MEFISTO PREPARED APPLICATIONS
MODELLING FISHERIES MANAGEMENT STRATEGIES IN THE MEDITERRANEAN

CASE STUDY 3:

The sardine (Sardina pilchardus) and the anchovy (Engraulis encrasicholus) of Málaga

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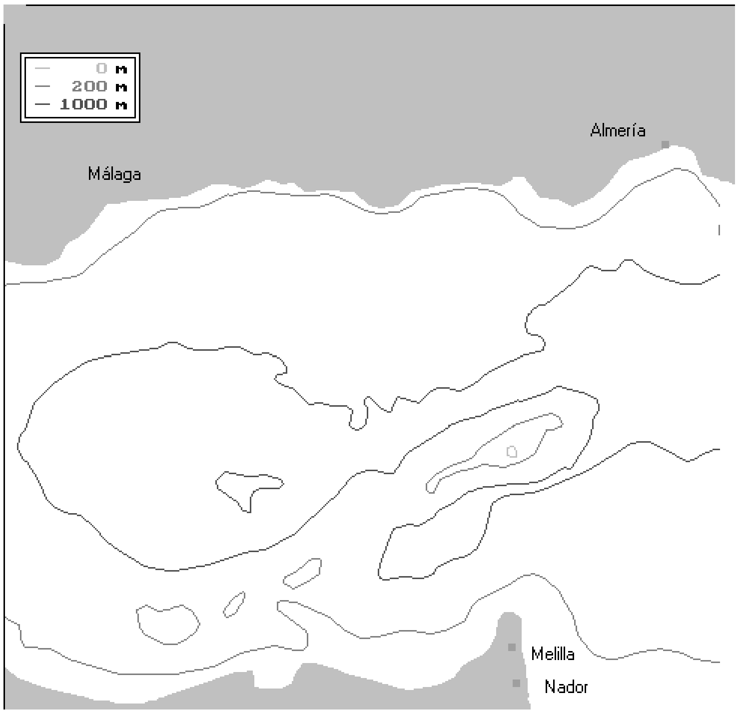
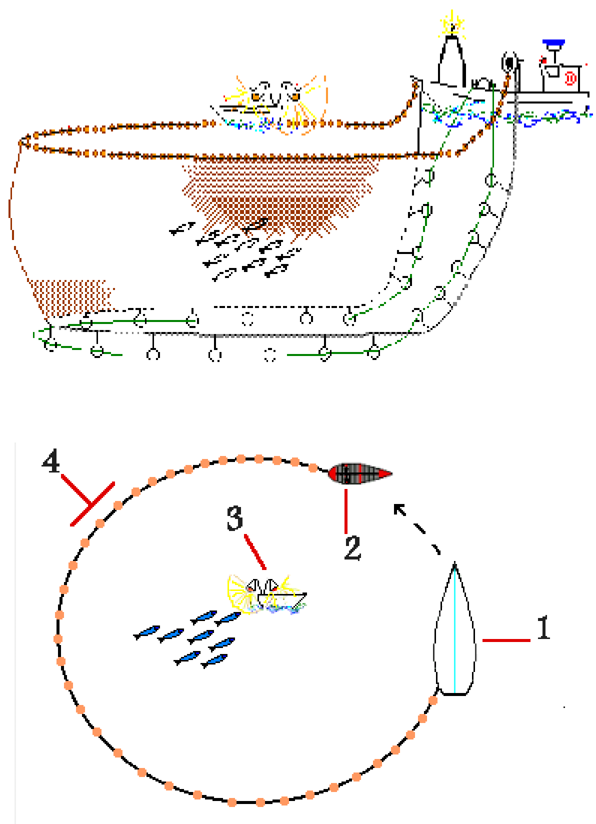
The parameters of this case are malaga.par & malaga.sim



1- General description

Malaga's case is about a small fleet, which is dedicated to fish little pelagic fishes like sardines, anchovies or other objective species, in the Mar de Alborán area. The gear used by those vessels is the purse seine, which works as shown in figures 1&2.

Figures 1 & 2: The purse seine enclose the net around a fish school



It is important to mention the characteristics of this fishery: the radio of action is reduced, it is extensive on work, with an irregular production and a small grade of transformation and also prices are uncertain because of the own properties of the product.

Otherwise, some technical characteristics are reflected also on the economic performance of this fleet. Those restrictions are the limitation of the gear to fish at night, with the sea on calm and, of course, the restriction of fishing on nights with full moon, because the fish is attracted with artificial light. So the gear reduces the effort, from the beginning, on the catches and at the same time it reduces the possibilities of the fishing.

The area of action of these eleven ships that are included on the report, those are the ones that belong to Malaga's Harbour, is very reduced because they used to fish on the coastal.

The characteristic of extensive on work is, in fact, related to the large crew in each ship between ten or eleven crewmembers per vessel.

The resources will be subject to a product that barely suffers transformation, with an irregular production, uncertain prices and also the quality of a perishable good and the question that it has to be sold as a fresh product.

The management of the Malaga's purse seine is structured over a closed census, with withdrawn' s programs[1] and temporary close season financed. The fishermen took advantage of temporary close seasons to arranged the vessels for example: to paint them, bring them to the mooring in fact it's about to tune the vessel up for the next season.

The management is also present at the investment subventions like: helps for constructions and modernization of fleets. It's about subventions to the costs of capital[2].

Another way of management is based on the limitation of exploitation techniques like the intervention on the mesh of the nets, on the gears.

The control of the landings is not easy for the Administration, as in other Mediterranean fisheries it is not possible to manage the fishery from the catches side because the high cost of that control. By this reason always the management is based in the control of effort.

Other problems of this fishery is the weak state of the fish's market, the adaptable character of the fishing communities and not the administration (the most part of the regulations is based on legal rules that have a slow process of adoption) and the lack of economical and social information and also the problem of unemployment.

The study of the uncertainty or irregularity of the prices, discussed before, in the case of Málaga gives as to face off a problem with the prices because those oscillate in a significant way. Bearing in mind that sardine price is always lower than the anchovy price. But with the market's globalisation and the foreign trade, all these prices go down.

About the economical application on the Mefisto model there are problems to estimate the total amount of fish introduced to the local market, not only from local catches, but also from the regional production from other harbours or countries. Another question concerned with prices is that it do not exist data that links sizes with prices and if we arrive to know them, of course the study, will be more concreted. By these reasons in the market box we consider the modifier price related to weight and supply equal to cero.

2- Biological data

In order to proceed to make the simulation, we can open the file “malaga.sim”. When this file is charged in the MEFISTO program, is possible to see the content of the different boxes. We open first the field “stock”. The next figure expresses how to go into the stock:

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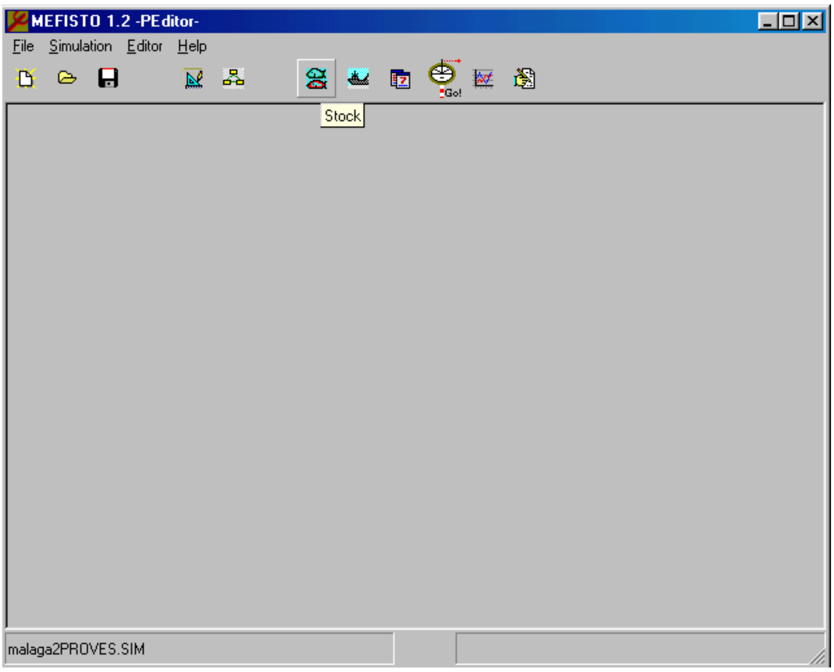
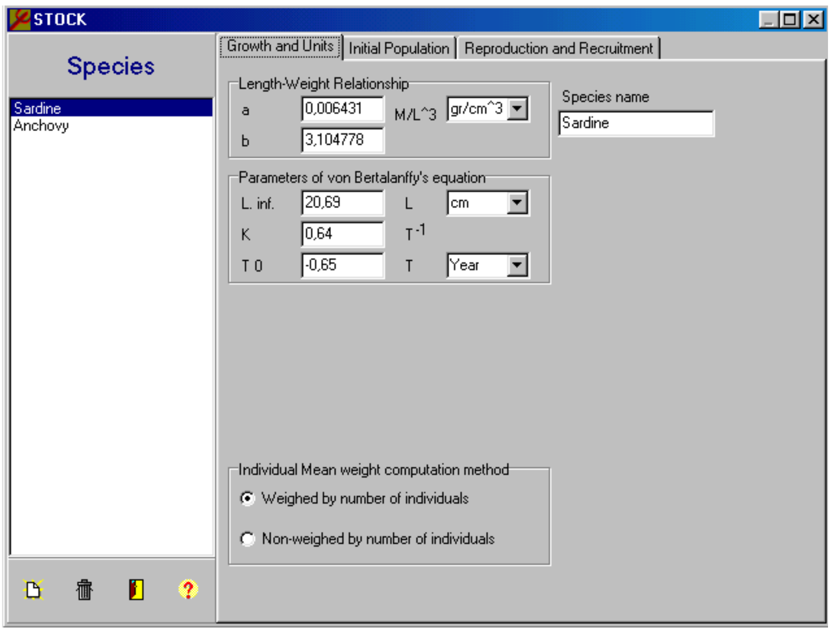
[1] These programs provide a subvention near of 7.000€ per GRT withdrawn in the actual MAGP of the European Union.

[2] Ramón Franquesa, Modelos bioeconómicos y políticas de regulación pesquera. Una lección introductoria. Biología Marina. Universidad de Murcia, 1997.



Then appears, for each species, a new figure that shows the growth and units of the stock, in that case we have two species. The next picture shows the figures of the sardine.



The information that is allocated is this boxes can be obtained from the VPA program. When we are running the VPA from the samples taken in the area, we obtain the data of the table 1, the growth parameters of sardine and anchovy.

Table 1.- Growth parameters of sardine and anchovy from the VPA

GROWTH AND UNITS	SARDINE	ANCHOVY
A	0.006431	0.00461
B	3.104778	3.1521
L. inf.	20.69	17.6
K	0.2	0.15
T O	-0.99	-1.2

When we open the field of "initial population" of the fishing stock in Málaga. There are only three cohorts of sardine and anchovy because the resource is overexploited (remember that in Tarragona case has 9 cohorts of sardine and 5 of anchovy). These data proceeded also from samples.

Table 2. - Number of invidious per each sort of age, Maturity index and F (mortality for fishing)

	Sardine			Anchovy		
Age	Initial Population.	Maturity index	Fg	Initial Population.	Maturity index	Fg
0	243,964,601	0.	0.44	535,458,386	0	0.32
1	70,577,870	0.139	0.47	212,282,305	0.7	0.47
2	19,736,812	0.899	0.40	72,554,472	0.909	0.60

Finally in the field of "reproduction and recruitment" we adopted the same criteria used in Tarragona. We use as in other cases of pelagic fisheries the model of Beverton & Holt, with the data obtained from the samples. The table 3 shows the characteristics of each possibility of recruitment.

Table 3. - Natural mortality, the reproduction and recruitment.

<table>
<tr><td rowspan="4">RECRUITMENT CONSTANT BEVERTON & HOLT</td><td rowspan="2">SARDINE</td><td>ASYMPTOTE</td><td>5,000,000,000</td></tr>
<tr><td>S AT 50%</td><td>2,686,153,280</td></tr>
<tr><td rowspan="2">ANCHOVY</td><td>ASYMPTOTE</td><td>1,000,000,000</td></tr>
<tr><td>S AT 50%</td><td>178,446,246</td></tr>
<tr><td rowspan="2">NATURAL MORTALITY</td><td>SARDINE</td><td colspan="2">0.6</td></tr>
<tr><td>ANCHOVY</td><td colspan="2">0.8</td></tr>
</table>

3- Economic data

The economic information introduced in the model is divided in levels as shown in table 4. The most generic is the country, the most concrete is the vessel. Table 4 expresses the way the information is obtained and at what level was introduced in the model.

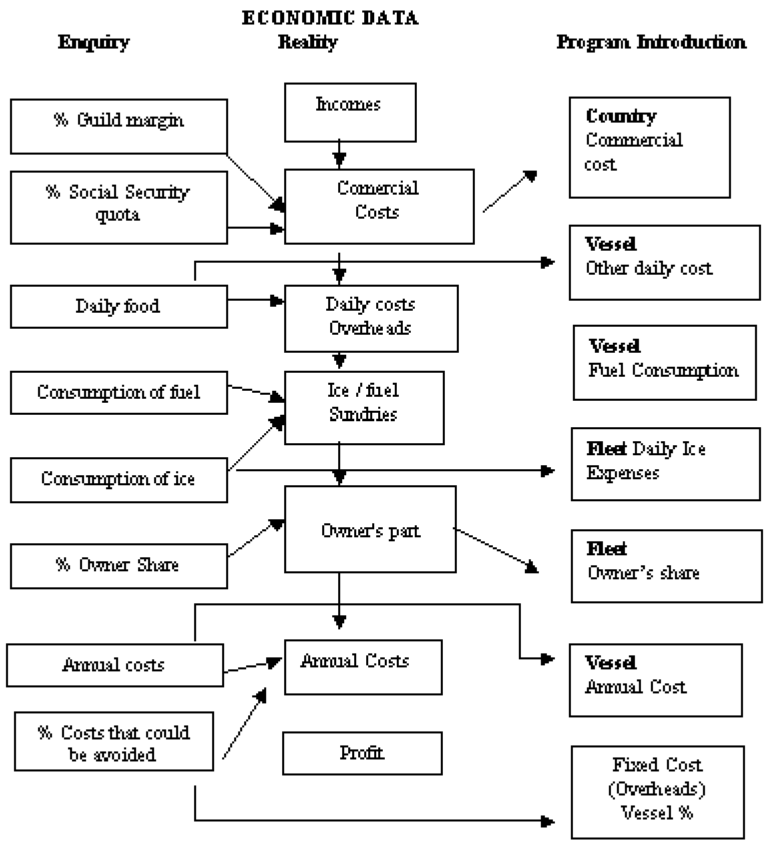
The proposal of the creators of MEFISTO is to obtain some data from the annual statistics, others from conjuncture statistics (for example the price of the fuel per litre at the moment of the study), but others only can be observed by surveying. Other kind of parameters can be introduced as hypothesis; in this case can obtain additional information in the "help" of the program.

Table 4.- Concept and sources of economic data introduced in MEFISTO by levels

MEFISTO inputs	Concept	Data Source
	Country	
% Maximum credit	% of debt allowed over the value of the vessel	Annual statistics
Fuel price	€ per litre	Annual statistics
Opportunity cost %	Debt public rate	Annual statistics
Financial cost %	Rate of interest to take a credit from the bank	Annual statistics
	Fleet	
Commercial Cost	Social security + trade cost + VAT +local taxes	Enquery
Owner's share	% of income to the owner	Actual
Fishing days	Total days allowed	Last year
Daily fishing hours	Total hours allowed	Last year average
Dismissal price	Subvention from the administration to dismissal (€ per GRT or GT)	Annual statistics or hypothesis
Daily ice expenses	€ per day	Last year average
Annual increase of Q	The catchability (Q) can be made to increase annually by specifying a percentage of annual increase, representing the technological progress	Hypothesis
Modifier Capital/catchability	This figure represents how much the catchability grows when the capital invested increases.	Hypothesis
	Vessel	
GT	Capacity of the vessel	Enquiry or census
Vessel value	Value of the vessel included gears and equipment to fish	Enquiry
Credit	Banking debts	Hypothesis zero by defect
Crew size	Number of people on board	Enquiry
Fuel consumption per day	litres	Enquiry over daily, weekly or year consumption
Other daily cost	Cost as food, oil, gas, light consumption, bait	Enquiry
Annual cost	Cost as hull painting, engine revision, insurance, mooring, licenses, gears maintenance	Enquiry, asked over total average
% Fixed cost over annual cost	Percentage of he annual cost, that is absolutely impossible not to pay at time: licenses, mooring, part of maintenance, etc.	Enquiry, asked as a part of the annual cost

The next graph expresses the relation between the reality, the enquiries and the data introduced finally in the model. More information about the way to elaborate and obtain the enquiries can be found on the help of MEFISTO.

Figure 3. -Interactions on the model



From the enquiries at the harbour of Málaga we have the information introduced in the parameters file of this case (malaga.par). We present in the next tables a summary of this information collected and included in the file.

In table 5 there is a summarized table with information about the general characteristics of the fishery, obtained from the outcome of the enquiries. This table shows the average of cost and technical structure obtained from the enquiries.

Table 5.- Cost structure and technical structure of Purse seine fleet

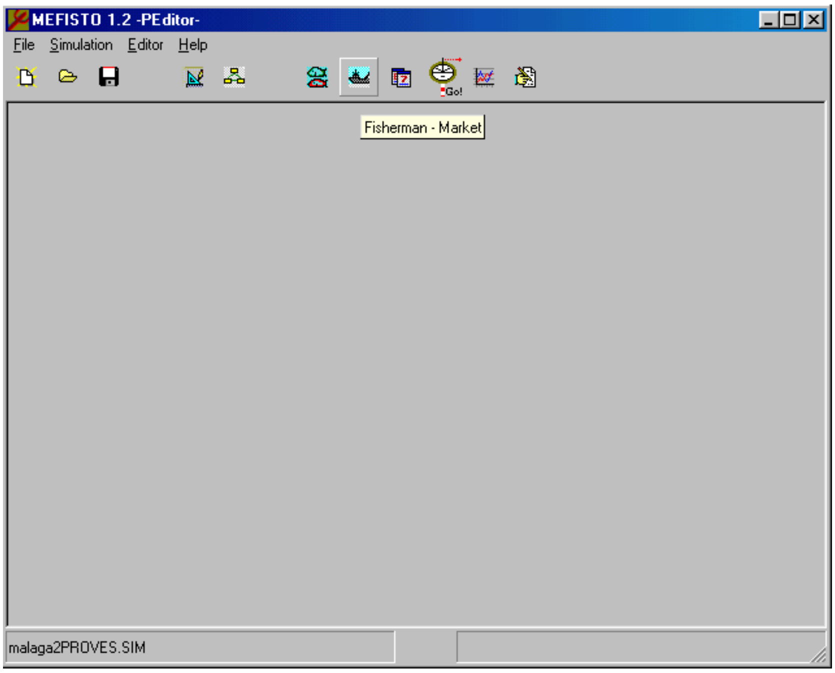
Capital (€) average by vessel	272,179.63
Insurance (€) x year, average by vessel	2551.68
Annual costs (€), average by vessel	13,551.68
Commercial cost %	17.50
Owner's share %	45
Daily ice's expenses (€ x day), average	33
GRT, average	17.74
Crew, average	10.73
Fuel consumption (liters x day), average	236.62
Fishing hours per day of fishing	10
Fishing days	175
Number of vessels	11

Other information used in the simulation is obtained from statistical information or by hypothesis, as example of this we can see the values presented in table 6. The opportunity cost is establish by hypothesis (close to the public debt rate in Spain during this period), also the financial cost (as a most frequent value of this rate in the private banks in this period). The price of fuel is the average price of this period.

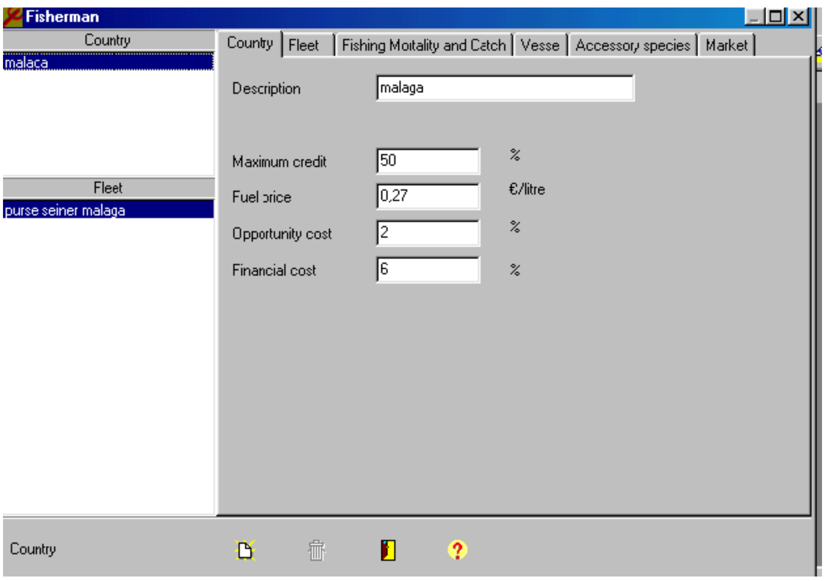
Table 6. - Other economic factors.

Opportunity cost	2%
Financial cost	6%
Fuel price	0.27 € per liter

If we go back now to the program, when we close the "stock" field, is possible to open the "fisherman-market" field. Then appears the next figure:

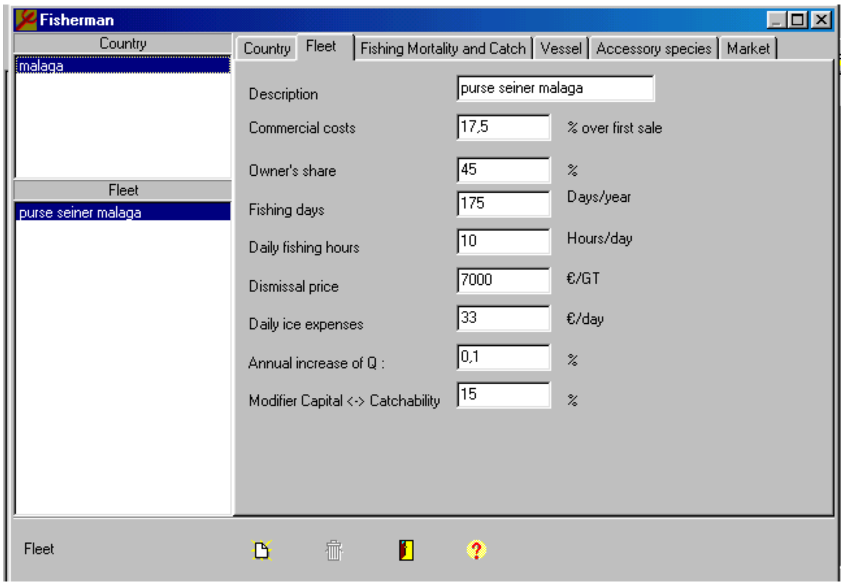


Every level is introduced in the model in a separated screen. The first screen named "country" presents an image as the next:

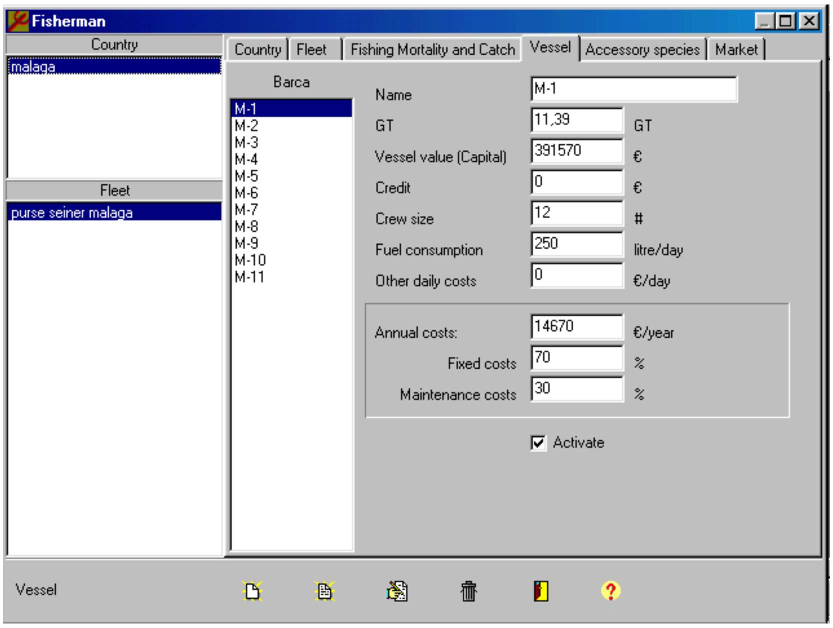


What we find here are the inputs at “Country” level (the most global) related to the purse seine of Málaga, the single fleet present in this case.

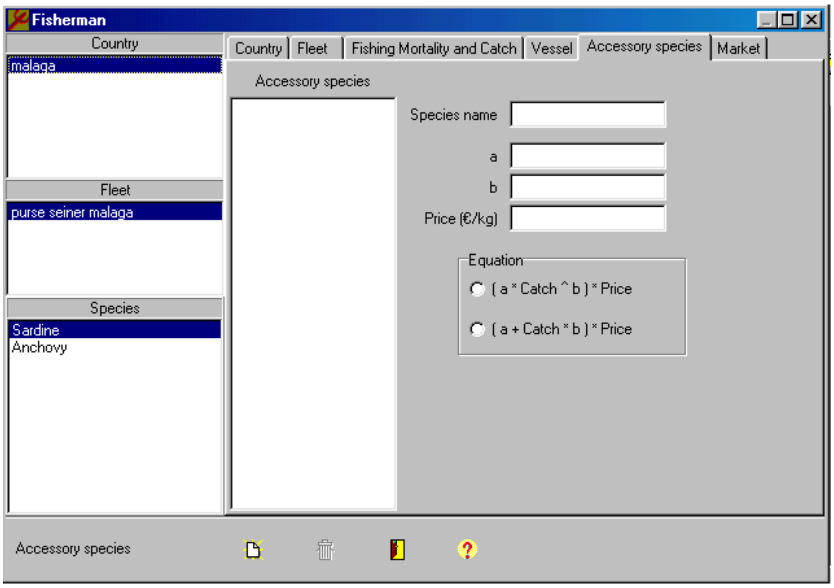
The next field “fleet” is about the inputs of the individual fleet of the model and shows the different data, that proceed from the data of enquiries (part of them are presented in table 5)



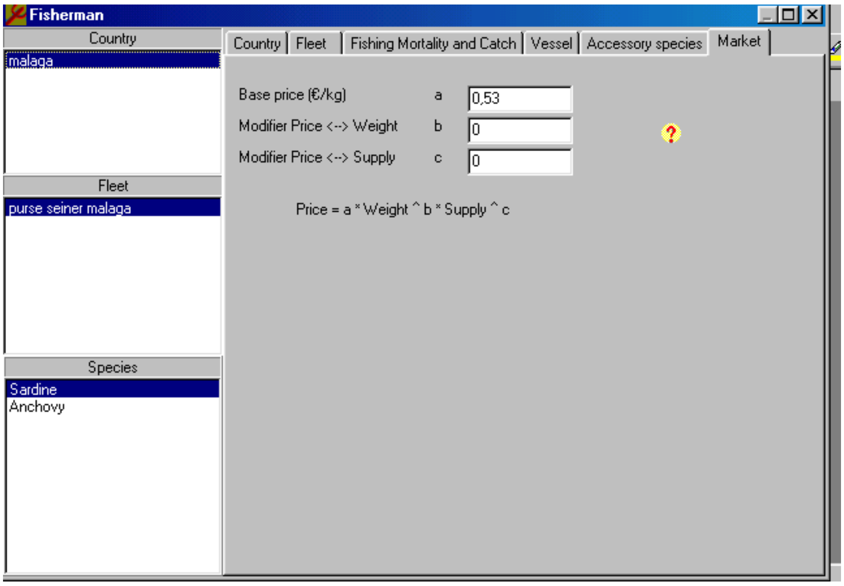
The next field present the individual information per vessel. The name of the vessels is changed by a code. This data was obtained by individual enquiries to the vessel owner. When we change in the central box the vessel selected, appear in the left box the characteristics of this individual vessel.



The next field is “accessory species”. We consider that in this case sardine and anchovy compose the catch and there are not accessory species so that is why everything is in blank.



The last field is about the market prices. The base price is calculated in Euros (€) per Kg and is a figured obtained from an average of the sardine prices of last year. As we explained before we considered the modifiers of the price related to weight and to supply equal to cero.



The table 7 is a sum up of the market prices of both species considering that the prices are consider in € per kg in the Mefisto program.

Table 7.- Market.

	PURSE SEINERS
Sardine price (€ x kg)	0,53
Anchovy price (€ x kg)	2,35

4. Application

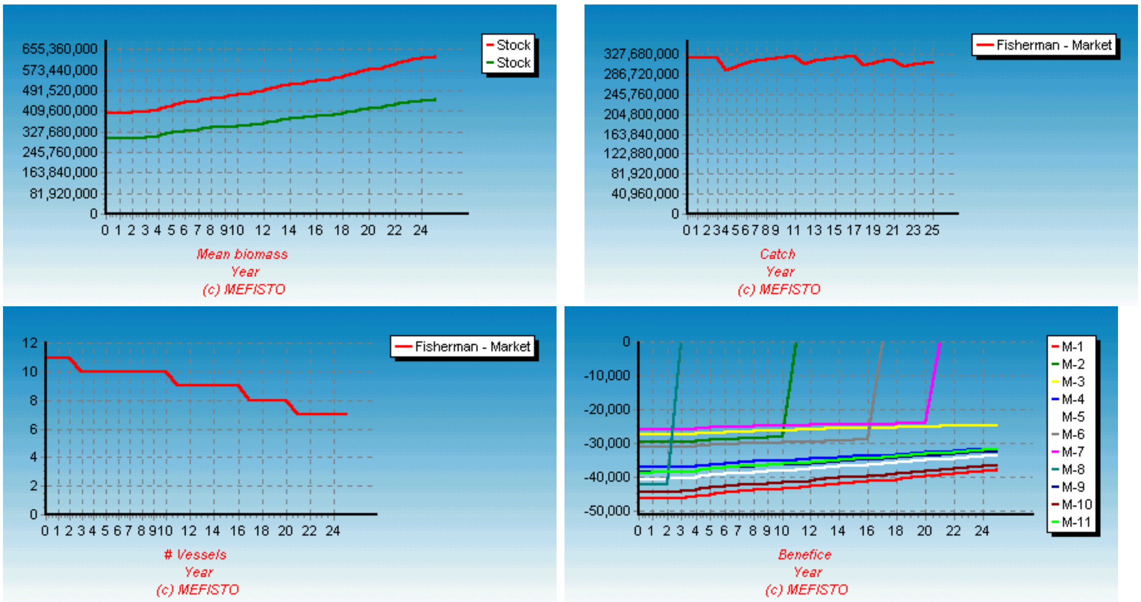
With the above data it is possible to run the model and obtain deterministic or stochastic outcomes. In this case, we obtain predictions of the fishery behaviour, if all the conditions established remain constant.

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 obtain the graphics you must go to the icon “graphs” and then open the simulation that you are testing.

The outcomes of the deterministic simulation are shown at figure 4

Figure 4. -Nowadays situation of sardine and anchovy fishing, 25 years projection.



The starting point is a weak fishery. If they are not subsidies from the administration, the overcapacity produces in the medium term a reduction of effort. In 25 years the losses produce a reduction from 11 vessels to 7, as consequence of this, a recover of biomass is expected.

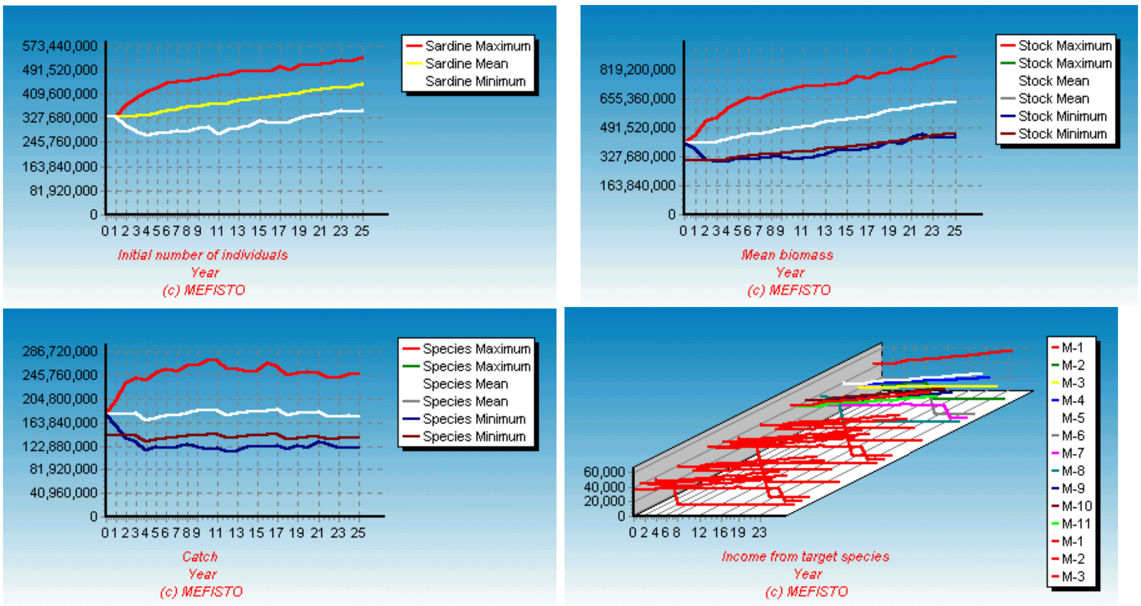
A risk in this fishery is the possibility that the irregular recruitments produce a collapse of the fishery. We go to run a stochastic simulation to analyse the potential effect of random changes in the catch.

To produce a stochastic simulation first we open the icon “scenario” (pencil and rule) and we selected “stochastic” in “simulation type”. Then appears a new box where is possible to made some selections. First box indicate the number of stochastic iterations (100 by defect, the larger this number is, more times needs the computer to complete all the iterations). The second number is a random number that indicates the selection of type of random distribution. If you are interested in repeating the same random distribution remember to put the same number the second. In other case the program selected automatically a random distribution every time. Finally the third box is used to select as a graphic output, only the 95% of cases that are more near of the deterministic outcome.

After we open in the species box, the option “stochastic errors”, which appears when stochastic is selected before. In this exercise we selected only for sardine a random distortion in the natural mortality. Take the option “natural mortality” and inside “Uniform”. Then appear the possibility to select the dimension of uniform error. We introduce here the value 0,5.

We go out of this box, save the changes and run the program. Now we need more time to wait until the simulation is complete. When this is finished, we go to graph option. If we take any graphic option in the third screen appears the option “stochastic”. Please unselect the option “upper” and “lower”, because in this version of the program the confidence interval is only running at level of cohorts.

Figure 5. –Stochastic simulation of sardine and anchovy fishing, 25 years projection. First box is only the number of individuals of sardine. The second box, appear the mean biomass also the anchovy, their stock does not change because the stochastic simulation is only over sardine.



When we obtain the graphics, the outcome shows that the fishery is stable from the biological point of view. The random distortion does not produce an explosive divergence, but the minimum and maximum have a parallel evolution to the deterministic solution from the third year. That shows that the high outcomes compensate the low outcomes.

In the last box of the graphic appears the evolution of all vessels. In this case appears that for some vessels, the maximum of natural mortality can produce in some cases the exit of some vessels. Is possible to see that the minimum income of some vessels go to zero in some cases: it is because their go outside of the activity.

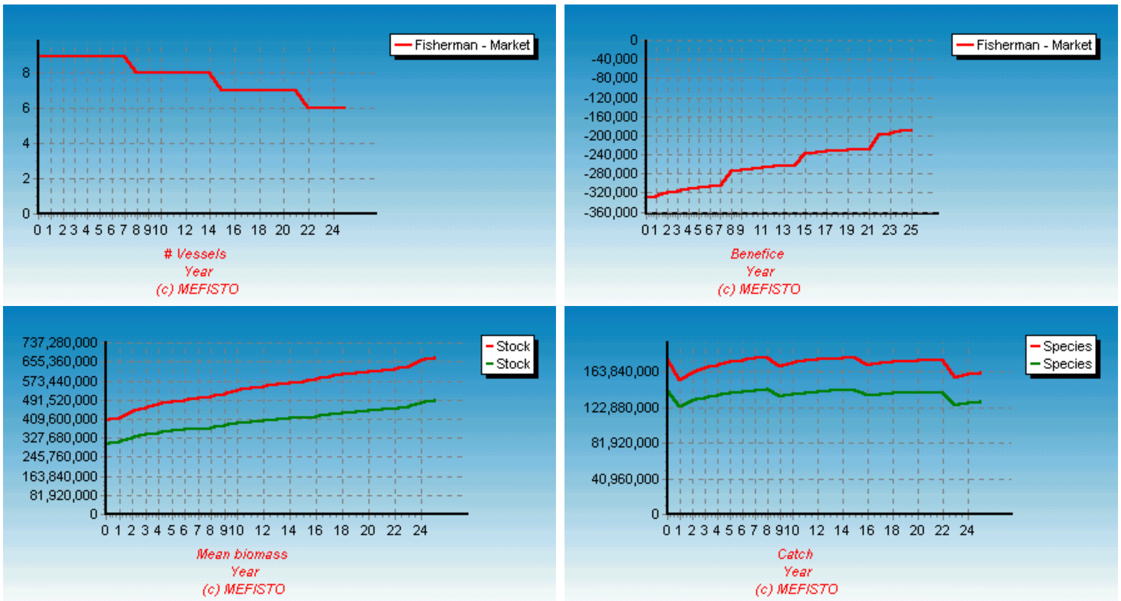
We are going to propose a modification of the initial situation and study the characteristics of the new scene. In this case we suggest changing the dismissal price.

Scenario 1: Increase of the dismissal price from 7000 € / Gt to 9000 € / Gt.

The dismissal price is the price that the administration pays to the owners to leave the fishing activity and beginning another new activity. The model uses the same way that the European Union pays to the owners, a quantity of money per GT (or GRT) invested in the vessel. If the losses are too large, the owners prefer to destroy their capital invested in the vessels and take this subvention for leaving the activity.

First we go to "configure scenario" and put the option "deterministic" at new. Then we go to modify the dismissal price to 9.000 € / GT in the fishermen box, fleet option. We save the changes and run the simulation. We obtain the next graph 6.

Figure 6. - The result of the simulation presented at the scenario 1, which was a modification of the dismissing price up to 9.000 € per GT



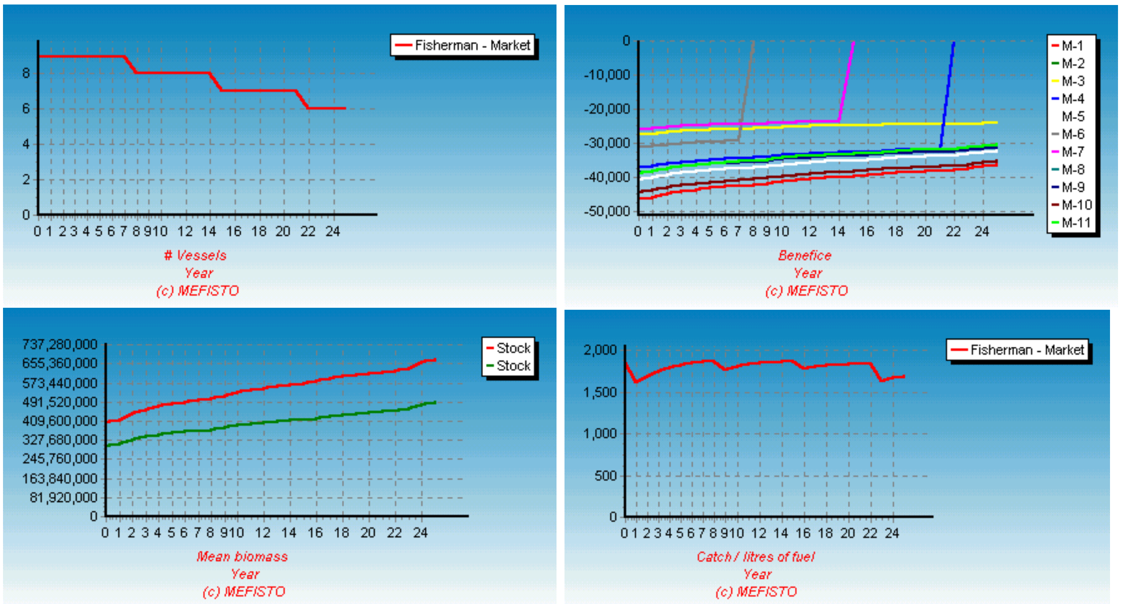
The outcomes show that now in the first year the number of vessel come from 11 to 9 and the adjustment to the biological possibilities is easier and faster. The biomass goes up from the beginning. Also the profits, which remain in any case under zero, are negative, as the vessels can't amortise their value. Finally the catch by vessel remains relative stable, then the reduction of vessels goes down, but in a short time they recover the mean value.

Scenario 2: Modification of fuel price from 0,27 to 0,6 €

The objective is to adapt the fleet to the biological possibilities. Other way that is not pay for leaving, is to charge more to the ones remaining in the activity. A reduction in the tax exemption for the fuel consumption is a way in this direction. We suppose that the price of fuel go up from 0,27 to 0,6 €. Remember that this change can also be produced by changes in the world price of fuel.

To introduce these changes in the model first we put out the changes in the dismissal price to 7.000 € at new. Then we go to fisherman box and to country option, and change the fuel price to 0,6 €. We save the data and running the model. We obtain the information represented in the graphic 7.

Figure 7. - The result of the simulation presented at the scenario 2, which was a modification of the fuel price up to 0,6 €



The figure shows in different graphs the effects of the modification of the fuel price. The outcomes are similar to the scenario 1: reduction of vessels, increasing of biomass and profits.

The catch per fuel, remaining stable In this case the increasing of fuel price does not produce a more efficient use of the energetic input, but allows to recover the resource. To obtain the same (or a very similar) outcomes the administrator can use the scenario 1 or 2, in function of the social and political considerations.