Deliverable 5.2

Documented framework to analyze the economic performances of alternative fishing gears

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SUMMARY

A R tool (SENSECO) has been developed in the BENTHIS project (task 5.1) to analyze economic consequences for fishing fleets or vessels of the adoption of new gears (or shift to alternative métier) in combination or substitution to the current gears (or métier). The tool adopts a microeconomic perspective. It performs static comparative analysis of economic performances under different conditions and assumptions of effort reallocation. It enables to analyze risk of gear change in terms of probability of being viable according to different criteria and to uncertainties parameters. It is also designed for exploration of economic impacts and economic incentives of alternative gear adoption according to expected CPUE, prices, or costs structure. The interactive interface enables real time variation of inputs and representation of impacts on outputs with opportunity for stakeholders consultation and expertise inclusion. The document is a guideline for the use of the SENSECO tool. It details the inputs, outputs, parameterization and possibilities of the model.

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INTRODUCTION

Objective of task 5.1 of the BENTHIS project is the development of a framework for the analysis of economic performances of alternative fishing gears:

- "This task will provide the **tools to analyze the profitability - including added value, wages, profits** - provided by the adoption of new gears **in combination or substitution to the current gears**. A generic framework will be developed based on existing tools such as the one developed in EU project ESIF- Energy Saving in Fisheries or the impact assessment bioeconomic model IAM (Merzéréaud *et al.* 2011).

- The framework will be used in case studies to compare the economic performances of gears mitigating fishing impact on benthic ecosystems. It will use available data, data collected in the trials in the case studies and generic data commonly available (such as the data collected in the DCR). The framework will allow taking into consideration **altered operational costs** but also **differences in fish prices**, caused by different selection patterns and quality differences. The potential **increase in biomass or change in the biomass structure** due to the use of more selective and less destructive gears will also be investigated when applicable."

The choice was made in the project to develop a R tool (SENSECO) to analyze economic consequences for fishing fleets or vessels (static comparison) provided by the adoption of new gears in combination or substitution to the current gears.
The methodological approach was to provide a tool:

- For static comparative analysis of economic performances under different conditions and assumptions of effort reallocation;

- For exploration of economic impacts and economic incentives of alternative gear adoption;

- Adopting a microeconomic perspective;

- With an interactive interface to enables real time variation of inputs and representation of impacts on outputs.

The tool developed is useful to analyze the economic impact of gear change or any other shift towards an alternative métier. It allows risk analysis due to gear change in terms of probability of being viable according to different criteria and to uncertainties parameters. The tool is also dedicated to the analysis of the incentives to change gear according to expected CPUE, prices, or costs structure.

The Deliverable 5.2 presents a description of the model and a guideline for the use of the SENSECO tool developed.

1 MODEL FRAMEWORK AND TECHNICAL CONSIDERATIONS

Based on a defined set of inputs (see section 2.1) SENSECO calculates a set of economic indicators. In addition, a graphic user interface (GUI) allows real-time modifications of all the input parameters and investigation of the impact on economic performances; the model performs risk analyses looking at the economic viability of fleets or vessels in the version including uncertainties on variables. It is, thus, useful for discussions with stakeholders on possible impacts of variations in input variables, and useful for inclusion of knowledge and expertise of stakeholders on possible costs structure, price or CPUE with an alternative gear or métier.
A simplified framework of the SENSECO tool developed is provided in figure 1.

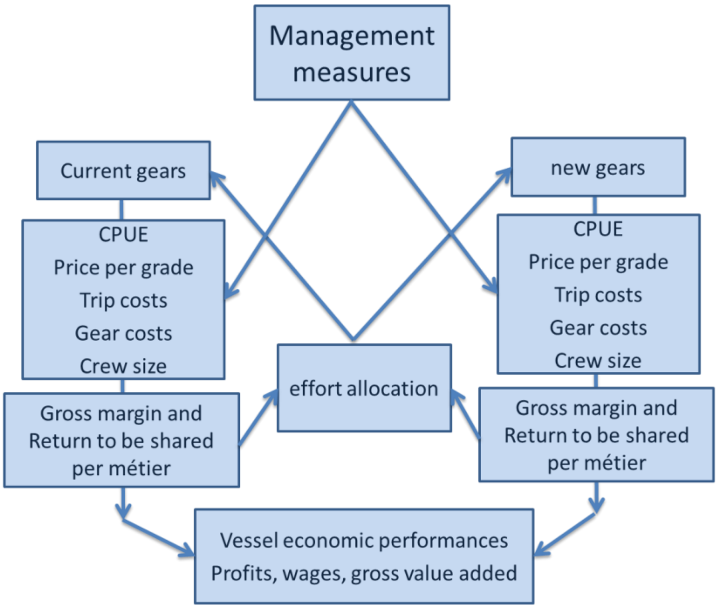

Figure 1: Simplified framework of the SENSECO tool

The SENSECO model is developed in R (R core team, 2014).
The following link enables users to find the R versions to run the model (>= 3.0.2 required)
Links R: http://cran.r-project.org/
The following R packages need to be installed to run the model: « gWidgets », « RGtk2 », « gWidgetsRGtk2 » and « cairoDevice ». To finalize the installation, don't forget to send the script line 'library(RGtk2)' that will ensure required GTK+ installation on your system.
R code editors are useful. Many are free and easy to find on the Internet (such as TinnR, Emacs, Notepad++, Rstudio,…).
This deliverable refers to the version 0.1 of the Senseco package.

2 INPUTS PARAMETERS AND OUTPUTS

2.1 Inputs

The underlying model is a static simplified version of the economic model integrated in IAM (Merzéréaud *et al.* 2011), applied to a specific fleet or vessel. Levels of potential differentiation of considered variables are the métier, the species and the fish market category, the two latter levels describe exclusively the price and the CPUE variables. The level of variables is indicated in their name, '_f' indicates the fleet or vessel level, common to all indicators, '_m' the métier level, '_e' the species level, '_c' the category level.

The model requires 6 kinds of data:

- Technical data on fleet or vessel characteristics
- Activity data on effort
- Production data by métier and species
- Price data by métier and species
- Variable costs data by métier
- Fixed costs data by fleet or vessel

The following data sources can be used to provide input parameters:

- DCF[1] transversal and economic data by métier (or more detailed data if available) : Effort and production by fleet-métier-species, prices by species (grades), costs structure by métier, fixed costs by vessel;
- Version with extended data collected in the case study through surveys or sampling programs on board (gear costs, crew costs, ice costs, bait costs) and at a finer scale (price per market category per métier and fleet);
- Outputs from other simulation models (simulated CPUE under management scenarios for example);
- Data provided by experts.

Table 1 summarizes the existing data sources or methods to provide the 6 types of input data presented above :

Table 1: Existing data sources or methods to provide the SENSECO inputs

Type of data	Data sources or methods for data collection
Technical Characteristics	European fishing fleet file Economic DCF data Administrative data (employment) Log-books Sales notes Questionnaire on vessel activity
Activity	Log-books Sales notes VMS Questionnaire on vessel activity and new activity or alternative gear
Production	Log-books Sales notes VMS Questionnaire on vessel activity, on new activity or alternative gear or self-sampling protocol on board (accurate effort data for passive gears) Caution : check up data completeness when direct sales (not at auction) questionnaire
Price	Sales notes Questionnaire on vessel activity, on new activity or alternative gear : price by species for direct sales (not at auction)
Variable costs	Economic DCF data : annual cost structure by fleet * Income by métier Accounts by trip crossed-reference with log-books (métier by trip) Questionnaire on vessel activity : variable costs by trip / métier (for instance : fuel consumption)
Fixed costs	Economic DCF data by fleet + questionnaire on potential modifications of the non variable costs with new métier (crewcosts, investments, repairs, licenses, others…)

Input parameters are described in Table 2:

[1] DCF :data collection framework of the EU see example of the data collected and available for EU countries on the JRC website (http://stecf.jrc.ec.europa.eu/reports/dcf-dcr)

Table 2: Input data for SENSECO.

Type	Variables	Description
Effort & crew inputs	*nbv_f*	number of vessels by fleet
	nbv_f_m	number of vessels by fleet by métier
	cnb_f	mean crew number by vessel
	cnb_f_m	mean crew number by vessel by métier
	nbTimeUnit_f_m	mean number of days at sea or fishing trips or hours at sea by vessel by métier by year
	nbGearUnit_f_m	mean number of gears (or km of nets or any other units appropriate for CPUE) used by fishing time units (number of traps hauled by days at sea for example)
Production inputs	*CPUE_f_m_e_c*	landings (in tons) per unit of effort & gear unit by vessel by métier by species by category (landings by trap by days at sea for example or landings by days at sea for trawlers)
	P_f_m_e_c	price of landings by métier by species by category, per kg
Fuel costs inputs	*fcons_f_m*	fuel consumption in L by vessel, métier and fishing time unit (L/Hours or L/days at sea..)
	fp_f	fuel price per L
Other Variables costs	**If disaggregated data are available :**	
	oilcUE_f_m	oil costs by vessel, métier and fishing time unit
	bcUE_f_m	bait costs by vessel, métier and fishing time unit
	icecUE_f_m	ice costs by vessel, métier and fishing time unit
	focCNBUE_f_m	food costs by vessel, métier, crew member and fishing time unit
	lc_f	landings tax (% of the gross revenue)
	gc_f_m	gear costs by vessel and métier[2]
	Otherwise DCF data indicators are used in the model :	
	ovcUE_f_m	other variable costs by vessel, métier and fishing time unit (including landings, oil, bait, food and ice costs)
Crew share	*cshr_f*	crew share by vessel (% of the return to be shared)
Fixed costs	**If disaggregated data are available :**	
	rep_f	repair and maintenance costs by vessel
	eec_f	employee contribution by vessel
	ecc_f	employers contributions by vessel
	onvc_f	other non-variable costs (including insurance costs, licence costs, comitee tax, etc) by vessel
	persc_f	crew costs by vessel
	Otherwise DCF data indicators are used in the model	
	rep_f	repair and maintenance costs by vessel
	onvc_f	other non-variable costs by vessel
Capital costs	*dep_f*	depreciation costs by vessel
	ic_f	interest costs (insurance value as a proxy of capital multiplied by the long term interest rate, or interest cost of surveys) by vessel

2.2 Equations and Outputs

From the inputs the model calculates several indicators per fleet or vessel per year following the equations described in Table 3. Outputs are given at fleet level, and are obtained by multiplying the output mean values by the total number of vessels in the fleet (Y(es) in ‘Out?’ column means that the resulting total value is an output of the tool) :

[2] Gear costs are included here in the variable costs section and in the calculation of the return to be shared when the variable costs are disaggregated, and in the non variable costs when detailed data are not available. It depends in fact of the métier considered. DCF includes those cost in the non variable costs more generally.

Table 3. Summary of types of outputs calculated by the tool.

Type	Variables	Out?	Description
Gross Value of Landings by vessel by métier	**GVL_FM**	**Y**	$GVL_{fm} = \sum_{e,c} CPUE_{fmec} \times nbTimeUnit_{fm} \times nbGearUnit_{fm} \times P_{fmec}$
Gross Value of Landings by vessel	**GVL_F**	**Y**	$GVL_f = \sum_m GVL_{fm}$
Net Value of Landings by vessel by métier **(if landing cost in % of the gross value of landings is available independently of the variable costs)**	**NVL_FM**	**N**	$NVL_{fm} = GVL_{fm} \times (1 - lc_f)$
Variable Costs by vessel by métier	**VCST_FM**	**N**	
	If disaggregated variable costs are available :		
			$VCST_{fm} = (fcons_{fm} \times fp_f + oilcUE_{fm} + bcUE_{fm} + icecUE_{fm} + focCNBUE_{fm} \times cnb_{fm}) \times nbTimeUnit_{fm} + gc_{fm}$
	If DCF variable costs are available :		
			$VCST_{fm} = (fcons_{fm} \times fp_f + ovcUE_{fm}) \times nbTimeUnit_{fm}$
Return to be Shared by vessel by métier	**RTBS_FM**	**Y**	
	If disaggregated variable costs are available :		
			$RTBS_{fm} = NVL_{fm} - VCST_{fm}$
	If DCF variable costs are available :		
			$RTBS_{fm} = GVL_{fm} - VCST_{fm}$
Return to be Shared	**RTBS_F**	**Y**	$RTBS_f = \sum_m RTBS_{fm}$
Gross Wage per crew member	**WAGEG_F**	**Y**	$WAGEG_f = RTBS_f \times cshr_f \times \frac{1}{cnb_f}$
Gross Value Added	**GVA_F**	**Y**	$GVA_f = RTBS_f - (rep_f + onvc_f)$
Gross Cash Flow	**GCF_F**	**Y**	$GCF_f = GVA_f - RTBS_f \times cshr_f$
Net Cash Flow	**NCF_F**	**N**	$NCF_f = GCF_f - dep_f$
Net Profit or Owner Surplus	**NP_F**	**N**	$NP_f = NCF_f - ic_f$

3 PARAMETERIZATION

3.1 Format settings

A method to import parameters into a structured R object has been implemented. It returns a specific class object that will be used as an input for the calculation of indicators and interfacing methods. This function reads a file in a fixed table format, and is built from the classic R import function *read.table* (see format in table 4).

Table 4: Format setting.

INDEX	NAME	FLEET	MÉTIER	SPECIES	CAT	VALUE	ALEA_dist	ALEA_paramA	ALEA_paramB	ALEA_paramC	CORR_index
11	CPUE_f_m_e_c	Fleet	metier1	Species1	Cat1	0.051592953					
12	CPUE_f_m_e_c	Fleet	metier1	Species1	Cat2	0.043497173					
13	CPUE_f_m_e_c	Fleet	metier1	Species2	cAll	0.027717268					
14	CPUE_f_m_e_c	Fleet	metier1	Species3	cAll	0.004712701					
15	CPUE_f_m_e_c	Fleet	metier2	Species1	Cat1	0.009210526	rnorm	0.009210526	0.001771727		
16	CPUE_f_m_e_c	Fleet	metier2	Species1	Cat2	0.003947368	correl	0.003947368	0.0003947	0.95	15
17	CPUE_f_m_e_c	Fleet	metier2	Species2	cAll	0.065789474					
18	CPUE_f_m_e_c	Fleet	metier2	Species3	cAll	0.009210526					
30	fcons_f_m	Fleet	metier1			390					
31	fcons_f_m	Fleet	metier2			390					
32	fp_f	Fleet				0.384	sample				1

The table is designed to initialize all the required parameters (previously listed in Table 2), while specifying the dimensions that characterize them. Thus, the 'NAME' and 'INDEX' columns are used to tag the considered variable, whereas its dimensions are described in the columns 'MÉTIER', 'SPECIES' and 'CAT' . The 'FLEET' information is not structuring as it’s simply used as a denomination for the analyzed fleet (or vessel). It can be added that the variables name gives information about the 'dimensions' columns that are required to be filled for each one of them. The column ‘VALUE’ contains the value initially assigned. Finally, the columns 'ALEA_' and 'CORR_index’ will allow assigning a random value to a given variable at a given level. The column 'ALEA_dist' means the application generating random values: a R function generating random variables ("rnorm», «runif», «rbeta»,...), or a more methodological designation ("correl" to generate a random variable correlated to another one already defined, "custom" and "sample" to integrate historical series of values, re-sampled or not). The columns «ALEA_param» contain settings that are applied when calling to this application (for example, according to the table above, for index 15 it will generate a random variable with normal distribution, with an average of 0.009210526, and standard deviation of 0.001771727). The variable INDEX 16 is correlated to the one previously described (CORR_index 15), with a mean value equal to 0.003947368 and a coefficient of variation equal to 10%, with a correlation coefficient equal to 0.95. Finally, a random draw in a historical data will be operated to simulate *fp_f.* In that case, 'CORR_index' value is used to point at the considered historical data from an input list, given as an argument of the import method. The document further details the integration of these random aspects within the purpose of parameterization and resulting indicators.

3.2 Setup object

Once this file is setup, it is possible to import the included information by using the "SENSECO.import" function that will read the data and format them to manage the iterative dimension. Indeed, taking into account the stochastic aspect is done through a replication of input data, integrating the added random components and assessing the indicators and their variability by simple application of Monte-Carlo type methods. The object retains the fixed reference setting (i.e., the raw data contained in the "VALUE" column) as a first iteration. Thus, for a number N>0 of iterations chosen by the user, the stochastic achievements will be recorded into iterations 2 to N + 1 (see Figure 2). Similarly, total estimators will be calculated on the basis of N iterations, thus ignoring the iteration No. 1 based on reference setting. Finally, it should be noted that these stochastic aspects are, for the moment, not applicable on effort and crew variables (ie *nbv_f*, *nbv_f_m*, *cnb_f*, *cnb_f_m*, *nbGearUnit_f_m*, *nbTimeUnit_f_m*).

The arguments of the SENSECO.import method are as follows:

- file: path to the Setup file ("character")
- iter: number of iterations to be considered for the random component ("integer")
- customAlea: list with parameters series called for random simulations of type "custom" and "sample." The 'CORR_index' value means the item in the list to be taken into account. ("list")
- desc: descriptor of the input ("character")

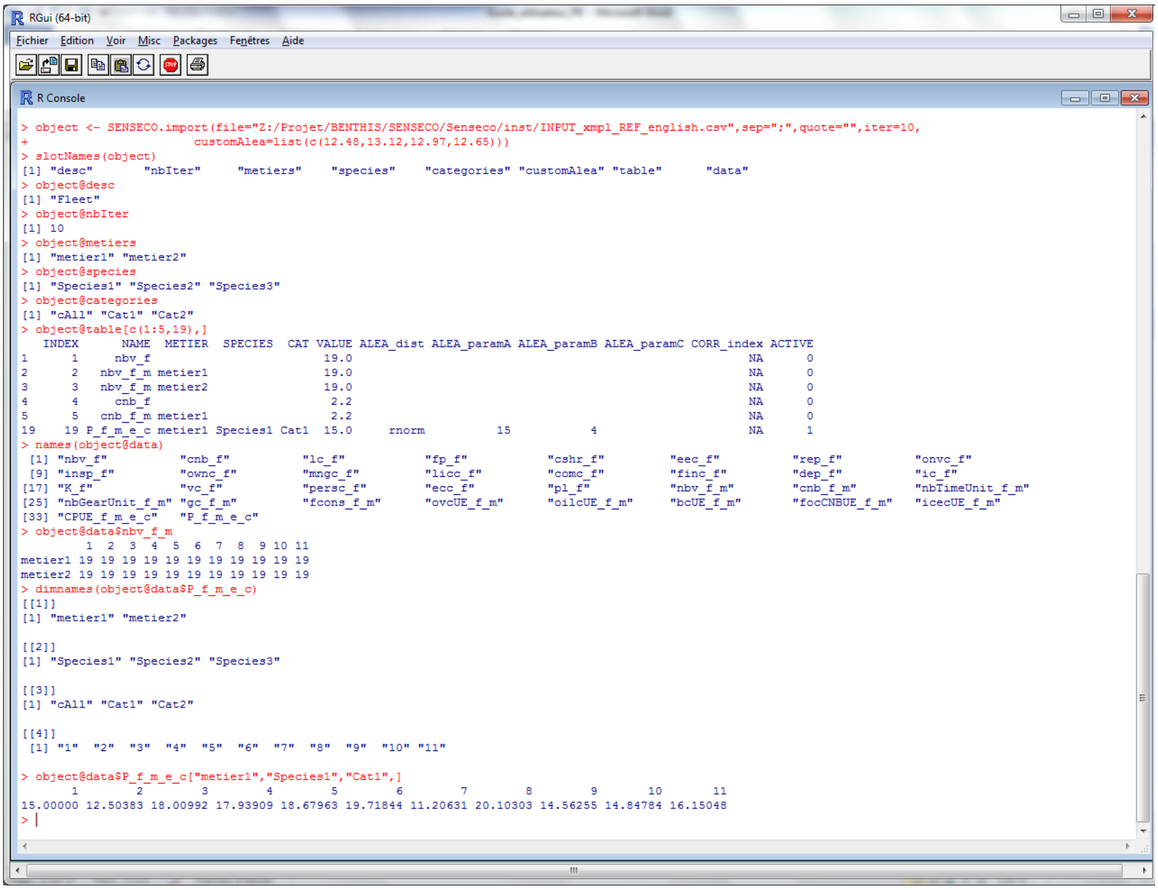

Figure 2. Screenshot of the R command looking at the input objects

4 CALCULATION OF INDICATORS

The calculation of economic indicators is carried out through the 'SENSECO.indeco' method that takes as its main argument the input object returned by the 'SENSECO.import' function. The economic model described previously is applied to the whole series of N + 1 parameter combinations including, as already mentioned, a reference setting and N 'random' settings for the N required iterations. This then generates N + 1 values for each of the output indicators. These outputs are put in a specific R list (see Figure 3), gathering the following indicators: EFF_F (respectively EFF_FM) the average effort in days at sea (respectively by métier), GVL_F (respectively GVL_FM) the total gross revenue (respectively by métier), RTBS_F (respectively RTBS_FM) the total rest to be shared (respectively by métier), GVA_F the total gross value added, WAGEG_F the average annual gross salary, WAGEN_F the average annual net salary, GCF_F the total gross cash flow.

The arguments of the SENSECO.indeco method are as follows:

- object: input object ("SENSECO.input" method output)
- aggOVC: inclusion, or not, of detailed variable costs ('logical')

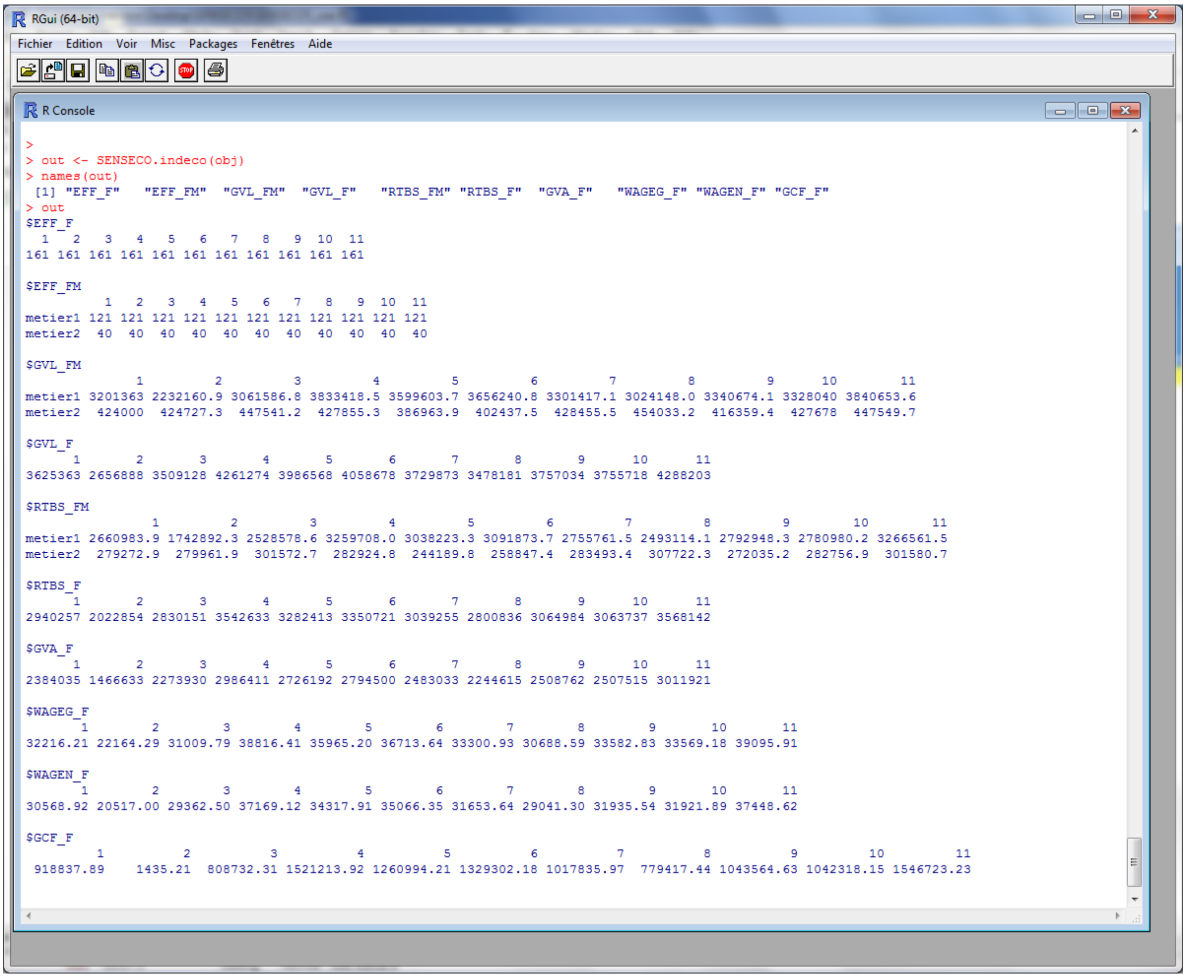

Figure 3. Screenshot of the information contained in the output of the model

5 PILOTING AND ANALYSIS INTERFACE

The 'SENSECO.gui' function provides an interface that enables graphical sensitivity analysis of economic indicators in response to changes in the input parameters. User can modify directly using the interface, the effort by métier according to different rules, the landing prices, fuel price, CPUE, variable costs... Outputs interface and graphs provides real-time comparisons between initial situation SQ (described in the parameter file) and the real-time simulated impacts of variation in inputs operated through the interface on the output indicators (gross value of landings, gross value added, wages, profits, effort allocation between métiers).

Thus, the method generates graphic illustrations of the model outputs showing the impacts of changing the inputs via the interface. Like 'SENSECO.indeco', this method takes as main argument the output object returned by the 'SENSECO.import' function, while the second argument is used to define the calculation method of mean variable costs according to the availability of the required settings (*cf.* setting of the model equations).

The interface is organized in three distinct sections: the first one (figure 4 in blue) is a workbook of tabular frames (of type 'notebook'), thematically regrouping and organizing the different widgets allowing easier parameter modifications. The second (figure 3 in orange) allows to set the variation step of parameters (for the moment, 10^{-6}, 10^{-4}, 10^{-2}, 0.1, 1, 10 or 100) when driven by the spin buttons. Finally, the third part (figure 3 in pink) manages the randomness that potentially affects the variables.

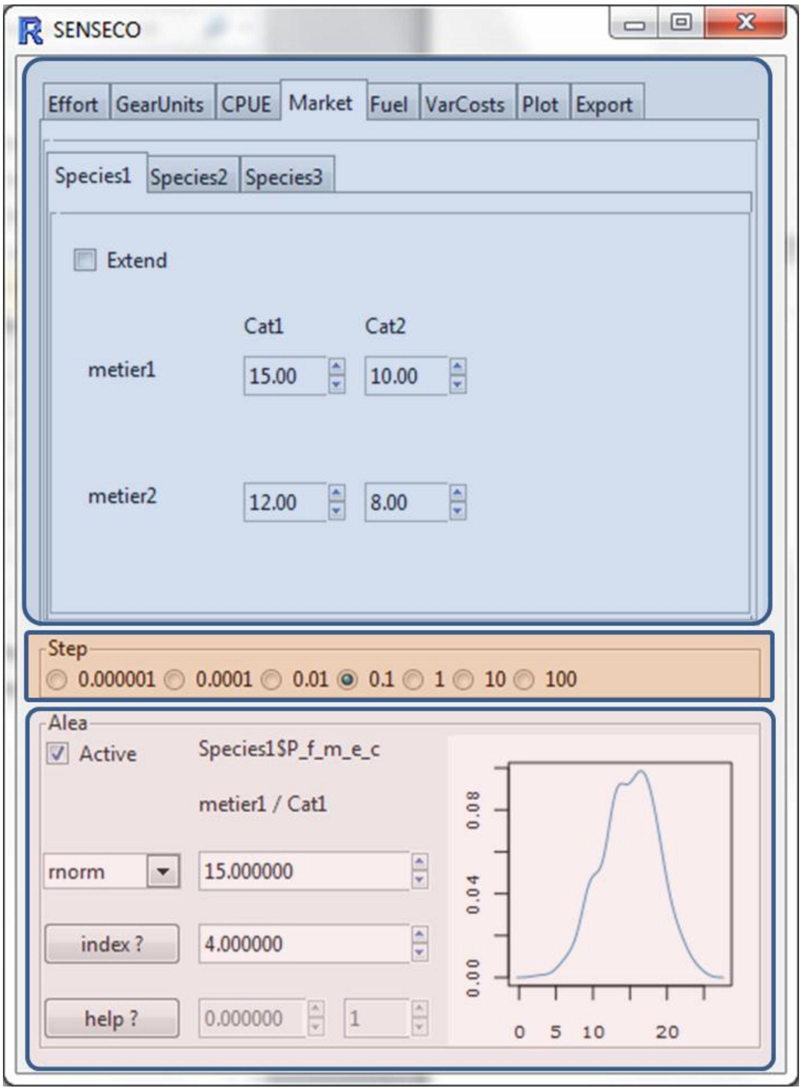

Figure 4. Graphic User interface of SENSECO

5.1 Part n ° 1: notebook widget

5.1.1 "Effort" tab

The 'Effort' tab allows the user to manipulate the effort variable (*nbTimeUnit_f_m*) both at the total fleet level and at the initial 'métier' level. Moreover, it offers the possibility of manipulating under different combinations of constraints associated with different kinds of effort report. Currently, three types of reports are implemented (see figure 5).

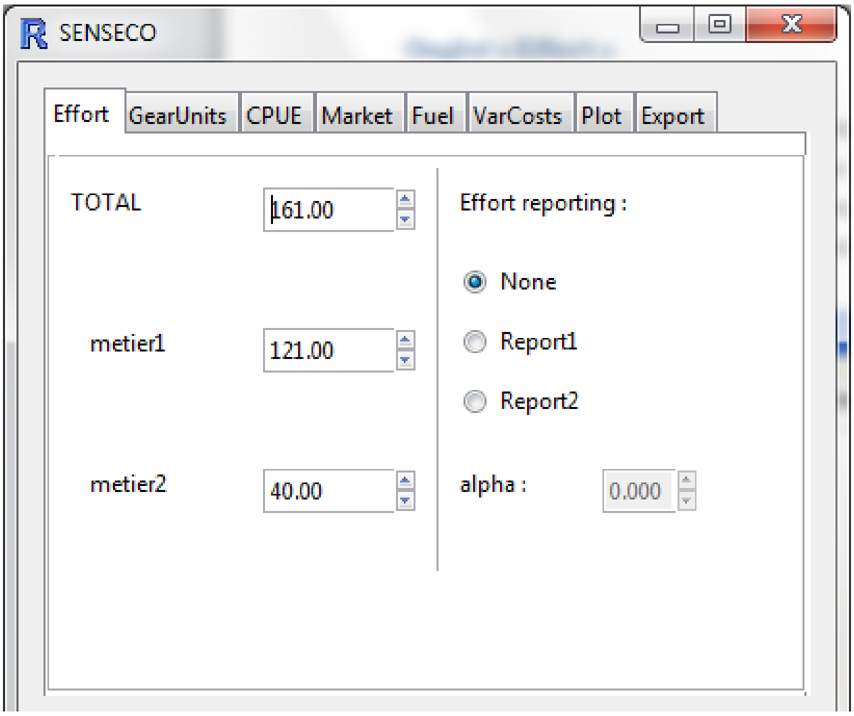

Figure 5. Effort tab of the SENSECO GUI

The left part of figure 5 shows the effort allocations described by the *nbTimeUnit_f_m* variable, either total or by métier, for an average vessel, and that can increment or decrement the user under the selected type of effort report. At the right, a menu allows one to select the type of report (and for option *Report2* the parameter *alpha*).

- No report of effort (***None***)

The effort can be modified at the total or métier level: if modified for at the total level, efforts by métier then will change proportionally to their initial distribution to sum to the total. Effort by métier can also be modified, in that case the total effort will increase or decrease by the same amount the effort by métier was increased or decreased so that the total still equals the sum of the effort per métier. It should be noted that any attempt of changing the total effort, regardless of the selected report option at this moment, will result in a systematic change to the type *None*. This total intervention is acceptable only in this context.

- Single effort report (***Report1***)

In the context of simple type effort reporting, the total effort is kept fixed at the original level. Modification to *Report1* causes a reallocation of efforts by métier based on specified total effort and on the proportion by métier declared initially. Any change in effort for a given métier leads to a reassessment of efforts on other métiers, such that the initial proportion of these other métiers is respected, and finally that the conservation of the total effort can be maintained (see equation below illustrating the involvement of a deferred value δ to a m_i métier).

$$\Delta E_{m_i} = \delta \Rightarrow \Delta E_{m_j} = -\frac{E_{m_{j,ini}}}{\sum_{k\neq i} E_{m_{k,ini}}} \times \delta, \quad \forall j \neq i$$

- Weighted effort report (***Report2***)

Here, the total effort is also kept constant at initial level and we consider a situation where a redistribution of effort per métier is based on a weighting of tradition (original distribution) and profit. The weights are defined using one parameter α, between 0 and 1, (1 - α) is the weight of the initial distribution of effort by métier on the one hand, and α the weight of the profit distribution generated by métier (denoted *profit* as in Marchal *et al.* 2011). Everything is relative to the total effort. One can thus formalize the effort by métier using the following equation:

$$E_{m_i} = \left[\alpha \frac{Profit_{m_i}}{\sum_i Profit_{m_i}} + (1-\alpha)\frac{Eini_{m_i}}{\sum_i Eini_{m_i}}\right] \times Etot, \quad \forall i$$

This report is potentially controlled with the *alpha* variable on the right side of the sheet. Several expressions of profit per métier $Profit_m$ are then possible: in the current version of the tool, a rest to be shared by unit of effort was considered, dynamic towards parameters modification.

This formulation indicates therefore by definition a feedback of the constitutive parameters of profit variables on the distribution of efforts by métier.

5.1.2 "GearUnits" tab

The «GearUnits» tab (figure 6) controls the number of gear units variable (*nbGearUnit_f_m)* at métier level (such as number of pots, meters of nets, etc). By default, for métiers for which this variable is not appropriate, the value is 1 (ex: for trawlers).

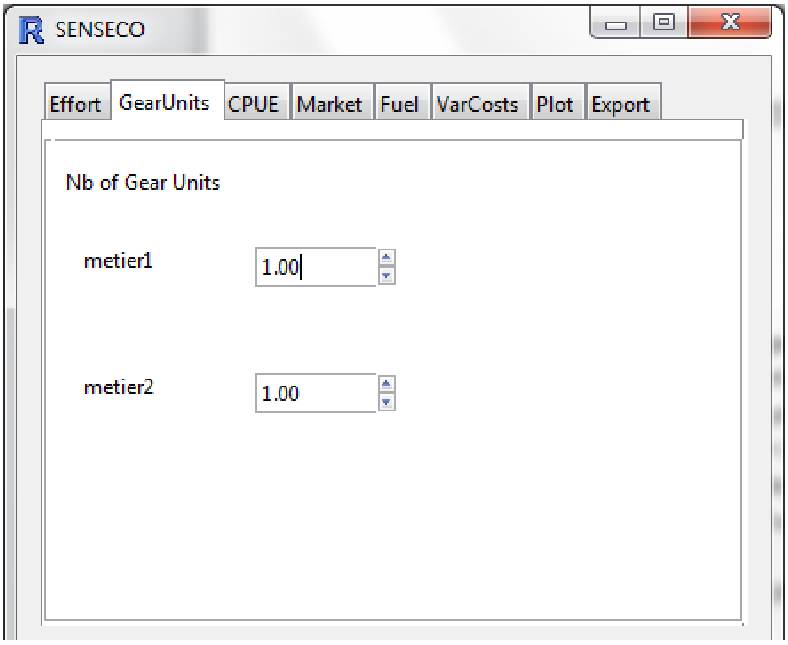

Figure 6 Gear Unit tab of SENSECO GUI

5.1.3 "CPUE" tab

This tab includes landings-per-unit-effort variable (*CPUE_f_m_e_c*) for each species. It includes a new workbook with a tab by parameterized species (see figure 7). For each species, it is possible to vary independently landings in tons per UE at the métier-market category level.

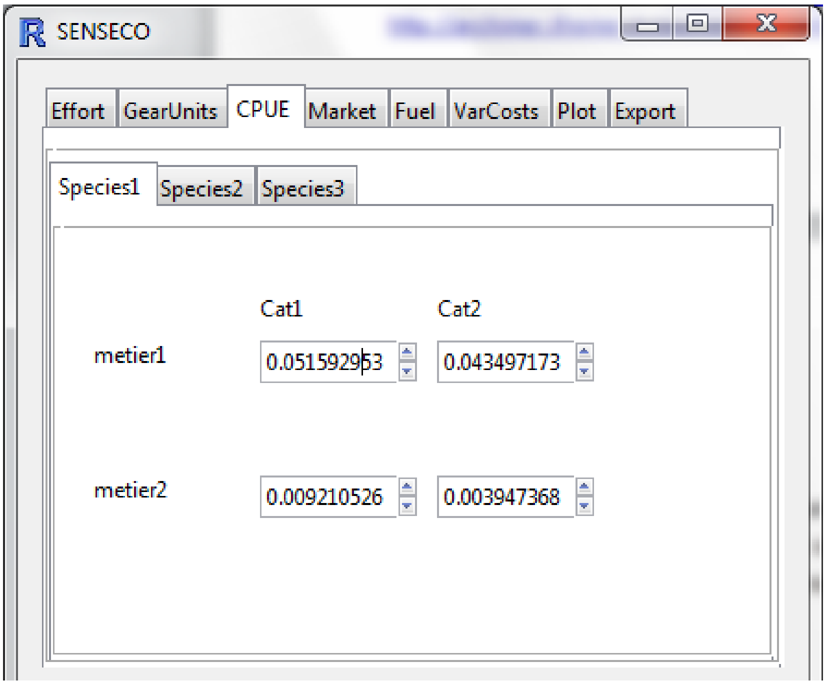

Figure 7 CPUE tab of SENSECO GUI

5.1.4 "Market" tab

This tab describes the fish price variables ' *P_f_m_e_c* '. Just like the «CPUE» tab, it includes a new workbook containing sub-tabs by species (see figure 8). For each species, it is possible to modify independently prices per weight unit (here in kg) at the métier- market category level. The 'Extend' option also allows one to assume that all métiers receive the same prices (so depending only on species and category).

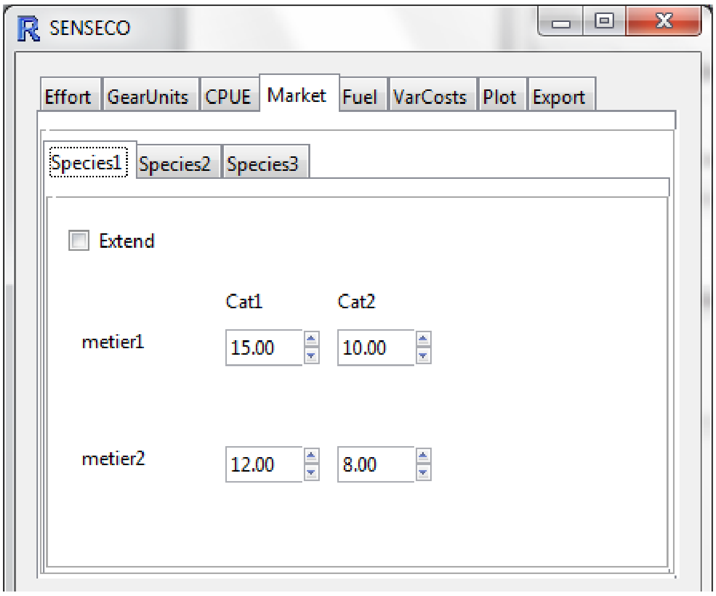

Figure 8 Market tab of SENSECO GUI

5.1.5 "Fuel" tab

The "Fuel" sheet describes variables related to fuel cost (see figure 9). It thus integrates consumption by practiced métier « *fcons_f_m* » (in liter per unit effort), as well as the fuel price per liter « *fp_f* ».

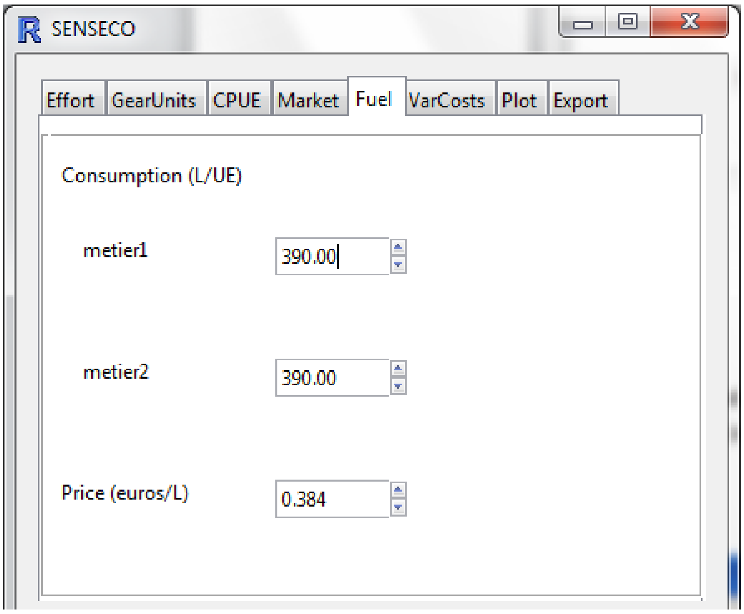

Figure 9 Fuel tab of SENSECO GUI

5.1.6 "VarCosts" tab

This tab summarizes in a workbook "variable costs" type indicators (except the fuel cost which is separated in a dedicated sheet, see 5.1.5). They include oil costs (*oilcUE*), bait costs (*bcUE*), food costs (*focCNBUE*), ice costs (*icecUE*) and other variable costs (*ovcUE*). Each of these costs per unit effort is adjustable by métier (Figure 10). For information, the average resulting total cost in euros is displayed.

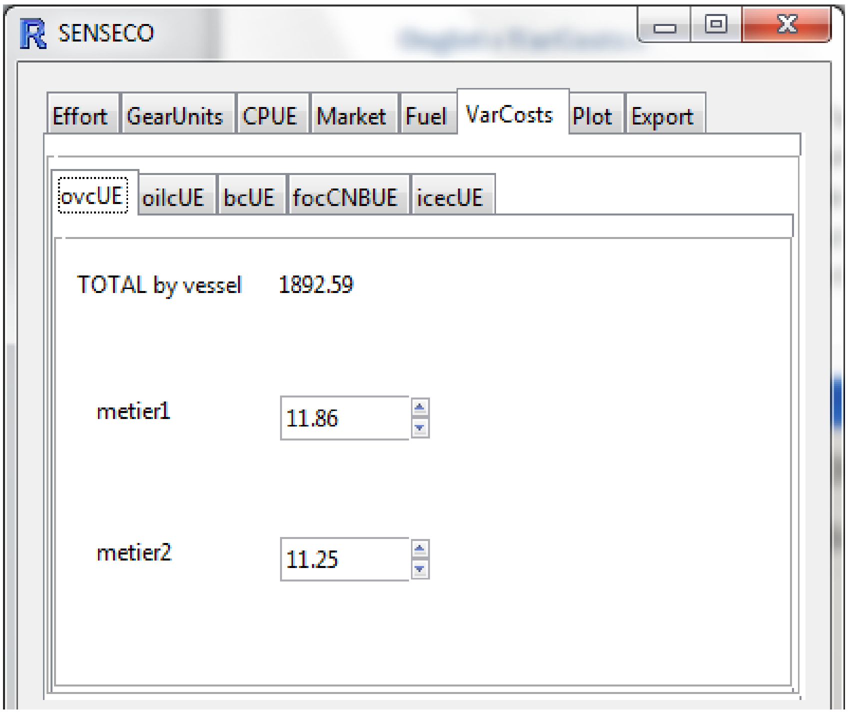

Figure 10. Variable costs tab of SENSECO GUI

5.1.7 "Plot" tab

This sheet is used to enable users to configure the graphs illustrating the output indicators returned by the model. The chosen options will define the graphics to be plotted. These plots will react dynamically to changes made on the different input variables. Currently, 5 economic indicators and effort may be shown at the fleet level: the total gross value of landings (GVL), the total rest to be shared (RTBS), the total gross value added (GVA), the total gross cash flow (GCF), the average annual gross salary (WAGEG), and the average effort (EFF). GVL, RTBS, and EFF are also considered at the métier level. The selection can be made at the left part of the tab (see figure 11). An R graphics device (figures 12 - 14) is opened in the session as soon as one of the variables to display is selected, and several indicators can be illustrated in the same chart window. The layout is automatically adjusted.

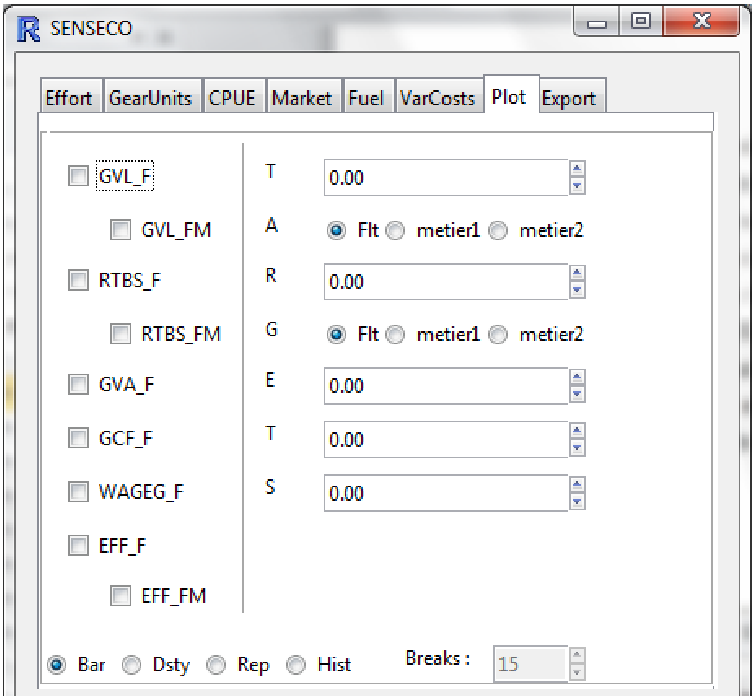

Figure 11. Plot definition tab of SENSECO GUI

At the bottom of the tab, the user can choose from 4 types of charts:

- Bar: a graph in bars with confidence intervals. The bar represents the average estimator, and intervals describe the 5%, 25%, 75% and 95% quantiles, and the median value. To facilitate visual analysis, the initial values (status quo SQ) and the scenario (SC) with the modified inputs are represented next to each other (see figure 12).

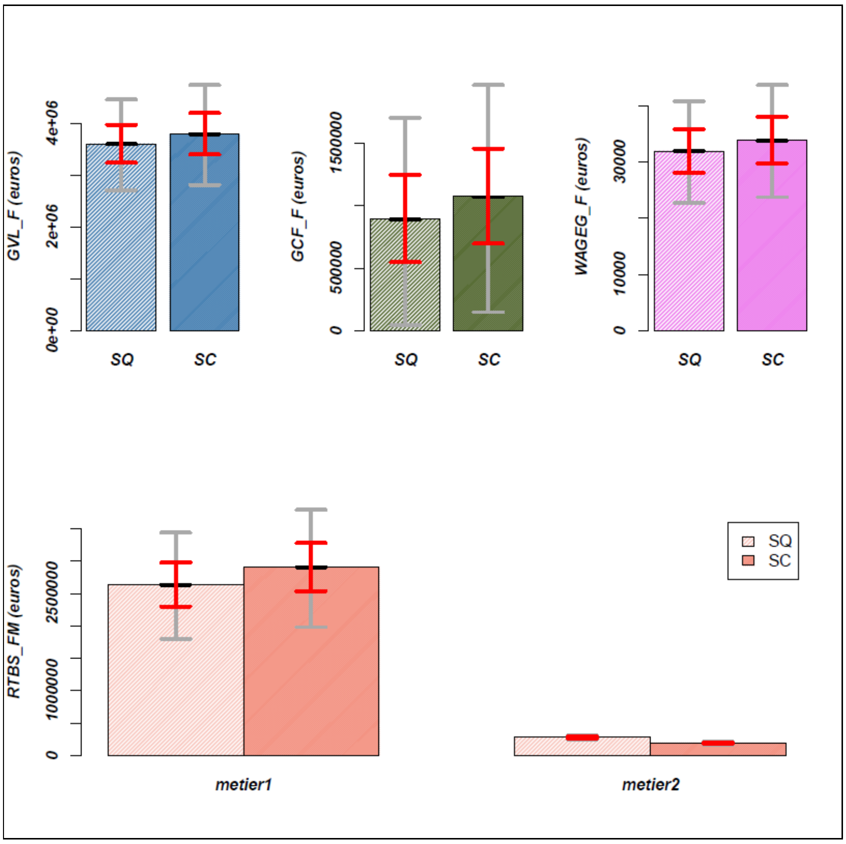

Figure 12. Example of bar graphic outputs of the SENSECO model

- Dsty & Hist: 'Dsty' the probability density curve from the current setting is displayed. Its mean value (SC) and the mean value from the initial setting (SQ) are indicated by a vertical line (see figure 13). 'Hist' adds to this graph a probability density histogram. In that case, the number of cells can be specified using the 'Breaks' spin button.

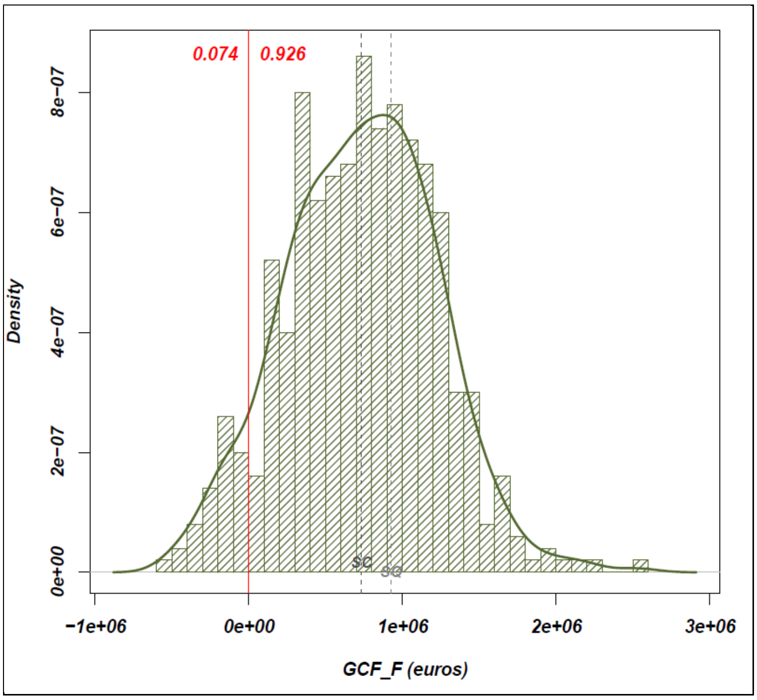

Figure 13. Example of density and bar graphic outputs of the SENSECO model

- Rep (repartition): the cumulative distribution function of the indicator is represented. Similar to the previous density graph, the average value resulting from the current setting (SC), as well as the average value from the initial setting (SQ), are displayed (see figure 14).

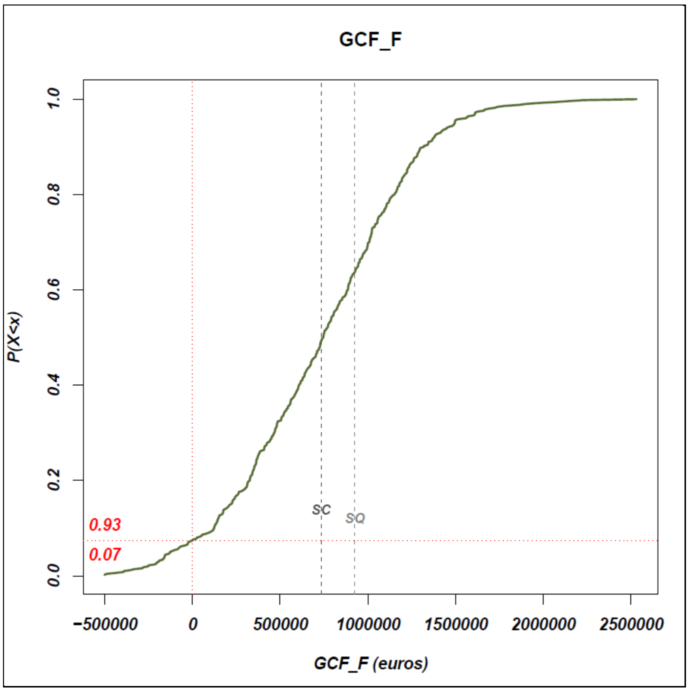

Figure 14. Example of rep graphic outputs of the SENSECO model

At the right of the tab, it is possible to define a reference value for each of the indicators represented (with the exception of effort). The method will then calculate the probability for the indicator to be less than or equal to this value, and will display the result in red on the chart (see figure 13 & 14).

5.1.8 "Export" tab

The 'Export' tab allows exporting parameters and resulting indicators, at any time of use. It is possible to concatenate multiple sets of parameters and indicators in a same output, assigning each a different scenario name. The export can be done in the form of an R object that will then be available in session, or in an external file in the .txt format (see figure 15).

- 'Append': appends a new set of parameters and outputs to the object/file. As long as 'Append' button has not been clicked, the object/file to export remains empty.

- 'Output (R object)': exports the output as an R object into the session. The name of the made object should be specified on the right side of the sheet. The object is a list of two elements, 'IN' and 'OUT', of *data.frame* type. The 'IN' table describes, for each scenario (*Scen* field), each variable (*VarType* and *Var*fields) and each dimension (*Métier*, *Spec* and *Cat* fields), conventional quantitative measures of inputs, potentially calculated from iterations (*Mean*, standard deviation *Sd*, minimum value *Min*, maximum value *Max*, and quantiles *Quant*). The 'OUT' table operates the same description on the output variables *EFF_F*, *EFF_FM*, *GVL_F*, *GVL_FM*, *RTBS_F*, *RTBS_FM*, *GVA_F*, *GCF_F* and *WAGEG_F*. It also includes a *Thresh* field that describes the potential threshold X applied to the variable via the tab "Plot", and *ProbPrctg* which presents the probability in percentage for the variable to be less than or equal to this threshold. Finally, the *nbIT* field provides information on the number of iterations considered to estimate the parameters. The object is not saved in a file.

- 'Output (.txt file)': exports the object to the .txt format. Two files are then saved, each corresponding to one of the two elements of the object 'output' described previously. The specified name of both files is supplemented by the suffix «_IN» or "_OUT" to distinguish both elements (input or output parameters).

- 'Suppress': deletes the object to export.

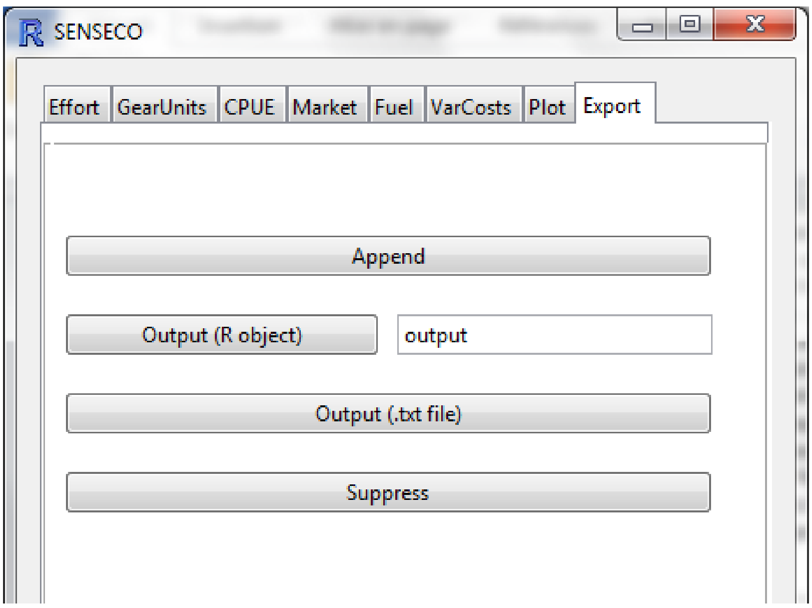

Figure 15. Export tab of the SENSECO GUI

5.2 Part n ° 2: variation step specification

As mentioned above, the central part of the interface allows defining the variation step of parameters that are controlled using spin buttons (for the moment, 10^{-6}, 10^{-4}, 10^{-2}, 0.1, 1, 10 or 100). It applies to all the spin buttons included in the interface.

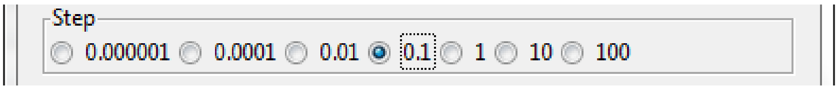

Figure 16. Step interval of the SENSECO GUI

5.3 Part n ° 3: management of the random aspects

The lower part of the interface is dedicated to the management of the random aspects impacting the input parameters. Specific characteristics of a variable and its level are displayed and are editable once the corresponding spin button is activated (see figure 17). Above, the 'Active' option determines whether the random variable is enabled. The name of the variable and, if appropriate, of the species, appears next. Below, the métier and the category considered are displayed. One can also see, in blue on figure 17, a dropdown button that allows the user to specify the parameter 'ALEA_dist', and the widgets allowing 'ALEA_param' and 'CORR_index' parameters settings, all these parameters ensuring random variables generation (see 'Setting Format' in 3.1 and figure 17). For example, as shown in this figure, the price variable associated with the species 'Species1', the métier 'metier1' and the category 'Cat1' will follow a normal distribution with a mean of 15 and a standard deviation of 4. The 'index?' button allows the user to print in the R session a table describing the impacted parameters. This can be particularly helpful to get an index reference when defining a correlation with another variable (*CORR_index* parameter). The "help?" button opens an HTML R help page about the selected R distribution function (*ALEA_dist* parameter). On the right, a preview of the density of distribution of the resulting variable is displayed.

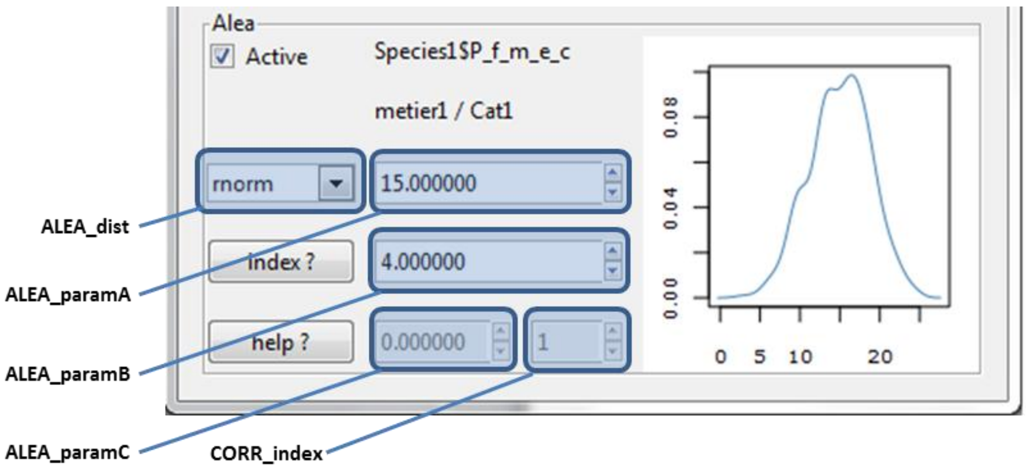

Figure 17. Definition of random effects of the SENSECO model

Description of applications for random setting:

- R-internal random generation function following a probability distribution («rnorm», «runif»...)

The associated stochastic is generated using the R function of the same name, with A and B parameters as second and third arguments (the first argument of random generation R function is the number of observations). Thus, the description of these parameters differs depending on the used function. For example, A is the 'mean' argument for «rnorm», but is the 'lower limit' argument for «runif». For further details, consult the R help page for each of these functions (accessible also via the button "help?"). C and Index parameters are disabled here.

- Random generation function following a correlated random variable ("correl")

In that context, the generated stochastic is such that its average is A, its standard deviation is B, and the correlation coefficient of Pearson between it and the random variable pointed to by Index reference is C (correlated data construction by Cholesky decomposition methodology is used, Press et al 1995). In order to know which index is assigned to the target variable, the 'index?' button displays a listing of variables with associated applications, the index being recorded in the INDEX column (see figure 18: the variable with index 20 is correlated with the variable with index 19). **WARNING: a modification of the reference variable will not update automatically the correlated variable. One needs to revalidate the "correl" application and its settings via the interface (by clicking for example on one of parameter fields).**

```
RGui (64-bit)
Fichier Edition Voir Misc Packages Fenêtres Aide
R Console
>
   INDEX     VAR_NAME  DESC  METIER  SPECIES  CAT DISTR_FUN PARAM_A PARAM_B PARAM_C CORREL_INDEX ACTIVE
1     11 CPUE_f_m_e_c FLEET metier1 Species1 Cat1     rnorm      NA      NA      NA           NA      0
2     12 CPUE_f_m_e_c FLEET metier1 Species1 Cat2     rnorm      NA      NA      NA           NA      0
3     13 CPUE_f_m_e_c FLEET metier1 Species2 cAll     rnorm      NA      NA      NA           NA      0
4     14 CPUE_f_m_e_c FLEET metier1 Species3 cAll     rnorm      NA      NA      NA           NA      0
5     15 CPUE_f_m_e_c FLEET metier2 Species1 Cat1     rnorm      NA      NA      NA           NA      0
6     16 CPUE_f_m_e_c FLEET metier2 Species1 Cat2     rnorm      NA      NA      NA           NA      0
7     17 CPUE_f_m_e_c FLEET metier2 Species2 cAll     rnorm      NA      NA      NA           NA      0
8     18 CPUE_f_m_e_c FLEET metier2 Species3 cAll     rnorm      NA      NA      NA           NA      0
9     19    P_f_m_e_c FLEET metier1 Species1 Cat1     rnorm      15     4.0      NA           NA      1
10    20    P_f_m_e_c FLEET metier1 Species1 Cat2    correl      10     1.0    0.90           19      1
11    21    P_f_m_e_c FLEET metier1 Species2 cAll     rnorm      NA      NA      NA           NA      0
12    22    P_f_m_e_c FLEET metier1 Species3 cAll    custom      NA      NA      NA            1      1
13    23    P_f_m_e_c FLEET metier2 Species1 Cat1     rnorm      12     3.0      NA           NA      1
14    24    P_f_m_e_c FLEET metier2 Species1 Cat2    correl       8     0.8    0.95           23      1
15    25    P_f_m_e_c FLEET metier2 Species2 cAll     rnorm      NA      NA      NA           NA      0
16    26    P_f_m_e_c FLEET metier2 Species3 cAll    sample      NA      NA      NA            2      1
17    30    fcons_f_m FLEET metier1          <NA>     rnorm      NA      NA      NA           NA      0
18    31    fcons_f_m FLEET metier2          <NA>     rnorm      NA      NA      NA           NA      0
19    32        fp_f FLEET    <NA>          <NA>     rnorm      NA      NA      NA           NA      0
20    33    ovcUE_f_m FLEET metier1          <NA>     rnorm      NA      NA      NA           NA      0
21    34    ovcUE_f_m FLEET metier2          <NA>     rnorm      NA      NA      NA           NA      0
22    35   oilcUE_f_m FLEET metier1          <NA>     rnorm      NA      NA      NA           NA      0
23    36   oilcUE_f_m FLEET metier2          <NA>     rnorm      NA      NA      NA           NA      0
24    37     bcUE_f_m FLEET metier1          <NA>     rnorm      NA      NA      NA           NA      0
25    38     bcUE_f_m FLEET metier2          <NA>     rnorm      NA      NA      NA           NA      0
26    39 focCNBUE_f_m FLEET metier1          <NA>     rnorm      NA      NA      NA           NA      0
27    40 focCNBUE_f_m FLEET metier2          <NA>     rnorm      NA      NA      NA           NA      0
28    41   icecUE_f_m FLEET metier1          <NA>     rnorm      NA      NA      NA           NA      0
29    42   icecUE_f_m FLEET metier2          <NA>     rnorm      NA      NA      NA           NA      0
>
```

Figure 18. Result of pressing “index?” button in random management tab

- Random generation function following a predetermined stochastic series ("custom" & "sample"):

The stochastic is generated from the "customAlea" list argument of the SENSECO.import method. Only the Index parameter is useful in that case, so only *CORR_index* widget is enabled. Its value refers to the index of the vector element in the "customAlea" list whose components will make up the stochastic series. For the type "custom", the series sequencing is respected. The required number of values (ie the number of iterations N) can be reached either by cutting the initial vector (if its length is greater than N) or by replication of the initial vector (if its length is less than N). For the type "sample", an N elements random sample with replacement within the initial vector is done to form the stochastic series.

6 TUTORIAL AND EXAMPLES

Appendix1 provides the R code to run the model. This tutorial is available in the package and provides an example of a fleet with two métiers, a usual métier 1 catching species 1, 2 and 3 and an alternative métier 2 catching only species 1 and 2 with higher selectivity on species 1 and lower fuel consumption.
During the WP5 meeting in Rome (April 2014), a presentation of the tool has been provided (see appendix 2) and an application of the tool was proposed to the participants based on the two following examples of applications relying on the demo input files provided in the tutorial:

6.1 Example 1

- Exploration of the outputs from input parameters: impact of an alternative gear on economic outputs
- Assessment of the impacts of different effort reallocation options when introducing an alternative gear
- Observed impacts of an increase in fuel price without reallocation of effort
- Find fuel price such that profit = 0
- Observed impacts of an increase in fuel price with reallocation of effort (a = 0.7) on effort reallocation when dynamic (option 3) or on profitability (~ incentives of alternative gear adoption created by fuel price increase)

6.2 Example 2

- Including uncertainties with or without correlations
- Assess the impacts in term of risks of having negative profit (for example) variable of CPUE (observed variation in experiments or use as input output CPUE by business area for example with associated uncertainties estimated) or of variable price per species

7 REFERENCES

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Merzéréaud Mathieu, Macher Claire, Bertignac Michel, Fresard Marjolaine, Le Grand Christelle, Guyader Olivier, Daures Fabienne, Fifas Spyros (2011). Description of the Impact Assessment bio-economic Model for fisheries management (IAM). Amure publications. Working papers series. D-29-2011. http://www.umr-amure.fr/electro_doc_amure/D_29_2011.pdf

Press, W. H., Teukolsky, S. A., Vetterling, W. T. Flannery, B. P. (1995). Numerical Recipes in C: The Art of Scientific Computing. Cambridge University Press: Cambridge, UK

R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

8 APPENDIX 1: CODE R FOR RUNNING SENSECO

```
#--------------------------
#--------------------------
# Senseco package
#--------------------------
#--------------------------


#--------------------------
# 1. Deterministic/fixed inputs
#--------------------------

library(Senseco)


   #--------------------------
   # 1.1 SENSECO input format
   #--------------------------

inputFile <- paste(.libPaths()[sapply(.libPaths(),function(x)  "Senseco"%in%list.files(x))][1],
                        "/Senseco/INPUT_xmpl_REF.csv",sep="")
inputFile


   #--------------------------
   # 1.2 SENSECO.import function
   #--------------------------

.input <- SENSECO.import(file=inputFile,sep=";",quote="")


   #--------------------------
   # 1.3 SENSECO.input object
   #--------------------------

class(.input)
slotNames(.input)
.input@desc
.input@nbIter
.input@metiers
.input@species
.input@categories
.input@customAlea
.input@table

names(.input@data)
.input@data

   #--------------------------
   # 1.4 SENSECO.indeco function
   #--------------------------

.out <- SENSECO.indeco(.input)
names(.out)
.out


   #--------------------------
   # 1.5 SENSECO.gui function
   #--------------------------

SENSECO.gui(.input,aggOVC=FALSE)



   #--------------------------
   # 1.6 Application case study
   #--------------------------

         # example of a fleet with two métiers, a usual métier 1 catching species 1, 2 and 3
         # and an alternative métier 2 catching only species 1 and 2 with higher selectivity
         # on species 1 and lower fuel consumption.

   #--------------------------
   #  1.  Outputs from input parameters: impact of an alternative gear on economic outputs
   #--------------------------

   #--------------------------
   #  2. Assessment of the impacts of different effort reallocation options when introducing
```

```
   #      an alternative gear
   # --> report options None, 1 and 2 (increase of effort on the alternative métier)
   # --> output Effort by métier and economic indicators (profit GCF)
   # "does the increase in effort on the alternative métier increases or decreases the
   # total profit according to its variable costs, yields and fuel consumption and
   # the effort allocated?"
   #--------------------------

   #--------------------------
   # 3. Observe impacts of an increase in fuel price without reallocation of effort  --> output  GCF
   # Find fuel price such that profit=0
   #--------------------------

   #--------------------------
   # 4.Observe impacts of an increase in fuel price with reallocation of effort(a=0.8, optionReport2)
   # on effort reallocation when dynamic and on profitability --> output Effort and GCF
   # (~incentives of alternative métier adoption created by fuel price increase)
   #--------------------------


#--------------------------
# 2. Integration of stochastic inputs
#--------------------------

   #--------------------------
   # 2.1 SENSECO input object...
   #--------------------------

inputStochFile <- paste(.libPaths()[sapply(.libPaths(),function(x) "Senseco"%in%list.files(x))][1],
                        "/Senseco/INPUT_xmpl_REF_stoch.csv",sep="")
inputStochFile

   #--------------------------
   # ... with custom stochastic components
   #--------------------------

aleaTS_1 <- c(12.72,13.05,12.98,13.12,12.84)
aleaTS_2 <- runif(10,13,14)
aleaTS_1 ; aleaTS_2

.inputStoch <-
SENSECO.import(file=inputStochFile,sep=";",quote="",iter=20,customAlea=list(aleaTS_1,aleaTS_2))


   #--------------------------
   # 2.2 SENSECO.input object
   #--------------------------

class(.inputStoch)
slotNames(.inputStoch)
.inputStoch@nbIter
.inputStoch@customAlea
.inputStoch@table

length(.inputStoch@data)
names(.inputStoch@data)
.inputStoch@data$nbv_f
.inputStoch@data$ovcUE_f_m

# Focus on P_f_m_e_c "price" variable

dim(.inputStoch@data$P_f_m_e_c)
dimnames(.inputStoch@data$P_f_m_e_c)
.inputStoch@data$P_f_m_e_c[,,,1]

.inputStoch@table[.input@table$NAME%in%"P_f_m_e_c",]

# Including uncertainties with or without correlations   --> presentation of the input files
  #line 1
.inputStoch@data$P_f_m_e_c["metier1","Species1","Cat1",]
plot(density(.inputStoch@data$P_f_m_e_c["metier1","Species1","Cat1",-1]))
  #line 2
.inputStoch@data$P_f_m_e_c["metier1","Species1","Cat2",]
mean(.inputStoch@data$P_f_m_e_c["metier1","Species1","Cat2",-1])
sd(.inputStoch@data$P_f_m_e_c["metier1","Species1","Cat2",-1])
cor(.inputStoch@data$P_f_m_e_c["metier1","Species1","Cat2",-1],
    .inputStoch@data$P_f_m_e_c["metier1","Species1","Cat1",-1])
  #line 3
.inputStoch@data$P_f_m_e_c["metier1","Species2","cAll",]
  #line 4
.inputStoch@data$P_f_m_e_c["metier1","Species3","cAll",]
.inputStoch@customAlea
  #line 5
.inputStoch@data$P_f_m_e_c["metier2","Species1","Cat1",]
plot(density(.inputStoch@data$P_f_m_e_c["metier2","Species1","Cat1",-1]))
  #line 6
.inputStoch@data$P_f_m_e_c["metier2","Species1","Cat2",]
mean(.inputStoch@data$P_f_m_e_c["metier2","Species1","Cat2",-1])
sd(.inputStoch@data$P_f_m_e_c["metier2","Species1","Cat2",-1])
```

```
cor(.inputStoch@data$P_f_m_e_c["metier2","Species1","Cat2",-1],
    .inputStoch@data$P_f_m_e_c["metier2","Species1","Cat1",-1])
  #line 7
.inputStoch@data$P_f_m_e_c["metier2","Species2","cAll",]
  #line 8
.inputStoch@data$P_f_m_e_c["metier2","Species3","cAll",]
.inputStoch@customAlea


   #--------------------------
   # 2.3 SENSECO.indeco function
   #--------------------------

.outStoch <- SENSECO.indeco(.inputStoch)
names(.outStoch)
.outStoch


   #--------------------------
   # 2.4 SENSECO.gui function
   #--------------------------

SENSECO.gui(.inputStoch,aggOVC=FALSE)


   #--------------------------
   # 2.5 Application case study
   #--------------------------

     # Assess impacts in term of risks of having negative profit (for example) of variable CPUE
     # (observed variation in experimentations or use as input output CPUE by métier zone
     # for example with associated uncertainties estimated) or of variable price per species
     # (example here)
     # --> observe output, proba of having positive GCF etc
```

9 APPENDIX 2: PRESENTATION AND TRAINING – ROME SESSION TASK 5.1.

BENTHIS

WP5

Task 5.1

- Objectives: Development of a framework for the analysis of economic performances of alternative fishing gears
- Development of a tool (SENSECO) to analyze economic consequences for fishing fleets or vessels provided by the adoption of new gears in combination or substitution to the current gears.
- **Timetable: Deliverable: month 24 → documented framework**

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1

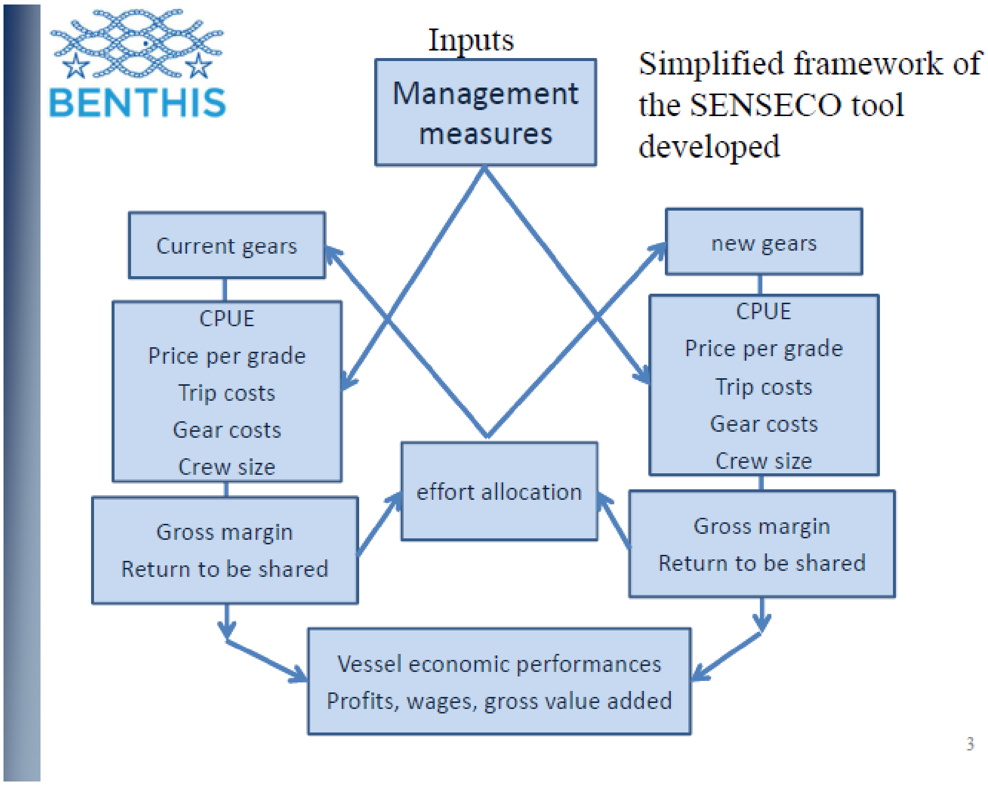
BENTHIS

Tool SENSECO

Tool SENSECO methodological approach:

- Static comparative analysis of economic performances under different conditions and assumptions of effort reallocation
- Microeconomic perspective
- Interactive interface to enable real time variation of inputs and representation of impacts on outputs
- For exploration of economic impacts and economic incentives of alternative gear adoption

2


BENTHIS
Inputs
Management measures
Simplified framework of the SENSECO tool developed
Current gears
CPUE
Price per grade
Trip costs
Gear costs
Crew size
new gears
CPUE
Price per grade
Trip costs
Gear costs
Crew size
effort allocation
Gross margin
Return to be shared
Gross margin
Return to be shared
Vessel economic performances
Profits, wages, gross value added
3

BENTHIS

Tool SENSECO

Input file:

DCF transversal and economic data by métier (or more detailed data if available):

- Effort and production by fleet-métier-species
- Prices by species (grades)
- Costs structure

+ collected data on alternative gears

and/or

outputs from other simulation models (simulated CPUE under management scenarios)

Or data provided by experts

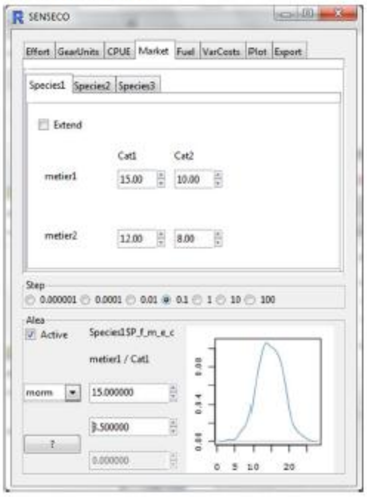
4

BENTHIS

Tool SENSECO

Interface

User can modify: effort by métier according to different rules, landing prices, fuel price, CPUE, variable costs… (alea is also included through different options)

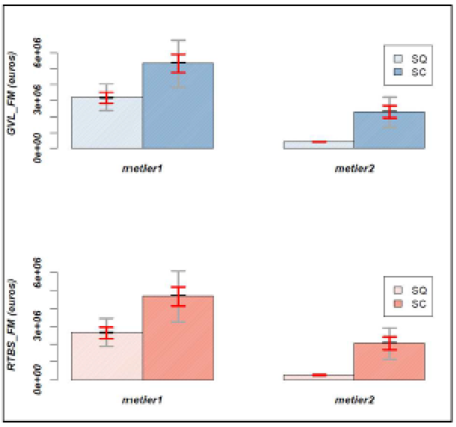


5

BENTHIS

Tool SENSECO

Graphical outputs provide comparison between initial situation SQ (described in the parameter file) and the simulated situation for gross value of landings, gross value added, wages, profits



- Enables real time modifications of all the input parameters and analyses of impacts on economic outputs
- Enables risks analyses of viability for fleets or vessels by including input uncertainties
- Useful for discussions with stakeholders on possible impacts of variations in input variables
- Useful for inclusion of knowledge and expertise of stakeholders of possible costs structure, price or CPUE with an alternative gear or métier

6

BENTHIS

Tool SENSECO

Main output indicators implemented

- GVL: gross value of landings : $GVL_{fm} = \sum_{e,c} CPUE_{fmec} \times P_{fmec} \times E_{fm} \times nbv_{fm}$
- RTBS: return to be shared : $RTBS_{fm} = GVL_{fm} - VCST_{fm}$
- GVA: gross value added : $GVA_f = \sum_m RTBS_{fm} - FCST_f$
- GCF: gross cash flow : $GCF_f = GVA_f - CC_f$
- FCST: Fixed costs
- VCST: variable costs
- CC: crew costs…

7

Some equations and options of the model

Effort module options:

1 – Variation of the global effort with constant initial proportional allocation between métier or variation of the effort by métier

2 – Constant global effort and variation of the effort by métier with adjustment of the effort of the other métiers :

$$\Delta E_{m_i} = \delta \Rightarrow \Delta E_{m_j} = -\frac{E_{m_{j,ini}}}{\sum_{k \neq i} E_{m_{k,ini}}} \times \delta, \quad \forall j \neq i$$

3 – Constant global effort and dynamic allocation of the effort by métier such that :

$$E_{m_i} = \left[\alpha \frac{Profit_{m_i}}{\sum_i Profit_{m_i}} + (1-\alpha)\frac{Eini_{m_i}}{\sum_i Eini_{m_i}}\right] \times Etot, \qquad \alpha \in [0;1], \forall i$$

Gravity model of effort allocation, with *Profit* independant of current effort *E*.

8

Use and examples

R-version ≥ 3.0.2

Package SENSECO (package dependencies : gWidgets, RGtk2, gWidgetsRGtk2, cairoDevice)

Input file

Example of a fleet with two métiers, a usual métier 1 catching species 1, 2 and 3 and an alternative métier 2 catching only species 1 and 2 with higher selectivity on species 1 and lower fuel consumption.

2 input files with and without stochasticity

Example 1 simple

Example 2 with alea

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Use and examples

Example 1

- Outputs from input parameters: impact of an alternative gear on economic outputs
- Assessment of the impacts of different effort reallocation options when introducing an alternative gear
- Observe impacts of an increase in fuel price without reallocation of effort
- Find fuel price such that profit=0
- Observe impacts of an increase in fuel price with reallocation of effort (a=0.7) on effort reallocation when dynamic (option 3) or on profitability (~incentives of alternative gear adoption created by fuel price increase)

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Use and examples

Example 2

- Including uncertainties with or without correlations
- Assess impacts in term of risks of having negative profit (for example) of variable CPUE (observed variation in experimentations or use as input output CPUE by métier zone for example with associated uncertainties estimated) or of variable price per species

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