

1. Issue and virtual system

The policy issue is the sustainable management of the mussel farming area of Chalastra. The last decade the operation of the WWTP of Thessaloniki altered the nutrient balance in Thermaikos gulf. At the same time, due to institutional and management failures, 60% of the owners of long-line mussel farms are operating illegally; the activity is under no official institutional control, having as a consequence illegal and extreme mussel farming techniques, in order to maximize production and profit. Nevertheless the mussel production is declining annually, causing economical and social pressure to the local community. The greater area of Chalastra is separated into four spatial compartments for formulation purposes, one of them being the mussel farming area, also separated into four sub-areas in order to identify the importance of placing on the mussel production.

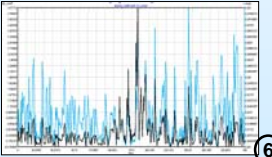
2. Extend model

The highest hierarchical level of the model demonstrates the three major components: ecological (inorganic nitrogen, phytoplankton, circulation patterns), mussel farming area (incorporating both the ecology & economy of the mussel farm) and social (management & "social welfare"). The three components can be managed individually, enabling the development or the alteration of each one, if required.

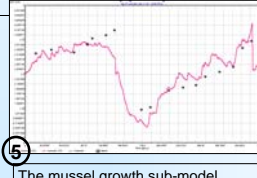
The social component is an on/off switch for the management "enforcement" & an accumulator of the profits.

Both the ecological and the economical component of the mussel farm provide user friendly choice panels, where someone can choose farming characteristics and cost parameters, thus testing different management scenarios.

The "mussel farming area" component is comprised from 5 sub-components, 4 demonstrating sub-areas of mussel farming and a reference area, for comparison purposes.

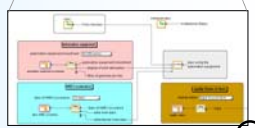


Mussel growth is depended on a) the availability of food (phytoplankton & TOC), b) the environmental conditions (temperature & circulation) and c) the farm characteristics influencing the density of the farm.



The mussel growth sub-model produces values that are presenting satisfying adaption to the filed data collected from the mussel farming sub-areas. The figure shows the observed values of mussels at the mussel farm representing sample stations M1 compared to the values produced by the model.

The "density coefficient" is related both to the farm characteristics & to the water velocity in the area, thus comparing the required water velocity for the feeding of the mussels to the current one. As shown in the figure, this coefficient is most of the times >1.



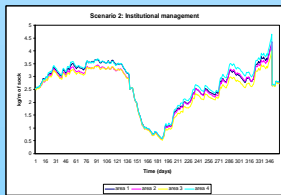
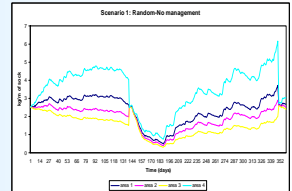
The economical sub-model is contacting a Cost-Benefit analysis for the individual mussel farm. The profits are then aggregated to produce a prospect for the amount of money entering the local community, as an indicator of the "social welfare".

3. Scenario analysis

Scenario 1	area 1	area 2	area 3	area 4
status	illegal	legal	illegal	illegal
line no	14	12	16	12
line distance (m)	9	10	8	5
sock distance (m)	0.6	0.4	0.4	0.8
sock length (m)	3.25	3	3.5	3.25
no of farms	13	18	12	12
individual profit (€)	41925	42920	40354	48340
area profit (€)	545032.21	772558	484243	580076
total profit (€)	2381908.53	retrib.	90009	

Present situation
No management, illegal farms and cultivation methods.

Mussel farms in area 4 are in a beneficial position compared to the other farming areas. Increased density of cultivation in this area (& in area 1) inhibits the water movement towards the majority of the farms, causing small growth rates and sometimes decline of the production in the other areas.



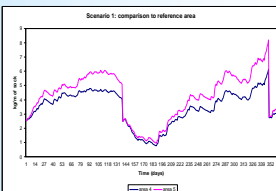
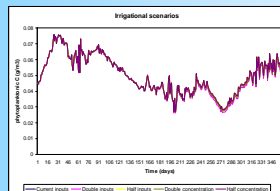
Institutional management

Farm characteristics according to regulations, legal farms.

Although the position of the farm is significant to the production, the inhibition effect is minimized and the production is balanced and satisfying to all the sub-areas. The profits are higher, with less cultivation lines (less costs) and the retributive benefits are 3 times higher.

Scenario2	area 1	area 2	area 3	area 4
status	legal	legal	legal	legal
line no	10	10	10	10
line distance (m)	10	10	10	10
sock distance (m)	0.5	0.5	0.5	0.5
sock length (m)	3	3	3	3
no of farms	13	18	12	12
individual profit (€)	47479.7	45587.4	41815.9	50803.0
area profit (€)	617235.9	820573	501790	609635
total profit (€)	2549236.0	Retrib.	275027	

Management changes in the agricultural area were tested in order to determine if they will affect the environmental situation in the coastal area of Chalastra, by affecting the quantity of phytoplankton available for mussel consumption. As demonstrated in the diagram, the phytoplankton concentration does not vary significantly even when the irrigational inputs are doubled both in quantity and concentration of inorganic nitrogen.



The estimated mussel production in the reference area is significantly higher than the production in area 4.

4. Comments

- Although the mussel growth is affected from multiple parameters, the scenario analysis demonstrated that the most important factor in the area is the inhibition of circulation because of high cultivation density and secondary from the food availability. The structure of the model, although it can be susceptible of multiple improvements and expansions when the appropriate data will be available, it can test multiple scenarios, altering both environmental, technical and economical features, thus demonstrating a variety of opportunities to the mussel farmers.
- The accompanying social analysis (choice experiment approach), implemented from the Aegean University Team, revealed that the local population values highly the state of the marine environment via a rational spatial planning (114.46€/person) and the maintenance of the employment positions in the activity (57.50 €/person).
- Nevertheless, the mussel farmers participating to the Stakeholders group are not willing to change their mussel farming practices if they are not obliged by a management authority. They also state that they prefer local to central management in order to have more access to the decision making procedure.