Economics and biology used in fisheries research or when social and natural sciences try to depict together the object of their research

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Abstract

Fisheries can be characterized as a network of interactions between natural and social systems, and thus should be viewed as complex, dynamic systems. Due to the multiplicity of components and processes, the involvement of various disciplines is required to understand the inter-relationships within and between the systems, and more so to adequately address management issues that typically affect several elements in the systems. To be successful, multidisciplinary approaches require mutual understanding of the perspectives, concepts, vocabulary and methods held by various disciplines, and agreement on the objects to be studied in common. In that spirit, at framework is suggested whereby fisheries systems are decomposed into related sub-systems that can be recognized by both Social and Life Sciences. Some key concepts attached to each module and to its interactions with the others are identified, and may be starting points for dialogue and common undertakings by various disciplines, with a view to improving our understanding of the dynamics of the whole system.

Keywords: Fisheries system, natural and social systems, multidisciplinary approaches, fisheries management, risk, production, uncertainty.

Économie et biologie des pêches : quand les sciences sociales et les sciences naturelles essayent ensemble de représenter l'objet de leur recherche.

Résumé

La pêche est une forme d'interaction entre des systèmes naturels et des systèmes sociaux dont elle hérite la complexité et le caractère dynamique. Du fait de la multiplicité des éléments et processus en jeu, la contribution de différentes disciplines scientifiques est indispensable pour comprendre les interactions au sein et à l'interface des systèmes concernés, et plus encore pour aborder les problèmes de gestion qui, typiquement, affectent de nombreux éléments de ces systèmes. Le succès d'approches multidisciplinaires suppose au minimum une harmonisation des points de vue, concepts et terminologies propres à chaque discipline, ainsi qu'un accord sur les objets à étudier en commun. Nous proposons ici un cadre de représentation, basé sur une décomposition du « système halieutique » en sous-systèmes interdépendants, qui vise à faciliter l'intégration des apports des sciences de la nature et des sciences sociales. Pour chacun de ceux-ci, on a identifié quelques questions clés dont le traitement permettra de mieux appréhender la dynamique du système halieutique, et qui sont autant de bases concrètes pour entamer une réflexion ou des travaux en commun.

Mots-clés : Système halieutique, systèmes naturels et sociaux, multidisciplinarité, gestion des pêcheries, risque, production, incertitude.

When you define an unit of observation you define the conditions of exclusion of other objects

Each fisherman is an "expert" with whom we cannot hope to communicate if we use the fragmented discipline-based approach that we have too often adopted for interactions between Nature and Society. An effort is necessary to identify the various components that make up his environment so as to understand his choices and his behaviour.

INTRODUCTION

The main question discussed here is relatively easily expressed: how can we represent the elements whose interactions determine the dynamics of fisheries systems. The approach proposed here considers fisheries systems to be the addition of the components of two continuously interacting sub-systems: the "productive" system and the management system. In this way, we make reference to systems approaches widely used in agronomy, which try to go beyond the characterization of productive unit operations, and concentrate on analyzing the relationships which have emerged in particular places between fisheries activities and the environment. In the case of fisheries, this is especially due to the importance of externalities and collective behaviour. This question of the representation of fisheries systems takes on a new dimension when set against two major approaches, that of scientists (whatever their discipline) asked about anthropisation processes, and that of decision-makers concerned with the future of the resources, ecosystems and coastal communities, and hence with management of fisheries systems. More generally, this question is also in keeping with a natural evolutionary process of the way in which the relationship between ecosystems and social systems is perceived (Jollivet, 1992). However, we will restrict this discussion to two major aspects. First, we will try to clarify a way of representing the object of scientific study common to Social and Life Sciences, in the particular case of fisheries. Then we will attempt to illustrate this approach with a few transverse questions which appear regularly in current scientific works concerned with fisheries. We will mention briefly in succession such notions or concepts as risk, fishing effort and objective functions.

Defining a common scientific object for social and life sciences

In itself the idea of defining a common scientific object for Social and Life Sciences is not new and must be differentiated straight away from attempts by some experts to replace decision-makers so as to preach a "technocratic model" where the scientist holds the key to important decisions (Joye, 1992). In fact, compared to other research areas, fisheries science started early to link the knowledge accumulated by Natural and Human Sciences (economics and biology in particular). But few attempts have been made to try and represent a common object of analysis. Yet it is clear that this path is paved with important issues concerning the relevant geographical scales and the definition of time scales appropriate to social, biological and ecological processes. Numerous problems already begin to emerge at this stage (Quensière, 1993 and ORSTOM, 1991). The scientific literature only considers as significantly new the bioeconomic models which, despite their useful contribution to a multidisciplinary approach, make only limited and patchy progress in integrating opinions from different disciplines (Clark, 1976, 1985; Charles, 1988, 1991; Hannesson, 1993). Bioeconomic models are limited by the difficulty of formalising the logic and behaviour of the actors (Catanzano and Cunningham, 1993), the effects of which are considered in terms of avoidance or efficiency loss of proposed management systems. Other forms of representation often escape notice as they are far from being sufficiently formalised and adapted to different situations. Yet more and more people concentrate on them (Charles, 1991; Quensière, 1993; Catanzano and Rey, 1993). Our approach is methodological and should be considered as a tentative proposal, for the sake of discussion.

Arguments and realities justifying the approach

Depending on whether we concentrate exclusively on fisheries research or try to cast the debate on fisheries management into an analysis of the relationships between ecosystems and social systems, different arguments emerge which justify a need for a revision of the methods used. Without developing each of the arguments already dealt with in the scientific, technical and politico-administrative literature, several arguments may be put forward relating to observations or unanswered questions: (i) the relative failure of most management systems whether of international, national or local fisheries; (ii) the institutional role of the expert and research in the decision-making process; and last (iii) the limited knowledge on interactions between social, ecological and biological domains that take place within fisheries activities. In fact, it is in an attempt to answer these three questions that we tried to redefine an analytical framework for looking at the interactions between the "productive" and management systems. These interactions bring together the actors directly affecting the ecosystems as well as most of the institutions (in the wide sense) which give a certain vision of the actors, their functions and the behaviourial characteristics of the components of fisheries systems. For example, with no pretence at being comprehensive, we could illustrate this with a few unhappy experiences.

There are several instances in which the advice provided by or requested from ICES (International Council for the Exploration of the Sea) could not be used efficiently for management purpose because the scale of observations was inadequate.

For the North Sea roundfish fisheries for example, TACs (Total Allowable Catches) are recommended for each species individually, based on forecasts of catches and SSB (Spawning Stock Biomass) under varying levels of effort in the human consumption fishery. To a large extent, the latter is a mixed fishery, and a majority of the vessels involved do catch all three species of cod, haddock, and whiting over the year. In recent years, the stock of cod has been in a poor state, calling for a strong reduction in fishing mortality (implicity, fishing effort), whereas the stock of whiting was in rather good condition and current fishing mortality was considered acceptable. If we treat the human consumption fleets as an aggregate, then managers are confronted with a major problem in setting TACs that are compatible with the requirements of effort reduction for cod and status quo for whiting. In view of the difficulty in identifying consistent fisheries directed at each of the roundfish species except saithe, ACFM (Advisory Committee on Fisheries Management) was led to recommend a uniform effort reduction in the roundfish fisheries, an advice that was essentially driven by the priority given to cod and haddock at the expense of whiting. Obviously, this approach exaggerates the problem by ignoring the fact that some vessels may actually fish either species selectively in some areas or seasons. What is lacking here is an appropriate resolution regarding the fleets and their effort distribution in space and time. One may expect that the detailed database set up by STCF (Scientific and Technical Committee for Fisheries) and now taken over by the Long Term Management Working Group, may help to alleviate this problem, although practical difficulties will certainly persist.

Another long standing problem regarding the provision of TAC advice by ICES and similar organisations is related to the time frame considered. In most instances, the consequences of management options are only given for the immediate future, making it impossible to spell out the trade-offs between catching the surplus production now or preserving part of the biomass to ensure better catches in the medium term. Of course, recruitment makes up a significant part of the catches, notably in overexploited stocks (many are), and reliable predictions of future recruitment are impossible. However, scientists have tended to over-emphasise this problem, thus reinforcing the tendency by fishermen and managers to concentrate on short-term considerations. The current efforts to take advantage of techniques developed for risk analysis indicate that appropriate tools can be envisaged to explicitly handle uncertainties in the biological and other parameters, so as to circumvent the shortcomings of myopic management advice.

The mixed fisheries in the Bay of Biscay are yet another example of the difficulties faced by managers in deciding technical measures. The predominant interactions occur between the fisheries for hake and for Nephrops (Norway lobster). The latter are allowed to use small- mesh gears and make considerable by-catches of juvenile hake that are concentrated on the Nephrops grounds. Trawl fisheries in that area have a long history of not complying with legal mesh sizes, which results in considerable discarding of small fish. The problem is further compounded by the fact that the fleets involved in these fisheries also catch a number of valuable species. The network of interactions has been described and quantified by the late Working Group on Fisheries Units in Sub-areas VII and VIII (*e.g.* Anon. 1990). One of its conclusions was that enforcement of the existing regulation should be a priority, as this would be beneficial to the whole fishery. Also gains were expected from a reduction of by-catches of hake in the Nephrops fishery, *e.g.* by use of selective trawls. The industry is reluctant to use such devices, however, as the revenue of the so-called Nephrops trawlers has become highly dependent on the by-catches of finfish. One of the shortcomings of the approach used by this working group is that the evaluations were made on a métier rather than on a fleet-basis, *i.e.* it was not explicit that vessels from a given fleet could operate in several métiers; conversely it was not clear how the fleets should be managed to obtain a desired pattern of fishing mortalities on the species caught by the various métiers. The type of model suggested by Laurec *et al.* (1991), that takes explicit account of how fleets allocate their efforts to the available métiers and, in that way, generate fishing mortality on specific components of the fish resources, would have been more appropriate, pending the availability of economic data. The most frustrating conclusion of this exercise, however, is that managers were apparently not prepared to handle the complexity of a system with that many interactions, as evidenced by the fact that they did very little to depart from status quo although this means the continuation of significant losses for some segments of the industry. The decisions to sacrifice some particular interests for the sake of the common welfare are too hard to take.

In the Mediterranean, in a different productive and regulatory context, we note that the scientific work underlying policy recommendations (in particular from FAO, via GFCM (General Fisheries Council for the Mediterranean) is in direct conflict with the position of local and national administrations whose opinion is based on the reality of fisheries development in areas such as for example the Gulf of Lions. Three analyses are proposed, each based on a particular representation of the fishery system and only taking into account one part of the explanatory components and interactions of the true dynamics. Only a reconciliation of the three analyses could lead to a solid diagnosis, to the establishment of a process of negotiation, and to the implementation of fisheries management by first defining management units (Bertrand *et al.*, 1994).

Generally speaking, many deficiencies of fisheries management in Europe stem from the fact that social and economic constraints are often invoked, but seldom spelt out explicitly by managers or the fishing industry. Although ICES has been reluctant to extend its expertise in that direction, it would be unfair to blame it only: STCF was supposed to be better equipped for the purpose, but did not meet all expectations either. Although their point of view is necessarily partial, biologists have been the only advisers to support their case with data and assessments (however imperfect they might be) on a regular basis.

A proposition for the representation of fisheries systems

Trying to explain the fisheries system means integrating viewpoints from several disciplines so as to build a general abstract mental picture of the object to be analyzed. This will help interdisciplinary work even before questions of appropriate scales are considered. Generally, a system can be defined as a group of coordinated and stable relations so as to be permanent, *i.e.* guaranteed to last for a certain period without being eternal. It is at this stage of "some permanence" that the object to be described is defined and characterised, via its components, perhaps with the aim of analysing its evolution (from the time when it emerges to the time when it disappears). The fishery system taken as a part of a bigger composite system (ecosystems, social systems, economic systems...) cannot avoid being affected by its dynamics. For more than twenty years, agronomists and other analysts from the agricultural world have been reconsidering some of the basic concepts for the analysis of agricultural and rural activities by adapting definitions dating from more than a century earlier. Over and above the semantic debate which followed, the establishment of new analytical and operational concepts (for management) has given an impetus to modern agronomy which is now seen as a leading discipline in a number of different sciences (Sebillote, 1979). Gradually, from then on, efforts have been made to place the analysis of agricultural systems at the focus point of interactions between nature and society. It is not surprising that we should use experiences from related disciplines if the representation project is similar. In our approach, it helps to formalise interesting analogies even though we are aware of the differences. This discussion leads us to a construction based on the following definitions:

The fisheries system is complex because of the nature, the multiplicity and the intrinsic characteristics of its components which, through their interactions, act as the vectors of its dynamics. At the highest level, two closely related sub-systems may be identified: a "productive" and a management system. The fisheries "productive" system may be defined as those elements which contribute to the flow of fisheries products. It may be further divided into three linked subsystems: catching, production and exploitation systems. The management system is constituted of elements concerned with the regulation of such flows. It can also be broken down into regulatory tools, their outcome and the context in which they operate (actors, decisions, institutions...) (*fig.* 1).

Such a representational structure should: enable to (i) take into account the factors and natural processes explaining the global dynamics of the fisheries system; (ii) characterize the principal interactions across the interrelated modules; and (iii) identify key concepts and interactions without forgetting to analyze their impact on the whole system, making it easier to reconcile different disciplinary viewpoints. We will give some examples later which will illustrate these ideas.

THE COMPONENTS OF THE FISHERIES SYSTEM

Four components of the fisheries system will be mentioned here. We will try to underline the

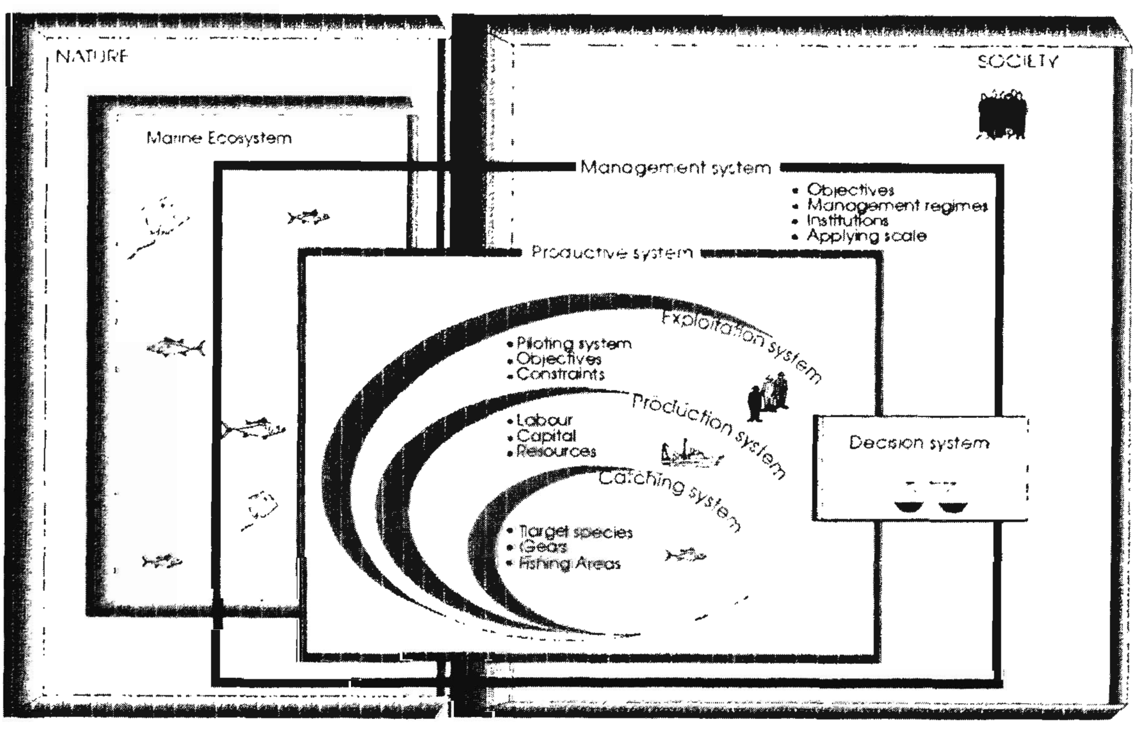

Figure 1. – Fisheries systems.

concepts and some of the questions that relate to them. These questions often reveal interactions that unify the components. Answering these questions requires the consideration of conflicting viewpoints. Such a representational structure should enable us to define and identify, via the relationships between each sub-system, the impact of the main interactions by analyzing them within the framework of the global dynamics affecting the whole fisheries system.

The catching system

The catching system can be defined as the totality of the elements and processes related to possible productive activities (or to the products) and to the techniques which can be used by fishermen. What to produce and how? Referring to the concept of "métier", the catching system appears to be a succession of métiers undertaken by a fisherman during a cycle of activity (a year for example) (*fig.* 2). Regarding the "how", the gear is the primary element. A gear change is often responsible for a change in various biological, ecological, technical and economic variables. It has to be considered as a change of métier. In many cases, the choice of gear is the primary factor in the fisherman's "project", even more so than the choice of the target species. If a gear is to be used efficiently, some technical knowledge is necessary (acquiring a certain know-how), a result of training or experience. This is valid for all gears, from the most sophisticated to those which appear the most simple (adaptation to their context). Most gears require a special vessel design or at least specific on-board equipment. In this way, further rigidity is introduced

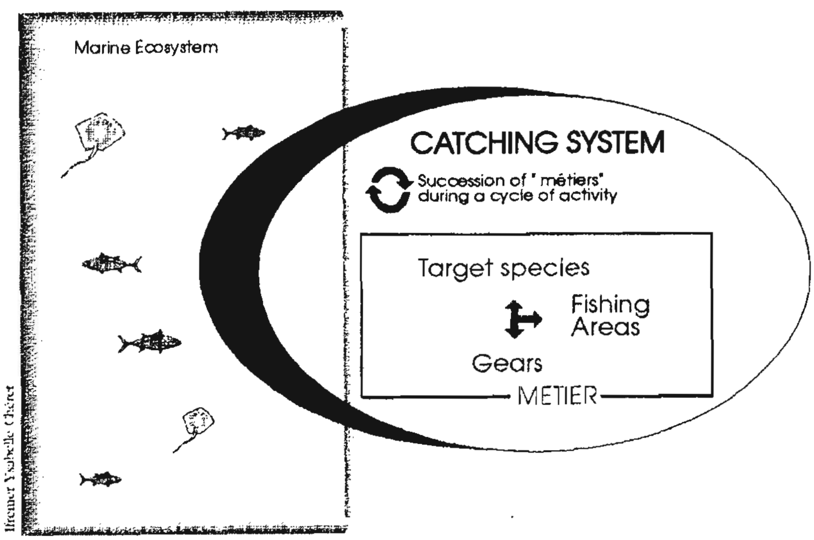

Figure 2. – "Métier" and catching system.

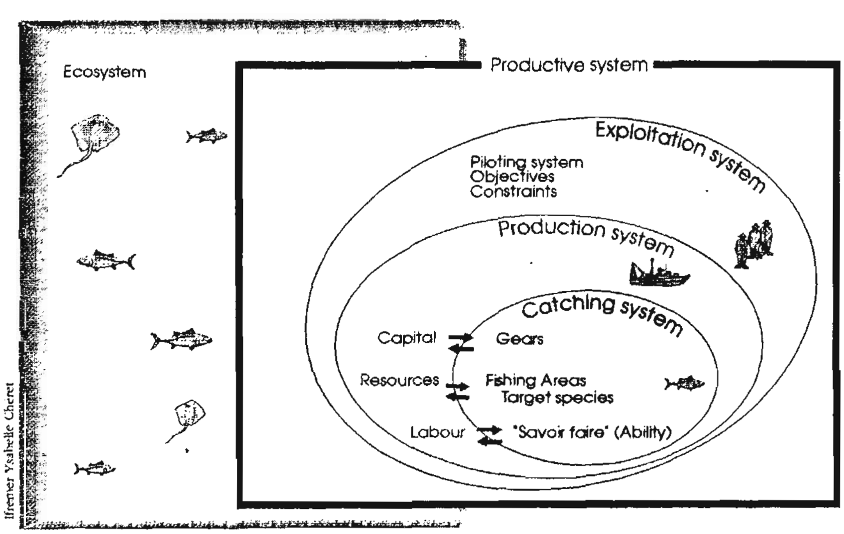

Figure 3. – Catching system and productive system.

against adapting the vessel to environmental changes. Lastly and certainly the main factor is the fact that, in the fisherman's mind, each gear is associated with some idea of efficiency, productivity and profitability. These can be perceived in terms of "nominal" performance for a given species, time period and area or in terms of versatility (variety of species, various types of grounds). When a fisherman claims that his métier is directed at some species, he in fact displays a preference or an intention and this is what matters when one analyses what determines his decision or his action. However, his actions do not necessarily reflect his intentions, and can even contradict them as judged from an examination of his actual catch. For example, the "Nephrops vessels" from southern Brittany have a traditional preference for Norway lobster, even though this particular species is sometimes scarce in their catch (Charuau, 1989). When the fisheries regulation validates this incongruity, by allowing surprisingly low percentages of the target species in some so-called special fisheries, the target species simply becomes an excuse to maintain previous practices that are often not justified in the present context. At this first level of decomposition of the fisheries system, many questions can be listed among which:

Table 1. – The catching system: some of the main questions.

Selectivity	Reduction of by-catch and positive secondary effects (species or size categories for a given species)
Non selectivity	Reduction of the risks by searching for a variety of species
Plasticity	Problem of technical and social adaptation so as to increase alternatives in response to environmental variations or shocks (bio-, eco-, sociological)
Versatility	Reduction of risks by maintaining a potential diversity in technical choices
Accessability	Being able to go and get the species, technical adaptability
Uncertainty	Incomplete information (resource dynamics, gear competitiveness, variability, environmental factors, hidden resources...)
Appropriation	Permanent or temporary technical (physical) occupation of productive zones/trans-appropriative resources
Innovation	Adaptation process of techniques to revised objectives or constraints

The production system

Classically, for social sciences, the analysis of production is complex. One option is to focus on the modes of production, where the fundamental characteristics are the identification of the owner, the worker, the productive means, the relationships between owners and workers and the productive collaborative relationships between the different economic actors. Alternatively, examining productive relations can be of interest, as they tend to concentrate on social relationships which affect access conditions, productive resources and ownership of the production means (*fig.* 3). This approach can also refer to the definition of a productive system which identifies production factors and represents a production function. Without neglecting the elements described in these first two options, the economist, if preoccupied by a mathematical formalisation of the act of production, may also favour the dynamic analysis of productive combinations expressed as a production function. The latter is developed within a wider set of constraints or of technical, social, legal or natural events which shape the relationships between inputs and outputs. Because of the character of the resource (renewable, non appropriable before being caught, mobile, difficult to assess...), fishing is quite particular. Only in a few cases are relevant comparisons possible with the cases of forestry, mining, energy resources or water. As it concerns a living resource, we could go further and, referring to the General System Theory (Von Bertalanffy, 1973; Le Moigne, 1984), consider that there are in this particular case two "pilots" within the fisheries system: man and the fish.

This is to emphasise the extreme complexity involved in the description of interactions between these two populations. Some of the questions that we are tempted to ask concerning the production system are:

Table 2. – The production system: some of the main questions.

Productivity	Differentiated result of production combinations
Natural productivity	Result of the dynamics of exploited populations
Substitution	Combination and adaptability of inputs
Complementarity	Production function, constraints and adaptability or flexibility
Intensification	Choice of particular production combinations
Competitiveness	Juxtaposition of distinct modes, forms or functions of production aiming at the same markets
Appropriation, property	Access or constraints on access to factors and concentration in the productive sector (common property, private, state, open access...)
Payment	Interest rate on technical capital, payment for labour
Costs	Related to knowledge on factor availability, access constraints and a function of the revealed preference, substitution Calculation of the opportunity cost of natural capital
Externalities	A source of potential conflicts between distinct productive forms and causes of extra costs
Renewal of capital	Natural capital has a renewal rate which adds another constraint to the utility function
Innovation	Dynamics of adaptation to the constraints and externalities of different nature
Fishing effort	Determination of an artificial standardised measure related to actual or expected results (nominal or effective effort)

The exploitation system

The exploitation system generally means a system concerned with the operating of productive units according to a logic of rational choices, the expression of these choices being followed by decision-taking. In most productive sectors, these decisions are a result of confrontations between the productive unit and the outside world depending on the strength of different effects. In the case of fisheries, it is different because externalities are very strong and so do not allow the productive unit to be isolated easily from a subset or from the whole of the productive units. Moreover, fisheries are also special due to the weight of environmental constraints and to the impact of human activities (ecological, biological, physical, social... constraints or effects). The objective then becomes to understand the behaviourial choices of producers and of the economic agents involved in production, according to different temporal and spatial scales, with reference to physical, ecological, biological, economic and social changes. Information flows underlying the process of choice must also be considered. The decision unit is hence more complex to identify as such and, as a result, it is more difficult to express individual rationalities. Among the main questions found at that level of observation, the following will be noted:

Table 3. – Exploitation system: some of the main questions.

Exploitation unit	How can it be defined? What are its limits in an unstable and reactive environment? What is its social significance?
Information, uncertainty	What information flows influence the choice process? and with what degree of uncertainty or with what bias?
Constraints	Differentiation of the choice constraints depending on the nature of the factors (ecological, physical, biological, economic, social, or cultural)
Institution	On what institutional processes is based the social organisation that governs exploitation?
Objectives	Specification of the objective function Result in terms of the aggregation of individual functions Time horizon (short-, medium-, long-term)
Behaviour	Nature and kinds of expectations Strategies regarding risks What rationalities (economic, political, merchant, social, ethnic, territorial....)?
Distribution	How and on what bases is defined the system of distribution of the results of the activities?

The management system

It must represent the elements and choices that contribute to regulating the productive system and thus the flow of fisheries products. It involves management tools which are going to constrain partially or totally the choices of target species, zones of activity, gear (at the level of the catching system); or the level of implication and/or availability of productive factors (at the level of the productive system); or else indirectly discriminate against certain kinds of exploitation through differences in access to information, to knowledge, to adequate legal status, enabling the development of some types of production (at the level of the exploitation system) (*fig.* 4).

Used in this way, all these tools aim at satisfying an implicit or explicit objective function (taking the form of multi-objective combinations) which will be the baseline against which the impact, efficiency, acceptability, viability of the chosen regulatory model can be evaluated. Social objectives (non monetarised objectives, self-sufficiency in food, survival economy, political agreement, sustainable development of the activity...), economic objectives (level of wealth created, level of income, employment...), bio-ecological objectives (resource conservation, biodiversity...) are mixed together in most cases (Charles, 1991).

Lastly and because it is definitely accepted today that using hypotheses of neoclassical rationality concerning the description of the fisherman's behaviour cannot suffice to understand the gap between the objectives and the results of regulation, institutional forms and dynamics have to be analyzed as they themselves produce effects which explain the dynamic interactions between the productive and management systems (Platteau, 1991).

Therefore the questions arising can be formulated as follows:

Table 4. – Management system: some of the main questions.

Management unit	What spatial, social, biological, ecological, institutional, political definition? Minimum unit of applicability and acceptability of designated objectives Adaptation of the respective dynamics of the productive and regulatory system
Management tools	Property rights, social, economic, political, spatial nature and implementation Constraints on input, output Direct financial constraints, constraints in physical terms
Objectives	Conservation, rationalisation, social/ community paradigm, sustainability Balancing private utility functions and regulatory objective functions (balancing social scales, private/ public, state/community, community/community...)
Efficiency	Functional economic appraisal of regulation
Equity	Social appraisal of the distribution of constraints and regulatory results
Regulation	Social acceptability, compliance, control

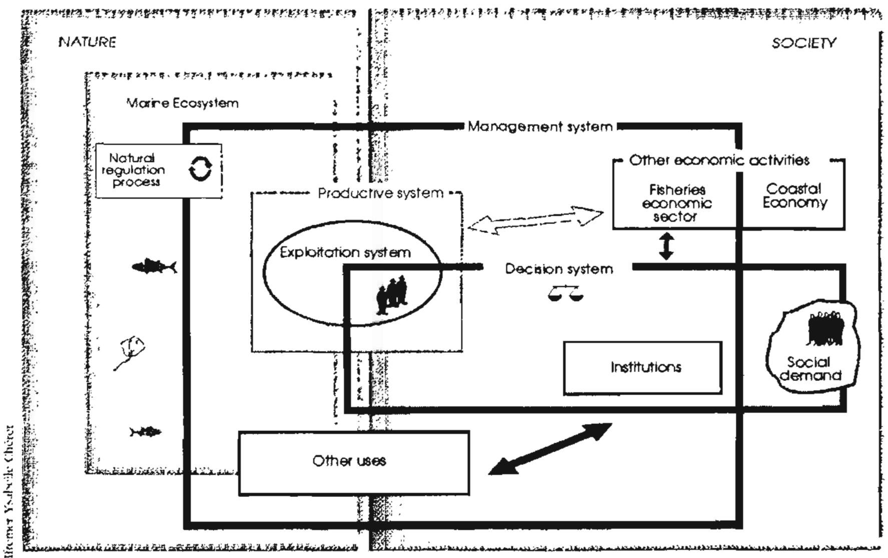

Figure 4 – Management system.

It is important not to restrict these questions to only one of the four subsystems, but to clarify their effects on all of them. The matrix so defined should help to bring together the discipline-based view and the real world which is the supposed object of our analysis. Let us use as an illustration a few specific examples related to the concepts of risk and uncertainty.

DISCUSSION

Risk and uncertainty are two of the concepts leading to a redefinition of the object studied

We can always initially define the subject under study and say that its component parts concern function, structure or decision to a greater or lesser degree. However, it is not rare to find that, between the initial and subsequent questions, the object of the study itself somehow evolves. Questions are then asked about the composition of the object and the way its different parts interrelate. This can be observed recurrently throughout the history of sciences (in earth sciences for example or chemistry or else medicine). Each time, the more recent questions are responsible for widening previous observations. In the case of the exploitation of living marine resources, among the subjects most frequently studied today some justify, and even require a redefinition of what is supposed to be integrated in the study of interactions between society and renewable living marine resources. Well up on the list are the following: fishing effort, objective functions, utility, compliance, sustainability, quality, adaptability, risk, uncertainty...

If we concentrate on the last two, it is generally accepted that the variations in the results of fishing business may be due to different causes such as variations in production (quantitative), variations in the quality of the catch and price changes of the harvested species. Such causes, partially exogenous, lead the fisherman (and consequently at another level, all of the sector's social, economic and political actors) to take decisions whilst in possession of imperfect information and in a situation of risk and uncertainty. Indeed, economic, ecological and environmental factors can influence the production outcome just as much as mere differences in productivity depending on the productive factors used. All acts, whether related to production or regulation, are subject to uncertainty or accompanied by risk, depending on whether the expected event is not commensurable or whether we are aware of the probable consequences (Knight, 1921). Far from being well differentiated, the ideas of risk and uncertainty, whatever their definition, involve all the disciplines to establish a preliminary inventory of those factors which express or increase risk or else can be considered a cause of uncertainty relating to different elements of the fisheries system affecting one or another actor in particular. To cite but a few: natural sources of uncertainty linked to the resource; those affecting economic variables and parameters (financial or commercial); and lastly changes in priorities which make the social future more or less predictable and so tend to increase (in the medium term) the instability of management options recommended on the basis of previous objectives. In fact, these concepts also tend to define more precisely what belongs to the fisheries system. Following on from the deterministic approach of Clark, uncertainty was first only considered as a random "noise" or as fluctuations within ecosystems or socio-economic systems (Mangel and Clark, 1993). Step by step, as described by Shotton (1993), references to these concepts have progressively developed, for example from the initial Decision Theoretical sense of risk. Whilst the loss of precision in meaning associated with the vulgarisation of concepts may be deplored, the disciplines' contribution to identifying a common meaning for the different components can be praised as it in fact contributes to a general definition of the system under study. In that way for example, when Peterson and Smith (1982) describe four causes of risk, they do nothing less than define the system being studied. Otherwise, the dynamics of the interactions of interest cannot be understood (resources and their environment; scientific knowledge; markets; management systems).

Although apparently simple, this approach to the domain to be analyzed is in effect a step on the way to the present proposal, where the defined global system is supported by relevant questions in terms of, for instance, risk, uncertainty... Consequently, these concepts are important not only in themselves but also because of the recomposition to which they lead. The system studied cannot therefore be defined or perceived solely in terms of risk and uncertainty as understood by the biologist/dynamicist working alone who focuses in the first instance on biological parameters necessary for estimating current or future abundance of stocks (natural mortality, growth, recruitment...). The same would apply to studies undertaken by economists or ecologists. As well as these causes of uncertainty, others have to be considered that are associated with economic, social, political factors at an individual (contractors, buyers, managers...) or collective level whether public or private (pressure groups, professional groups, cooperatives, industrial groups, state...). The problem is no longer to work on individual roles but to work on the whole system, based on the interactions that have been validated and for which archetypes can be characterised and differentiated (*e.g.*, by preliminary typologies of the sub-systems within the fisheries system).

Compared to approaches which have long been adopted, clearly the causes of uncertainty which now have to be taken into account require that the scientist should know more than about the environment and the resources, their variability, their dynamics, estimated abundance, simulated mobility, migrations and anticipated physical shocks. He must also take into account changes due to the social and economic environment, changes in objectives, in rationalities, in priorities; try to identify and explain how to reduce uncertainty brought about by imperfect information and not simply by a lack of knowledge. In this way, the perception of a system as a series of interwoven elements having distinct functions can facilitate the reconcilation of different disciplinary viewpoints focusing on each of its components without an *a priori* ranking of the expected effects. Neither risk, whether related to investment or marketing, nor uncertainty linked to research concerning a particular stock will be approached in a dissociated way. Instead, in order to understand the dynamics of exploitation, it is necessary to take into account all the parameters involved and those variables thought to explain the logic of development of a particular type of exploitation which is characterised by these structural parameters as much as by their function and by the social form of its organisation. In fact, it means recognizing that the dynamics of actors and structural elements in the system cannot be interpreted in isolation from their environment. When dealing with risk or uncertainty, it is necessary not only to establish an inventory of their sources but also to consider their combinations and the way in which they affect together or successively a particular group of actors. Instead of differentiating the actors according to rationalities established *a priori* by a particular theory (maximisation of utility according to consumer or producer theory...), differences related to risk and uncertainty can be integrated so as to characterize strategies or behaviours (Opaluch J.J., N.E. Bockstael, 1984).

Table 5. – Some general arguments for a discussion about uncertainty and risk.

Uncertainty

1. Natural resources subjected to fluctuating and unpredictable environmental factors
2. Inherent variability in abundance (recruitment), availability, growth, fecundity...
3. Inability to observe the resource directly
4. Dynamics of species poorly understood (adequacy of models, estimation of parameters, cascading effect of biological variables, identification/selection of causal variables, stability, bifurcation, chaos...)
5. Evaluation of abundance, distribution of species
6. Uncertain economic and trading environments, externalities
7. Strong interactions between sectoral regulations (public or collective), public targets and private strategies
8. Difficulty in predicting the evolution of the public's perception of issues about the marine environment (dolphins, pollution problems...)
9. Complete lack of management objectives
10. Imperfect economic, marketing and social information (markets and competition).

Risks

1. Decrease in abundance, in prices...
2. Unstable inputs, effort, management decisions...
3. Unstability ; closure of areas, quotas, international markets ....
4. Loss of social cohesion; inadequacy of social structures, institutions ....
5. Restricted access to capital and productive factors
6. Irreversible choice in technical investment, no potential for adaptation
7. Influence of multiple activities, versatility...
8. Payment modes (share system for the crew)
9. Administrative and legal penalties due to management, institutions
10. Damage to the environment by effects outside of the fisheries sector
11. Competition for appropriation of maritime space. Property rights, exclusion from national zones.
12. Technological innovations and changes in fishing strategies.

To conclude, the need to redefine the fisheries system comes from new questions that arise whilst trying to understand interactions within the system, which is known to be complex, and for which it is unwise to expect to understand independently from the whole the behaviour of a particular group of actors (even when the group is clearly identified). In this context, common concepts such as discussed here are the best example from the point of view both of disciplinary reconciliation and of the artificial frontiers established for analysis.

REFERENCES

Anon. 1990. Report of the Working Group on Fisheries Units in Sub-areas VII and VIII. ICES Doc. CM 1990, Assess. 23, 129 p.

Berkes F., M. Kislalioglu 1991. Community-based Management and Sustainable Development. In: La Recherche face à la pêche artisanale, Symp. Int. ORSTOM-IFREMER, Montpellier France, 3-7 juillet 1989, J.-R. Durand, J. Lemoalle, J. Weber eds. Paris, ORSTOM, t.II: 567-574.

Bertrand J., C. Caboche, J. Catanzano, H. Rey, E. Tempier 1994. Programme Pilote de Gestion Halieutique, Contrat CNPM/Ifremer-CEE, N0XIV-1-MED 91.015b.

Catanzano J., S. Cunningham 1993. A Note on Progress in the Bioeconomic modelling of fishing activity in the North Sea. Work. doc., ICES Working Group on Long Term Management, 19-28 January 1993.

Catanzano J., H. Rey 1993. Gestion des Pêches, Chronique d'une Révolution Annoncée. 5e Conférence de l'EAFE, Bruxelles, Belgique, 24-26 mars 1993.

Charles A.T. 1988. Fishery socioeconomics: A survey. *Land Econ.* **68**, 276-295.

Charles A.T. 1991. Small-scale fisheries in North America: research perspectives. In: La Recherche face à la pêche artisanale, Symp. Int. ORSTOM- IFREMER, Montpellier France, 3-7 juillet 1989, J.-R. Durand, J. Lemoalle, J. Weber eds. Paris, ORSTOM, t.I: 157-184.

Charles A. T. Optimal Fisheries and Investment under Uncertainty. *Can. J. Fish. Aquat. Sci.* **40**, 2080-2091.

Charuau A. 1989. La dynamique des pêches côtières du pays bigouden. IFREMER, Ministère de la Mer, contrat 87.08.05, 140 p.

Clark C.W. 1976. Mathematical Bio-economics: The Optimal Management of Renewable Resources. Wiley-Interscience, New York, NY.

Clark C.W. 1985. Bioeconomics Modelling and Fisheries Management. Wiley-Interscience, New York, NY.

Hannesson R. 1993. Bioeconomic Analysis of Fisheries, F.A.O. and Fishing News Books.

Jollivet M. 1992. Ecosystèmes et systèmes sociaux. In: Environnement et société: la contribution des sciences sociales. Séminaire UNESCO, Neufchâtel, 21-22 novembre 1991.

Joye D. 1992. Gestion de l'environnement. In: Environnement et société: la contribution des sciences sociales. Séminaire UNESCO, Neufchâtel, 21-22 novembre 1991.

Knight F.H. 1921. Risk, Profit and Uncertainty, Chicago, The University of Chicago Press.

Laurec A., A. Biseau, A. Charuau 1991. Modelling technical interactions. ICES Mar. Sci. Symp. **193**, 225-236.

Le Moigne J.L. 1984. La théorie du système général. Théorie de la modélisation, Paris P.U.F., 2ème édition.

Mangel M., C.W. Clark 1983. Uncertainty, search, and information in fisheries. *J. Cons. int. Explor. Mer.* **41**, 93-103.

Opaluch J. J., N.E. Bockstael 1984. Behavorial modelling and fisheries management. *Mar. Res. Econ.* **1**, 105-115.

Perterson S., L.J. Smith 1982. Risk Reduction in Fisheries Management. *Ocean Manage.* **8**, 1, 65-79.

Platteau J. P. 1991. An Analysis of Contractual Relationships in the Maritime Fishing Sector: the Contribution of the New Institutional Economics. In: La Recherche Face à la Pêche Artisanale, Symp. Int. ORSTOM-IFREMER, Montpellier France, 3-7 juillet 1989, J.-R. Durand, J. Lemoalle, J. Weber eds. Paris, ORSTOM, t. II: 763-774.

Quensière J. 1993. De la modélisation halieutique à la gestion systémique des pêches. *Natures Sciences et Sociétés* **1**, 211-220.

Sebillotte M. 1979. Cours d'Agronomie. Institut National Agronomique, Paris-Grignon, 5 tomes.

Shotton R. 1993. Risk, Uncertainty and Utility A Review of the Use of these Concepts in Fisheries Management. ICES C. M. D71, Sept. 1993.

ORSTOM 1991. Séminfor 4: Le transfert d'échelle. Textes réunis et rassemblés par C. Mullon, Orstom Ed. Paris.

Von Bertalanffy L. 1973. La théorie générale des systèmes. Dunod, Paris.