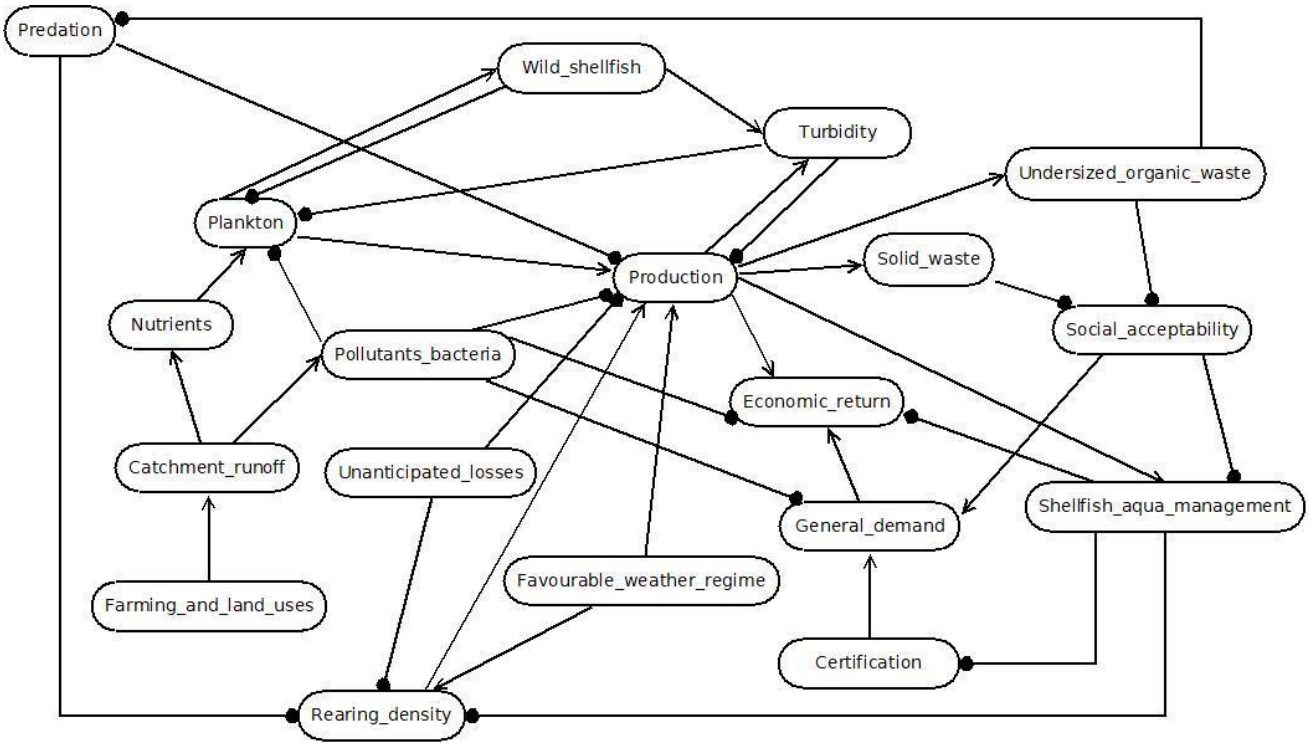
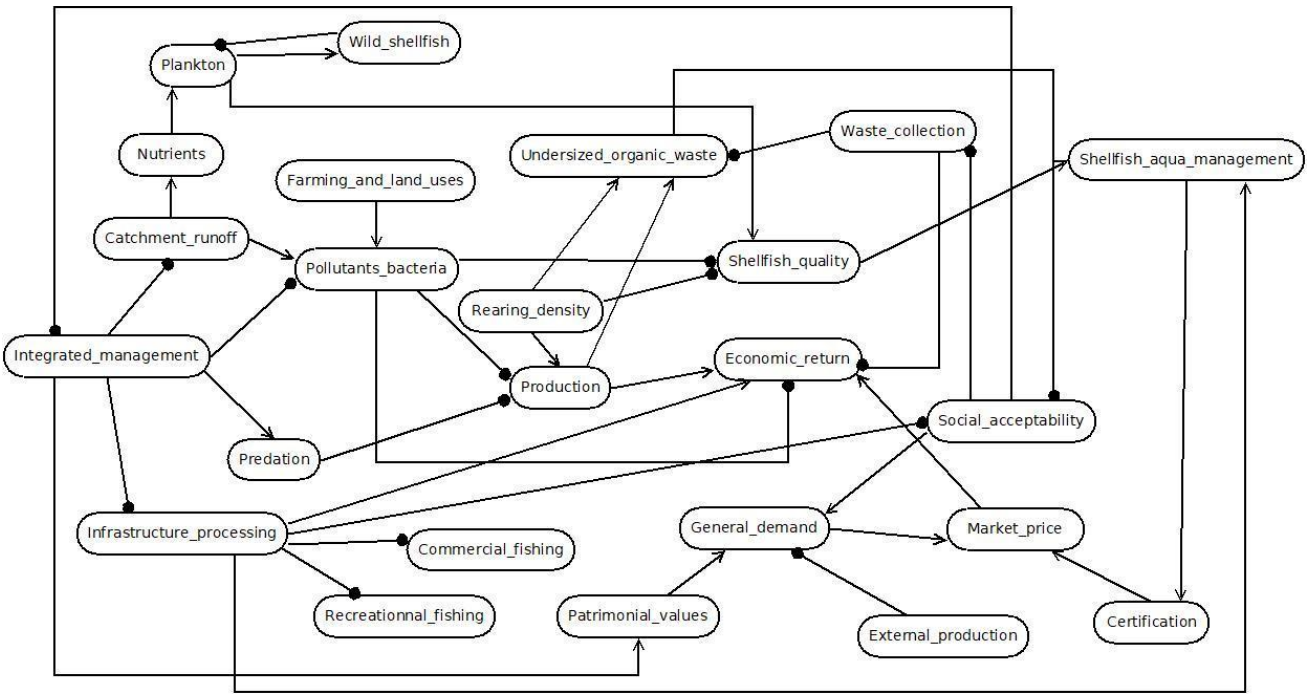
Supplementary Material

Supplementary Material contents the seven conceptual models built during the seven participatory workshops, a table with a list of variable names with their description, a table with the description of the links of the synthetic model, and an Rmarkdown code providing all the detailed analyses presented in this paper.

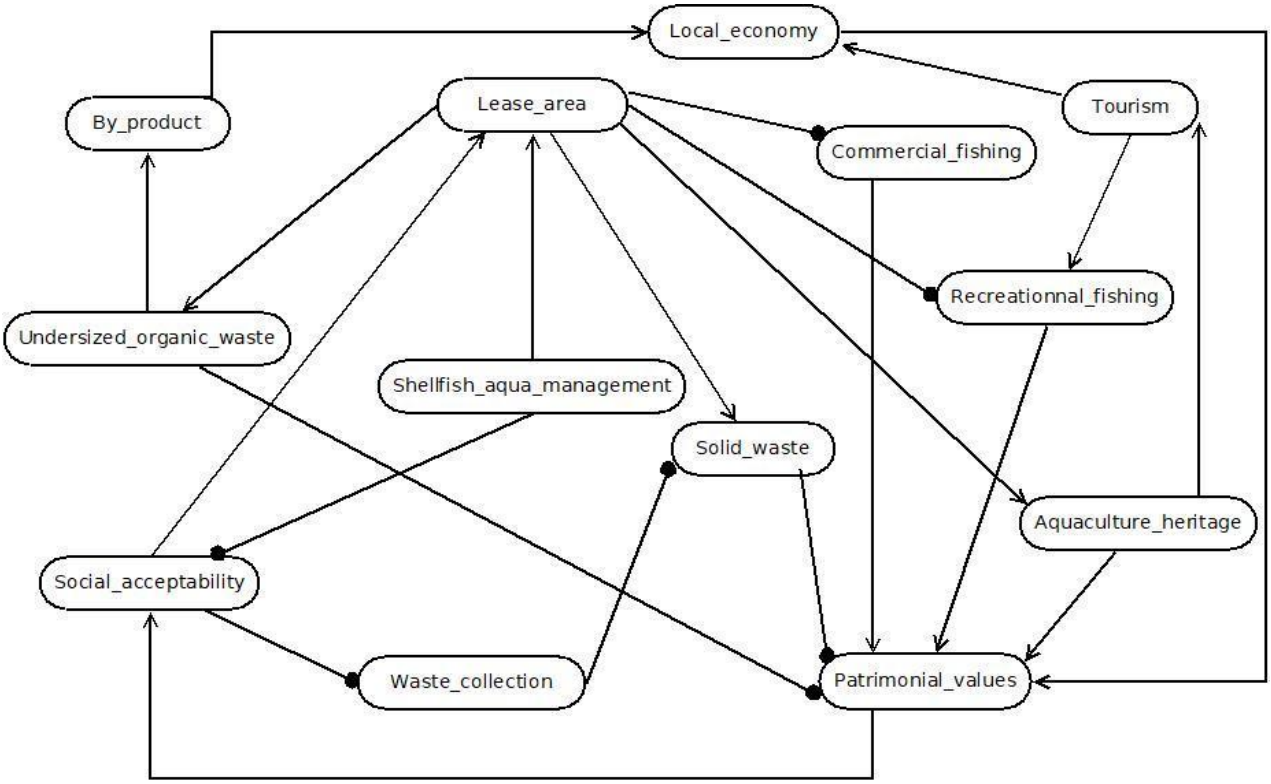
1 Supplementary Figures



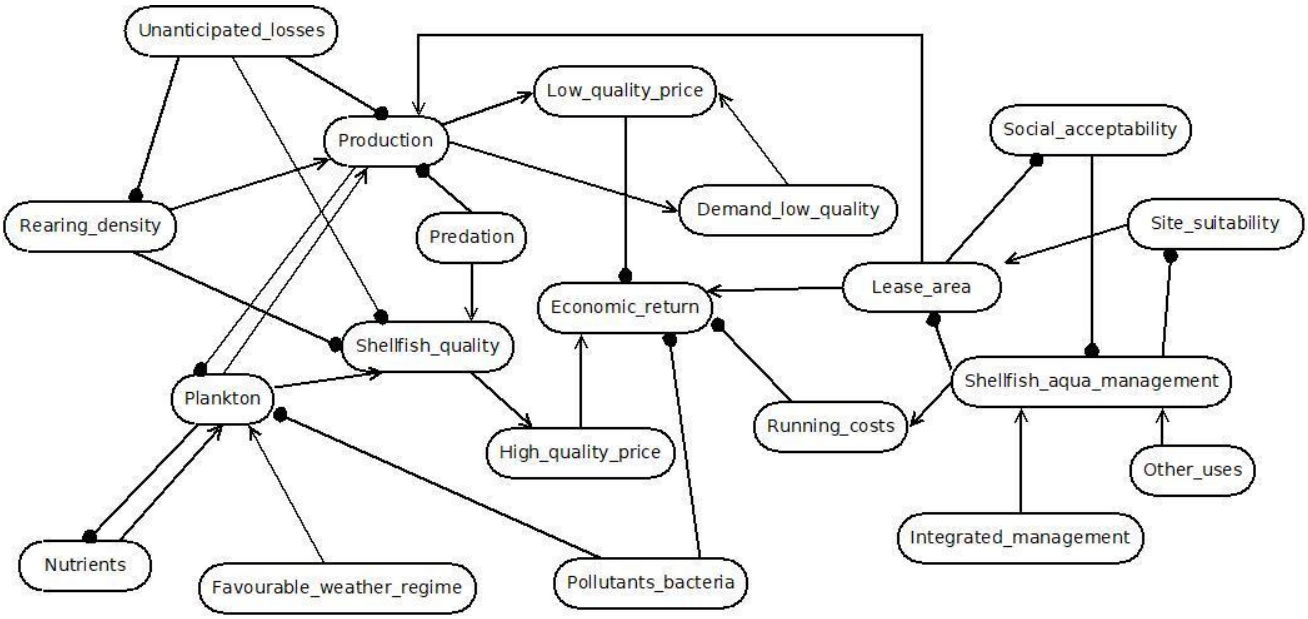
Supplementary Figure 1. Simplified sign-directed graph built during the workshop with shellfish producers in Brittany (i.e. B1 model).



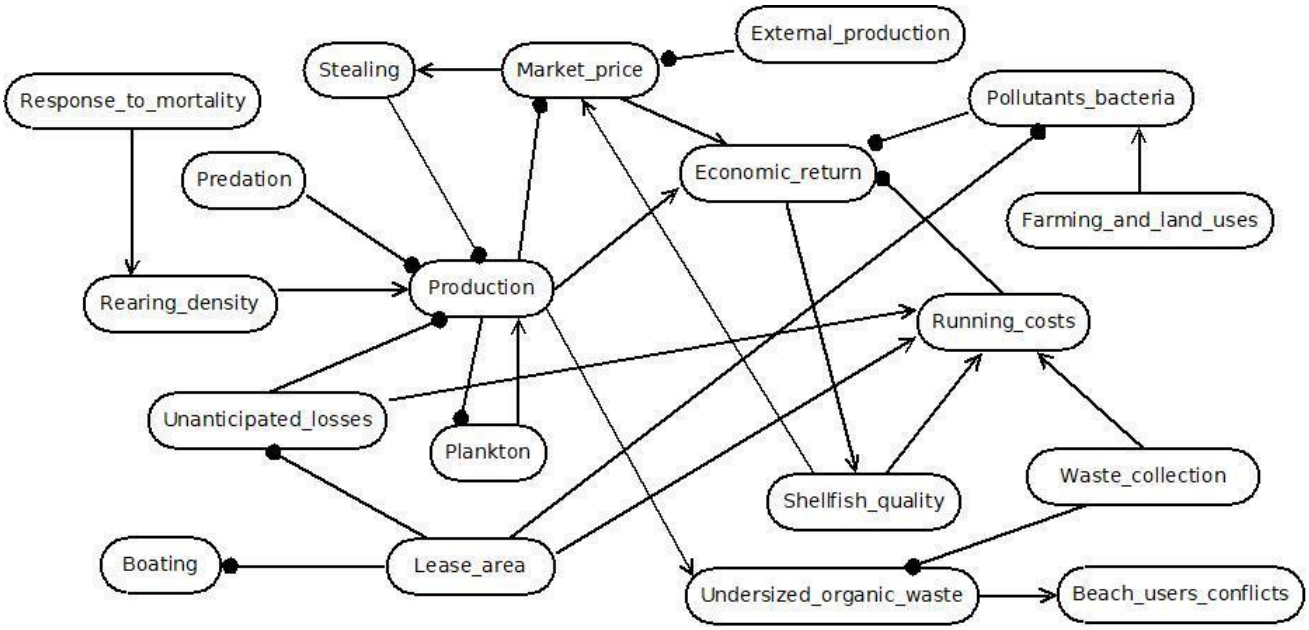
Supplementary Figure 2. Simplified sign-directed graph built during the workshop with managers in Brittany (i.e. B2 model).



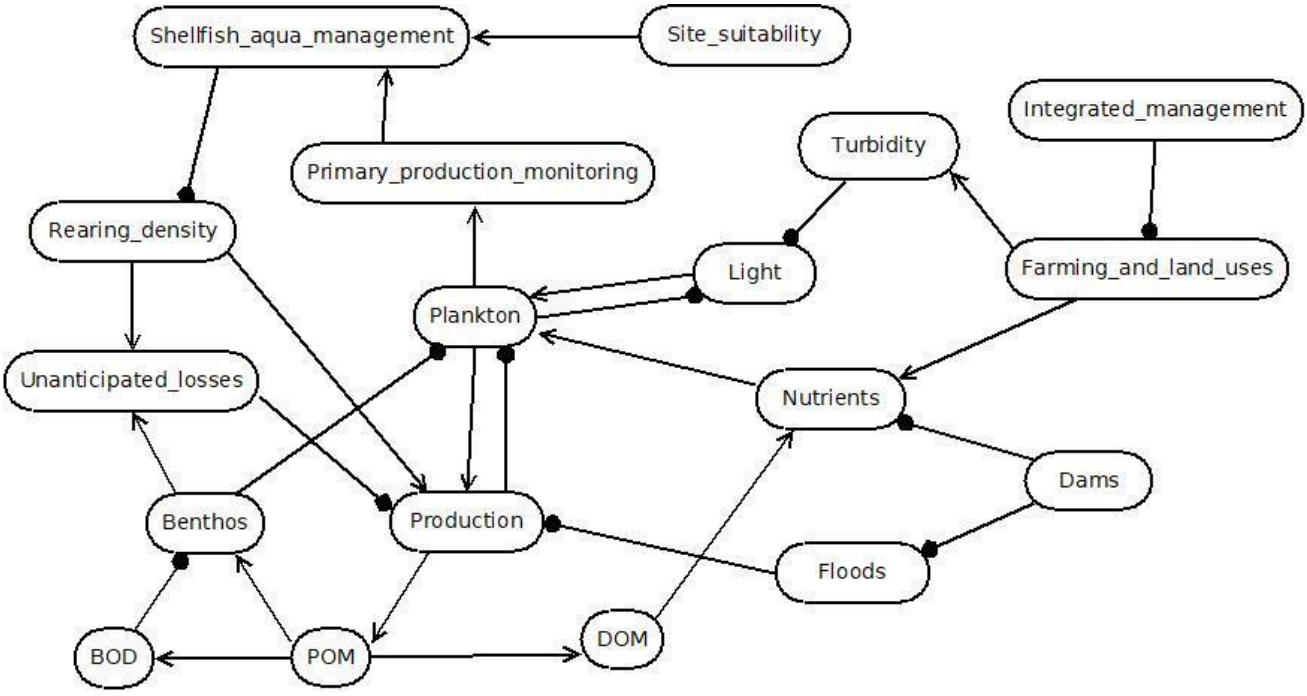
Supplementary Figure 3. Simplified sign-directed graph built during the workshop with "other stakeholders" (representatives from professional and recreational fishers and environmental NGOs) in Brittany (i.e. B3 model).



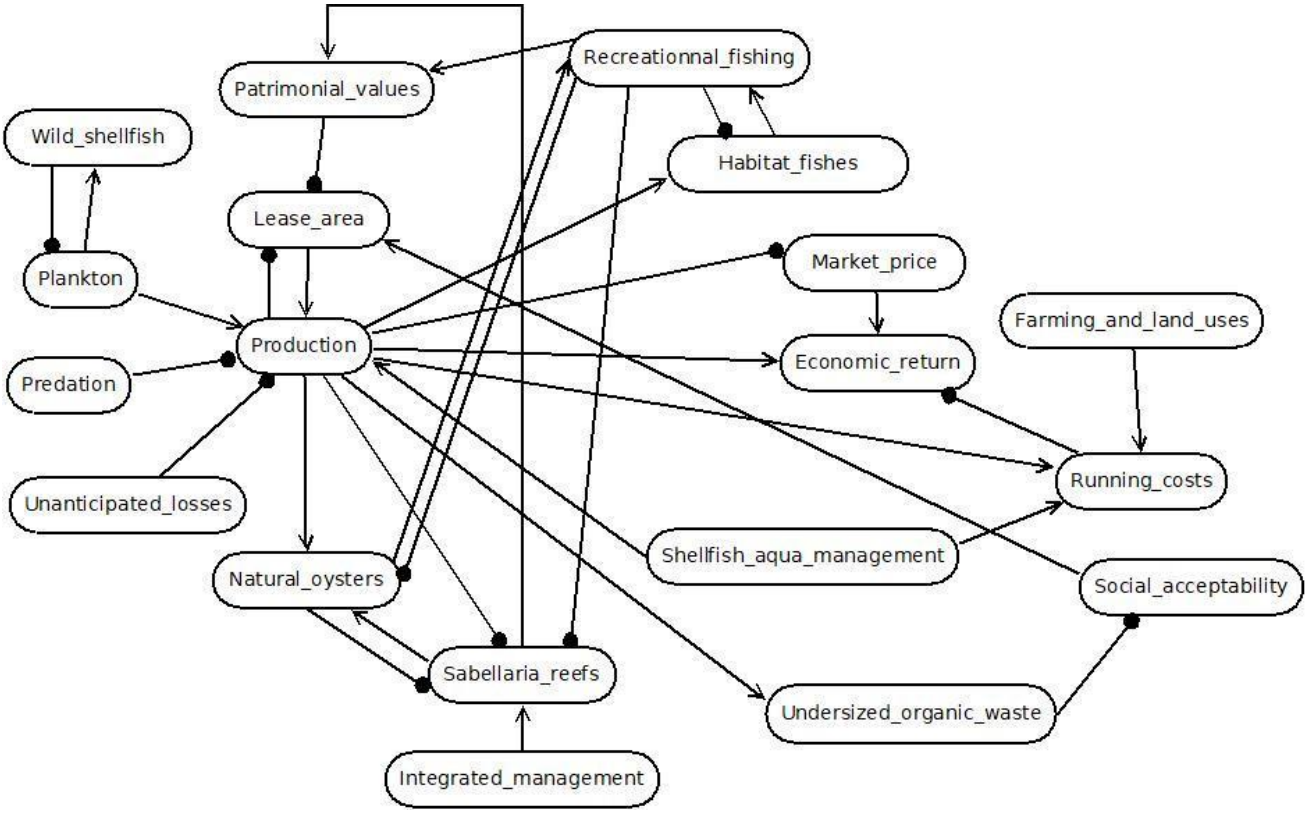
Supplementary Figure 4. Simplified sign-directed graph built during the workshop with shellfish producers in Normandy (i.e. N1 model).



Supplementary Figure 5. Simplified sign-directed graph built during the workshop with managers in Normandy (i.e. N2 model).



Supplementary Figure 6. Simplified sign-directed graph built during the workshop with "other stakeholders" (representatives from professional and recreational fishers and environmental NGOs) in Normandy (i.e. N3 model).



Supplementary Figure 7. Simplified sign-directed graph built during the workshop with Researchers (i.e. Re model).

2 Variables

Supplementary Table 1. Description of the variables shared by at least two of the models developed. The numbers assigned to the variables are the same as those assigned in Figures 2 and 3.

The colours of the variables correspond to their attributed dimension (ecological in green, economic in blue and social in red).

#	Variable name	Description
1	Plankton	Small and microscopic organisms drifting or floating in the water column
2	Production	Harvested biomass of farmed oysters and mussels
3	Rearing density	Number of oysters per bag or mussels per rope
4	Shellfish aquaculture management	Different processes supervising shellfish aquaculture activity, such as management measures and limits, surveillance for quality, etc..
5	Economic return	Profit (revenues minus costs)
6	Farming and land uses	Land uses including agriculture, urban growth and sewage
7	Nutrients	Nutrients necessary for plankton growth, such as nitrates and phosphates
8	Pollutants and bacteria	Pollutants such as pesticides and insecticides and bacteria affecting the sanitary conditions of the water
9	Predation	Predation mainly by fish and birds (such as seagulls and ducks)
10	Social acceptability	Social license to operate, opposite to public concern
11	Unanticipated losses	Various mortalities due to manipulation, weather, and/or diseases affecting different stages (seed, spat, adults)
12	Undersized organic waste	Undersized mussels that are deposited on the shoreline and become organic waste
13	Integrated management	Management policies related to conservation areas, regulation, biodiversity and environment protection, water quality, etc.
14	Shellfish quality	Quality of oysters and mussels such as condition index
15	Waste collection	Activities of waste removal (usually managed by shellfish farmers themselves)
16	Lease area	Spatial area designated for aquaculture activity
17	Catchment runoff	The flow of river water ending in the shellfish growing area
18	Certification	Protected Designation of Origin (PDO)
19	Favourable weather regime	Favourable weather for the growth of plankton and shellfish
20	General demand	Demand from consumers for oysters and mussels
21	Solid waste	Garbage like ropes and plastic bags usually ending on the shores
22	Turbidity	Particulate matter in suspension
23	Wild shellfish	Shellfish that are not cultivated and that are in competition for resource and space with farmed shellfish, as it is the case for slipper limpets
24	Commercial fishing	Professional shellfish gathering fishing
25	External production	Production of oysters and mussels from elsewhere
26	Market price	€/kg
27	Patrimonial values	Relates to the heritage value of the Mont-Saint-Michel Bay, but also to the image and reputation of the Bay
28	Recreational fishing	Nonprofessional gathering fishing

29	Running costs	Production and operation costs of the shellfish aquaculture activities
30	Site suitability	Suitability of the site for shellfish aquaculture

Supplementary Table 2. Meaning of the links in the synthetic model. The colours of the variables correspond to their attributed dimension (ecological in green, economic in blue, social in red).

From	To	Sign	Meaning
Nutrients	Plankton	+	Nutrients feed the plankton
Plankton	Nutrients	-	Plankton take in nutrients to feed themselves
Plankton	Shellfish quality	+	The more plankton, the better the quality of the shellfish
Plankton	Production	+	Plankton feed shellfish, which increases the production biomass
Production	Plankton	-	Shellfish take in plankton for food
Production	Economic return	+	The production sold increases the economic benefits
Production	Shellfish aquaculture management	+	The more production there is, the more shellfish aquaculture management measures there are
Production	Undersized organic waste	+	Production results in the deposition of undersized organic waste on the foreshore
Undersized organic waste	Social acceptability	-	The presence of undersized organic waste on the foreshore reduces the social acceptability of shellfish aquaculture

Undersized organic waste	Predation	-	Shellfish waste on the foreshore attract birds, which therefore predate less on the farmed shellfish
Predation	Rearing density	-	Predation on poles and bags (by birds, winkles) leads to a decrease in rearing density
Predation	Production	-	Predation on poles and bags (by birds, winkles) leads to a loss of production
Pollutants and bacteria	Production	-	Pollutants decrease production
Pollutants and bacteria	Plankton	-	Pollutants reduce the quality of plankton
Pollutants and bacteria	Shellfish quality	-	Pollutants and bacteria reduce the quality of shellfish
Pollutants and bacteria	Economic return	-	Pollutants, leading to purification costs, reduce economic benefits
Unanticipated losses	Production	-	Mortalities reduce production
Unanticipated losses	Shellfish quality	-	Mortalities reduce the quality of shellfish
Unanticipated losses	Economic return	-	Mortalities lead to economic costs, which reduce the economic return
Unanticipated losses	Rearing density	-	Mortalities reduce rearing densities
Rearing density	Production	+	The higher the rearing density, the higher the production biomass
Rearing density	Unanticipated losses	+	The higher the rearing density, the more mortalities occur
Rearing density	Undersized organic waste	+	The higher the rearing density, the higher the undersized organic waste

Rearing density	Shellfish quality	-	The higher the rearing density, the lower the quality (e.g. due to competition for plankton)
Shellfish quality	Shellfish aquaculture management	+	The greater the production of quality shellfish, the greater the amount of work for the shellfish aquaculture management to validate and control
Shellfish quality	Economic return	+	Quality shellfish sell at a higher price, allowing for better economic returns
Economic return	Shellfish quality	+	Good economic returns encourage the adoption of production methods for high-quality products
Lease area	Production	+	The larger the area for shellfish aquaculture, the greater the production
Lease area	Undersized organic waste	+	The larger the area for shellfish aquaculture, the higher the waste
Lease area	Social acceptability	-	The larger the area of shellfish aquaculture activity, the lower the social acceptability to local residents and other stakeholders
Social acceptability	Lease area	+	The better the social acceptability, the less pressure there is from stakeholders on managers, the more the shellfish farming area can expand and licenses can be given
Social acceptability	Waste collection	-	The better the social acceptability, the less pressure there is from stakeholders to collect waste
Social acceptability	Integrated management	-	The better the social acceptability, the less pressure there is from stakeholders for integrated management
Social acceptability	Shellfish aquaculture management	-	The better the social acceptability, the less pressure there is from stakeholders for shellfish aquaculture management

Shellfish aquaculture management	Economic return	-	The management of shellfish aquaculture imposes standards, particularly in terms of sanitation, which, by increasing operating costs (e.g. purification), reduce the economic benefits
Shellfish aquaculture management	Rearing density	-	Shellfish aquaculture management limits rearing densities
Shellfish aquaculture management	Lease area	-	Shellfish aquaculture management imposes the spatial area, licenses, etc. designated for aquaculture activity
Integrated management	Predation	+	Bird protection measures (e.g. Natura 2000) tend to increase predation pressure by birds
Integrated management	Pollutants and bacteria	-	Integrated management measures tend to reduce the amount of pollutants in the water
Integrated management	Shellfish aquaculture management	+	Shellfish aquaculture management is a component of integrated management, that is detailed in the system representation
Integrated management	Farming and land uses	-	Integrated management measures such as SAGEs (Water Development and Management Plan) tend to reduce inputs from agricultural activities
Farming and land uses	Nutrients	+	Fertilizers used by agriculture and human activities increase the amount of nutrients in water
Farming and land uses	Pollutants and bacteria	+	Pesticides used by agriculture and human activities increase the amount of pollutants in water
Waste collection	Undersized organic waste	-	If there is waste collection, there is less waste
Waste collection	Economic return	-	Waste collection incurs costs, which reduce economic return