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# The Deterioration of the Environment, Flexibility of Reactions, and Rent : The case of a lagoon area

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## I - STUDY REPORT

This report follows 3 previous reports by the Centre d'Etudes de Projets :

- A report on the flexibility in fisheries activities[1] for the second EAFE meeting.

* There are singularities in the capacity and will to adapt in aquatic farmers in relation to the changes in their environment. Examples taken from the 4 sub-divisions (traditional aquaculture, the new aquaculture, non-industrial fishing, trawler and tuna fishing) allow us to note the mechanisms of the emergence or the freezing of flexibility in production units.

- A report on the systems of shellfish-breeding exploitations in the Thau Lagoon[2].

** The existence of secondary activities by the shellfish breeder or of outside family income can lead to specific strategies in the sector of marine cultivation. The analysis is done on the basis of an investigation of shellfish-breeding in the Thau Lagoon which allows for the setting-up of a typology of firms with different strategies concerning parameters of size and reproduction.

A publication on the evaluation of the effects of a lagoon dystrophy in the Thau Lagoon[3].

*** During the summer of 1987, the emergence of a lagoon pollution of the "malaigue" type in the Thau Lagoon in Languedoc-Roussillon resulted in direct and indirect losses. The object of the study is to propose an evaluation of the measurable costs by using various successive aproaches as well an identification of the costs which cannot be numerated.

**The present objective is to begin a study on :**
**- The integration of the rising environmental risks in shellfish-breeding activities in the Thau Lagoon in Languedoc-Roussillon.**
**- The consequences of the deterioration of the environment in terms of variations of the financial income and the rent of these producers[4].**

This study will include 3 very specific ecological risks : dynophysis, the "malaïgue", and salmonella. The first 2 risks appear locally in a recurrent fashion, whereas the last has

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[1] "Risk, internal and external flexibility in halieutic and aquatic activities" - Lisbonne 5-7 March 1990 - M. Garrabé, M-H Dabat, H. Rey.

[2] "The systems of the shellfish-breeding exploitations in the Thau Lagoon: multi-dimensional approaches" - FIOM contract - June 1988 - M. Garrabé, N. Daures, M. Antona, H. Rey.

[3] "Evaluation of the effects of an example of lagoon pollution : the case of the malaïgue in the summer 1987 in the Thau lagoon in Languedoc-Roussillon" - Revue de l'Economie Meridionale 1990 N° 151 - M. Garrabé.

[4] Our definition of rent : payments made to a production mean beyond its opportunity cost.

appeared one single time on the Mediterranean coast. The first risk concerns the Thau producers indirectly whereas the last two have directly concerned the lagoon production.

## II - RISKS AND PRODUCTION

### 21 - The operational typology of risk

The functionning of an activity in a given environment is susceptible to 4 types of risks[5] :

- An external recurrent risk,
- A non-recurrent external risk,
- A recurrent internal risk,
- A non-recurrent internal risk.

* The first concerns a type of normal risk: prices or market variables fluctation, or even a frequent risk such as a bacteriological accident.
* The second represents an exceptional risk, not necessarily a major one, but thus of less interest. As in the previous case, the producer has no control over this risk.
* The third concerns a type of risk which the environment must support due to the activity, but which, because of the insertion of the one in the other, affects it directly and continually.
* The last type of risk has the same characteristics as the precedent excepting the repetition.

The classes of risks proposed can be combined in certain cases and may or may not lead to irreversible conditions. They determine, however, specific flexibilities of reactions.

### 22 - A recurrent internal-external risk : the "malaigue"

A phenomena which chronically affects the lagoons of Languedoc-Rousillon. During the "malaigue", which intervenes principally in the summer, the lagoon waters become cloudy and change color (becoming reddish or whitish, sometimes brownish). This modification is accompanied by a release of hydrogen sulphide with a nauseous odor and a decrease and finally the disappearance of the oxygen dissolved in the water which then becomes dangerous for the life of most aquatic organisms. This results in massive mortalities of fish, crustaceans, and shellfish. When the winds begin again in a continous fashion, the waters clear and the biological cycles return. There have been such dystrophic crises in the Thau Lagoon in 1975, 1982, 1983, and 1987. The shellfish production lost due to the malaigue in 1987 was estimated between 19 MF and 43 MF (1987 francs) according to the sources ((Affaires Maritimes, shellfish-breeders, Centre d'Etudes de Projets) and the hypotheses used.

### 23 - A non-recurrent external risk : the salmonella

Salmonella is a bacteria susceptible of poisoning oysters and other shellfish, but which does not result in any mortality in the biomass as opposed to the preceding case. It is the origin of more or less serious cases of gastro-enteritis in the consumer of infected shellfish, and can sometimes be deadly. The prohibition of the commercialisation of shellfish from the Thau Lagoon for a period of a month and a half (from the beginning of December 1989 to mid-January 1990) because of salmonella resulted in a massive economic setback for the local shellfish-breeding industry to the sum of 56 MF (francs in 1990), corresponding to 4500 T of oysters and 1000 T of mussels[6]), as the producers generally commercialise a high percentage of their oysters during the Christmas Season.

### 24 - A recurrent external risk: dynophysis

This vegetable plankton composed of unicellular algae secretes a diarrhoeic toxin called the DSP toxin which can become dangerous for the consumer when there is a certain concentration in the mollusca (a gastro-intestinal type of intoxication). The infestation period is usually from April to September, and the vehicles of disease are principally mussels and certain

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[5] O. Favereau : option value and flexibility : from substancial rationality to procedural rationality. in Cohendet and Llerena, Flexibility information and decision ECONOMICA 1989.

[6] Overestimated value because there is no production loss but a delay of the commercialisation. There are certainly effects but without a direct relation to the given figures.

shellfish obtained by fishing (filtering mollusca) : pullet shells, sunset shells, and olive shells. Oysters, sea urchins, and voilet shells are not toxic (slight contamination). Dynophysis does not develop in lagoons as the biological conditions are very different from those of the sea.

## 25 - Occurrence factors and risk causes

*** Malaïgue**

The factors leading to this are essentially climatic: very hot weather, an absence of wind for several days resulting in the stagnation of the water, the presence of a slight north wind which is favorable to the rising of deep water, and a very sunny period explain the triggering and the propagation of the dystrophic process between the months of June and September.

However, the real causes of the malaigue are the factors of the accumulation of organic matter in the lagoon: natural bio-deposition, the natural macrophytic development of the border zones, shellfish bio-deposition[7], the waste from the detaching[8] of the oysters, urban, agricultural, and industrial effluents, and the recent development of the Sargasse algae.

Here it can be mentioned that the type of management used by the breeders seems to play a role in the phenomena of organic accumulation: an increase in the density of the shellfish breeding increases the bio-deposition in proportion, and the decrease in light penetration due to this density increase limits the consumption of hydrogen sulphide even more. The absence of controls for waste deposits (organisms on the breeding structures) is also an aggravating factor.

*** Salmonella**

The sources of pollution which can have an effect on the development of salmonella in the Thau Lagoon are: the overflow of used water in the municipalities of Bouzigues and Marseillan (bordering the lagoon) which happens regularly in periods of heavy rains, the unallowed dumping lots in the countryside behind the sea which pollute the underground springs, the lagoon filtering station at Mèze which rejects salmonella into the lagoon, Mourre Blanc which is badly equipped with sanitary equipment, the purification stations in the municipalities of Pinet and Pomérols which are disturbed by the wastes from the wine cooperatives, and two areas of the town of Séte (concerning 6000 inhabitants) which are not connected to the purifying station[9]. These different sources of pollution do not account for the same level of pollution nor the same frequence of contamination. The overflow of waste water is limited to periods of heavy rain, and the pollution connected to the wine cooperatives only occurs at a certain period of the year. All these factors certainly converged in November and December of 1989.

## 26 - Typology of the causes of risks

The causes of malaigue and salmonella are in fact related to three types of factors: natural factors, factors related specificially to the shellfish breeding activity, and factors which are external to shellfish breeding. The following table proposes the typology of the causes of risks.

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[7] 20 T of dry waste per year and per table = 400 kgs per m3 (HAMON 1991).

[8] On the Thau lagoon, the estimated annual production (CEPRALMAR 1988) reaches 10 000 T of waste for approximated 20 000 T of shellfish produced, 9 to 13 000 T per year (HAMON 1991).

[9] Report by P. Deltour DDASS.

Table 1 : Causes of Risks

| Types of causes | Causes | Risks |
|---|---|---|
| Natural factors | - Natural bio-deposition | Malaigue |
| | - Natural macrophytic development in the border zones | Malaigue |
| | - The recent development of the Sargasse algae | Malaigue |
| Internal shellfish breeding activity factors | - Shellfish breeding bio-deposition | Malaigue |
| | - Oyster detaching waste | Malaigue |
| | - Insufficient cleaning of waste deposits on the structures | Malaigue |
| | - Bad sanitary equipment at Mourre Blanc | Salmonella |
| Factors external to shellfish breeding | - Urban, agricultural, and industrial effluents | Salmonella |
| | - The overflow of waste water | Salmonella |
| | - Unallowed dumping lots in the country behind the sea | Salmonella |
| | - The lagoon filtering station at Méze | Salmonella |
| | - Wine cooperative wastes | Salmonella |
| | - Areas of Séte not connected to the purifying station | Salmonella |

The ecological risks presented by the malaigue, salmonella, and dynophysis seem to be more and more important.

An investigation conducted among the producers (CEPRALMAR) tends to show that the cases of **malaïgue** are not more numerous than in the past but that those observed during the last few years have become more important (more extensive damage, larger areas being affected). Before the beginning of the 70's, the malaigue occurred essentially in bordering zones, with its extension limited in size (a few hectars) as well in time (a few days to a week). It was exceedingly rare that a same zone would be affected several times in one season. A natural phenomenon, the malaïgue was even considered to be an advantage : purification of the environment and plentiful fishing. Beginning in 1970-71, the cases of malaigue became larger in size, not being limited to the edges of the lagoon, and having the tendency to last. In 1975, the shellfish mortality attained 100% of the stock in the deep part of the shellfish zone A in the East of the basin. In July 1982, 200 tables in zone B were completely polluted and even more in November of the same year. In July 1987, the malaigue extended into zones B and C, avoiding only the zones further out and ruining 10.5 T of shellfish (Affaires Maritimes).

Concerning **salmonella**, the absence of recurrence does not allow for the affirmation of a rise of the risk. The reinforcement of controls by scientific bodies raises the probability of detection of this bacteria. According to professionals, the gastro-enteritis episodes did not begin in 1989 (particularly numerous in 1987), but a rise exists in the expectations of the consumers.

Concerning the cases of the concentration of **dynophysis** in sea mussels, they are becoming more and more frequent on the Mediterranean Coast.

## III - REACTIONS AND FLEXIBILITY

### 31 - Types of identified reactions

Certain reactions used by shellfish breeders have the effect of increasing the biomass in suspension in the Thau Lagoon (essentially the first three of the following) :

*** Tendency to resoak the sea mussels in the lagoon**
The producers tend to resoak the mussels, either with the aim of avoiding dynophysis (the transfer at the beginning of the summer of contaminated shellfish to dynophysis-free water for a long period[10]), or because all of the mussels which have been detached and prepared out of water have not obtained a commercial size (these resoakings are done all year round and allow the producers to avoid the cost of the return of small mussels to the lines as well as to dispose of a nearby stock). Concerning dynophysis, if a resoaking of 30 days was sufficient in 1987 as well as for those done in the beginning of June 1989, it was not the same for those transferred from the beginning of June to the end of July : 6 weeks of decontamination were necessary.

*** Tendency to furnish the shellfish tables all year round**
Until 1982 or 1983, it could be estimated that the oyster-breeding biomass was close to the annual commercial production. The oysters were put into breeding in February or March and mainly sold during the Christmas Season. During the intermediary period, the profitability was assured by the sale of mussels. As mussels are being more and more replaced by oysters, the professionals, in order to assure their profitability, are now obliged to sell oysters during the whole year, and thus to breed during the whole year. Thus, from 1980 to 1986 the oyster-breeding biomass was almost zero in January and February, and reached 35 500 T in November and December. In 1987, and after the observations of 1988, it appeared that the lagoon supports a biomass approaching 25 000 T the year round.

*** The breeding of large-size mussels**
In the same direction, more and more farmers are putting large-size mussels into breeding (4 cm half-size mussels). They only spend a part of the year in the lagoon and are immediately replaced after the sale. It is thus possible to have 2 or 3 rotations in a year and the tables are practically permanently full. The impact of this method is limited considering the reduction of the number of mussels in the lagoon.

*** Predatory attitude towards the lagoon**
The shellfish farmers, in spite of some improvements, still retain a predatory attitude which is harmful for the environment or which is detrimental for the growth of shellfish and raises the risks of malaïgue and salmonella : the throwing of the waste from the detaching back into the lagoon or near to it, the insufficient cleaning of the waste deposits on the structures, no collection of the deposits accumulated under the tables, and insufficient sanitary equipment in certain farmhouses.

### 32 - Types of corresponding flexibility

The reactions of resoaking the mussels from the lines in the lagoon and the increase of the rotation of stocks of mussels and oysters indicate a certain flexibility in production units[11].

*** External (or decisional) flexibility of initiative**
In the case of resoaking the sea mussels in the lagoon /dynophysis : an attitude of strategic integration of the information received with regard to modifications expected by the exterior environment.

*** Internal (or productive) technical flexibility**

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[10] One month of decontamination is necessary. The risk of contamination for a healthy sector by tranfer is minime (nearly 0).
[11] "Risk, internal and external flexibility in halieutic and aquatic activities" Op. Cit.

In the case of the resoaking of the sea mussels in the lagoon /dynophysis and other reasons (avoiding the cost of a return to the sea, having a security fallback in the lagoon) : this flexibility measures the space of the capacities to modify the nature, the volume, and the organisation of production in the choice of process as well as in the internal development of them.

*** Internal (or productive) organisational flexibility**
In the case of the modification of the producers strategy : the capacity for external development in the production-distribution process which is exercised under technical constraints.

The predatory method of the shellfish farmers corresponds to an absence of flexibility.

## IV - RENT, PRODUCTION CYCLES, AND THE OVERLOADING OF THE LAGOON : THE T. BOX

The identification of reactions in the face of risk can lead to a certain number of consequences :
- short term consequences,
- middle term consequences.

### 41 - Overloading and production cycles

- In the short term, the main consequence is apparently an excessive increase in the biomass of the tables of the lagoon which results in a longer maturation cycle for the shellfish.
- It is also possible that the mussels could become rarer in the short term in zones B and C.
- In the middle term, the lengthening of the cycle and the mono-production could risk the disappearance of the weaker rents of the lagoon and the massive eradication of the more defavorised zones.

*** Increase in the loading of the tables**
It is generally accepted that in order to obtain a satisfactory growth and size for the shellfish, a table should not support more than a thousand cords[12]. But, from 1980 to 1987, on 70% of the tables in the lagoon, the number of cords per pole[13] varied from 9 to 14. This number went up to 21 for a minority of extremely loaded tables (2-3%), indicating the likelihood of the overloading of some exploitations which could be harmful to the surrounding tables. In addition, between 1980 and 1987, the number of tables rose from 2058 to 2548 ( 2816 planned) in the lagoon. The average nomber of cords per table increased during the same period from 867 to 998.9 (from 841.4 to 1061 for zone A, from 844 to 894.8 for zone B, from 918 to 1041 for zone C), with zone A having the highest rise in loading.

*** The increase of the biomass in the lagoon**
The increase of the biomass in the Thau lagoon between 1980 and 1987 is very clearly shown by the IFREMER scientists since they observed an increase of 5000 T or 14%. The biomass in oysters and mussels was 30 397 T in 1980 (calculated by counting the cords and the observation by sample diving during the tourist period); it rose to 35 501 T in 1986. The figures for 1987 (25 389 T) are not indicative (one single year, a large proportion of mussel broods, year of the malaïgue) but it can be assumed that the production has gone from a model of a "growing load" during the year in order to reach a maximum of 35 000 T in November and December to a lower "model with a constant load" of approx. 25 000 T, but permanently in the lagoon, since the shellfish farmers now breed during the whole year (a spreading of the load with an increase of the total load per time unit).

*** The resoaking of the line mussels in the lagoon**

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[12] Cord is a special technique used in Thau lagoon. Shells grow on cords suspended in the water from wooden floating structures.
[13] 51 poles per tables.

The estimate of the production of mussels from the lines is problematical (between 5000 and 9000 T for 1990 according to the source). All the license holders do not give figures and those who do generally supply incomplete figures. Scientists have difficulty distinguishing mussels from the line from other mussels, and as flows occure between the sea and the lagoon all year long, it is difficult to follow them.

*** The lengthening of the shellfish maturation cycle**

The IFREMER biologists very carefully assume that the oyster cycle could now be actually from 12 to 24 months for glued oysters as compared to the cycle of 12 to 14 months at the beginning of the 80's. Certain shellfish farmers even speak of a 3-year cycle for the oyster. This long-term lengthening of the cycle is however not demonstrated as it is related to the short-term enrichment of the plankton in the lagoon (the biomass load is not the factor for the lengthening of the cycle, other factors such as sunlight and rainfall also have important effects). For example, the producers ascertain a present good growth of shellfish (1991).

*** Impact of the change in biomass on the environment**

(biological limit of the T. box)

The knowledge acquired[14] concerning the relation between the biomass and the environment (estimation of the number of shellfish in breeding made from the estimated tonnage, and by the quantity of filtered water and thus indirectly of the ingestion of nourishing particules) and the theoretical work done by IFREMER on the parameters of the Thau lagoon[15] tend to indicate that the lagoon has a sufficient trophic capacity to assure a steady growth of shellfish (the equivalent of the total capacity of the lagoon was filtered in 2.81 days in 1986, and the quantities of plankton taken off by the shellfish were reconstituted in 24 hours). However, the quantities of plankton were calculated as if the mollusca were spread out over the 7500 hectars of the lagoon. In addition, only the breeding mollusca were taken into consideration whereas the rivals such as the ascidian (tunicate - large quantities during certain parts of the year) and the various natural layers also utilise plankton.

## 42 - Flexibility and Rent

Two significant types of rent are generally distinguished concerning the non-renewable resources or renewable resources with an excessive depletion : the Malthusian rent and the Ricardian rent. The **Malthusian rent** measures the advantages of present opportunities for the users who now have a resource whereas the **Ricardian rent** measures the advantages of disposing at the beginning of exploitation conditions with growing incomes.

In the case of the Thau lagoon, the reserves in nutriments, even though variable, would be stable for the short-term. On the contrary, the biological mass in suspension increases, and thus the annual exploitation production decreases. This is the opposite situation as in agriculture where the fall of fertility is stopped by an increase in intrants, which diminishes the production, and where the periodicity of the production is maintained by increasing the costs of production. In shellfish farming in the Thau lagoon, the periodicity cannot be maintained (it would be necessary to spread the nutriments which would transform the traditional aquaculture into intensive aquaculture); on the contrary, the annual costs are maintained but with a decrease of annual production because a lower production corresponds to these costs. This means, concretely, that for the same quantity of product, the annual cost rises.

The rent we are speaking about here is the Ricardian rent. This model is appreciated in time and in space. In the Thau lagoon, there are differentiated zones : 3 geographical zones (A, B, and C) and 7 productivity zones.

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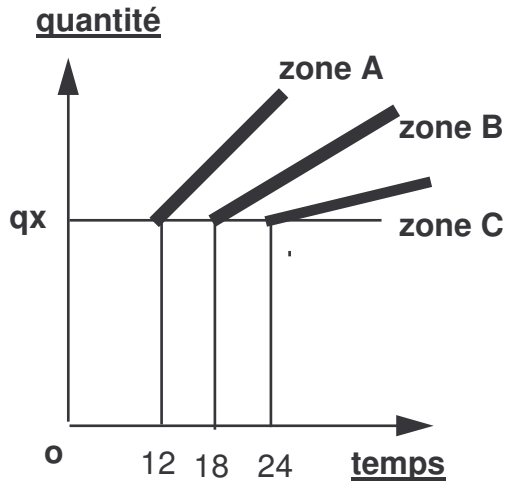
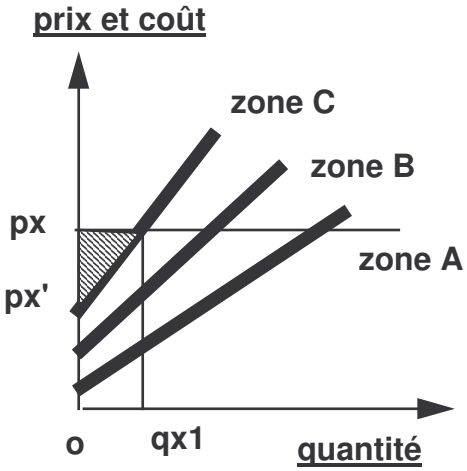
[14] Arakawa (1972), Bayne (1976), ,Walne (1972), Bernard (1972), Haven et Morales-Alamo (1972).

[15] Hamon (1983 and 1991), Henard (1978), Tournier and Pichot (1987).

* General representation




graphique 1




graphique 2

In space, the rent can be measured : the rent from zone C (the most unfavorable) is probably near zero for many exploitations. In this zone secondary activities express (and mask) the reality of conditions from the profitability. The rent of C is cancelled when the price falls from p to p'. For a price p, the rents from the zones are graded.

Thus for quantity Q, given for each of the zones, the respective rents are :

$$R(A) = op \times oq - \int_0^q cm_A(q)\, dq$$

$$R(B) = op \times oq - \int_0^q cm_B(q)\, dq$$

$$R(c) = op \times oq - \int_0^q cm_C(q)\, dq$$

donc :

$$R(A) \rangle R(B) \rangle R(C)$$

si :

$$\int_0^q cm(q)\, dq \rangle \int_0^q cm(q)\, dq \rangle \int_0^q cm(q)\, dq$$

* The lengthening of the production cycle

We introduce the variables income (R), mussel-broods (or half mussels or oysters) (N), production costs (CP) as well as the result (RBE).

- With a 2-year cycle

$$R_t = N_{t-2} + \sum_{t=-2}^{t=0} CP_t + RBE_t$$

$$R_t - RBE_t = N_{t-2} + \sum_{t=-2}^{t=0} CP_t$$

- With a 3-year cycle

$$R_t - RBE_t = N_{t-3} + \sum_{t=-3}^{t=0} CP_t$$

cost of the lengthening of the cycle (K) :

$$K = (N_{t-3} + \sum_{t=-3}^{t=0} CP_t) - (N_{t-2} + \sum_{t=-2}^{t=0} CP_t)$$

* Lengthening of the cycle with reproduction expenses (DR)

- With a 2-year cycle

$$RNE_t^i = R_t^i - \left[ N_{t-2} + \sum_{t=-2}^{t=0} CP_t^i \right] - \sum_{t=-2}^{t=0} DR_t^i$$

- With a 3-year cycle

$$RNE_t^i = R_t^J - \left[ N_{t-3} + \sum_{t=-3}^{t=0} CP_t^i \right] - \sum_{t=-3}^{t=0} DR_t^i$$

Rent for a single exploitation before the lengthening of the production cycle

$$\Delta \text{ Rente} = RN_t^i - RN_t^i$$

* Lengthening of production cycles with expenditures of reproduction and the increase in the loads of the cords

$$RNE_t^{i*} = R_t^{i*} - \left[ (1+a) N_{t-3} + \sum_{t=-3}^{t=0} CP_t^{i*} \right] - \sum_{t=-3}^{t=0} DR_t^i$$

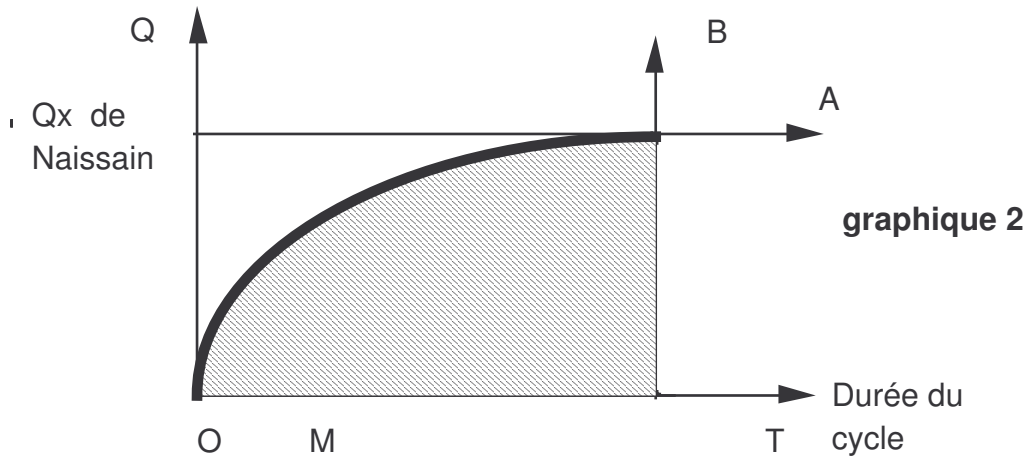
(a) being the overloading rate

* The T. BOX

The observations carried out in the Thau lagoon show that there is a relation between the initial biological load and the length of the maturation cycle (relation must be specified in the future by the biologists). The change of method by the producers, who now use exclusively half-products, could result in the lengthening of the traditional cycle in addition to purely economic

considerations. Then the maintaining of the length of the production cycle, under these new conditions, confirms the growth of the production costs.

This relation between the biological load and the length of the cycle supposes, however, 2 limits: one biological, the other economical.



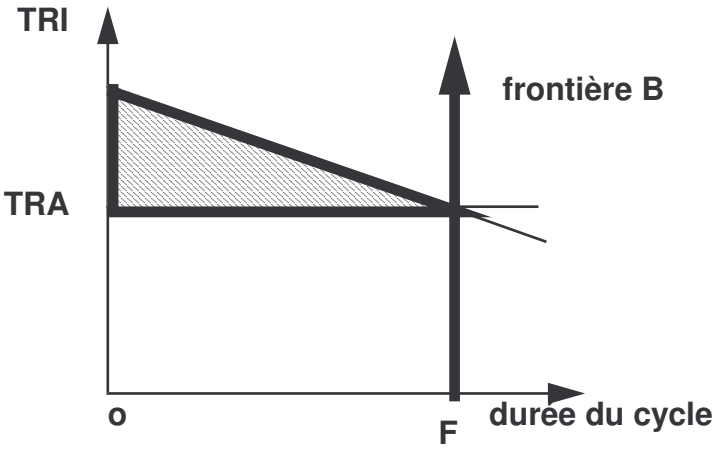

**graphique 2**

Limit A represents the biological limit for the quantity of shellfish in the lagoon, considering their nutritional needs and other biological and economical constraints.

Limit B represents the economical limits of the length of the production cycle. This is a limit beyond which the farmers would partially or totally abandon their shellfish breeding activities.

2 types of flexibility can correspond to this limit :

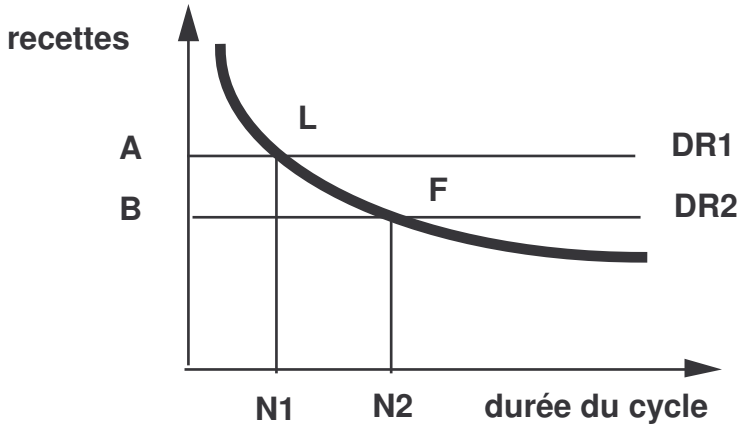
**- A flexibility for a large exploitation (Zone A) :**




**graphique 4**

The lengthening of the cycle wiil result in a decrease of the annual TRI by one marginal unit of investment. The economic limit marking the maximum length of the production cycle appears when the rate of profitability of opportunity banances the falling TRI. The expected net rent is in the filled-in area.

**- A flexibility specifically for smaller exploitations (Zone C)**




**graphique 5**

The annual income decreases when the productive cycle lengthens,with the result that when the decrease reaches the level DR1, and for a time period of N1, the farmer is not able to cover his needs of reproduction and must partially abandon his exploitation. N1 thus figures the length of the cycle which corresponds to the appearance of secondary activities for a zone and for a given exploitation. Secondary activities allow for the placing of the level DR1 to DR2 and thus the acceptance of a new deterioration of his situation (indicated in this case by an increase in the length of the exploitation cycle).

## V - CONSEQUENCES AND SOLUTIONS

3 types of consequences can result from a decrease in the rent : a smaller number of shellfish farmers in the lagoon, a shifting of the production zones with the disappearance of the least productive and a loss of value added in the local production line.

*** Decrease in the number of shellfish farmers**

- With a given cycle length (longer than the initial length) : either by the disappearance of the large exploitations having obtained a TRI inferior to the alternative production rate (graph 4), or by the disappearance of smaller exploitations where the secondary activities are not sufficient to fill the divergence between the expenses of total reproduction and shellfish income (graph 5).
- With a rising cycle length : by the aggravation of the previous effects (disappearance of the more resistant units) due to continual lengthening of the cycle.

*** A sliding of the zones with the disappearance of certain zones**

As the concessions in the Thau lagoon are not in equal production zones, we can expect that the present profitability of the most productive tables (zone A, with the most rapid growth rate) could become a profitability of the type of zone B, which would in turn become a zone C type profitability, with the tables of the least productive zone in the lagoon (zone C) disappearing because of the going over of the economic limit in the T. Box.

*** Loss of the value added in the production line**

The decrease in shellfish breeding activity by means of the disappearance of a certain number of producers would have effects on the firms working upstream and downstream in the production sector, particularly at the local level : 163 000 MF of value added (production sector 143 000, upstream sector 17 000, and the downstream sector 3 000) and 875 jobs in the production line[16] in 1986.

Solutions are to be recommended (or are being applied) to clean up the Thau lagoon in order to limit the ecological risk and to limit the decrease of the rent by means of a restructuration of the Thau lagoon exploitation.

*** "Le contrat de Baie" (Bay Contract)**

The knowledge and awareness necessary for a purification of the lagoon has been realised by the "Contrat de Baie" (1990-1995) of a total cost of 188 MF (principally financed by the EC, the basin agencies, and the local municipalities) :

- The improvement of the knowledge of the eco-system of the lagoon : the contributions of the hillside basin, water-sediment exchanges, exchanges between the sea and the lagoon, and the technological and scientific supervising of the basin;
- The improvement of the quality of the water : the treatment of all the effluents from the territorial communities on the sloping side of the basin, the treatment of the wastes from detaching, the curettage of the rivers and the retaining basins, and the treatment of the residual water from the industrial firms.
- The modernisation of the shellfish breeding production line (collective work of the improvement of the shellfish zones and hydraulic work : water-taps, input or evacuation piping and the modernisation of the production and expediting buildings).

*** "Un schéma conchylicole" (a shellfish breeding scheme)**

This scheme, at the present only on the drawing board, would aim at the reorganisation of the tables in the Thau lagoon from a spatial point of view. A different spatial installation with the installations farther out and the spacing of the tables and the cords on the tables should allow for a more rapid growth of the product.

## CONCLUSION

The relations between the parameters considered here ( economic, biological, and ecological types) and the decrease of the rent can be synthesized as in the following scheme :

[16] "Sector diagnosis of shell-fish breeding in the zone of the winefield-lagoon charte" M. Garrabé, H. Rey - June 1987.

Relations are to be indicated in the previous model :
- As the supposed connection between the increase of the risk and the method of spreading of the shellfish breeder's production,
- Or the interactions between the increase of the load of the basin and the lengthening of the cycle of the exploitation of shellfish (limit of overloading).

The observation of the shellfish biomass in the Thau lagoon was executed by IFREMER until 1987[17] and then interrupted at that time. The continuation of the observation of this biomass according to the different modalities (sampling system to be redone, several measurings during the year) given the modification of the exploitation strategy by the shellfish farmers, is indispensable to the continuation of this analysis.

We can stress the fact here that the rarefaction of the mussels in the Thau lagoon (mono-production) may result in a certain rigidity of the shellfish exploitation.

**DOCUMENTATION**

- "Malaïgue in the lagoon of the Languedoc-Roussillon coast" - G-F FRISONI IARE, A-M CEJPA CEPRALMAR, February 1989.

- "Study of the mollusca stocks breeded in the Thau lagoon from 1981 to 1987" P-Y HAMON, H. TOURNIER IFREMER, 1991.

- "Risk, internal and external flexibility in halieutic and aquatic activities" - Lisbonne 5-7 March 1990 - M. GARRABE, M-H DABAT, H. REY.

- "The systems of the shellfish-breeding exploitations in the Thau Lagoon: multi-dimensional approaches" - FIOM contract - June 1988 - M. GARRABE, N. DAURES, M. ANTONA, H. REY.

- "Evaluation of the effects of an example of lagoon pollution : the case of the malaïgue in the summer 1987 in the Thau lagoon in Languedoc-Roussillon" - M. GARRABE, C. CABASSUT, CEP, December 1989..

**THAU LAGOON :**

A salt-water lagoon of 7500 hectares
19.5 kms long with a capacity of 300 m3
Second largest lagoon in France
700 shell-farming exploitations and 850 concessions (1987)
Production : 17 000 T oysters and 8 000 T mussles (1987)
Value added for the complete production line : 163 000 MF

[17] Hamon Tournier Op. Cit.