6438	6620	6000	4111
22	2	1990	2707	1477	2451	1826	925	1851	1406
23	3	93	99	109	47	231	158	205	151
24	4	1	3	3	9	29	25	42	13
25	5	0	0	0	4	12	5	12	5
26	6	0	0	0	2	3	2	3	2
27	7	0	0	0	0	1	1	2	1
28	8	0	0	0	0	0	0	0	0
29	9	0	0	0	0	0	0	0	0

Figure 9: Catch at age data file for option 4, catch at age provided at metier level.

```
# Create the fleets object
fleets <- create.fleets.arrays(stk_objs,
                               caa_objs = c("caa_HKE.xlsx", "caa_LDB.xlsx",
                                            "caa_MEG.xlsx", "caa_MON.xlsx"),
                               caa_objs_path = file.path(tdir,'fleets/'),
                               catch_obj     = file.path(tdir,'fleets/catch.csv'),
                               effort_obj    = file.path(tdir,'fleets/effort.csv'),
                               flt_obj = NULL,
                               stk_nms =  c('HKE', 'LDB', 'MEG', 'MON'),
                               flt_nms = flnms,
                               flt_mt_nms = flt_mt_nms,
                               flt_mt_stk_nms = flt_mt_stk_nms,
                               ages = list(HKE = ac(0:15), MON = ac(0:30),
                                           MEG = ac(1:7), LDB = ac(0:7)),
                               hist.yrs = 2000:2017,
                               sim.yrs = 2018:2025,
                               mean.yrs = 2015:2017,
                               caa_flt_mt_correspondences = NULL,
                               paa_flt_mt_correspondences = NULL,
                               caaOpt = c(HKE = 4, LDB = 4, MEG = 4, MON = 4),
                               update_price = FALSE,
                               priceOpt = NULL,
                               excel = TRUE)
```

Now we have to calculate the catchabilitis by age for all the fleets and metiers. 'create.fleets.arrays' functions assumes that the 'alpha' and 'beta' parameters of the Cobb-Douglass function are equal to one and calculates the catchability euqal to the ratio between the catch at age at metier level and the product of the biomass in the middle of the total effort and the effort share in the metier. The retention ogives are calculated from the

historical data as the rati between the landings at ate and the catch at age. For the projection the mean of the last three years is used.

```
fleets <- calculate.q.sel.flrObjs(biols, fleets, NULL,
                                  mean.yrs = ac(2015:2017), sim.yrs = ac(2018:2025))
```

Check that the object has been built correctly.

```
validObject(fleets)
```

```
## [1] TRUE
```

The Economic data.

Price

Once the FLFleets object has been created we can fillin the economic slots with the economic data. Price data is filled with the same function 'create.fleets.arrays'. We could have fill in the price dat together with the catch data. But we can do it separately as shown here. We have to turn of the 'update_catch_effort' and 'update_weight' arguments and turn on the 'update_price'. The conditionin of the price is done in the same way it is done for catch at age. Furthermore, the 4 options available for catch at age are also available for price. In this case we will use different options for each stock, for hake and monkfish the option 3 and for the megrims de option 4. In the case of price, in the data files there is only one matrix for the price and the shape is the same used for landings at age.

```
# Update the object with the price data
fleets <- create.fleets.arrays(flt_obj = fleets,
                               price_objs = c('paa_HKE.xlsx', 'paa_MEG.xlsx',
                                              'paa_LDB.xlsx', 'paa_MON.xlsx'),
                               price_objs_path = file.path(tdir,'fleets/'),
                               priceOpt = c(HKE = 3, LDB = 4, MEG = 4, MON = 3),
                               paa_flt_mt_correspondences = file.path(tdir,'fleets/price_correspondence
                               update_catch_effort = FALSE,
                               update_price = TRUE,
                               update_weight = FALSE,
                               hist.yrs = 2000:2017, sim.yrs = 2018:2025,
                               mean.yrs = 2015:2017,
                               excel = TRUE)
```

Economic Indicators

Figure 10 shows the economic indicators used in FLBEIA at fleet and metier level. The 'create.ecoData' can be used to fill in the objects. The economic data is stored in two different objects, the FLFleets object and the covars object.

The FLFleet object has the following economic slots:

- fcost: An slot at fleet level with the fixed costs. It is given at vessel level, that is in an annual implementation it constains the annual fixed costs of a vessel in the corresponding fleet.
- crewshare: An slot at fleet level with the proportion of the gross value that is used to pay the crew.
- vcost: An slot at metier level that measures the associated cost per unit of effort.
- capacity: The maixmum effort that a fleet can exert in a given time period.

The help page provides some information in the use of the function.

```
?create.ecoData
```

The economic indicators are provided in an excel file with one sheet per fleet, see Figure11. In turn, in each sheet the yearly data at fleet and metier level is provided. The fleet level indicators are provided in the fleet

Variable	level	Description
fuel cost	metier	€ per unit of effort
crew share	fleet	% of the gross value used to pay the crew members as variable salarie
other variable cost	metier	€ per unit of effort different to fuel cost
fixed salaries	fleet	€ fixed salary per crew member
depreciation	fleet	the loss of value in € of individual vessels.
other fixed costs	fleet	other fixed cost not included in capital value, fixed salaries and depreciation
capital value	fleet	€ per vessel
maximum effort	fleet	the maximum effort a vessel can execute in each time step, the unit must be the same used to measure effort.
crew	fleet	number of crew members per vessel
vessels	fleet	number of vessels in the fleet
new vessel	fleet	€ the cost of a new vessel
investshare	fleet	if capital dynamics are included using SDC function the % of the gross surplus that is invested in incorporating new vessels in the fleet
w1	fleet	the maximum annual increase in number of vessels
w2	fleet	the maximum annual decrease in number of vessels

Figure 10: Economic indicators at fleet and metier level used in FLBEIA.

column and then there must be one column per metier with the economic indicators at fleet level.

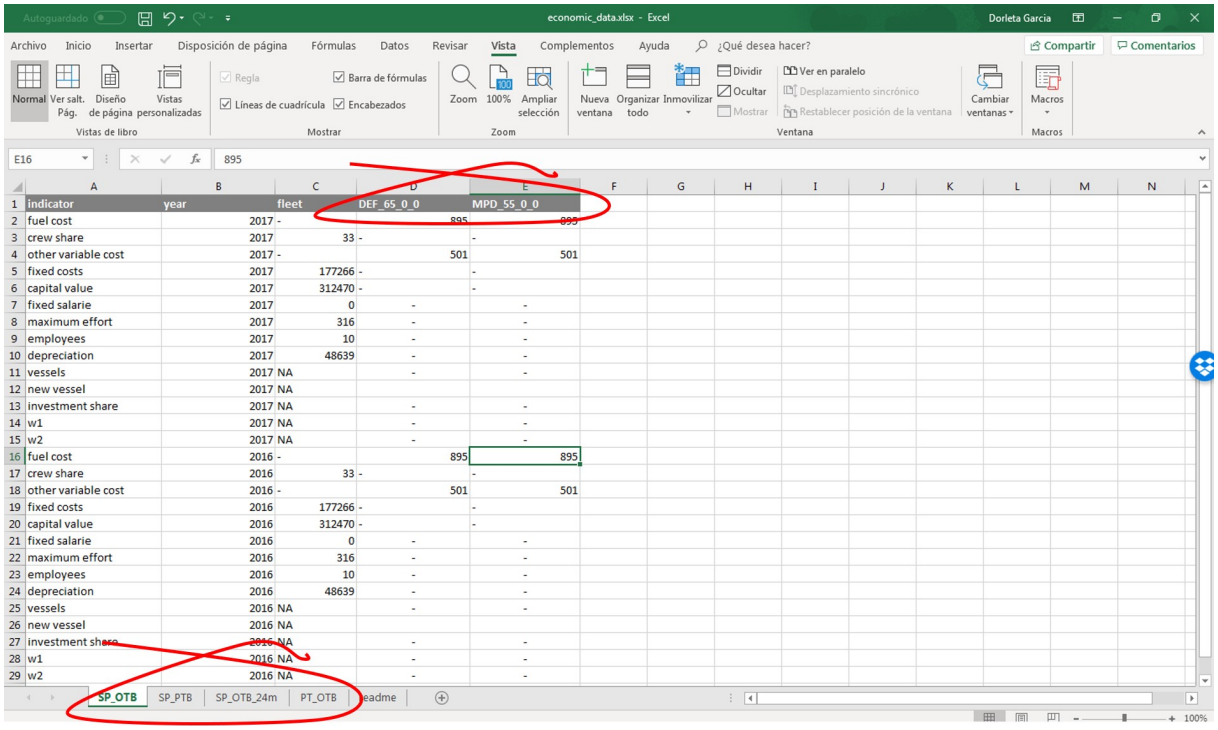


Figure 11: Shape of the file used to pass the economic data at fleet and metier level to FLBEIA.

In the function call we need to provide the name and path of the excel file with the data, the FLFleets object and historicall years, the years used to calculat the mean and the projection years. The function provides a list with two objects, the fleets object with the updated FLFleets object and a covars object with a list of FLQuants with the economic indicators.

```
ecoD <- create.ecoData(file.path(tdir,'fleets/economic_data.xlsx'), fleets,
                       hist.yrs = 2005:2017, mean.yrs = 2017,
                       sim.yrs = 2018:2025)
```

```
## Warning: Capacity slot in fleet  SP_PTB  has been set to 1e12 to avoid problems in the projection.
## Warning: Capacity slot in fleet  SP_OTB_24m  has been set to 1e12 to avoid problems in the projectio
```

```
covars <- ecoD$covars
fleets <- ecoD$fleets
```

Finally, modify the weights in some of the stocks to match the values used by the assessment working group.

```
for(fl in names(fleets)){
  for(mt in names(fleets[[fl]]@metiers)){
    if('LDB' %in% catchNames(fleets[[fl]])){
      fleets[[fl]]@metiers[[mt]]@catches[['LDB']]@landings.wt[,ac(2018:2020)]  <- c(0.002,
                                    0.034,  0.069,  0.086,  0.106,  0.133,  0.162,  0.218)
      fleets[[fl]]@metiers[[mt]]@catches[['LDB']]@discards.wt[,ac(2018:2020)]  <-  c(0.004,
                                       0.024,   0.041,  0.054,  0.069,  0.094, 0.116,   0.094)
    }

  if('MEG' %in% catchNames(fleets[[fl]])){
      fleets[[fl]]@metiers[[mt]]@catches[['MEG']]@landings.wt[,ac(2018:2020)]  <- c(0.064,
                                             0.098,    0.135,  0.18,   0.222,  0.284,  0.396)
      fleets[[fl]]@metiers[[mt]]@catches[['MEG']]@discards.wt[,ac(2018:2020)]  <-  c(0.035,
                                               0.062,  0.091,  0.125,  0.062,  0.038,  0)
  }
  }
}
```

More information

- You can submit bug reports, questions or suggestions on this tutorial at https://github.com/flr/doc/issues.
- Alternatively, 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.
- You can submit bug reports, questions or suggestions specific to **FLBEIA** to flbeia@azti.es.

Software Versions

- R version 3.5.2 (2018-12-20)
- FLCore: 2.6.13
- FLBEIA: 1.15.4
- spict: 1.2.3
- fishmethods: 1.11.0
- **Compiled**: Thu Feb 27 10:17:30 2020

License

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References

Garcia, Dorleta, Sonia Sánchez, Raúl Prellezo, Agurtzane Urtizberea, and Marga Andrés. 2017. "FLBEIA: A Simulation Model to Conduct Bio-Economic Evaluation of Fisheries Management Strategies." *SoftwareX* 6: 141–47.