



SSA14 - Mar Piccolo of Taranto



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The Coastal Zone



The Taranto marine area consists of different basins with peculiar geo-morphological and ecological features.

Mar Piccolo is a shallow, nearly enclosed basin, roughly divided between two basins (Seno I and Seno II) that have a maximum depth of 13 and 10 m respectively

The exchange with Mar Grande occurs through a primary navigation channel and a small inlet

Mar Grande is a larger semi-enclosed bay with a maximum depth of 33 m and that opens into the Gulf of Taranto and the Ionian Sea

Human Activities

Mar Grande and Mar Piccolo are strongly utilised by:

- an intensive mussel commercial fishery
- the moorage for the regional fishing fleet
- the largest Italian Navy base
- a major port
- a large heavy industry site

These activities constitute the main employers at Taranto, and they all influence the environmental quality and the ecosystem productivity (e.g. the local mussel farms)

Mar Piccolo



The circulation is driven by a positive water balance (runoff + precipitation – evaporation >0) of ~40 million m³/yr.

The estuarine flushing (~ 2-3 mos) due to the exchange through the inlet is moderate and varies seasonally depending on the pressure differences with the Mar Grande.

During summer season a weak stratification develops that induces hypoxia in the lower layer.

Wind mixing is low due to the limited fetch and tidal-mixing is low due to the limited tidal range of ~ 30-40 cm

Most of the water input derives from 34 submarine freshwater springs (locally called "Citri") and the discharge from small drainage ditches that carry agricultural chemicals.

In addition, there is the combined discharge of 14 sewage pipes coming from the northern area of Taranto and from 8 nearby towns. These discharges account for about 18,272 m³ d⁻¹ (of which 85% at the Second Inlet), with organic matter equal to 6,767 kg d⁻¹ of BOD₅.

The Policy Issue: The Impact



Taranto has always been one of the most important mussel farming area in Italy and Europe. Recently, in 2002-03 there were two important policy actions that have caused some modifications:

- New concessions and the enlargement of the old ones are over-exploiting the existing natural resources, impacting the ecosystem trophic chain

Mussel farms



Before 2000



Today



Not permitted area



The Policy Issue: The Impact

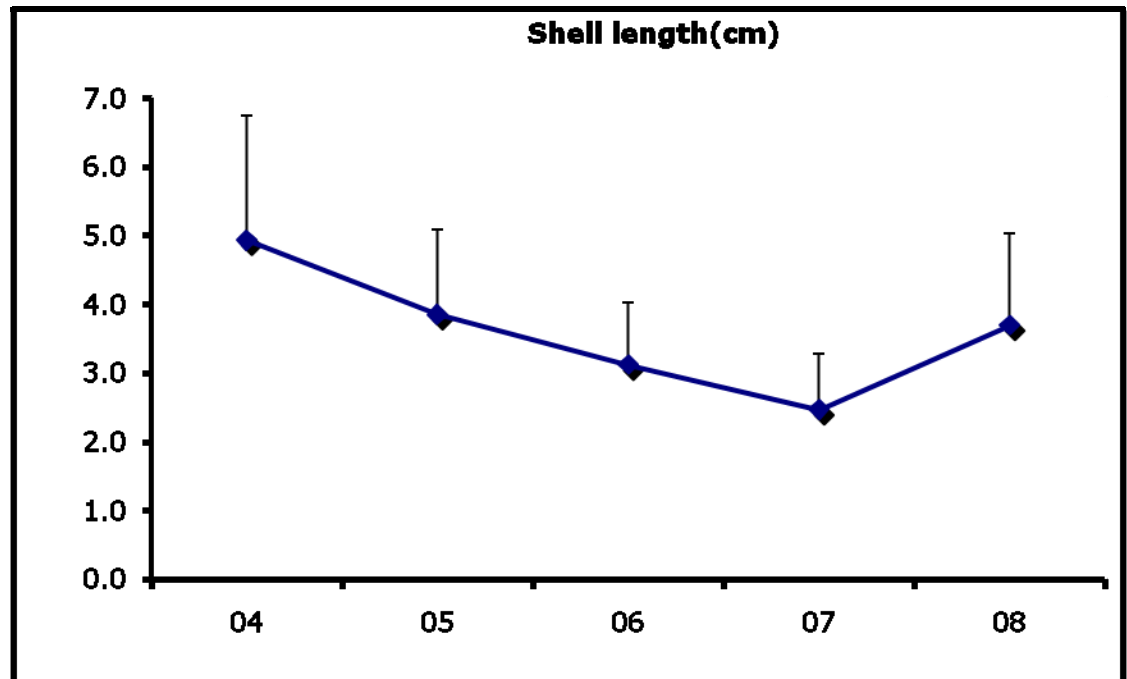


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- New concessions and the enlargement of the old ones are over-exploiting the existing natural resources, impacting the ecosystem trophic chain
- The closing of 9 sewage pipes to improve the water quality and its healthiness

The combined effect was to increase the harvest and decrease the nutrients

This leads to hypothesise that these two actions were causal to the decline



The Policy Issue: The Impact

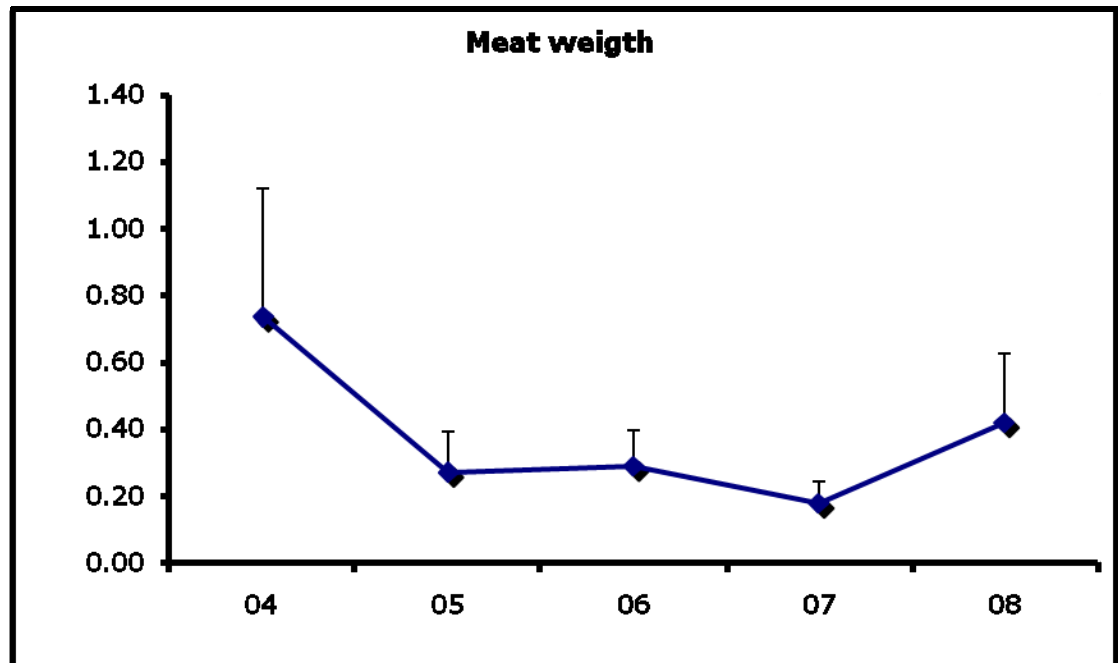


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The Policy Issue: Stakeholder Involvement

Our SSA Team met several times with a Participant Group of Policy Makers and Stakeholders:

- to identify the main concerns for the SAF implementation
- to select the Policy Issues for the SSA

How to include mussel culture in a management plan for the sustainable use of the Mar Piccolo resources



The stakeholder PG

- Regional Environmental Agency of Apulia Region
- Province of Taranto (Productive Department)
- Province of Taranto (Environmental Department)
- Province of Taranto (Tourism Department)
- Municipality of Taranto (Ecological and Environmental Department)
- Municipality of Taranto (Productive Activities)
- Municipality of Taranto (Culture and Tourism Department)
- Health Board in Taranto
- Harbour Board in Taranto
- Harbour Office
- Industrial Handcraft and Agricultural board of trade
- Eni Spa
- ILVA Spa
- “Amm.Michelagnoli” Foundation ONLUS

Stakeholder Concerns



To outline the approach:

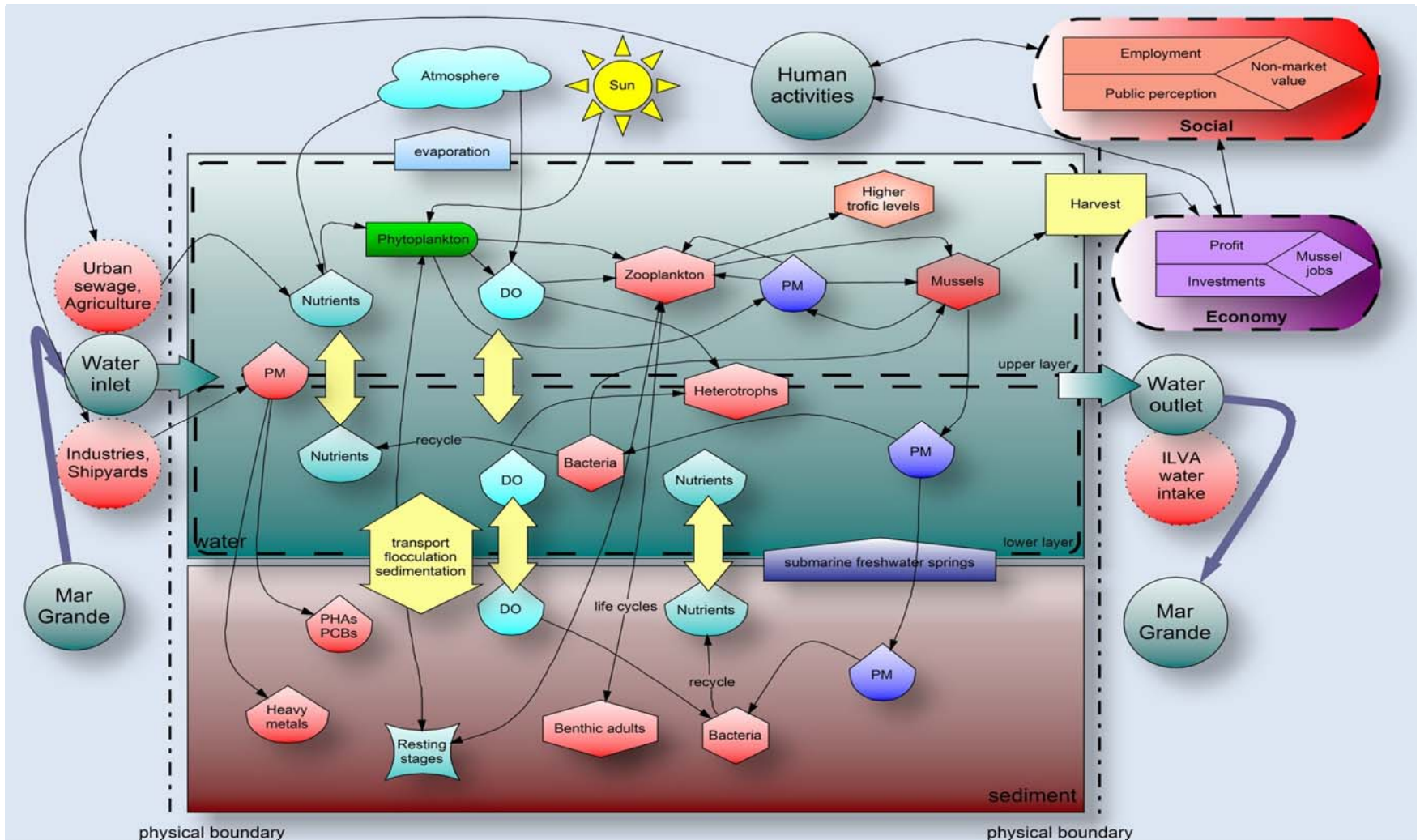
- How do different stakeholders perceive water quality?
- What are their demands with respect to water quality?
- Can a “good” water quality be reached in such impacted basin?
- If no what would be the alternatives?
- What are the sustainable policy options for reducing the decline of the productivity and quality of the mussels?
- How can this be done to the best long-term interest of the end-users and preserve the bio-productivity of the Mar Piccolo?
- What trade-offs and options would minimize such policy decisions?

The Scenarios

We have identified three categories:

- 1 What are the environmental conditions that control or are causing the mussel decline?**
- 2 What would be the costs and benefits derived by enacting the measures needed for sustainable mussel growth?**
- 3 What are the effects on human health derived from the exposure to hazardous levels of contaminants or microorganisms?**

The Virtual System



The VS functionality with regard to the Impact (reduction in mussel size) and the causal set of environmental conditions driven by its waste discharges

Major Problems about Data

Ecological Data

Scarce Information on:

- Geo-Chem-Bio-Physical Variables
- Ecosystem Functioning and Carrying Capacity
- Freshwater Fluxes from Streams, Land Drainage, and Aquifers
- Input Data on Waste Discharge (nutrients, particulate matter, synthetic chemicals)

Lacking Data on:

- Observational Sampling: e.g. Time Series, Depth Profiles, Spatial Coverage
- Process Observations: e.g. Primary Productivity, Sedimentation Rates, Mussel Filtration Rates and Assimilation

Major Problems about Data

Lacking of Socio-Economic Data

MARKET DATA

- Official prices were not available (maybe inexistent) for the Taranto market
- Official harvest figures were also not available (maybe inexistent)
- Quantitative estimate of Illegal production was not available

FINANCIAL BUDGET OF THE MUSSEL FARMS

- None of the major operation costs were available yet (!)
- Distribution of revenue was not available yet (!)
- We are waiting for the data from Chamber of Commerce

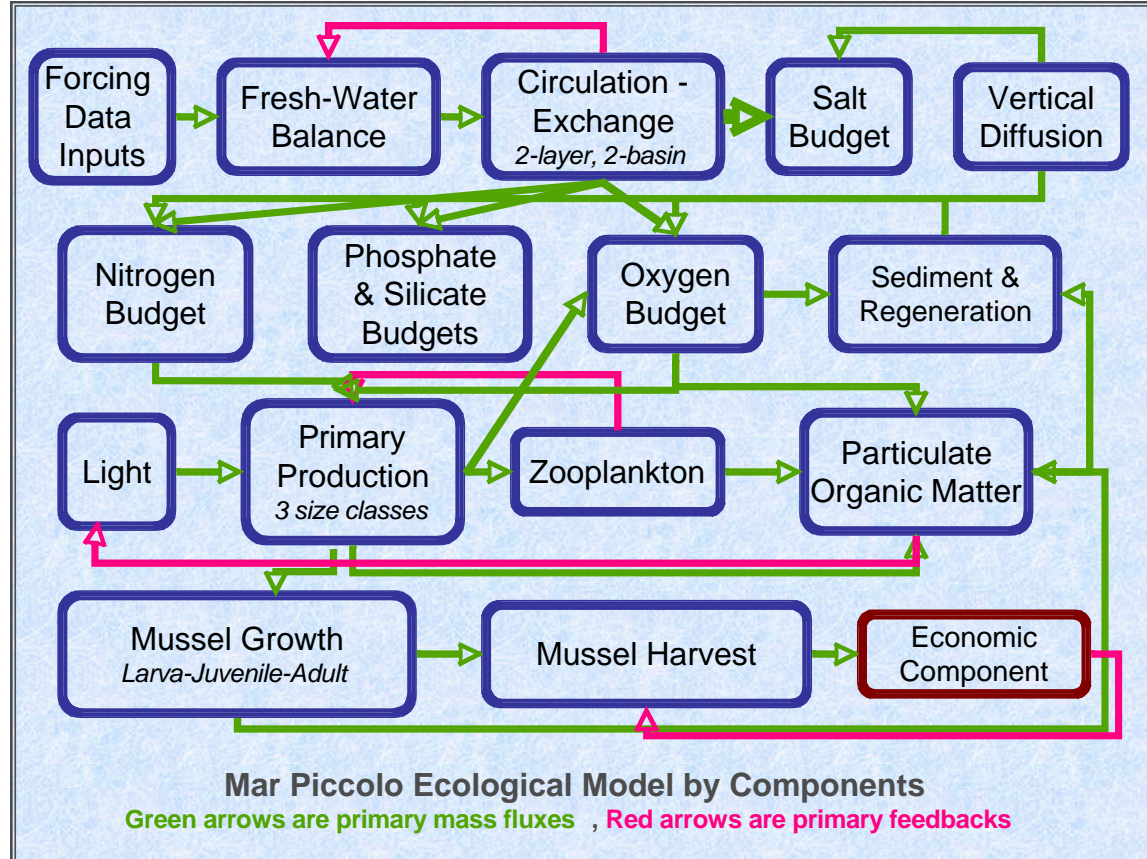
HEALTH COSTS

- Were not available for the public costs concerning exposure to mercury and PAHs due to mussel consumption

WILLINGNESS TO PAY

- At present we have not completed the analysis of questionnaires on willingness to pay and public perceptions

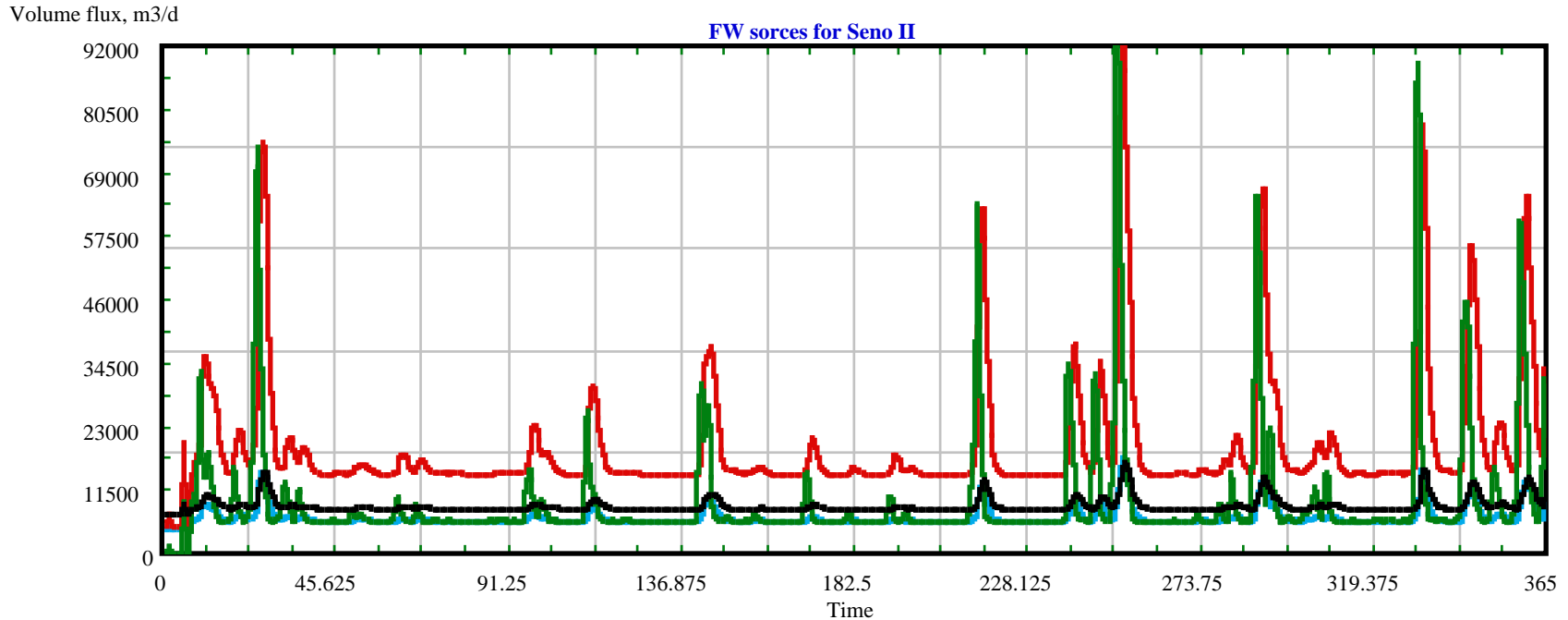
Ecological Component



The major components of the **Ecological Component** model (Extend) for the Mar Piccolo
Only the primary interactions are shown

FreshWater Balance

Fresh Water discharges into Seno II, Mar Piccolo in 2003



The various runoff components freshwater input to Seno II, Mar Piccolo
These were derived from annual means using simple land-runoff block

Annual Means

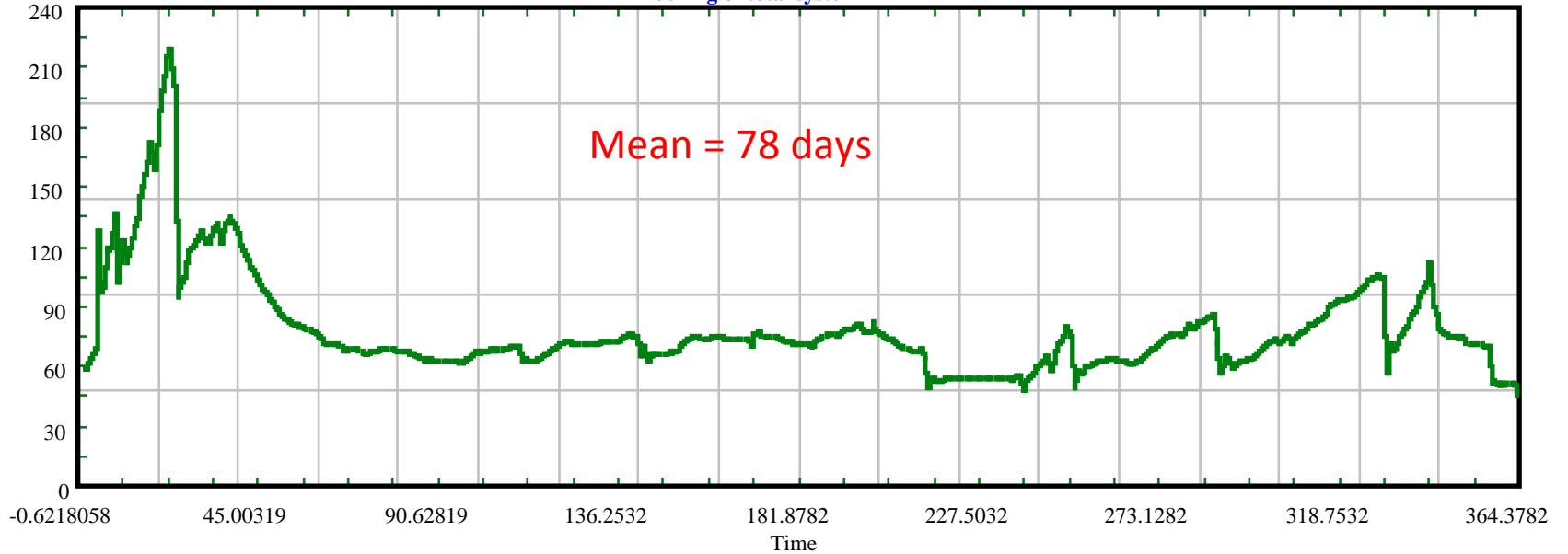
Ayedda Channel, Obs: 6,600 Mod: 6,629 Riso & Cervaro River, Obs: 19,267 Mod: 19,195

Le Copre Aquifer, Obs: 8640 Mod: 8718 Taranto urban runoff, Obs: ?? Mod:9491

Flushing

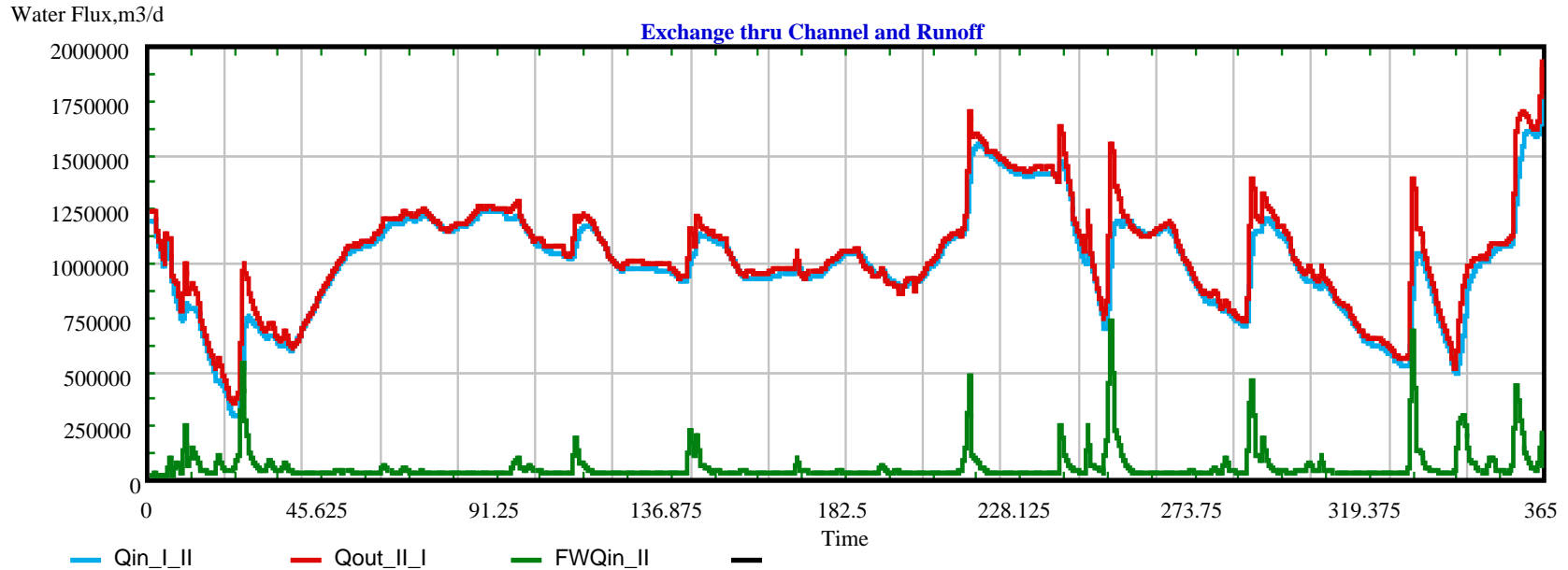
Flushing time, days

Flushing of total system



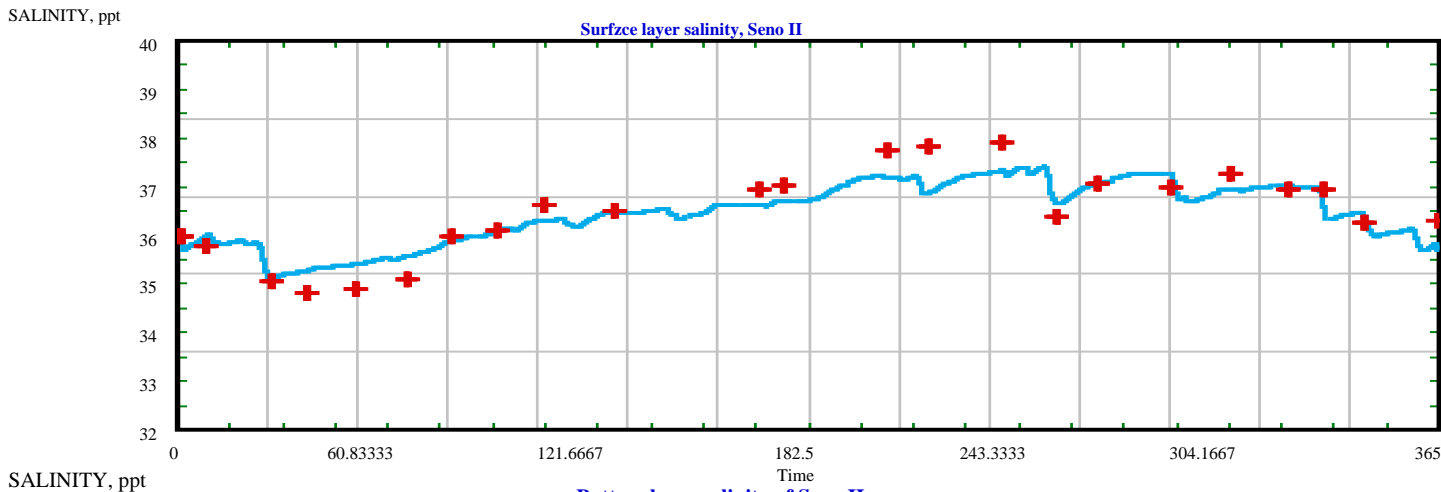
The daily flushing value (outflow/volume) for Seno II

Circulation Exchange



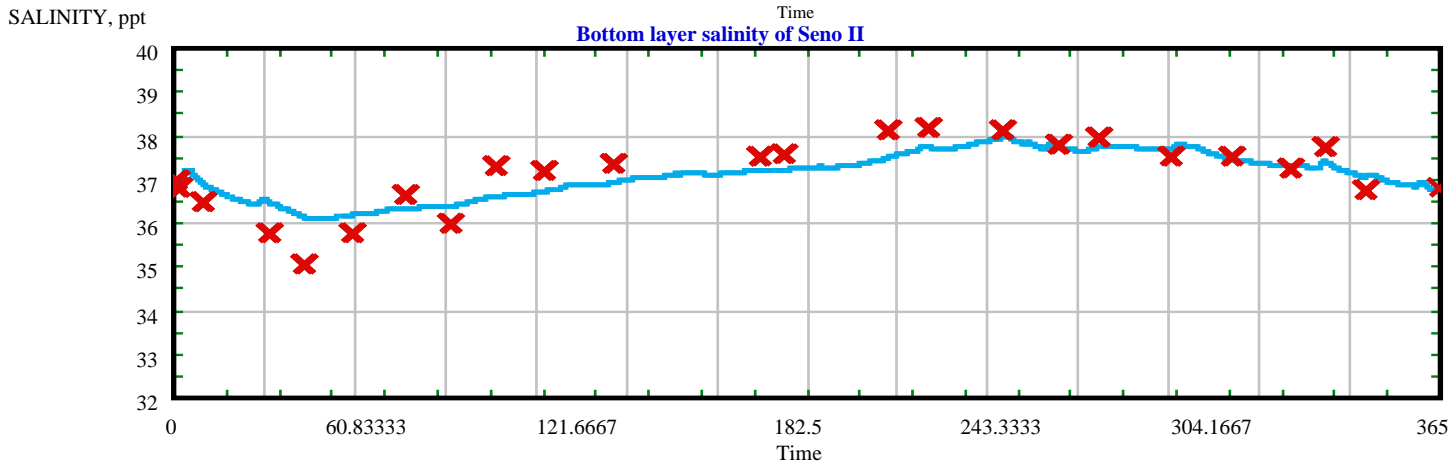
The Seno II inflow (blue), outflow (red), freshwater inflow (green) for the test year of 2003. This model uses the Thermohaline Exchange Method to determine the net exchange at its opening to a seaward water body. For each, time step calculates the internal salinity and the upper and lower layer fluxes from the inputs: meteorological, salinity outside, and runoff. (Hopkins, 1999)

Salt Budget



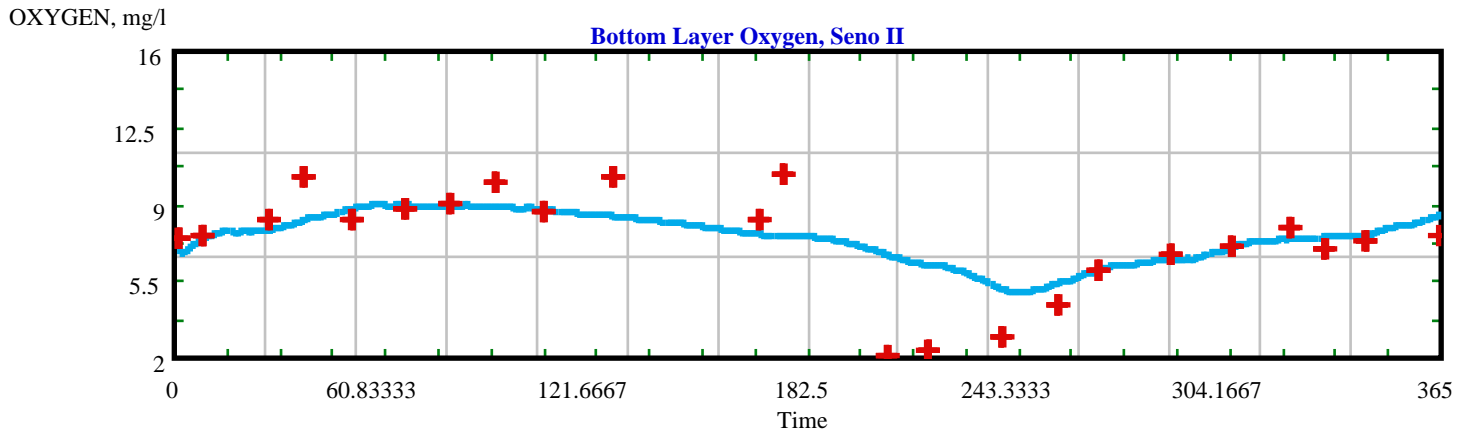
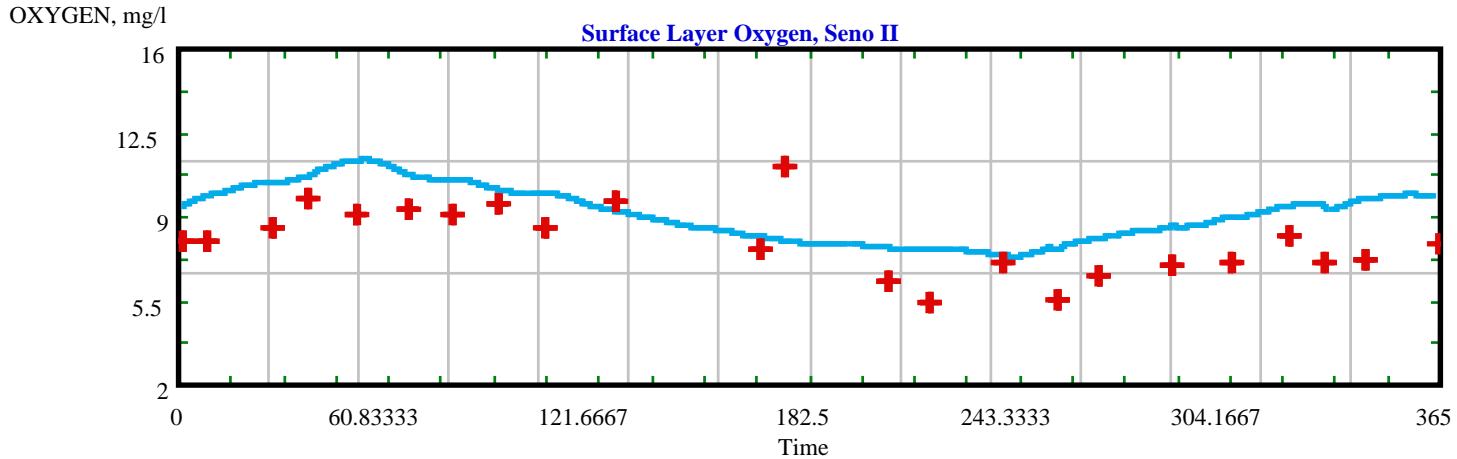
Annual averages

| | |
|---------|------------|
| Bottom | Obs: 36.46 |
| | Mod: 36.46 |
| Surface | Obs: 37.11 |
| | Mod: 37.10 |



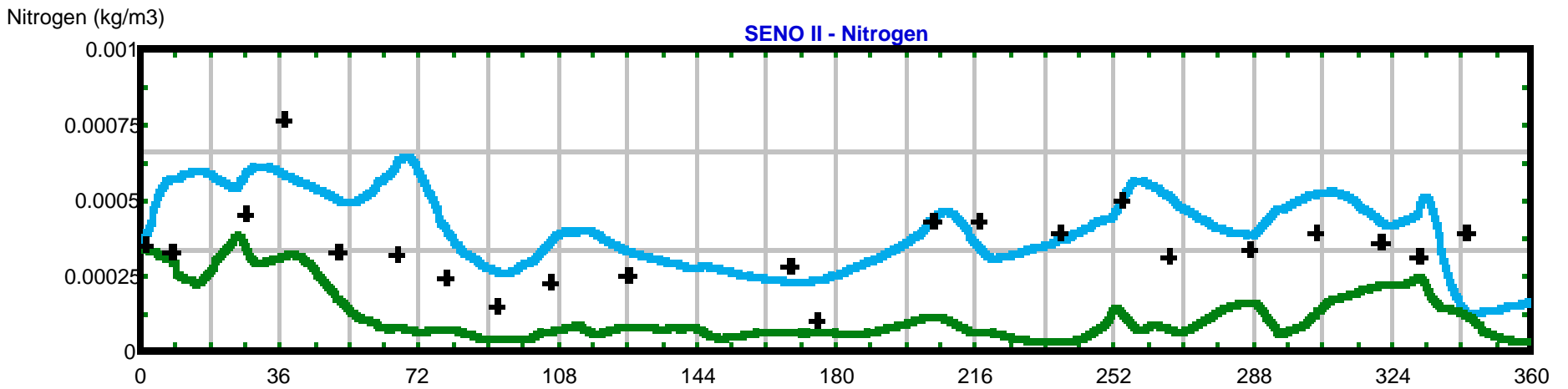
The Surface and Bottom layer salinities in Seno II (blue line) compared with vertically integrated salinities (red x) from a single station approximately in the center of the Seno II. Calibrated through the 3 parameters controlling the salt flux: Channel Restriction, Vertical Diffusion, and FW flux correction.

Oxygen Budget



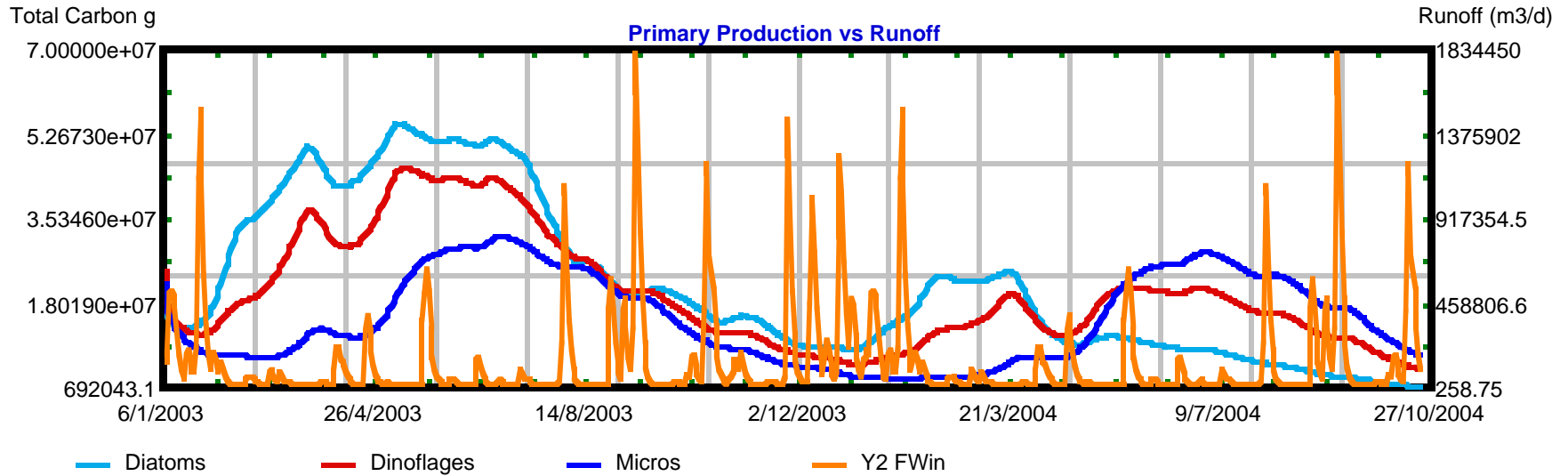
The Surface and Bottom layer Oxygen in Seno II (blue line) compared with vertically integrated oxygen (red x) from a single station approximately in the center of the Seno II. Fine tuning of calibration has not been done yet awaiting refinements in the Nitrogen and Phytoplankton Components.

Nitrogen Budget

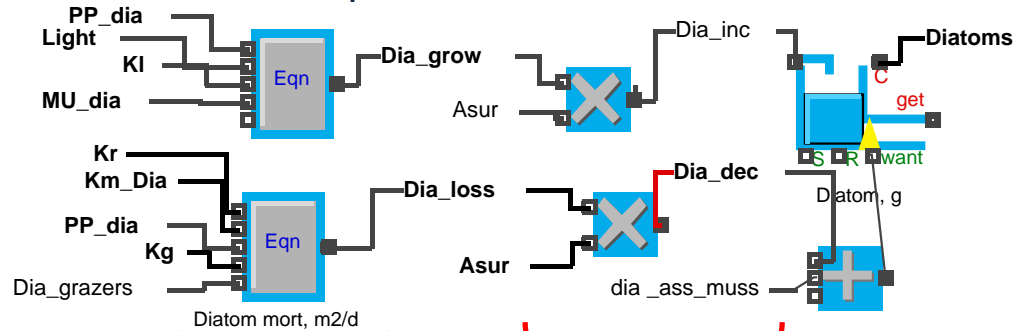


The surface and bottom nitrogen in Seno II
This component is still being refined

Phytoplankton



Example for Diatoms Growth



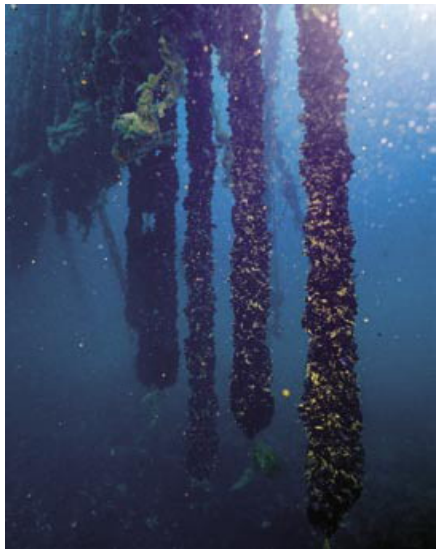
Natural mortality and ZP grazing

Mussels grazing

Mussels

Dimensional parameters:

- farming area
- line length (min:max)
- number of lines (min:max)
- wrap distance (min:max)
- wrap length (min:max)
- Initial stock (seeds): 1/7 of the final production



These controls will allow to test the carrying capacity of mussel farming for MP

Mussels Farm Controls

A screenshot of a software interface for controlling a mussel farm. It features four vertical sliders, each with a numerical value and a range. The sliders are labeled: 'line length' (value 247.5, range 0-250), 'number of lines' (value 8000, range 0-8000), 'wrap distance' (value 2, range 0-2), and 'wrap leng' (value 3.72, range 2-4). A 'Help' button is located at the bottom right. The interface is connected to a photograph of a person on a boat handling a mussel farming line in the ocean.

Mussels Farm

line length

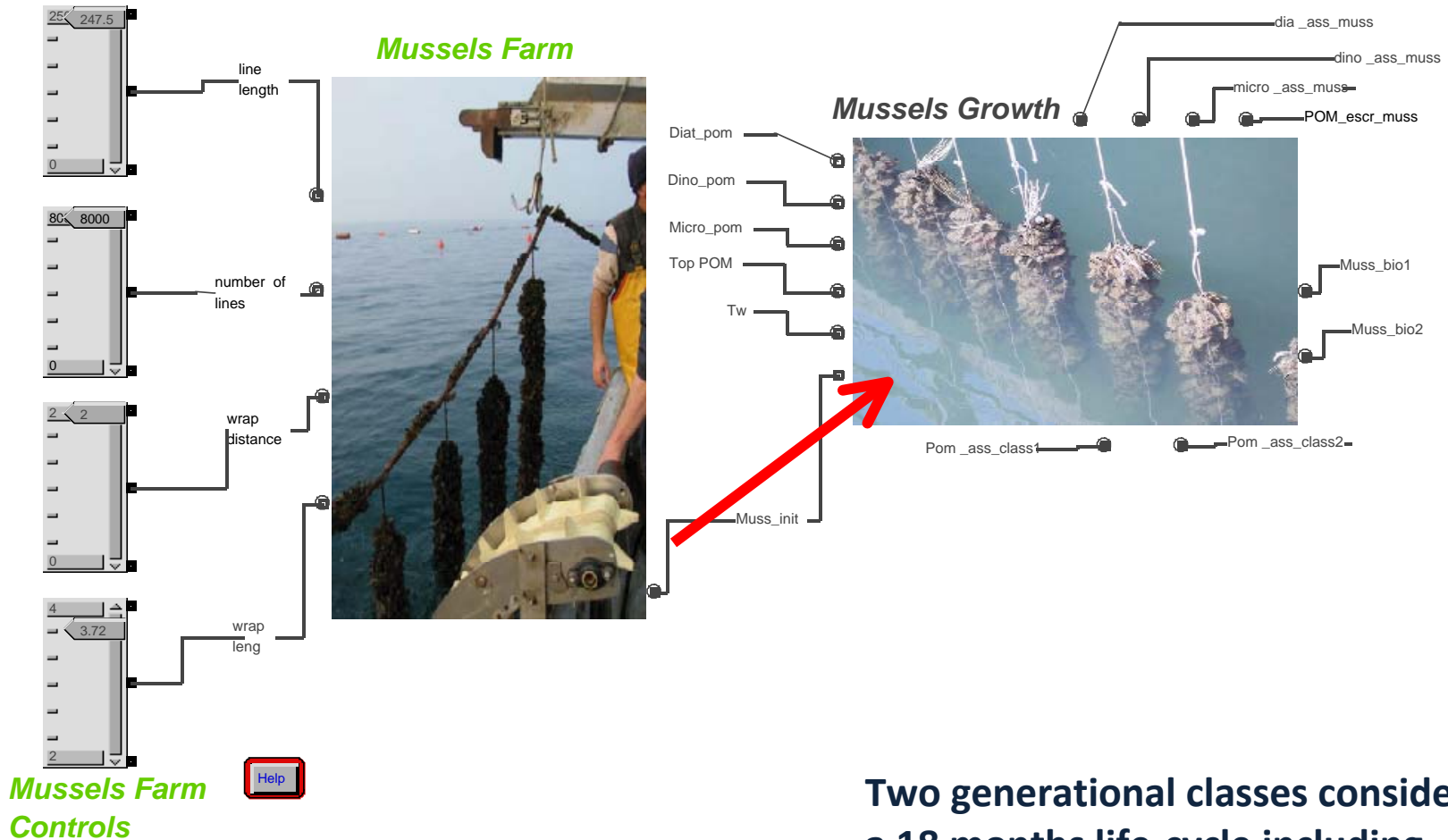
number of lines

wrap distance

wrap leng

Help

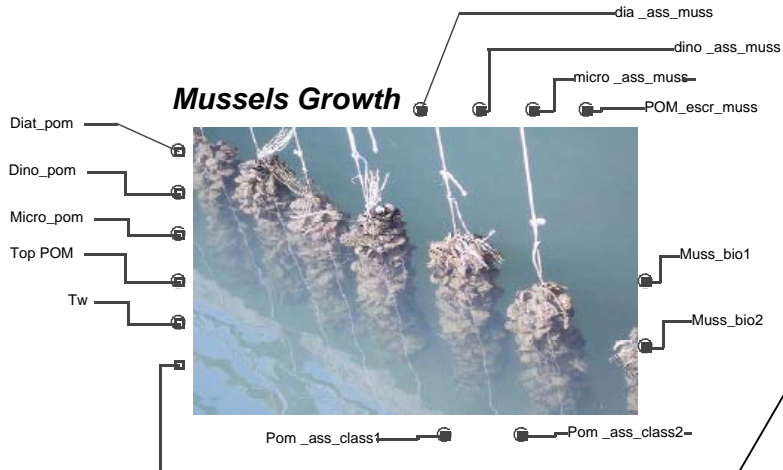
Mussels



Two generational classes considering a 18 months life-cycle including harvesting phase

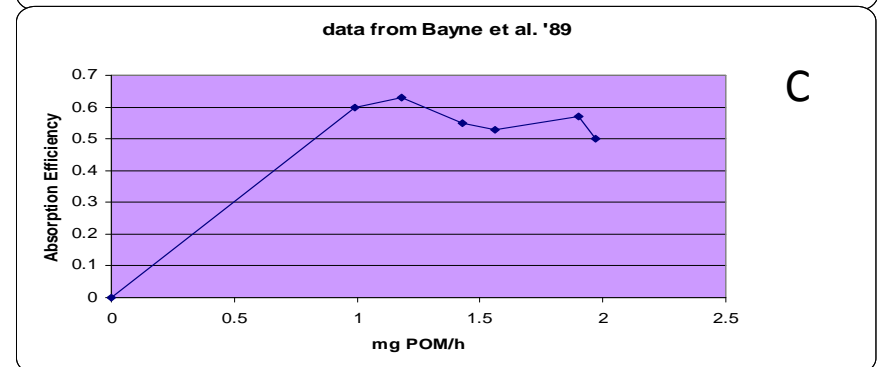
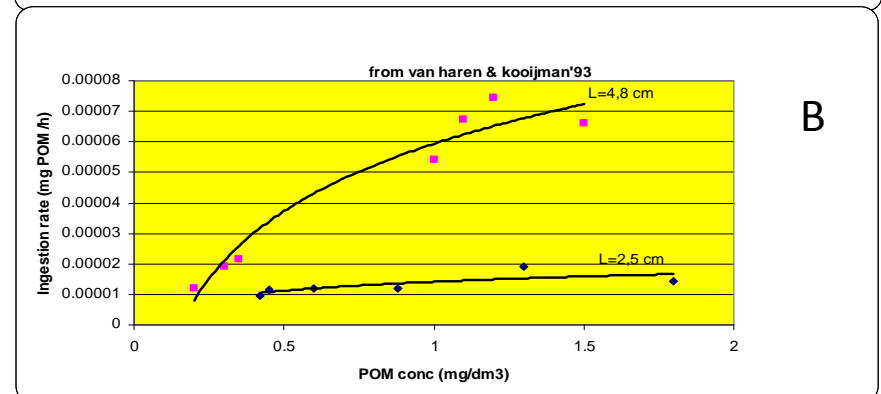
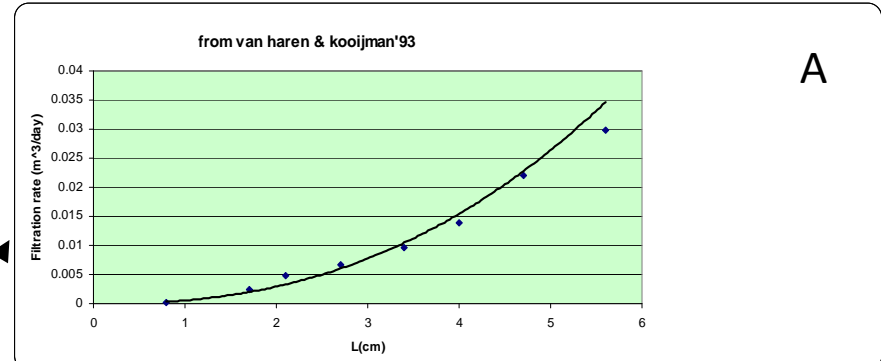
Mussels: Formulation of Growth Rates

Growth parameters according to a bioenergetic model by Van Haren & Kooijman, 1993

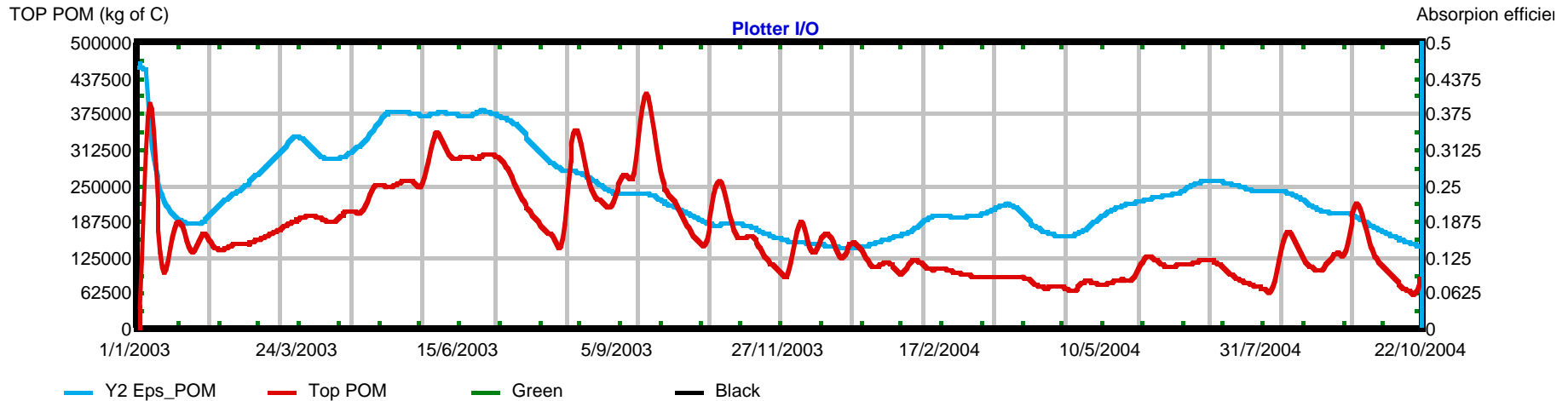


Empirical curves used to formulate three critical processes:

- A. Filtration Rate**
- B. Ingestion Rate**
- C. Absorption Rate**
(depending on POM composition)



Mussels: Absorption Efficiency



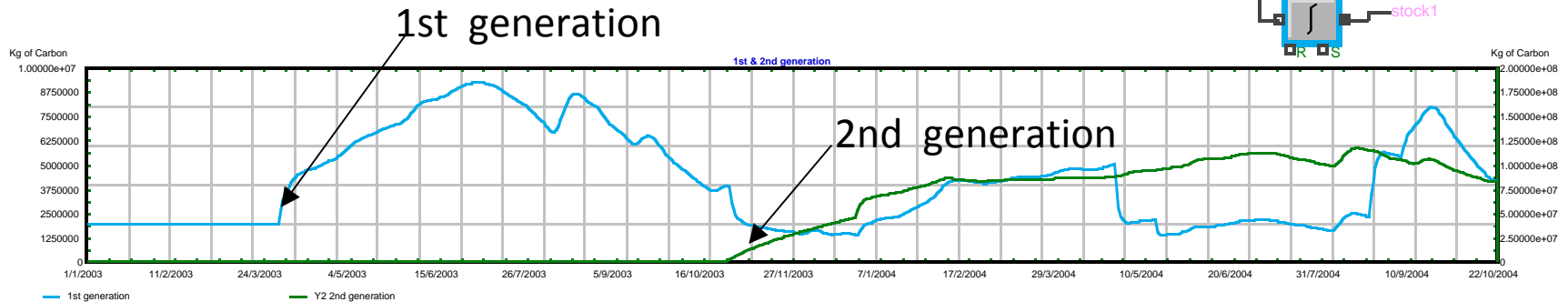
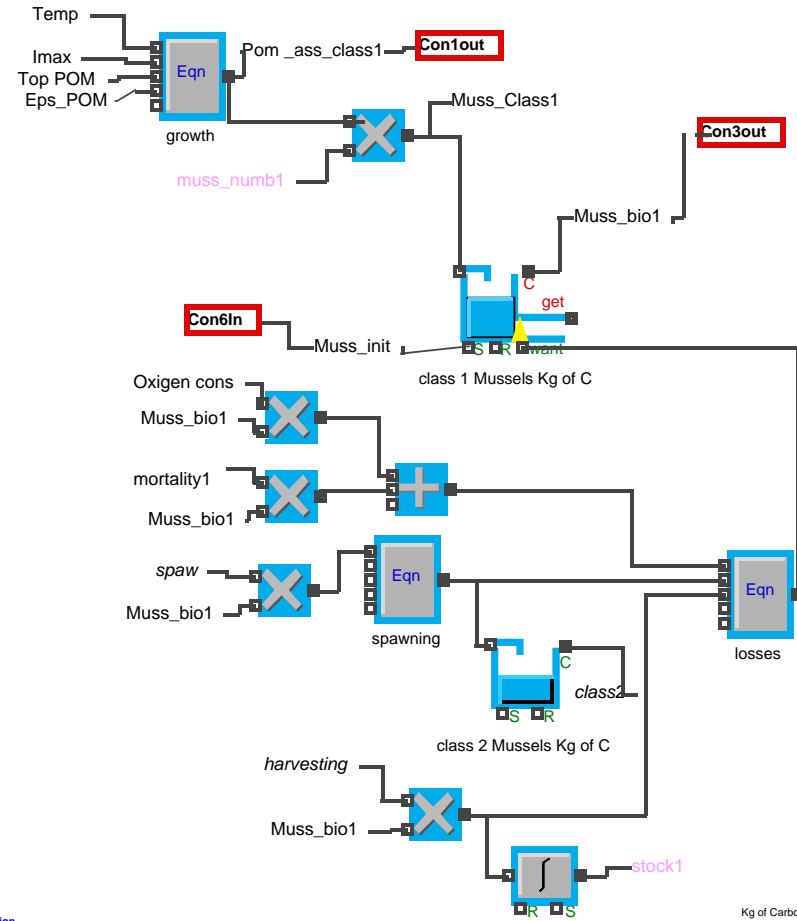
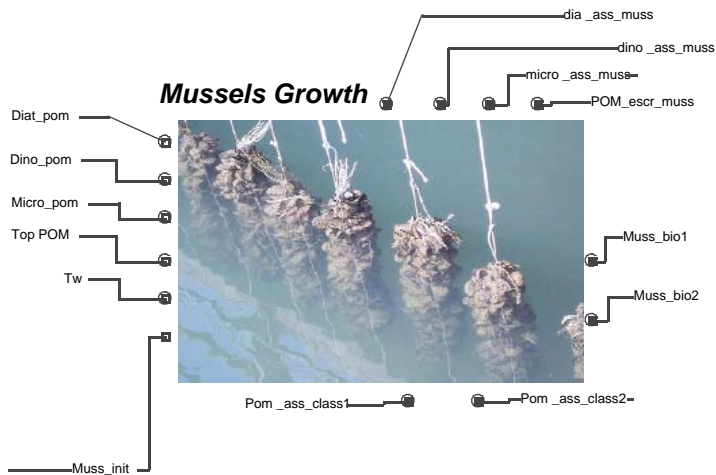
Three coefficients were used to represent the absorption efficiency due to POM composition:

- A. Diatom Efficiency (45%)
- B. Dinoflagellate Efficiency (30%)
- C. Nanoplankton Efficiency (25%)

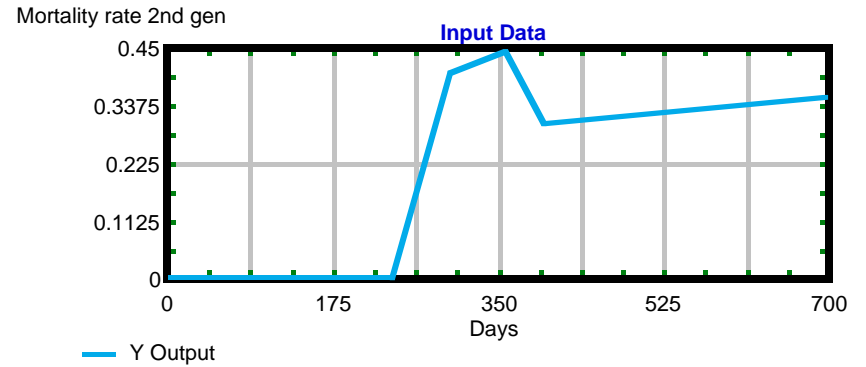
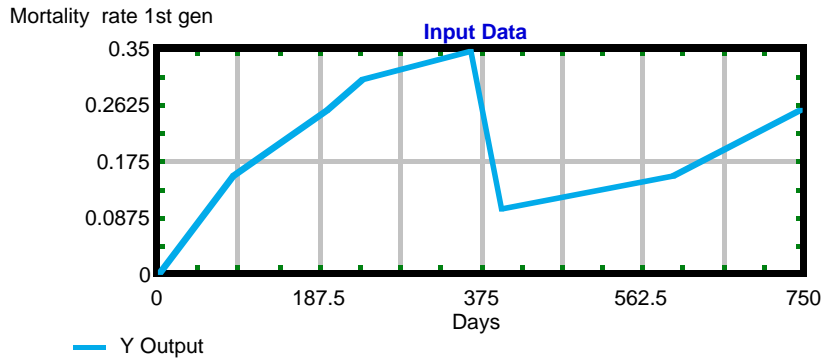
Mussels: Biomass Curve

1st Generation

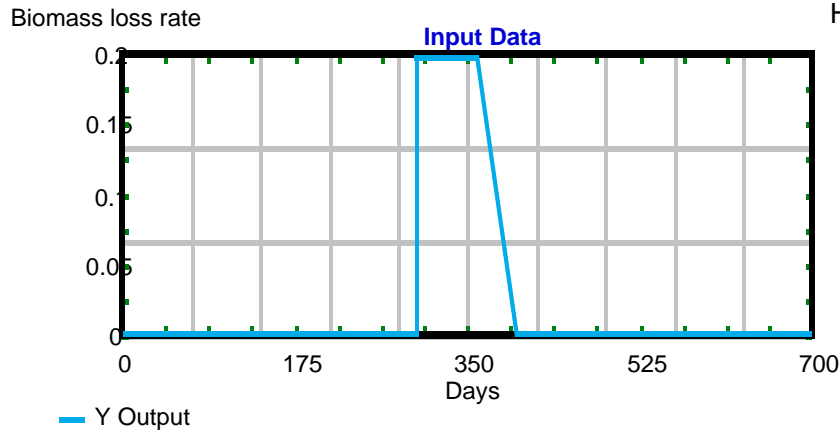
Mussels Growth depends on Temperature (Q10), Ingestion rate, Absorption Eff. and POM



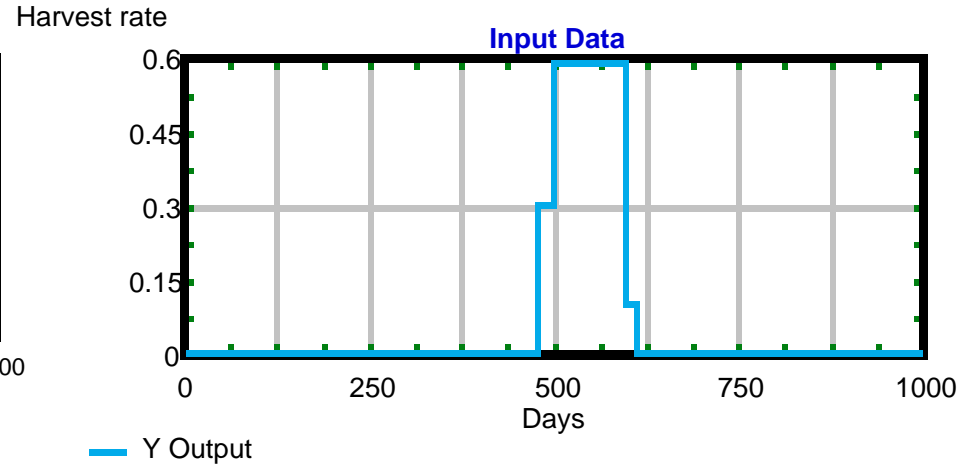
Mussel Growth: Loss Terms



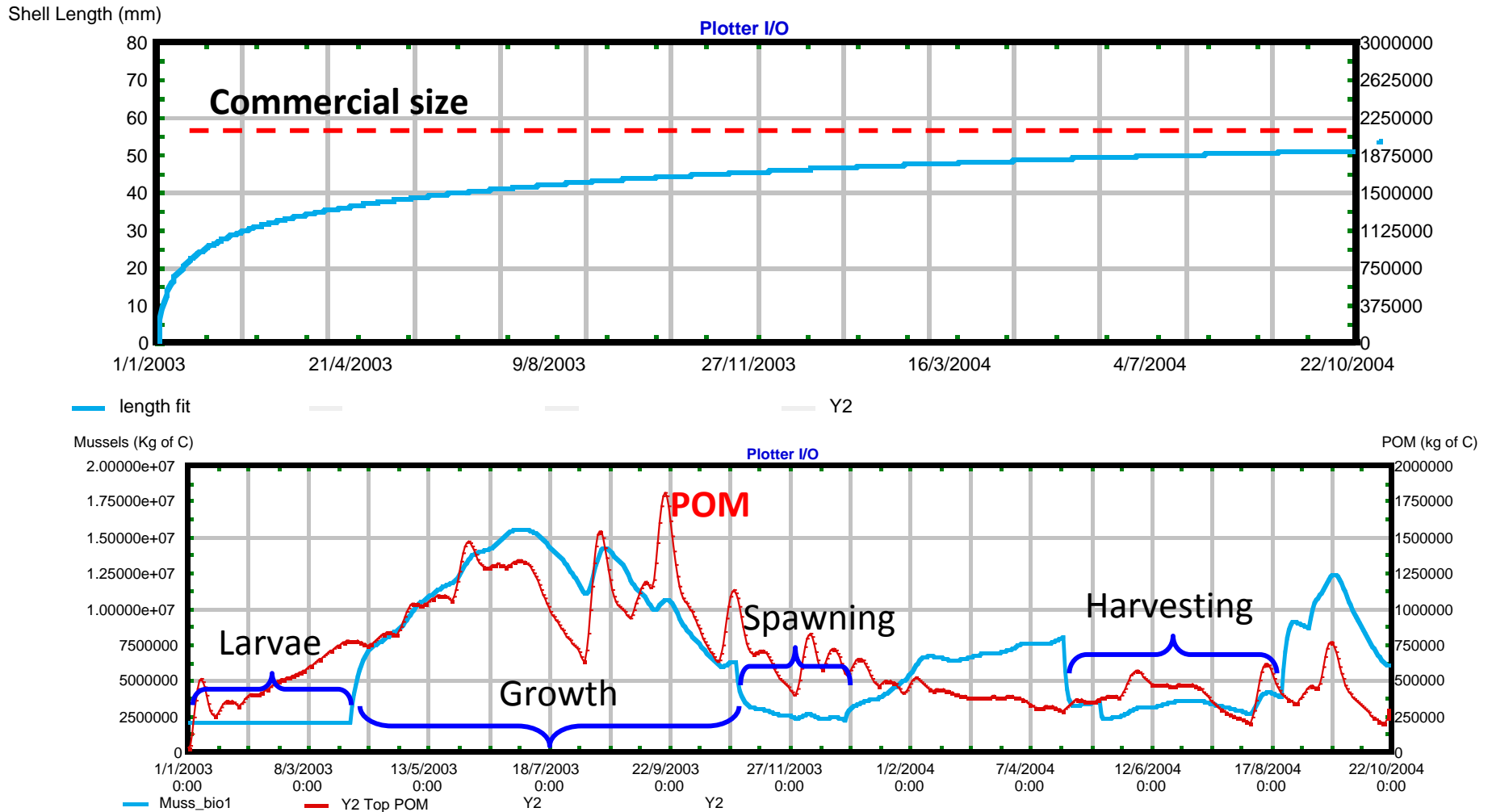
Biomass loss due to spawning



Biomass loss due to Harvest



Mussel Growth: The Whole Picture



The MP mussels life cycle simulation is based on 18 months, including harvesting

Modifications In Progress

- **To complete the interface between biomass of mussels and biomass of harvest**
- **To connect the two basins of the Mar Piccolo**
- **To calibrate the phytoplankton biomass**
- **To estimate the sustainable yield of the system (C:N ratios)**
- **To simulate various nutrient ratios and loading**
- **To simulate the Condition Index (CI) [shell weight/meat weight]**

Socio-Economic Dimension, Simulated

The socioeconomic dimension of SSA 14 is Focused on some of the socio-economic responses related to the decline of the mussel culture

Mussel Farm Socio-Economy

Relation with Coastal Zone Socio-Economy

Socio-Economic Dimension, Simulated

The socioeconomic dimension of SSA 14 is Focused on some of the socio-economic responses related to the decline of the mussel culture

Mussel Farm Socio-Economy

- In Taranto the mussel farms are mostly managed as Cooperatives (about 80%)**
- The mean age of employees has increased progressively because of failure of generational turnover, characteristic of traditional family-run enterprises**
- The “illegal” employment consists of family members of the managers of each cooperative, who are utilised during the harvest. This is a cultural tradition typical of farming in southern Italy**
- Evidence exists that a Consortium of the Cooperatives would be a better way to manage the mussel farming**
- As a Consortium there will be advantages in terms of employment benefits and net revenue**

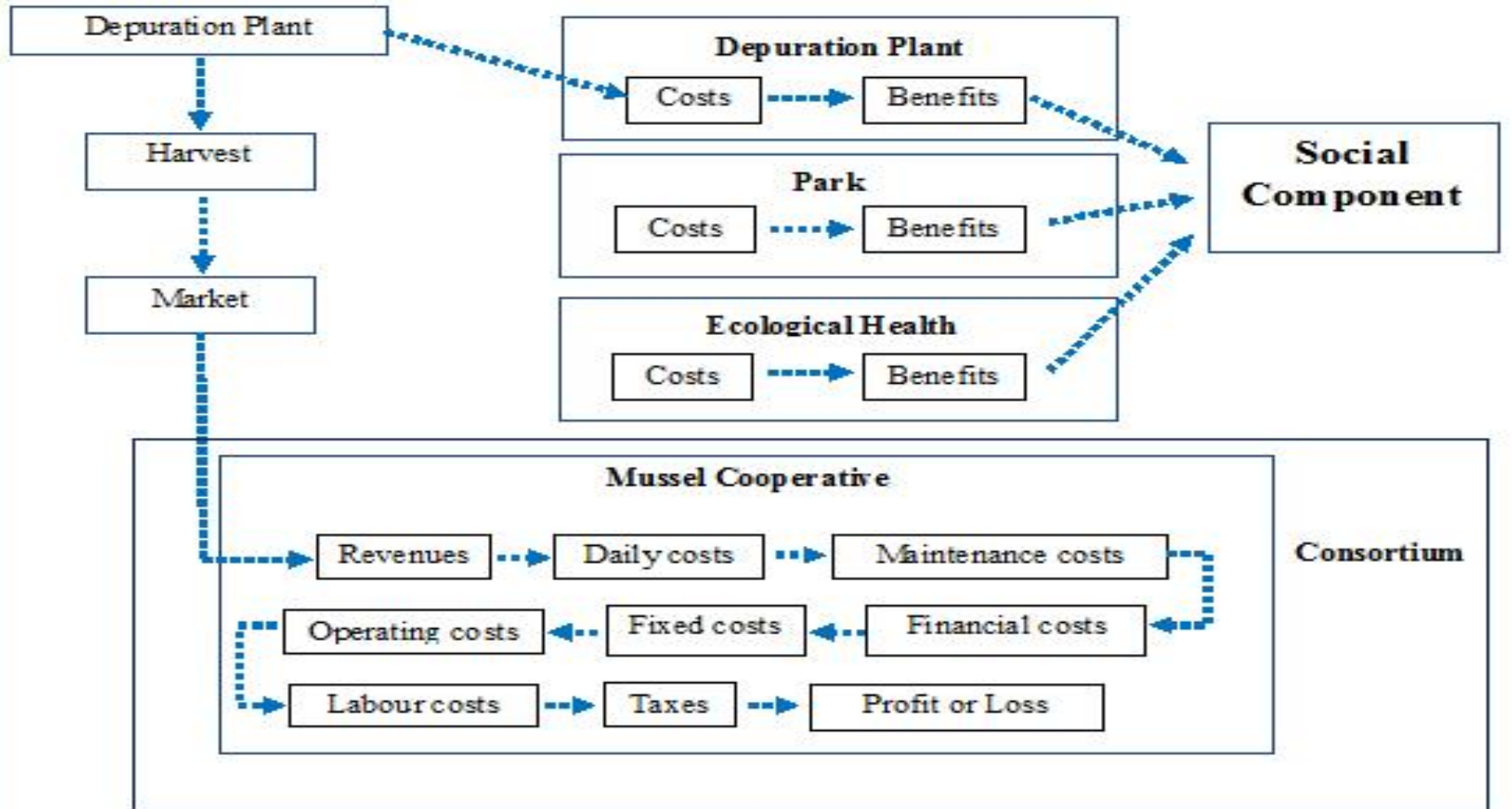
Socio-Economic Dimension, Simulated

The socioeconomic dimension of SSA 14 is Focused on some of the socio-economic responses related to the decline of the mussel culture

Relation with Coastal Zone Socio-Economy

- The need for coordinated waste-disposal plan (nutrient ratio management and elimination of toxic substances, etc.)
- The need to evaluate options for improving the ecosystem health and perceived use value of the Mar Piccolo (shoreline beautification, urban park, fishing, mussel tourism, etc.)

Economic Component



Depuration Plant

Harvest

Market

Depuration Plant

Costs

Benefits

Park

Costs

Benefits

Ecological Health

Costs

Benefits

Social Component

Mussel Cooperative

Revenues

Daily costs

Maintenance costs

Operating costs

Fixed costs

Financial costs

Labour costs

Taxes

Profit or Loss

Consortium

C.B.A.

DEPURATION PLANT

- Improvement of the water quality
- Improvement of the mussel quality and perception
- Increase of the willingness to invest on building around the Mar Piccolo of Taranto.

ECOLOGICAL HEALTH

- Directly linked to the Benefits of the park and the depuration plant:
the increase of value of real estate market

PARK

- Increase of value of real estate market
- Energy saving (less use of air conditioning)
- Mitigation of greenhouse effect (uptake of CO2)
 - Decrease of air pollution (vegetation filters a part of pollutants).



Market



Harvest

- Harvest_tot
- Price_1_time_Coop
- Price_2_time_Coop
- Price_3_time_Coop
- Price_1_time_Consortium
- Price_2_time_Consortium
- Price_3_time_Consortium

Harvest_Tot



Harvest_Cooperative

- Price_1_time_Consortium
- Price_2_time_Consortium
- Price_3_time_Consortium
- Harvest_tot
- WTP_Mussel_Quality



- Cost_Traditional_Dep
- Benefits_Traditional_Dep

- Price_1_time_Coop
- Price_2_time_Coop
- Price_3_time_Coop
- Price_1_time_Consortium
- Price_2_time_Consortium
- Price_3_time_Consortium
- Harvest_Tot
- Harvest_Cooperative



- Tot_Rev_Consortium
- Profit_Coop_Consortium

- Price_1_time_Consortium
- Price_2_time_Consortium
- Price_3_time_Consortium
- Harvest_tot
- WTP_Mussel_Quality



- Cost_Natural_Dep
- Benefit_Natural_Dep

- Harvest_Cooperative
- Price_1_time_Coop
- Price_2_time_Coop
- Price_3_time_Coop



- Tot_Rev_Cooperative
- Profit_Coop
- Loss_Coop

WTP_Ecological_Health



- Cost_Ecological_Health
- Benefit_Ecological_Health



- Cost_Park
- Benefit_Park

Experiment...

*We have imagined to contribute to the realization of a Consortium
of Mussel Cooperatives*

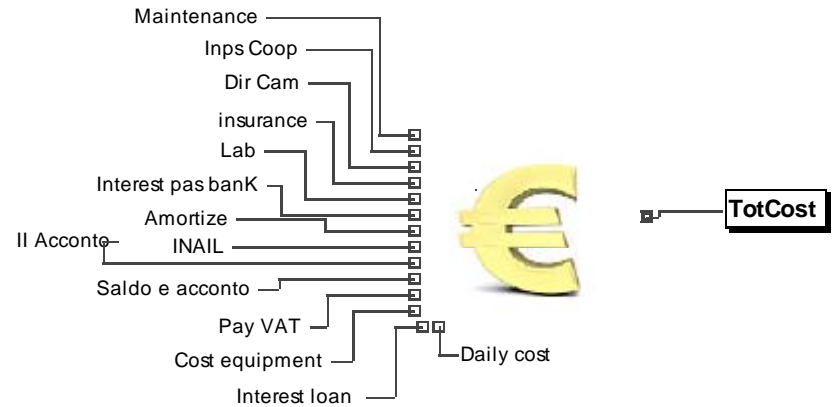
INDIVIDUAL
COOPERATIVE



COOPERATIVES OF
CONSORTIUM



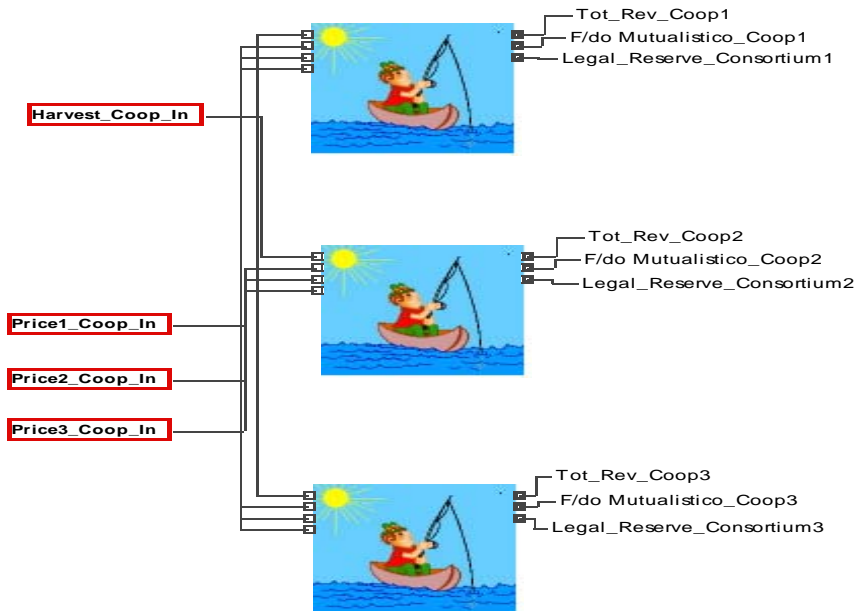
Mussel Cooperative



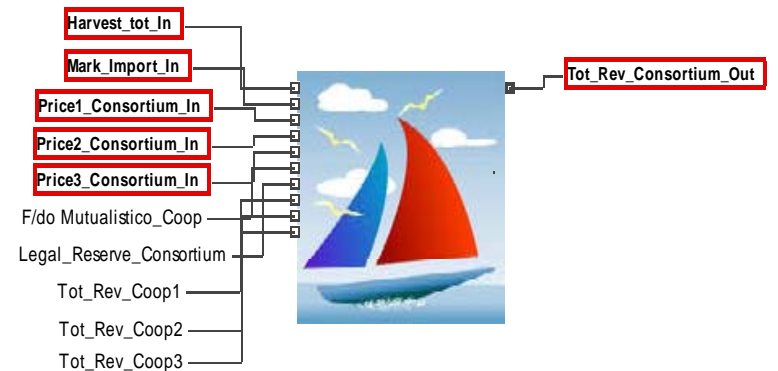
Mussel Consortium



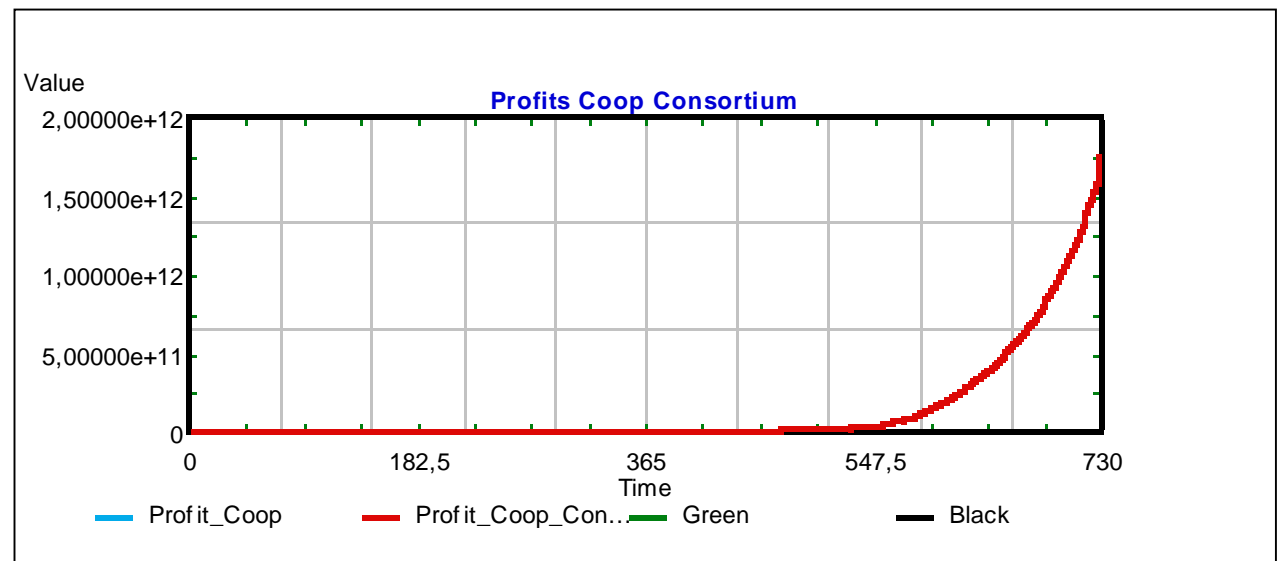
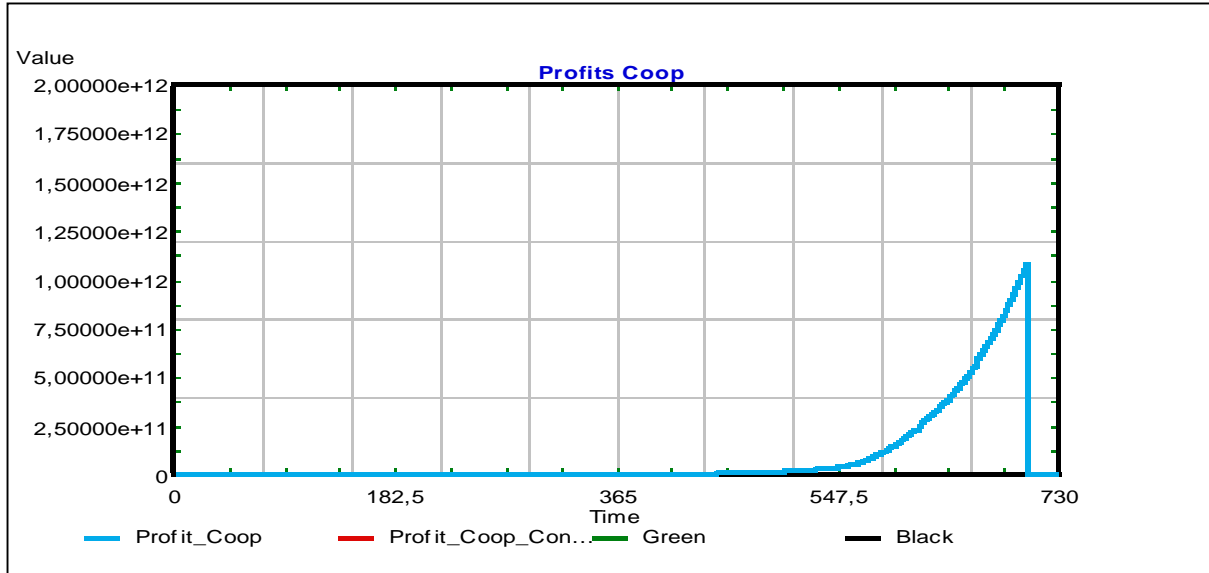
Cooperatives of Consortium



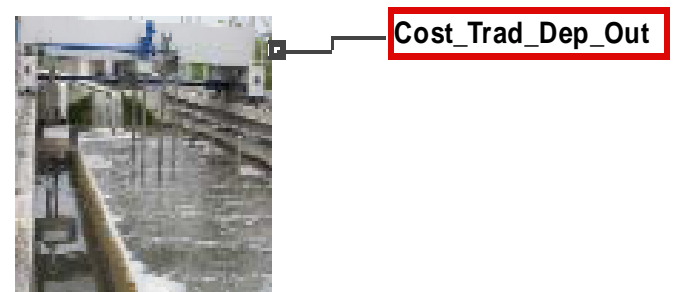
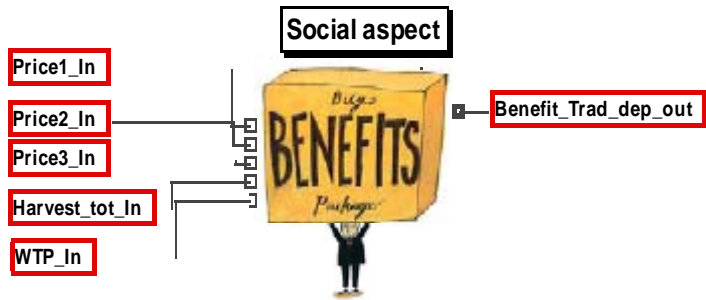
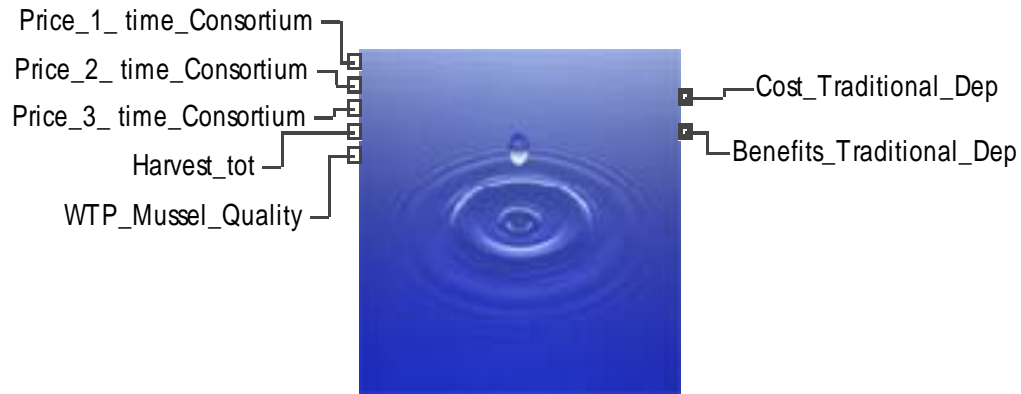
Consortium



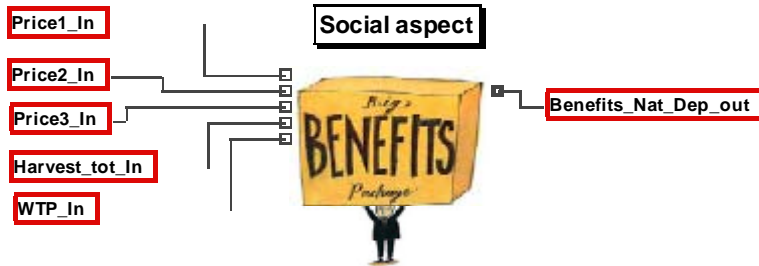
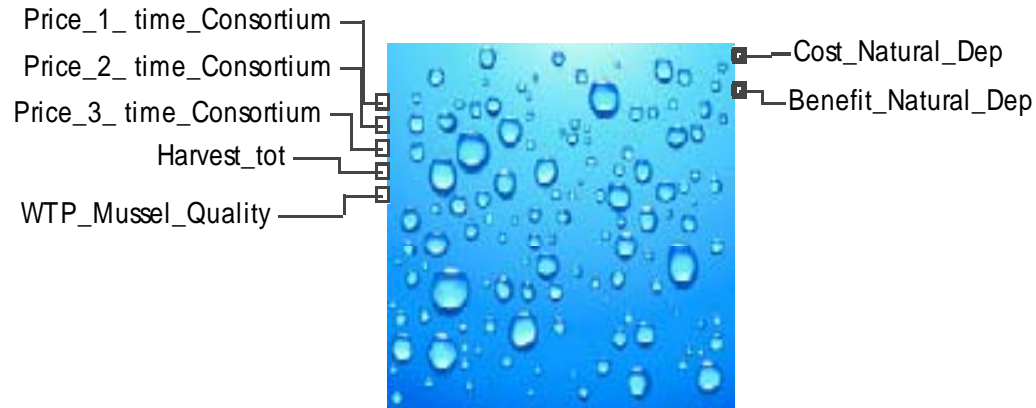
Cooperatives vs Consortium of Cooperatives Profit



Traditional Depuration Plant

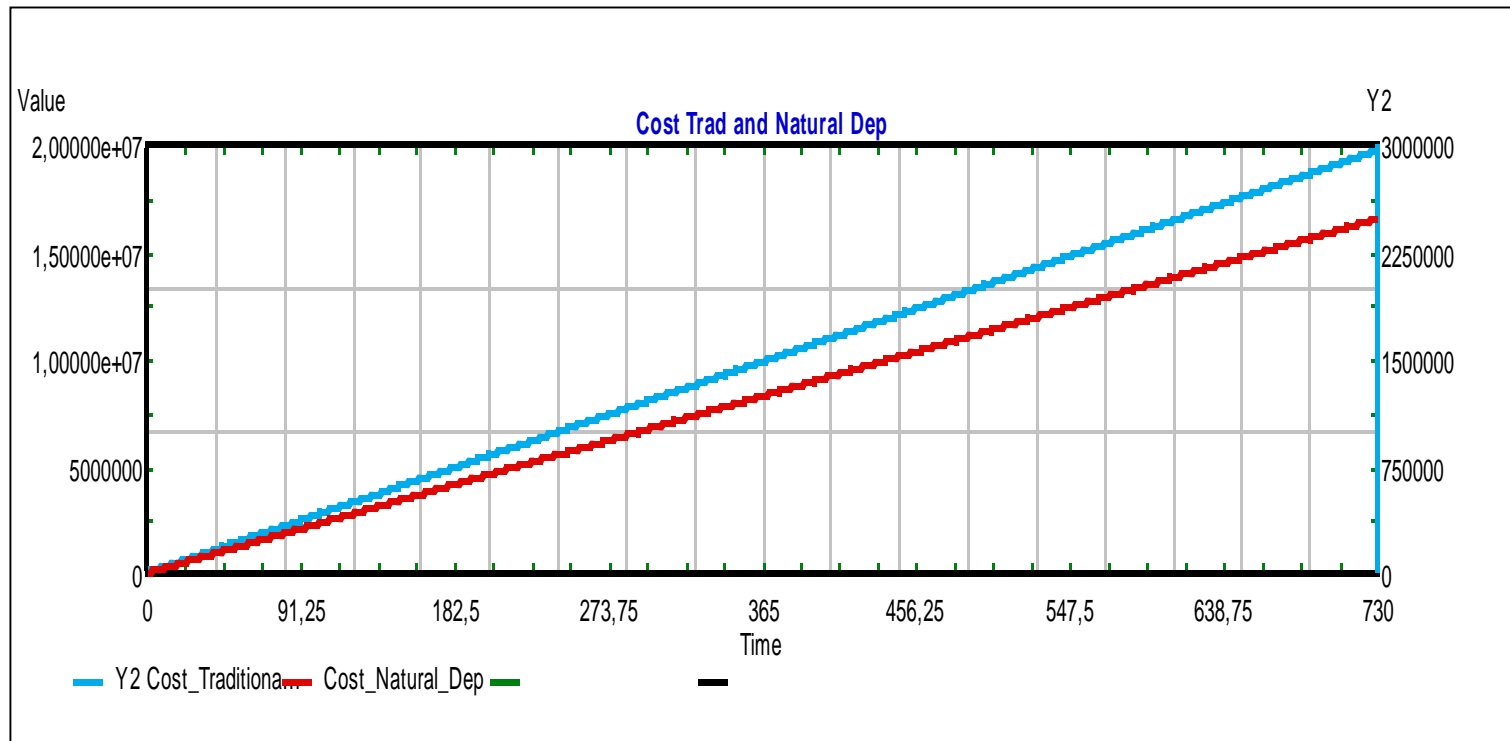


Natural Depuration Plant



Cost_Nat_Dep_out

Traditional vs Natural Plant Costs



Environment & Public Health

WTP_Ecological_Health



Cost_Ecological_Health

Benefit_Ecological_Health

Social aspect

WTP_Ec_Health_In

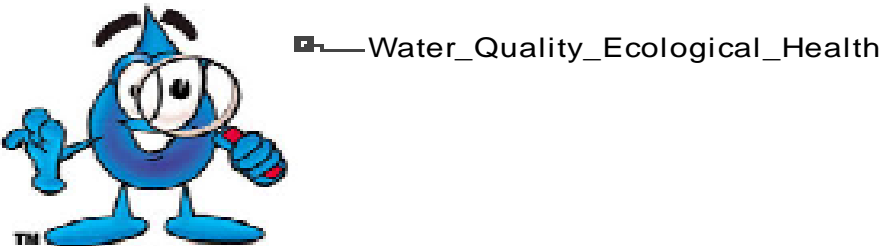
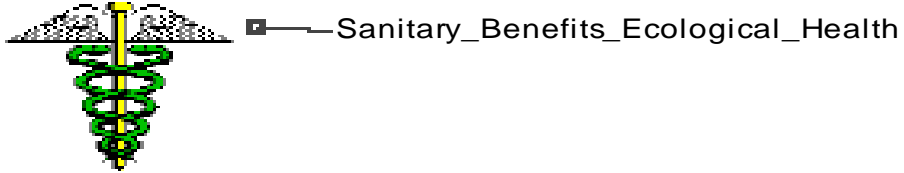


Benefit_Ecological_Health_out



Cost_Ecological_Health_Out

Benefits for Environment & Public Health



Park

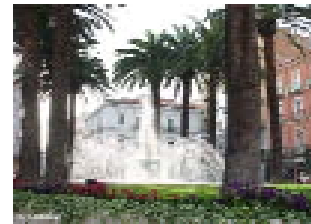


- Cost_Park
- Benefit_Park

Social aspect

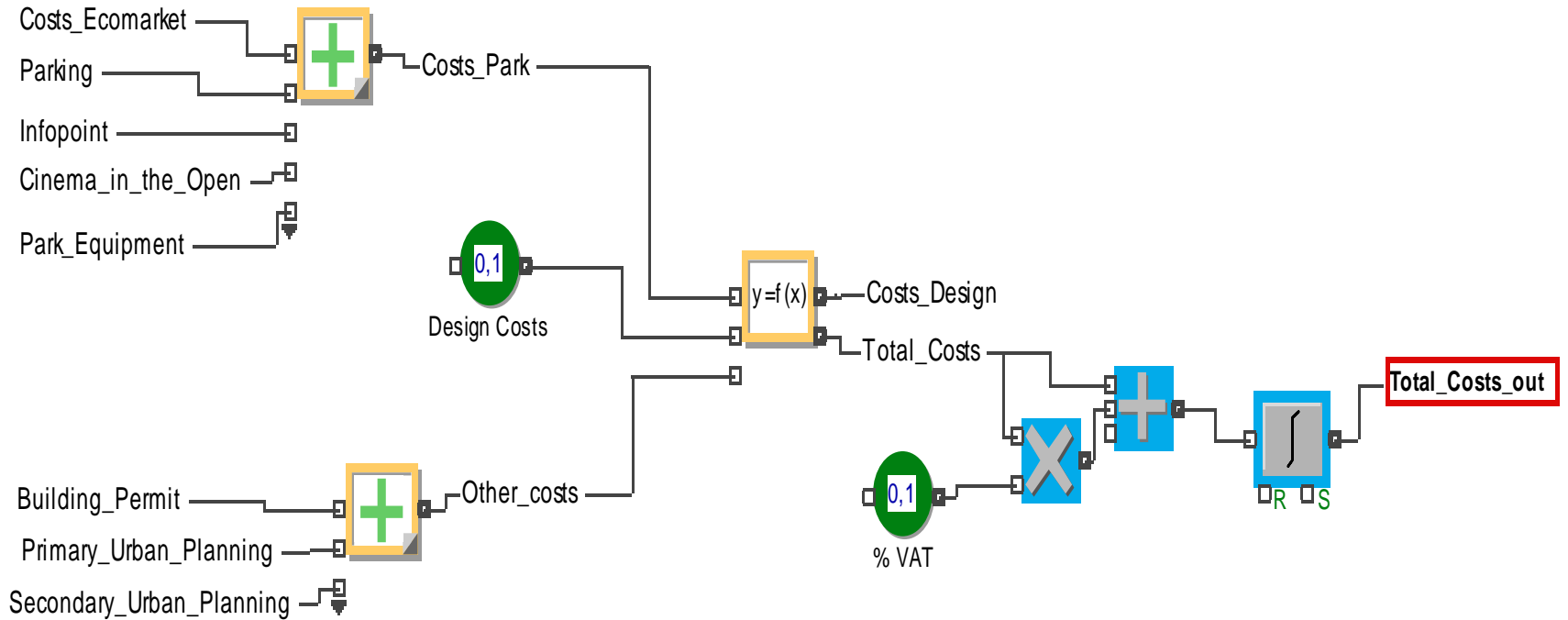


Benefit_Park_out



Cost_Park_Out

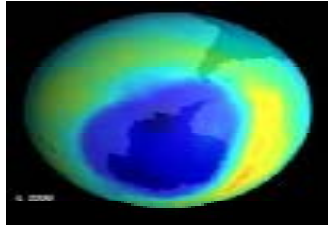
Park Costs



Park Benefits



■ — Total_Energy_Saving



■ — Mitigation_Greenhouse_Effect



■ — Decrease_Air_Pollution



■ — Increase_Real_Estate_Market

Costs vs Benefits of the Park

