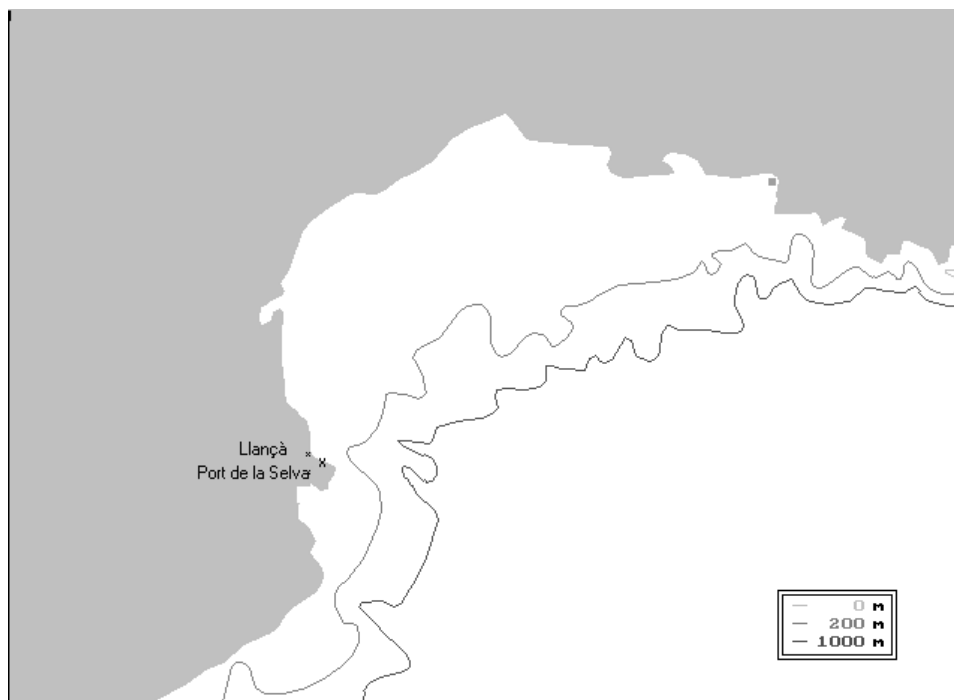


MEFISTO PREPARED APPLICATIONS
MODELLING FISHERIES MANAGEMENT STRATEGIES IN THE
MEDITERRANEAN

CASE STUDY 1:

The hake (*Merluccius merluccius*) of Catalonia (Gulf of the Lion)
Laura Recasens, Begoña Fernández

The parameters of this case are Ivon.bar & Ivon.sim



1. - General description

The European hake (*Merluccius merluccius*) is one of the most important commercial species in the Western Mediterranean (Aldebert & Carries, 1988; Martín, 1991; Oliver & Massutí, 1995). In the Gulf of Lion the hake is the main demersal target species. Annual registered disembarks are about 3000 tons, 500 tons of them are from the Spanish fleet (Aldebert & Recasens, 1996). Bottom trawls basically capture recruits and juveniles, while the adults are mainly caught with French gillnets and Spanish longline (Aldebert, et al. 1993). The introduction of longliners in the 1980's (Leonart, 1990 UE DG XIV, Brussels) meant a considerable increase in the exploitation of the adult stock. The population of Hake in that area have shown very clear symptoms of growing overfishing.

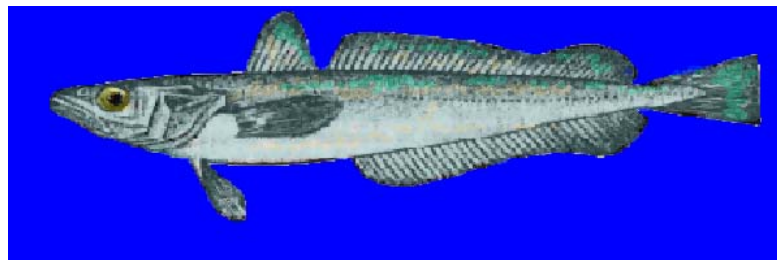


Figure 1. - *Merluccius merluccius*

So the problem with the hake fishery at Gulf of Lion is a consequence of the amount of different gears used in the area. The gear most used is the bottom trawl, then the longline followed by the gillnets. In the area that we are studying the most important gears are the longline and the trawl (Aldebert et al. 1993), so in order to model from the biological point of view, the effects of the competence between gears for the same resource must be taken into account.

2. Biological parameters

Biological parameters are obtained, mostly; from the bibliography (Aldebert et al. 1993; Aldebert & Recasens, 1998; Bozzano et al. 1997; Recasens et al. 1998) The other parameters are calculated following the characteristics of the Gulf of Lion area. To calculate the population data it has been used the VIT program (Lleonart y Salat, 1992).

The biological initial conditions are in table number 1

Table 1. - Biological parameters and populations for the hake of the Gulf of Lion

Relation size-weight	$w_{(g)} = a * Lt_{(cm)}^b$	Equation de von Bertalanffy
a = 0.0069		L inf (cm) = 86.8
b = 3.03		k (years-1) = 0.137
		to (years) = -0.367

Maturity scales of the Hake	
AGES	SCALE OF MATURITY
0	0
1	0
2	0.08
3	0.57
4	0.95
5 & over...	1

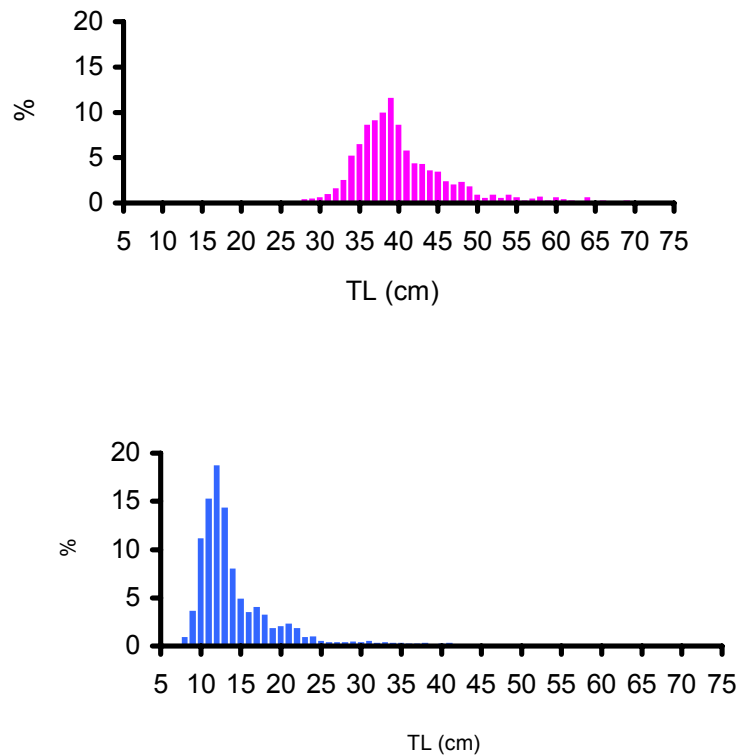
Natural Mortality	Recruitment (constant) o Beverton & Holt
M = 0.2	6709272 Asy: 10000000; S 50%: 218943029

Growth parameters for the hake from the VPA for Gulf of Lion case	
A	0,0069
B	3,03
L. inf.	86,8
K	0,137
T O	-0,367

Number of invidious per each sort of age, F (mortality for fishing) and catch					
Age	Num. Ind. Population	F (trawl)	F (longline)	Catches trawl (Tons)	Catches longline (Tons)
0	6709272	0.487	0	17.25806	0
1	3375578	0.739	0	85.14	0
2	1320483	0.459	0.005	72.69117	0.02289125
3	683166	0.411	0.044	69.40759	7.410661
4	354925	0.410	0.244	54.79016	32.63113
5	151118	0.261	0.381	22.05434	32.20173
6	65132	0.158	0.420	8.040394	21.36414
7	29900	0.170	0.519	4.82205	14.66902
8	12291	0.108	0.503	1.588308	7.367629
9	5463	0.013	0.504	0.1046964	4.024131
10	2668	0.043	0.458	0.1952638	2.058873
11	1323	0	0.544	0	1.330261
12	629	0	0.395	0	0.5398548
13	347	0	0.204	0	0.1820338
14	232	0	0.491	0	0.2748611
15	116	0	0.433	0	0.1323203
16	62	0	0.120	0	0.0000059
17	51	0	0.276	0	0.04327585
18	31	0	0.425	0	0.04007103
19	17	0	0.270	0	0.01510209

The exploitation pattern of each gear is shown at Figure 2. The first graph shows the frequency of longliners' sizes and the next shows the frequency of trawlers' sizes.

Figure 2. – Exploitation pattern of Longline (pink) and Trawl (blue) of *Merluccius merluccius* by size



3. Economical parameters

The study of this case includes the harbours of Port de la Selva and Llançà. We studied those harbours together because of their nearness and the similitude of the ships.

In the model we inserted the data like if there was only one harbour, but the model also permits to introduce the data individually like if they were two or more harbours. In fact the model offers you the opportunity to individualise the study even by vessels.

We analysed 31 vessels (14 longliners and 17 trawlers). The economic data obtained from enquiries is summarised in tables 4, and 5 where is possible to see the general economic trends on these fleets. Here we can see the number of vessel of this case, the total capacity expressed as GRT, the engine power of the vessels and the crew's size referring in each case trawlers and longliners. What we can see in the next sum ups are the total amounts and the average of the figures, the economic figures are in Euros (1€=166,38 ptas.).

Table 4. - General information of the case of the Gulf of Lion

<i>Gulf of Lion</i>	TRAWLER	LONGLINE
COMMERCIAL COSTS (%)	19	19
OWNER SHARE (%)	50	50
FISHING DAYS	200	180
FISHING HOURS PER FISHING DAY	11	12
DAILY ICE EXPENSES (€/DAY)	9	7
AVERAGE GRT	72,15	11,38
AVERAGE INSURANCE (€)	5227,19	4218,69
AVERAGE CREW SIZE	4,87	3,00
AVERAGE ANNUAL COSTS (€)	15377,18	12180,62

Table 5.- Characteristics of the vessels

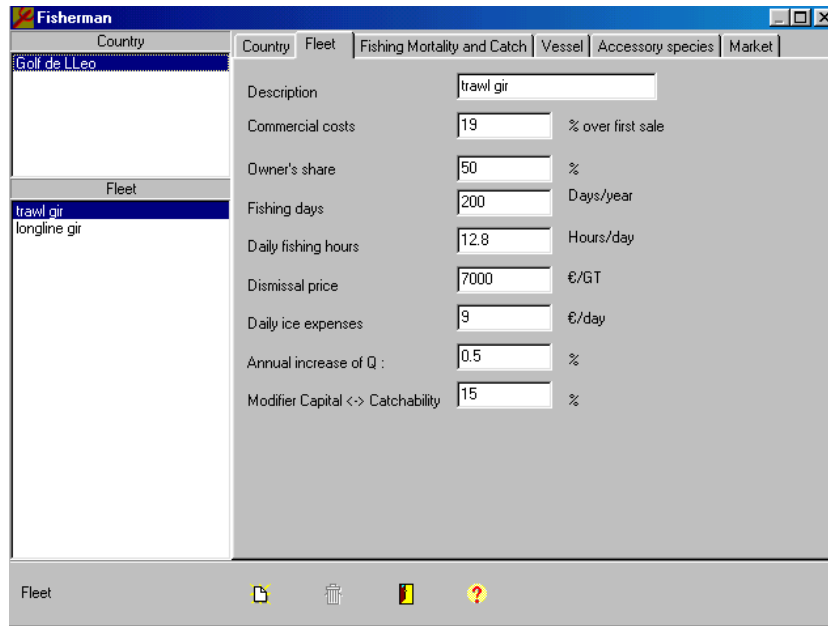
	TRAWLERS		LONGLINES	
	TOTAL	AVERAGE	TOTAL	AVERAGE
VESSELS	16	-	14	-
GRT	1.154,34	72,14	182,06	11,37
POWER	7365	460,31	1.879	117,40
CREW SIZE	78	4,87	48	3,00
CAPITAL ESTIMATED (€)	7.631.950	476.996,87	2.864.680	179.042,5
INSURANCE COST (€)	86.635	5.227,1875	67.499	4.218,6875
ANNUAL COSTS (€)	246.035	15.377,1875	194.890	12.180,625

The information obtained from the enquiries is introduced, as it is shown below. The user can introduce automatically this information after opening MEFISTO program, and select in the menu the option “file”, then “open” and take the file “lyon.sim”. Then it is possible to see the information of the case.

When in the general menu is open the field “fishermen” (a vessel icon) appears the economic data. In the first field “country” is shown the general economic information of the area: maximum level of credit authorised (up to 80% of vessel value), the price of the fuel, the opportunity cost (rate to other alternative invest without risk: treasure bonds) and the financial cost (rate to take a credit from the bank).

In the next field “fleet”, can be observed the parameters of each individual fleet. When in the field “fleet” (in the left) is selected “trawl” or “longline” appears in the right the information on the different costs common to the vessels of each fleet: commercial cost, owner’s share, fishing days, daily fishing hours, dismissal price per GT (in this case is used the GRT, then is necessary to use the same unit in the fleet field when demand the GT per vessel), daily ice expenses, annual increase of catchability (produced by technological innovation) and the rate of modification over the catchability for each increase of the capital.

The next picture shows the data of the trawl fleet appearing in the field “fleet”.



The field “fishing mortality and catch” show the related data for each fleet commented in part 2 (biological data) of this paper. The next picture shows the field “fishing mortality and catch” of the hake in the case of the longline and trawl in the Gulf of Lion.

The screenshot shows the 'Fisherman' software interface. The 'Fishing Mortality and Catch' tab is active. The left sidebar shows a tree view with 'Country' (Golf de LLeo), 'Fleet' (trawl gir, longline gir), and 'Species' (hake). The main area displays a table with columns: Age, Fg, Catch for VPA, and Selectivity factor.

Age	Fg	Catch for VPA	Selectivity factor
0	0	0	1
1	0	0	1
2	0	0	1
3	0.044	0	1
4	0.244	0	1
5	0.381	0	1
6	0.42	0	1
7	0.519	0	1
8	0.503	0	1
9	0.504	0	1
10	0.458	0	1
11	0.544	0	1
12	0.395	0	1
13	0.204	0	1
14	0.491	0	1
15	0.433	0	1
16	0	0	1
17	0.276	0	1
18	0.425	0	1
19	0.27	0	1

Age	Fg	Catch for VPA	Selectivity factor
0	0.487	0	1
1	0.739	0	1
2	0.459	0	1
3	0.411	0	1
4	0.41	0	1
5	0.261	0	1
6	0.158	0	1
7	0.17	0	1
8	0.108	0	1
9	0.013	0	1
10	0.043	0	1
11	0	0	1
12	0	0	1
13	0	0	1
14	0	0	1
15	0	0	1
16	0	0	1
17	0	0	1
18	0	0	1
19	0	0	1

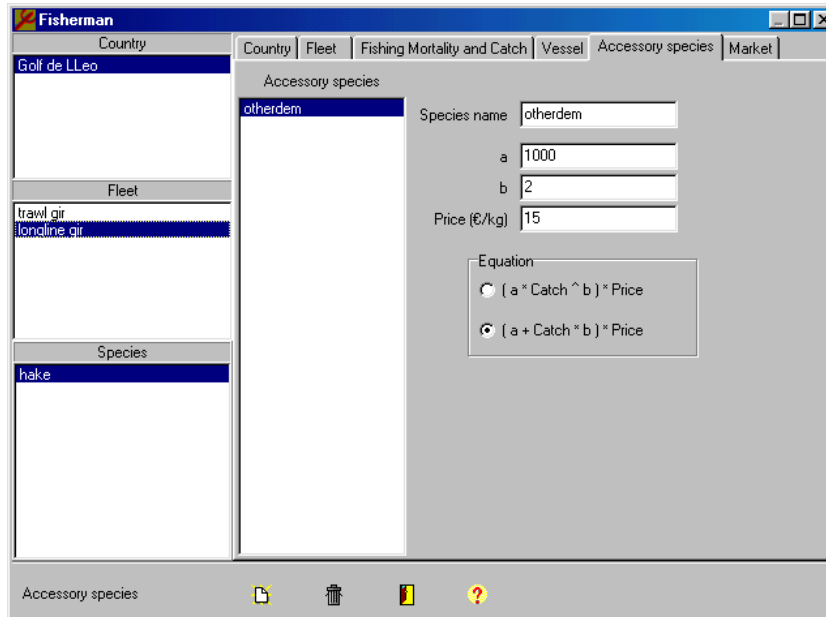
The field “Vessel” shows the individual data for each vessel obtained from the enquiries. When in the left is selected each fleet, on the middle appear all the vessels of the fleet, then when a individual vessel is selected (the name of each vessel is changed by a number of reference), on the right side appear their individual characteristics.

In the next picture appears the data of the vessel number 6 from Port de la Selva (p), which is a trawl vessel. Here we can see their GRT, value, crew's size, consumption of fuel, other daily cost, annual costs and the percentage of this annual costs that is possible to delay (but by reducing the catchability) as the maintenance cost and the percentage of the annual cost that is not possible to postpone (insurances, mooring, licences, etc.). We consider in all cases that the initial level of credit demanded to the bank is zero, as this was not demanded in the enquiries.

Name	p-6	
GT	43.88	GT
Vessel value (Capital)	210850	€
Credit	0	€
Crew size	4	#
Fuel consumption	450	litre/day
Other daily costs	28	€/day
Annual costs:	11330	€/year
Fixed costs	70	%
Maintenance costs	30	%
<input checked="" type="checkbox"/> Activate		

The field “accessory species” demands to select an equation in order to relate the value of other species to the catch of hake. In this case we choose the second option and introduce the parameters that allow us to relate the value of this accessory species with the catch of hake.

The next picture shows the parameters of the accessory species caught by longlines.

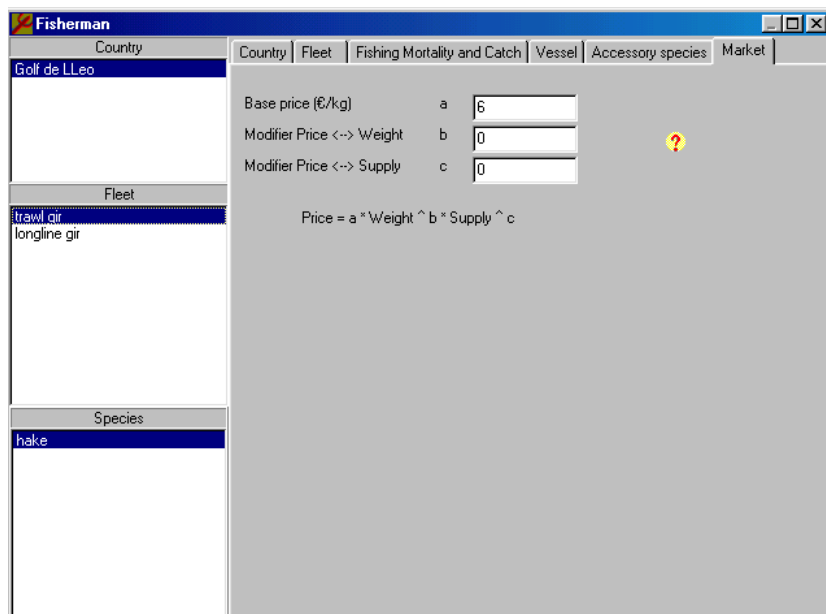


Finally the field “market” shows the formation of the prices. No information is obtained in order to establish a relation between price with size of the catch and the total production. By this reason the parameters b and c are equal to zero. The parameter a is the base price. It is calculated in € per Kg and is a figure obtained from an average of the hake prices of the previous year. Table 6 offers the prices of the specie in relation to the gear, longline presents a better quality of hake, and therefore price is higher than in trawl.

Table 6. – Market (€ x kg)

	TRAWLER	LONGLINER
Hake	6	9
Other species	3	15

The next picture presents the market field for the trawl fleet.



4. Application

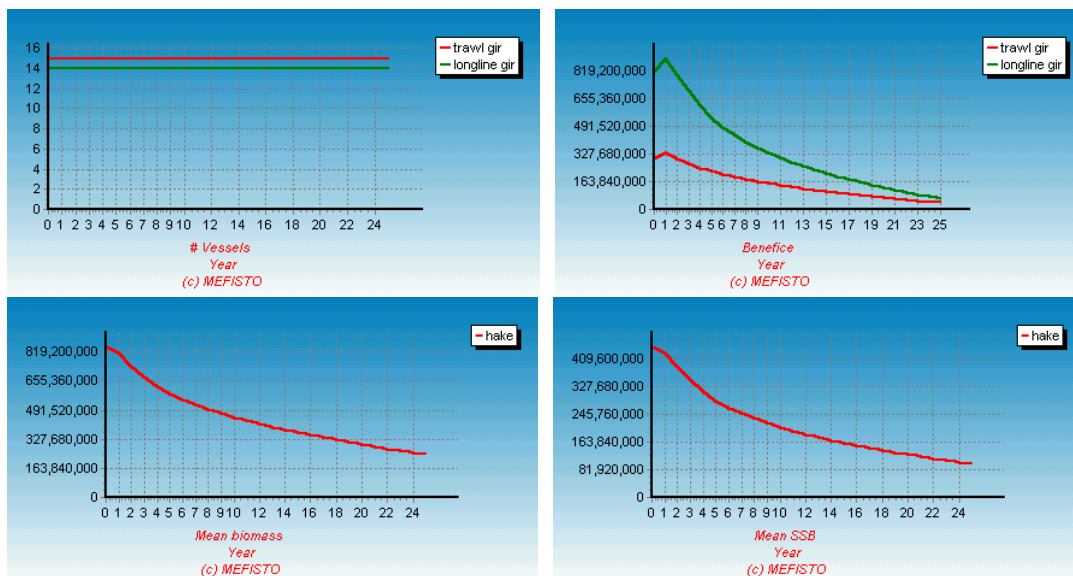
After the introduction of the biological and economical parameters of the fishing, the program had to be run to obtain the initial simulation. In order to do this you must press the icon “go”. You must remember to save the program before clicking on the simulation. The simulation is projected to run on a 25 years scenario but this is also easy to modify.

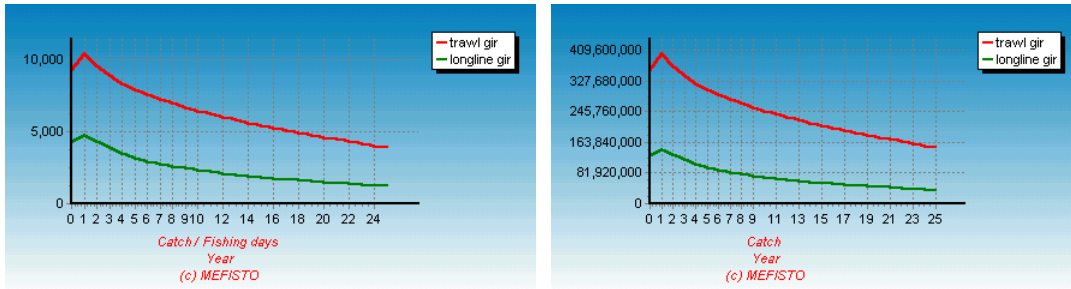
In order to do graphs you must go to the icon “graphs” and then open the simulation that you are testing.

A simulation has been shown at figure 3. The results showed that the stock and catches after a small initial increase, they were taking a decreasing tendency. The same tendency is observed in the benefits, but the level of activity and the number of vessels remain constant. The level of benefit takes the tendency to be asymptotic to zero and equal between trawl and longline. This shows an acceptable socio-economic tendency, because when the profit is zero, the economic exploitation has positive outcomes (the cost of opportunity for the owner is the normal profit for the capital in any activity) and has no incentives to increase the investment (increasing the effort). The problem in this case is the reduction of the biomass, because one of the reasons that the equilibrium has been achieved is the reduction of the dimension of the natural resource.

If the tendency was the contrary and the benefits were increasing, there are more incentives to increase the effort. But initially the model does not let you increase the fleets, but is possible to increase the catchability by additional investment. It is important to remember that if benefits grow, the administration will suffer pressure by the sector in order to increase the amount of effort (hours, fishing days, licenses...).

Figure 3. -Nowadays situation of the hake fishing and a 25 years projection.





There must be remembered that this is only a projected simulation and there are no measures of management contemplated and if we want to include a measure it must be done by using the event thumb index.

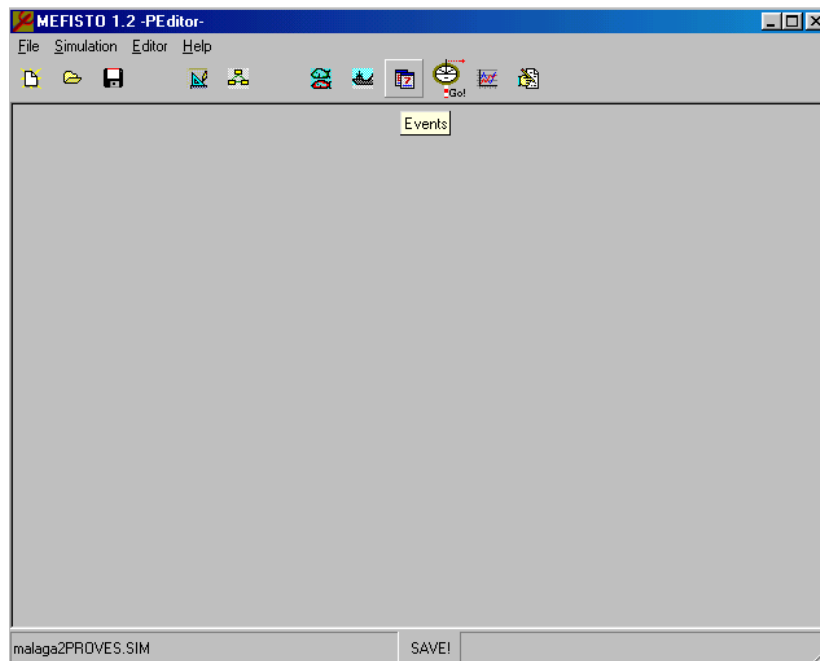
We are going to propose a simulation where the initial situation is modified and then we can study the characteristics of the new scenarios.

These measures, due to the initial reduction of biomass are related to the reduction of the fishing effort. Simulations are projected on a 25 years scenario. Three new scenarios are presented, defined by events introduced in different years, in order to notice the changes on the management measures.

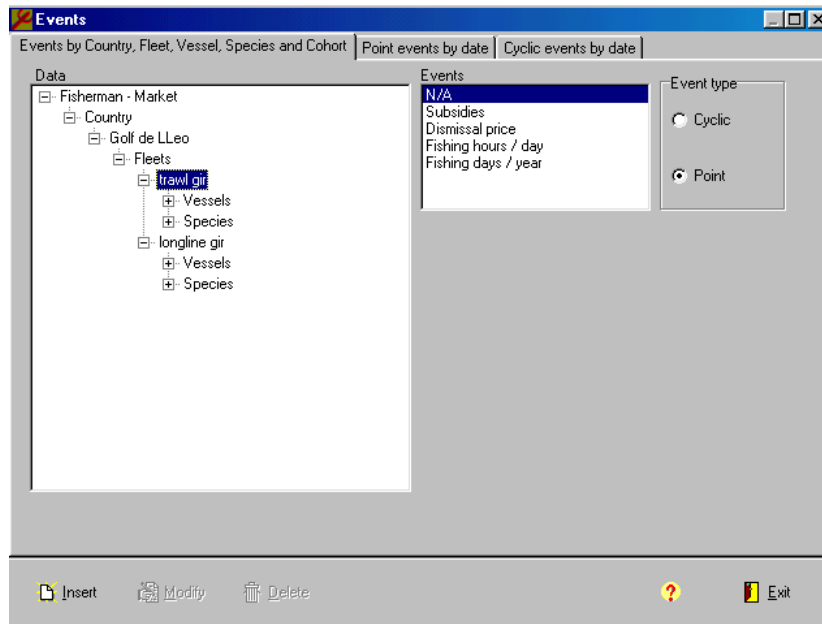
Scenario 1: a decrease of the trawl fishing time from 12.8 hours/day to 9 hours/day, and during five days a week. The results are exposed at Figure 4.

That scenario is a modification proposal of the initial one, so what we are going to do is explain how to create an event and then study the characteristics of the new scenario.

First what we have to do is go into the event by clicking the event icon, which is a calendar icon.



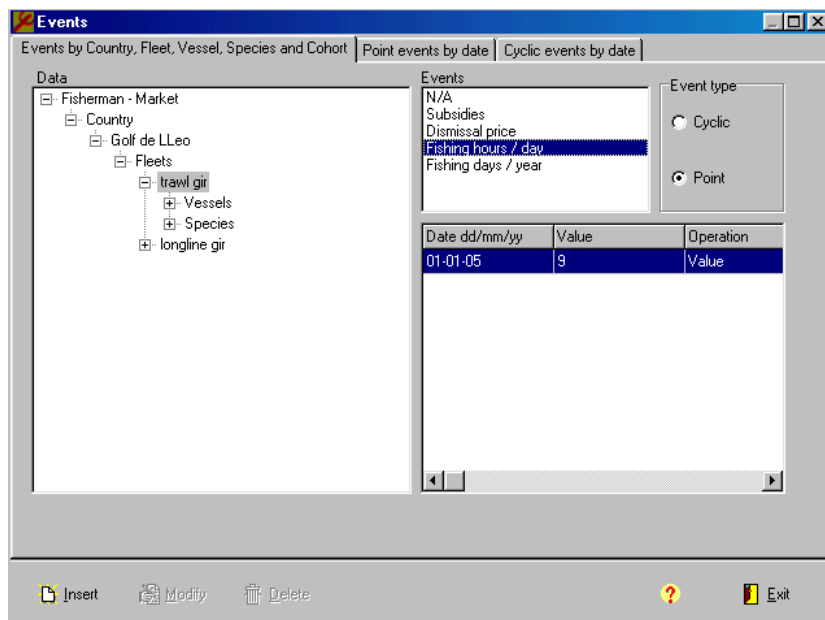
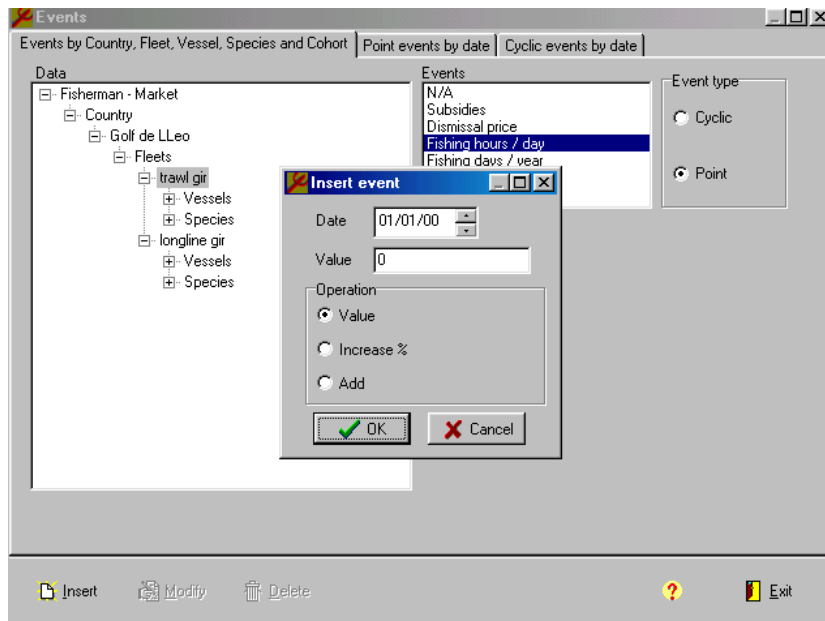
Then we find the next screen:



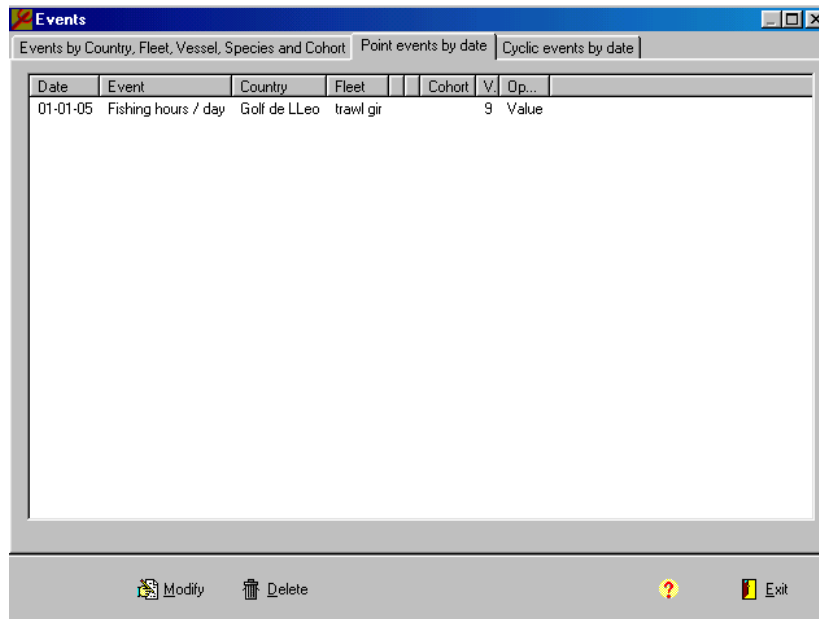
Here we have the possibility to produce an event, in this case we have selected a part of the fleet, the trawlers, in order to follow the proposal of the scenario which is the reduction of the trawl fishing time from 12.8 hours/day to 9 hours/day, during five days a week.

What we are going to do now is to insert the event by following the next steps: First you must select the event that you want to do from the list given to you at the list on the top right and then insert, by clicking the symbol at the bottom on the left, and another little screen, called insert event, appears. In that screen you must make the selection between:

- A) The date when you want the event to happen; is always better not to located the date at the beginning of the projection because then is difficult to notice the differences, unless you have the previous graph to compare them.
- B) The value of the event; means the figure that you want to be modified and here you have three possibilities which are to enter a figure because is the value you want, the second possibility is to enter a figure that you want as a percentage (%) which will increase the value of the figure, and then the third possibility is to add a value to the figure.



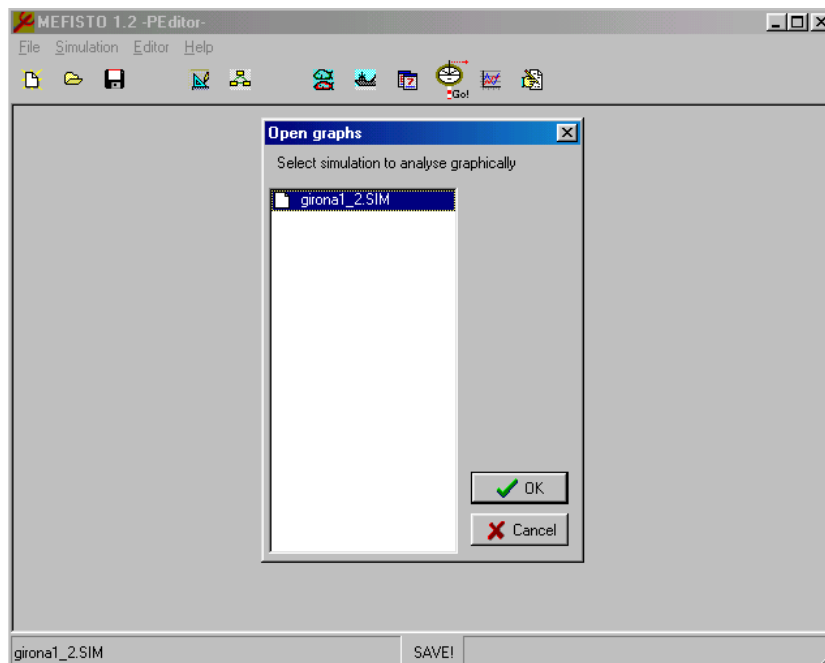
That screen explains what we had inserted and when: We have selected the trawl fleet and we modify the fishing days per a value of 9 after the year fifth.



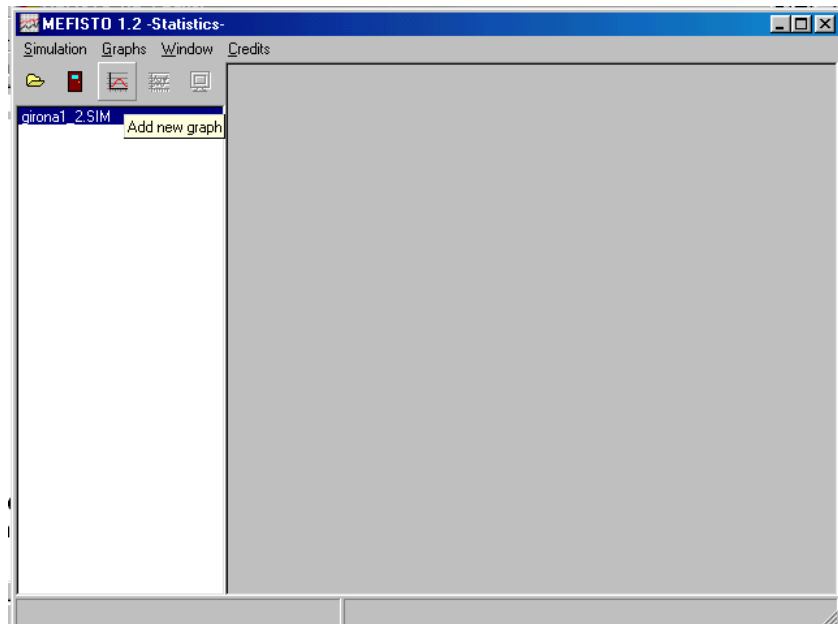
That screen is a sum up of what it has been doing and we have the same information as before. The cycling events by date are for what you are proposing to prepare cycling events. Remember that you must save the program before to click on the simulation (“go” icon).

After that, everything is ready to do the graphs so what you have to do is simulated the program in order to make the program adapt the new information to the model and insert the event.

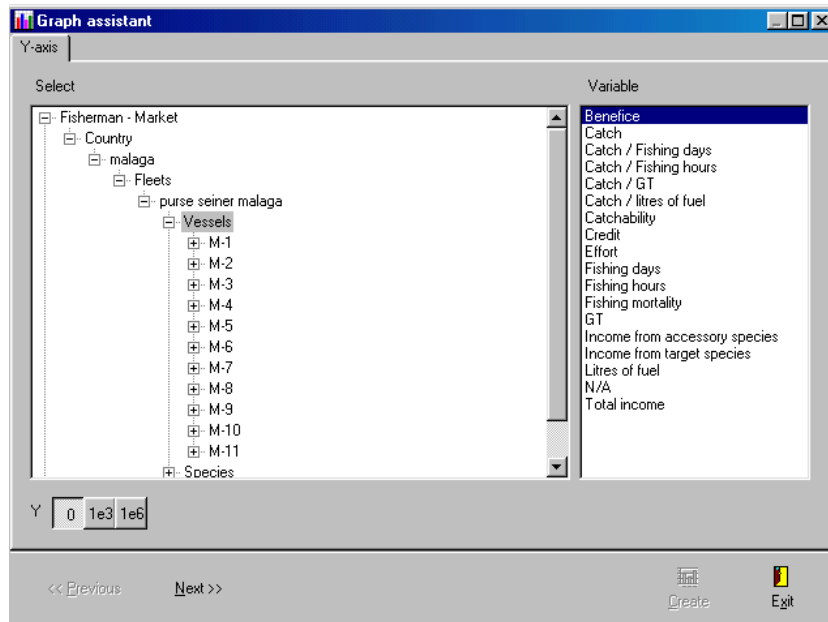
In order to do graphs you must go to the icon of graphs and then open the simulation that you are testing.



When you have to select the simulation to analyse graphically the selection must be printed in blue before selecting the icon “graph”.

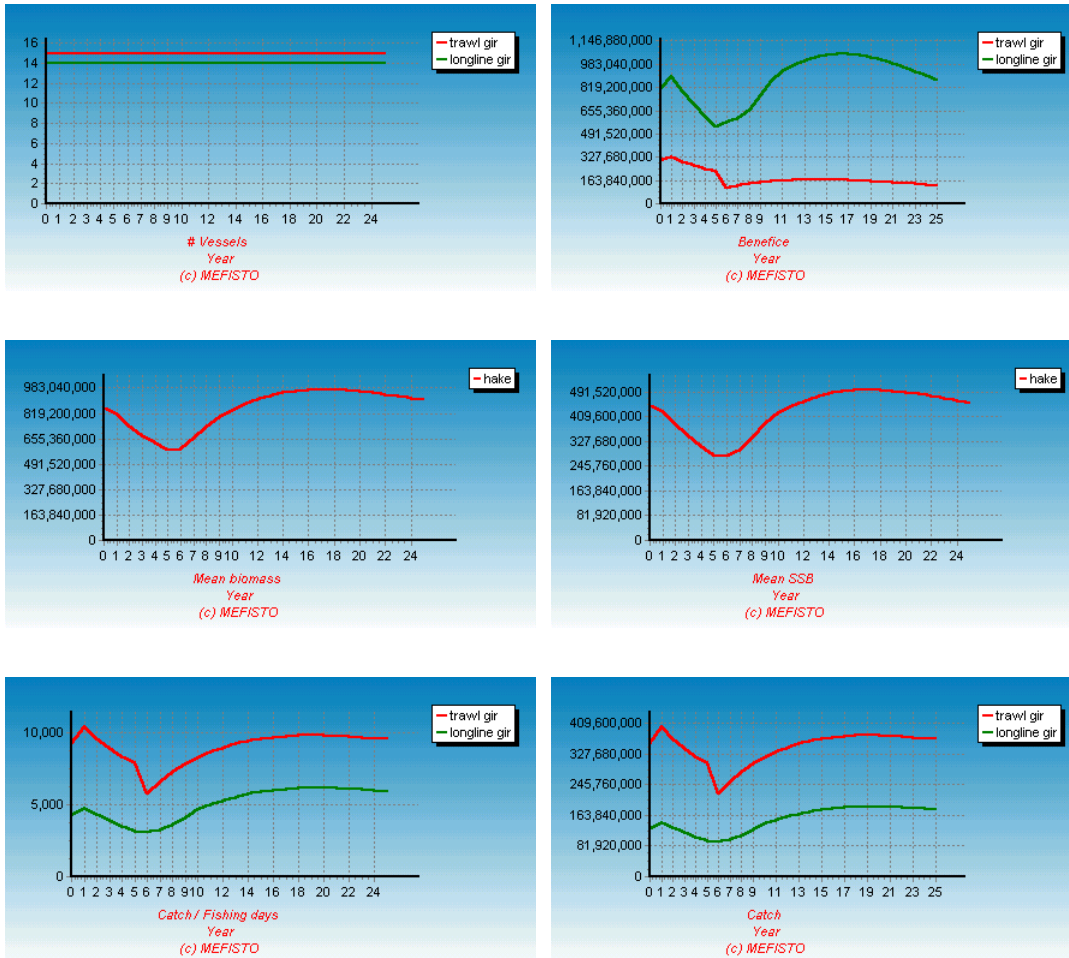


When you open the graphs, you obtain the following screen:



When you arrive at that point you have to select what characteristics you want to obtain from the graph from. For example, on our scenario we selected the fleet and the variable was the vessels. So the only thing to do here is to edit the graph clicking twice on top of the "Next" and then on top of "Create" on the third screen and by doing this you get the following graphs.

Figure 4: The result of the simulation presented at the scenario 1, which was a decrease of trawl fishing time from 12.8 hours/day to 9 hours/day, and five days a week, introduced at the year 2005, which means the year 5 of the graph.

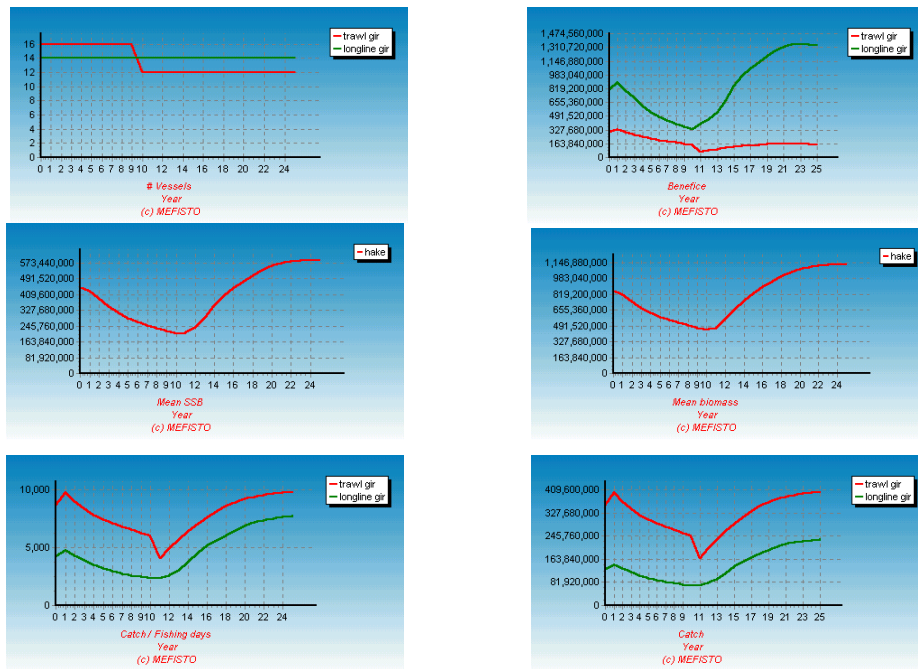


The outcomes of Scenario 1, show the effect of the fishing hours reduction by day on the trawl fleet from year 5. In this case the stock shows an immediate increase. Catches from the longline fleet start increasing from year 5, but catches for the trawl one decreases between the year 5 and 6, and then there is an increase until reaching a catch level higher than the initial level. Longlines benefit strongly, while trawlers reach positive benefits and increases in catches at the end of the period simulated.

Scenario 2 supposes a reduction of the trawl fleet by deactivating the 4 main vessels of the trawl fleet. The results are shown on Figure 5.

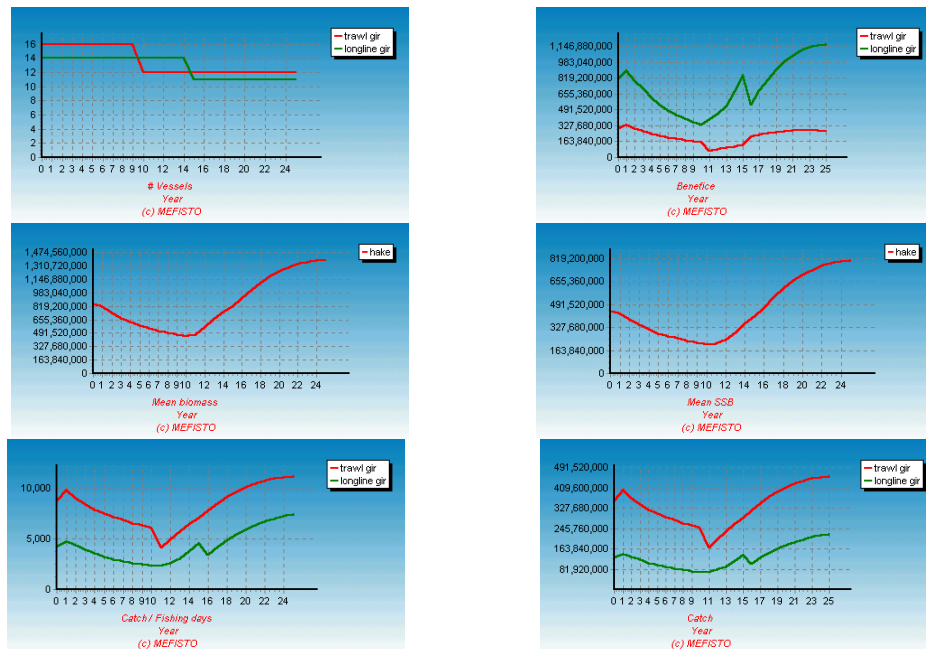
If the reduction is realized over the trawl fleet, the biomass of the stock reaches the highest point. The catches of the trawl are reduced initially and then by the year 14 achieve the highest level. The longline catches increase, exceeding the trawl catches at the 13th year. The benefit results are positives for the longline, while the tendency for the trawl is slight positive.

Figure 5. - Scenario 2: shows the effect of a reduction of the trawl deactivating the 4 main trawl vessels.



Scenario 3 supposes a reduction of the trawl fleet by deactivating the 4 main vessels of the fleet and also a reduction of longline vessels. The results are shown on Figure 6. In this case the reduction of the trawl fleet by the deactivation of the 4 main vessels in 2010 and after that the reduction of the longline fleet by deactivating the 3 biggest longline in year 2015.

Figure 6. - Scenario 3: shows the effect of reduction of the trawl deactivating the 4 main trawl vessels in 2010 and the reduction of the longline deactivating the 3 main longliners in 2015.



The effect of deactivating the four main trawl vessels at 2010 produces a direct effect at the longline fleet because their benefits increase directly. When we also introduce the second event at 2015 it has consequences in both fleets increasing their benefits and their catches.

From the economical point of view the stability of the fishery is achieved when the benefit is near to zero. In this situation there are not incentives to enlarge the effort and there are no incentives to leave the activity (as benefits are not negative). Remark that in the initial situation the activity has a tendency to this equilibrium (but thought a important reduction of biomass). In the other scenarios the tendency is to increase the benefit, and this produces strong incentives to increase the effort in the fishery.

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