BALANS

Balancing impacts of human activities
in the Belgian part of the North Sea

Funded by Belgian Science Policy

[1]

What, who and how ?

The main goal of BALANS was to gain experience in correlating and balancing relevant social, economic and ecological data, through the elaboration of indicators, and weighing these indicators through the development of a conceptual policy model for a *Sustainable Management of the North Sea*.

Partners from various disciplines (economics, biology, eco-toxicology, fisheries and modelling) cooperated over a 4 year period (2002-2006) towards this aim, focusing on sand and gravel extraction and shrimp fisheries on the BPNS.

[2]

What, **who** and how **?**

Project coordinator : Maritime Institute, University of Ghent

Partners :

- Institute for Agricultural and Fisheries Research
- Section Marine Biology, Department of Marine Biology, University of Ghent
- Laboratory for Biological Research in Aquatic Pollution, University of Ghent
- Management Unit of the North Sea Mathematical Models (MUMM)
- Ecolas nv

[3]

SUMANOS workshop – Ghent – November 23-24, 2006

What, **who** and how **?**

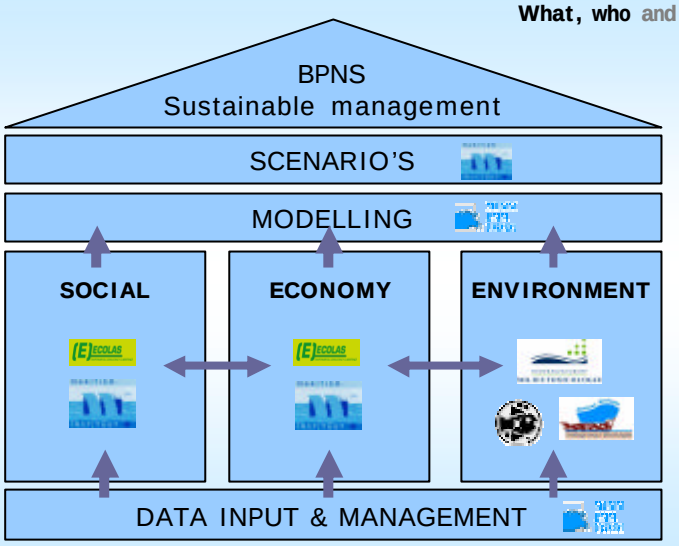
Mutidisciplinary study,

at the level of sharing (theoretical) thoughts, not only results

➔ emphasis on methodology or, at least, a common framework

[4]

What, who and how ?



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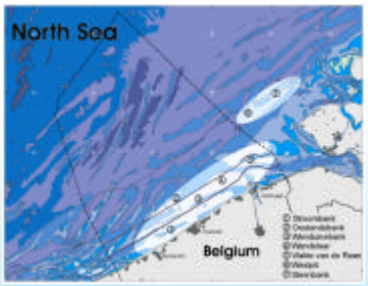
What, who and how ?

Two activities:

- Sand & Gravel extraction
- Shrimp fisheries



[6]

What, who and **how ?**

Modelling methodology

Step 1	•Setting–up of the conceptual model •Validation of the conceptual model
Step 2	Identification of the state variables (i.e. the time-varying fundamental elements describing the system) and of the relationships between them (conceptual model matrix)
Step 3	•Inventory of the available information on the variables (units, initial values, ranges, level of uncertainty, uncertainty range) •Description of the form (logical, analytical, qualitative) of the relationships •Description of the internal dynamics of the state variables •Inventory of the available information on the parameters of the relationships, where applicable, and of the internal dynamics of the state variables (units, values, ranges, level of uncertainty, uncertainty range)

Step 4	Consolidation (simplification) of the conceptual model on the basis of the identified available information
Step 5	Translation of the conceptual model into a computer model
Step 6	•Tests of the computer model •Sensitivity analysis (influence of both the variability and the uncertainty) •Possible iteration (from step 2)
Step 7	Documented scenario's

[7]

SUMANOS workshop – Ghent – November 23-24, 2006

What, who and **how ?**

1) The basic conceptual model describes the behaviour of a system in general terms. It usually answers the following questions:

« Model » ????

- ***•Conceptual model***
- ***•Mathematical model***
- ***•Numerical model***
- ***•Computer model***

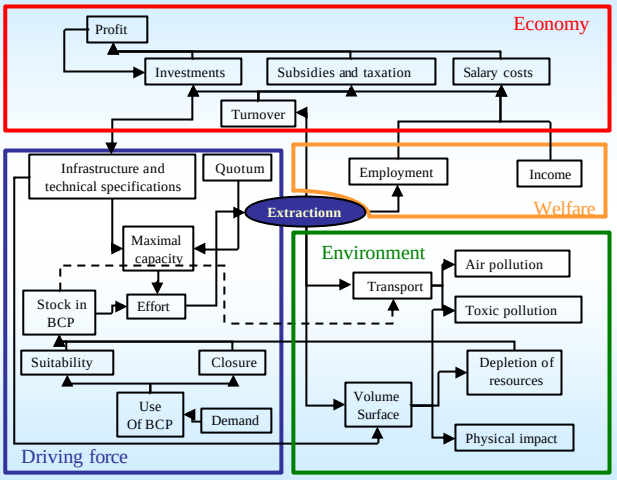
- What are the variables that describe the state of the system ("state variables"): V_1, V_2, ... V_n?
- What are the key relationships between theses state variables?
- What are the key parameters of these relationships: p_1, ..., p_n?
- What is the domain $\Omega(t, f, ?, V_1, V_2, ...V_n, p_1, ... p_n)$ of investigation?
- What is the initial state of the system and the constraints at its boundaries?

[8]

What, who and **how ?**

First elaborated draft of the conceptual model for the S&G extraction activity

N.B.: Arrows mean "has an influence on"



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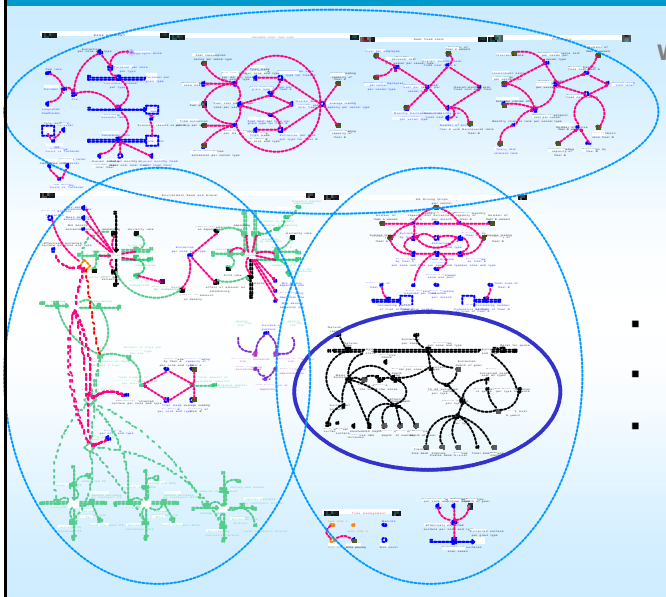


What, who and **how ?**

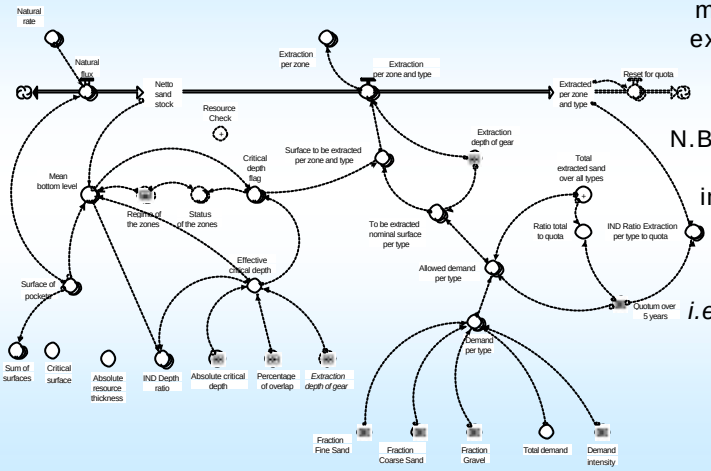
Final conceptual model of the S&G extraction activity.

- Socio-economics sub-model
- Environmental sub-model
- Driving forces

[10]

What, who and **how ?**

Final conceptual model of the S&G extraction activity (abstract).



N.B.: Single arrows mean "has an influence on" but double arrows represent fluxes, *i.e.* the dimension "time" is now included

[11]

What, who and **how ?**

1) Conceptual model

2) Then, a mathematical model can be built, where the relationships mentioned above are translated into mathematical and logical functions:

Key relationships = key processes = $\frac{dV_i}{dt} = F_{ij}(V_1, V_2, \ldots V_n, p_1, \ldots p_n)$

[12]

What, who and **how ?**

Each element of the conceptual/mathematical model is described with:

Definition	explaining what exactly this box represents
Equation	explaining how this element is mathematically described
Array	does the element designate more than one item and, if so, along what dimension(s) (e.g. shrimp size classes)
Units	Physical units (kg, m, ind./m², ...)
Value	initial value and possible range
Type	what does the element represent: a state variable, a flux (process), a parameter
Function	scenario, policy choice, objective (calculated final output of model that is used as a measure for further policy changes); or calculation (intermediate result used in calculation of "objective")
Links	input (elements leading "into" this element); output (element leading "out" of this element)
Data	values and sources of reference data

[13]

What, who and **how ?**

1) Conceptual model
2) Mathematical model

3) In most cases, the equations of the mathematical model do not have an analytical solution (*i.e.* a solution than can be expressed using the same mathematical language than the problem). They are thus transformed ("discretized") in order to be solved. The resulting model is a "numerical model" (*i.e.* numbers can replace abstract mathematical objects).

$$\frac{dV_i}{dt} \xrightarrow{becomes} (V(t)-V(t-dt))/dt$$

[14]

What, who and **how ?**

1) Conceptual model
2) Mathematical model
3) Numerical model

4) The computer model is a piece of computer code incorporating
   - the discretized equations,
   - the initial and the boundary conditions and
   - all the other elements (like data) needed to evaluate them,
   - the solving algorithm and
   - some sort of input/output mechanisms in order to allow the user to set some parameters and to access the results of the computation.

➔ Need for a software environment ➔ Stella

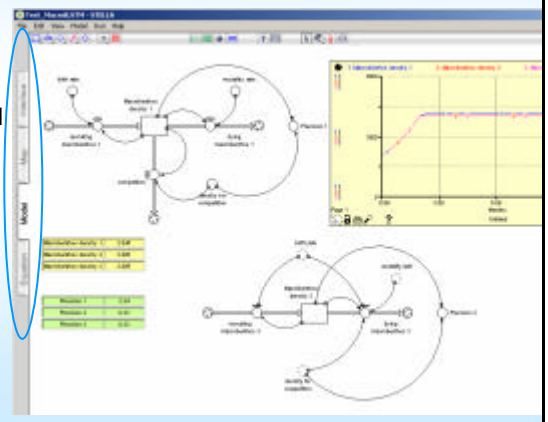
http://www.iseesystems.com/

[15]

What, who and **how ?**

The Stella modelling environment consists of an "execution kernel" and four layers:

(1) the map layer,
(2) the model layer,
(3) the equation layer, and
(4) the interface layer.



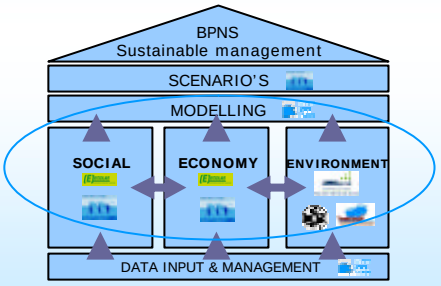
[16]

What, who and **how ?**

Integration/Merging (1)

- Sub-models were developed "independently" using some commonly agreed concepts and prototypes of the other components.
- Stella isn't really suited for collaborative work, nor is it "modular".

➔ A lot of work needed to interconnect things in a consistent way

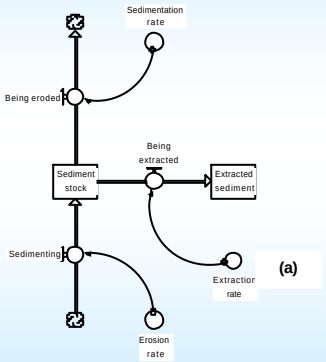


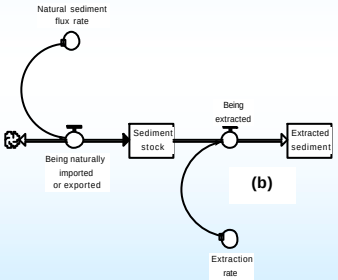
[17]

What, who and **how ?**

Integration/Merging (2)

Validation of the structures and possible changes



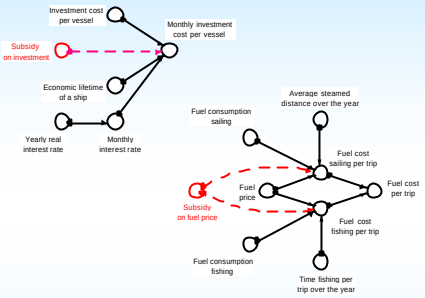


[18]

What, who and **how ?**

Integration/Merging (3)

- Adaptations deriving from tests with the model

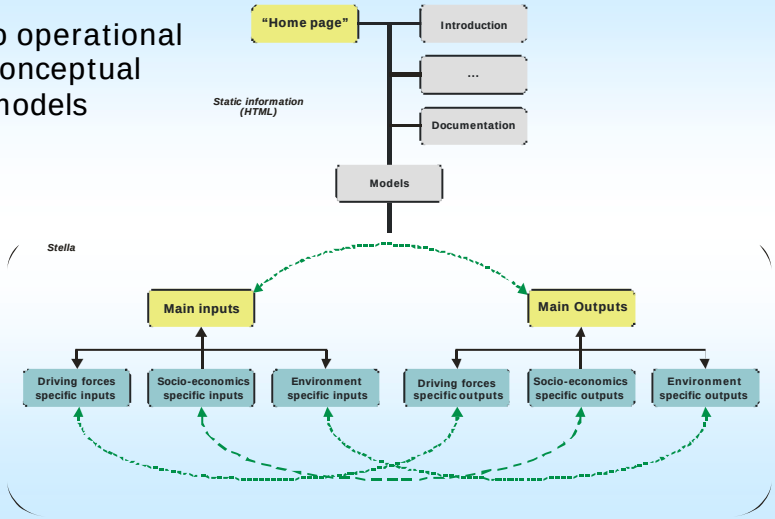


- Tuning resolution algorithm (time step, ...)

[19]

Products

Two operational conceptual models



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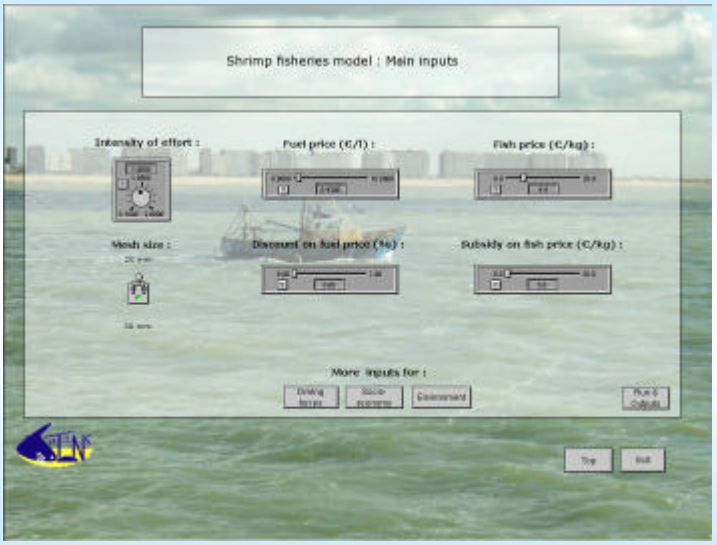
Products



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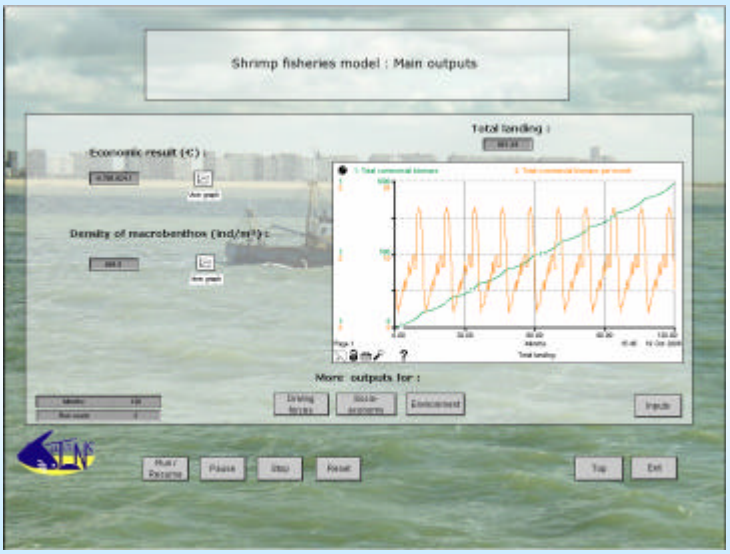

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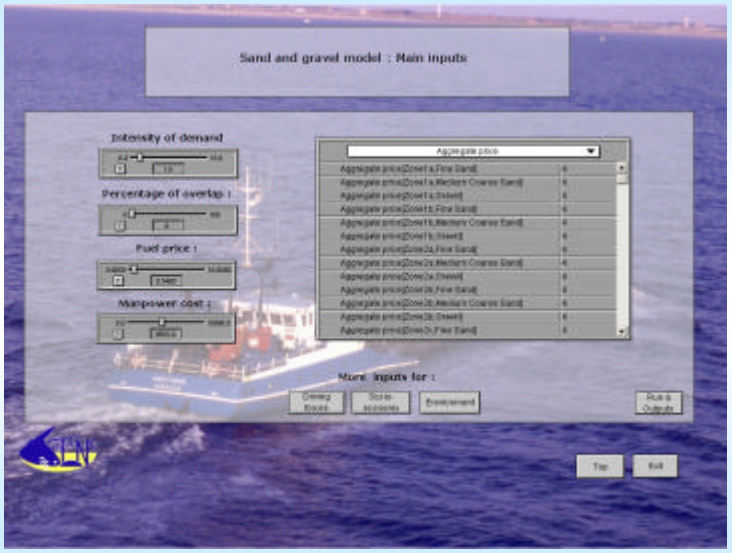
Products



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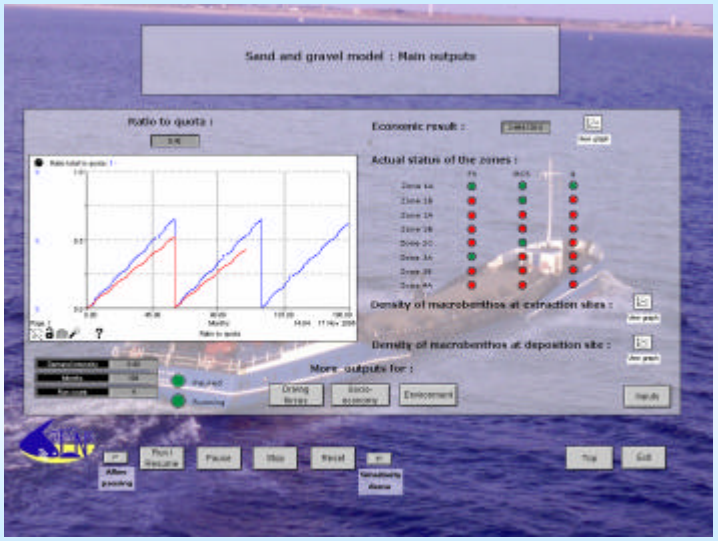
Products



[24]

Products

Development of economic, social and environmental scenarios

- "How to ensure a steady state of the system?" ("sustainability")
- "What if policy measures restrict the exploitation for the purpose of environmental protection?"
- "What if the market demand induces 10 times the current level of exploitation?"

Consequences on indicators pertaining to each of the three domains in response to a system change can be explored.

[25]

Products

"*We don't manage the ecosystem, we manage the human activities interacting with it!*"

The system adapts dynamically and continuously to internal and external changes

[26]

Methodology (a)

Products

1. Define simulation objectives

We are interested in knowing how the system will react and evolve when some endogenous or exogenous changes occur.

2. Identify evaluation criteria

Key indicators of the state of the system

Model	*Driving forces*	*Socio-economics*	*Environment*
Fisheries	•Ratio (Dead+Waste) vs. Commercial catch •Total landing	•Turnover •Economic result •Total costs •Ratio economic results/costs •Landings Per Unit of Effort	•Density of macrobenthos
Sand and Gravel	•Ratio actual depth/critical depth •Ratio extracted sand/quota •Total extracted surface	•Turnover •Economic result •Total costs •Ratio economic results/costs	•Density of macrobenthos at extraction sites •Density of macrobenthos at deposition site

[27]

Methodology (b)

Products

3. Determine relevant scenario characteristics

This step requires identification of the actual values the input parameters are likely to take in the future.

It includes making credible assumptions on the evolution of the external market (*e.g.* price of fuel), of the internal market (*e.g.* changes in the demand of gravel, change in the price of fish), of the policy (*e.g.* potential policy restriction on the deepening of sand extraction zones), of the field strategy (*e.g.* changes in fish grounds, changes in the spatial intensity of sand extraction), and the possible combination of these specific changes. The models allows to explore the effects of the increase of fuel price, of a more strict "policy" about deepening (sand and gravel), or variations of the fishing effort, *etc*.

4. Analysis of the effects

A standard simulation is to be run, where the scenario parameters are set to their default value, which correspond to their present value. It serves as a reference basis for the analysis scenarios. Values and trends can then be compared.

[28]

The quest for sustainability (1)

Products

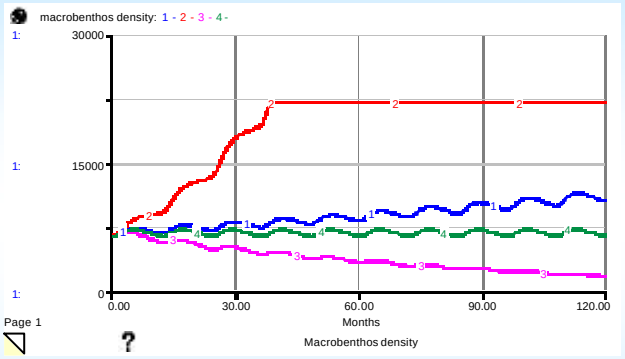


Figure 2-2: Evolution of the macrobenthos density as a function of the fishing intensity, all other things staying the same. Curve labels correspond respectively to: '1', Effort intensity (EI) = 1; '2', EI = 0.5; '3', EI =1.5 and **'4', EI = 1.1145**.

[29]

The quest for sustainability (2)

Products

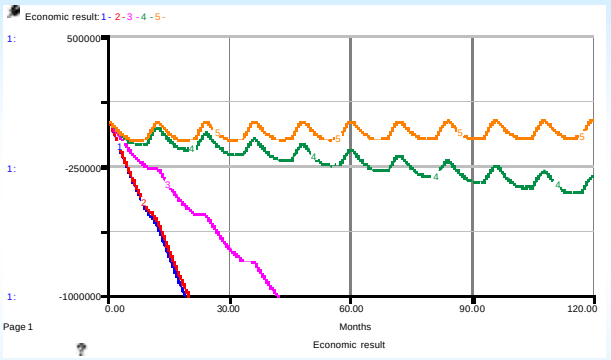


Figure 2-3 : Evolution of the economic result as a function of the fishing e ffort and of the subsidies on investment, all other things staying the same. Curv e labels correspond respectively to: '1', Effort intensity (EI) = 1 and no subsidy; '2', EI = 1.1145 and no subsidy; '3', EI = 1.1145 and a subsidy of 50% of the investment value; '4', idem '3' + a subsidy of 3.50€/kg on the fish price and, finally, **'5', idem '4' + a discount of 25% on the cost of the fuel.**

[30]

Products

"What if" scenario's (1)

	Sand & Gravel extraction
Business as usual	80% overlap
Green line	No overlap allowed
Heavy business	Full overlap, twice as much extracted quantities

[31]

Products

"What if" scenario's (2)

	Present density of shrimps	Twice as much shrimps
Present intensity of fishing effort	Scenario 1 B.A.U.	Scenario 2
Twice as much fishing effort	Scenario 3	Scenario 4

(See report and demo)

[32]

Concluding remarks

+	-
Useful exploration tool	Not a true prognostic tool
Lack of data is not a limit	Lack of data limits the interpretation of the results
Several disciplines in one conceptual tool	Integration sometimes challenging
Integrated tool allows to identify more easily components to improve	
« What if? »	« So what? »
Use of the model made us think of several possible improvements	Use of the model made us think of several possible improvements

[33]

Connections with other projects

- ***Marebasse :*** better knowledge of the spatial repartition of the various categories of aggregates
- ***Gaufre :*** basis for the coupling the two activity models, through the possible concurrent use of zones in BPNS
- ***Maredasm :*** basis to link the damage to the non-market goods to the cost of the activities
- ***Projects dealing with benthos :*** could provide a finer and more site-specific information on how the activity interacts with the benthic communities

[34]

Possible future (1)

- *How to incorporate feedback of users into a next version?*

- *Direct improvement of the existing model:*

For both activities:

- *To incorporate more "feedback effects", like the closing of zones devoted to a given activity when the macro–benthos density falls under a given threshold and their re–opening when this variable has reached a sufficient level again;*
- *To eliminate, if possible, formulations that prevent the use of the faster and most accurate integration scheme;*

For the shrimp fishery:

- *To distinguish clearly everywhere possible the two fishing grounds (e.g. in the environmental sub–model);*
- *To let the shrimp population vary as a function of the season and of the fishing ground;*
- *To develop and couple a shrimp population model.*

[35]

Possible future (2)

- *Direct improvement of the existing model (Cont'd)*

For the sand and gravel extraction:

- *To allow for a greater flexibility in the input of the demand, in order to allow for these quantities to vary over the years;*
- *To provide for a more realistic extraction pattern, in case of partially or full "intensive" activity;*
- *To allow to change the reference harbour and, hence, the distance exploitation vessels have to travel to and from the extraction zones.*

- *To find ways to validate the results*

- *To increase the complexity of the modelled systems*

- *To merge the two activities*

[36]

[37]