SMALL-SCALE FISHERIES ANALYSIS IN A SUSTAINABLE DEVELOPMENT PERSPECTIVE.

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ABSTRACT

An international symposium devoted to *Research and small-scale fisheries* (Durand, Lemoalle, Weber, 1991) in Montpellier (France) in 1989 came from increasing evidence that "*the complexity of small scale fisheries calls for applying knowledge from many fields in combined studies that can take advantage of a whole range of information*". Has this assessment changed twenty years later? The references to sustainable development and to socio and bio-ecological diversities have highlighted the relationships between small-scale fisheries and natural, economic, social, cultural, and institutional aspects. In this paper we exemplify such interactions in different small-scale fisheries contexts in relation with poverty and food security issues. We question the consequences of different types of fleet dynamics in terms of adaptability, vulnerability and resilience of harvested ecosystems, and the impacts of the regulation systems on fishing communities. More generally, we question the paradigm of sustainable self-regulated small-scale fisheries. Finally, with references to several worldwide case studies and ecosystems we provide a description of the diversity of small scale fisheries, of the frameworks used to represent them, and of associated sets of relevant indicators used in monitoring and management programs. This presentation may be a first step toward a revisited pluri-disciplinary research framework for small-scale fisheries. This could be based on a research network built in order to produce and mobilize knowledge from a more comprehensive set of small-scale fisheries case studies.

Keywords: Systemic approach, Sustainable Development, small-scale fisheries…

INTRODUCTION

The complexity of small-scale fisheries calls for applying knowledge from many fields in combined studies that can take advantage of a whole range of information. This sentence from the proceedings of the 1989 Montpellier symposium *Research and small-scale fisheries* (Durand, Lemoalle, Weber, 1991) is probably still up to date more than twenty years ago.

It is therefore useful to present the way and the context in which knowledge from many fields has been used to better understand small-scale fisheries in order to assess and if possible improve their sustainability. This complexity may be perceived as a constraint to our capacities to understand the dynamics of small-scale fisheries and exploited resources and ecosystems but it should also mainly be seen as a scientific challenge, encouraging new approaches, in particular a better balanced relationship between all concerned scientific fields.

First of all we have to describe the evolution of the research context in terms of representation of fisheries exploitation and to investigate particularly how the complexity of small-scale fisheries is accounted for.

The key words underpinning this evolution may be the *systemic approaches* (Rey et al, 1997) in the context of *sustainable development* (Charles, 2001). Sustainable Development refers both to an overall

goal and to a framework, combining the dynamics of different capitals (social, economical, natural, institutional…). Evolution of development and management goals or frameworks is concomitant with an evolution of observations and information systems on fisheries exploitations. More specifically, the erosion of the old paradigm of centralized management and the shift toward co-management and participatory decision making (Berkes, 2001) has very important implications on the nature of the required information and on the way to collect it.

For the sake of simplicity, we may consider two steps in this evolution,

1 The mono species (stock) assessment and management.

In this first step, the dynamics of a single component (one stock) of the resource is represented conditionally to a time series of fishing mortality proportional to a "standardised effort". This effort accounts for the overall fishing activity and associated fish mortality exerted by one or several fishing fleets.

Here the predicted variable is the resource abundance. Results and objectives are therefore necessarily functions of this abundance and of some associated information such as fishing costs, ex-vessel prices etc. (eg MSY, MEY, Open access Yield…).

The management objectives can be to estimate a single parameter, one for each resource stock. This means that it is possible to define optima corresponding to single values of fishing mortality but also of fishing effort with straightforward consequences about the desired level of economic activity in the fishery.

The definition and the research for optima was the most common attitude, even if management sometimes aimed to specify some "acceptable domain", for example in the context of viability theory (Béné, Doyen and Gabay, 2001) or precautionary approaches (e.g., with the use of reference points such as Minimum Biomass Acceptable Levels).

The data needed here are only directly related to the studied species: total catches, fishing efforts, abundance indices…

2 The small-scale fishery "problem"

During this first phase of fishery research, many fisheries, often (but not always) small-scale fisheries, appeared challenging in terms of management and in terms of data collection for estimation of target parameters for several reasons.

The first difficulty came from the multi-species nature of catches. In many cases it was not really possible to identify unique target species. Estimating pooled catches for several species and using these estimations for each of the mono-specific studies was therefore required. But then deciding which species was targeted and calculating reliable stock abundance indexes was hardly achievable. Therefore such abundance indexes were indirectly estimated from other fishing fleets catches and effort (industrial, generally assumed to provide more reliable abundance indexes) or from scientific fishing surveys, or directly obtained from fishery-independent approach (hydro-acoustic, eggs abundance, visual observations, etc).

As a consequence, surveys were not any more devoted to a single species, but to the activity and the results of a fishing sector. This yielded important changes since surveys data were multi-purpose (i.e., the management of each harvested species) and used to consider management of the fishing sector as a whole: As a consequence the management units were not only the individual fishing stocks any more.

The fact that surveys are not any more devoted to one single purpose may explain, to some extent, that these surveys are now often considered as “observatories”…

The second difficulty is more problematic and can be identified through data analysis when searching for catches and standardized efforts estimators. The problem is that typologies of fishing actions are based on their impact on the resource (i.e., two fishing actions belong to the same category if they generate a similar impact on each resource component; this definition may be quite paradoxical if two different gears may generate exactly the same mortalities on the each of the resource components, but this would be very unlikely with a multi-component resource…), efforts may then be given by weighted sums of numbers of fishing actions per types.

The problem arises from the flexibility of fishing units who may practice several types of fishing actions, using different gears or using the same gear in different ways sequentially or even during the same fishing trip. If so, a given “nominal” fishing effort defined as an activity (e.g. a given number of trips made by the units of a fishing fleet) may generate different “effective” fishing efforts defined as impacts on the resource, inside a wide range of possible values. The effective effort value generated by a nominal effort is decided by the fishing units, depending on their decision rules, their objectives and some exogenous factors (costs, prices).

In this context the question of the level of effective cumulated efforts leading to a given state of the resource still makes sense… but we must acknowledge that no “institution” (i.e. a governance context in which the level of effort can be decided and strictly enforced) may specify a given effective effort level anymore. The question of this decision becomes central for management studies and leads to questions about the institutions and about the flexibility, the decision rules and the objectives of the various decision-makers. As a result, instead of models of resource dynamics conditional to a given fishing activity, one must consider models representing the joint dynamics of the resource and exploitation.

The major consequence of this statement is that nothing remains “single”. We must study exploitation systems integrating a multi-species resource harvested by a “multi-métiers” fishery with several fishing fleets with more or less versatile fishing units. In this context, the questions dealing with the decision rules and the objectives of the various decision-makers become central for management studies and lead to questions about the institutions and “governance” as a whole. This is all the more important since the number of involved stakeholders has dramatically increased. Twenty years ago, two main stakeholders were considered: fishers and fisheries managers backed-up by fisheries scientists. Fishing was mainly a question of resource management and economics. The over exploitation and ecosystem degradation problems have arisen the conservationist place in the fishing game and the ecosystem approach is now mainstream, enlarging the scope of scientific studies to wider aspects such as physical oceanography, productivity, fish behavior, top-predators studies, etc, or more generally speaking, fishery ecology. Fishery economics is gaining ground as well, but social issues remain the poor side of fisheries. Fisheries dynamics is still considered as a question of interaction between a prey and a predator. The emphasis is made on the ecological relationships between the prey and its biocenose but there is a tremendous lack of considering the fisher-predator as a social animal. Studies on the interactions between economical, social and natural aspects are not still common enough.

In other words, the fact that the diversity of actors generates a diversity of goals makes it necessary to consider multi-criteria objectives. These objectives must be defined in reference to the pillars of sustainable development (natural, social, economic) leading to consider fisheries exploitations from many points of views sometimes difficult to conciliate. Fisheries exploitation and regulations are now related to conservation, social, economic, and therefore political issues. This leads to consider governance as a central theme for small-scale fisheries studies, where governance is defined as "the whole of public as well as private interactions to solve societal problems and create care interactions and care for institutions that enable them» (Berkes 2009)

According to this recent research phase we may then consider two main aspects dealing with the widening of management questions and the evolution of fisheries information systems.

QUESTIONS

The questions about the state of the resource (i.e. the natural capital, also considered recently as a patrimony) still remain important. As before they concern single stocks, but they now also account for inter-specific relationships and environment as a whole. This takes place within a general trend towards Ecosystem Approach to Fisheries.

Existing ecosystem models consider complex relationships between the components of the ecosystems. But the fisheries are represented through their impact (e.g. fishing mortality levels) on the components of the ecosystem (like independent variables in regression models, [Walters et al 1997, Christensen and Walters, 2007]). Ecosystem approach definitions also usually consider that fishers and, more generally, societies are part of the ecosystem, but it is difficult to integrate this aspect in fisheries representation. It implies, at least, that models include some assessment of human and economic capitals.

A more integrated (systemic) approach makes it necessary to represent the flexibility of fishing units including their decision making rules as a model component in order to be able to predict the fishing activity and its impacts as functions of the state of the whole system (e.g. what is the consequence of a price change for one target species on the fishing mortality on all the harvested species).

One of the main questions here deals with the *paradigm of sustainable self-regulated small-scale fisheries*. The flexibility of fishing units leads to such a "self regulation" (see for example Pech et al. 2001), but this does not means that this regulation is necessarily efficient, it simply means that fishing units may individually benefit from changes, but this profit may be positive or negative at a global level. For example, the interruption of fishing mortality generated by an industrial fisheries ban on an endangered species may have negligible consequences if small-scale units can replace them (Laloë 2004) But, in this particular example, a decrease in the price of the species may lead to achieve a fishing mortality decrease.

If self regulation does not necessarily means sustainability, it means that knowledge on management cannot any more be only reduced to questions on consequences on given fishing mortalities on one or several resource components, even if these components are defined in the context of some ecosystem model.

INFORMATION

The second step also generates a widening of the need for data. Data on fisheries activity will be used as before to estimate effective efforts (fishing mortalities), but also now to understand how this effective effort is generated in the context of the system. For this, models describing the decision rules must be used (e.g. Holland and Sutinen, 1999; Laurec et al 1991). Random utility models appears here very useful and data must be available to define typologies of fishing units defined by their "available set of choices" (Mac-Fadden 1973). In the usual context of sampling surveys, these data can be multispecies catches per fishing actions obtained by identified fishing units, allowing to make analysis of articulations between resource components (stocks or species), fishing units according their possible choices (strategies) and fishing actions defined in reference to catchabilities (tactics) (Pech et al 2001). Such analysis needs of data on social and economical aspects of exploitation, for example to be able to estimate utilities associated to various available choices.

More generally, in order to understand and represent the global context of governance, requested data are also relative to the diversity of stakeholders and to relationships between them. Specific surveys must be done in order to collect such data. They may imply local actors participation to usual data collection. This

participation may also take place in focus groups or in Role-Playing Games where actors provide information on their privates and public interactions, their objectives, their decision rules…

Here, as usual, data are used for model building and to compute estimates of values of variables and parameters needed to provide the information in a multi-criteria context were the state of the system is described according to the pillars of the sustainable development. The widening of information needs cannot be presented through a single design for data collection with an exhaustive list of all variables and observation units that could be adapted for each case study. Each framework depends on the case studies with specific ecosystems and governance contexts.

There is therefore a diversity of situations. It may be illustrated with several types, or points of view from which questions are addressed. We propose here a list of such types and then provide a few number of cases studies which correspond to various combinations of these types.

Diversity of situations

Type 1 Simple articulation between natural capital and a fishing technology (or technique)

Most information here takes the form of catch-effort surveys. The objective is to estimate fishing mortalities and biomass indices conditionally to the level of exerted fishing effort, Small-scale fisheries make sometimes problems (dispersion of landing places, no registration of fishing units, diversities of gears and target species lack of written results, high flexibility…). Then activities and results from industrial fleets are generally assumed to provide more reliable estimates of biomass indexes. Most indicators are common to industrial and small-scale fisheries, but the first ones remain the reference.

Type 2 Human and social capitals oriented

Information here is more global and qualitative, it aims to understand the small-scales fisheries specificity and complexity at various scale levels, more often national, sometimes more locally when dealing with complexity. Nevertheless, most management tools remain at the level of the fishery sector and territories are not explicitly been taken into account. Here description of small-scale fisheries may imply to define specific indicators.

In developing countries small-scale fisheries management is now considered more related to the questions of human development and poverty alleviation (Neiland and Béné, 2004 ; FAO, 2005; De Young et al, 2008) New management orientations did try to satisfy at the same time the management of fish resources and the livelihood approach proposed by the World Bank.

After decades of management oriented to modernization or eradication of small-scales fisheries, its own interest seems now to be fully recognized, particularly its adaptation capacity, which has been already demonstrated by long term historical works (Chauveau, 1991).

Type 3 Local approach highlighting natural and institutional capitals

Spatial integration of sustainable development oriented policies led to implementation of local agenda and resource management encouraged changes from sector and value chain approaches to a more integrated frame (Integrated Coastal Zone Management ICZM), including all coastal activities and uses. This supposes a participative management system dedicated to the identification of common representations and goals.

Many conditions are considered necessary here: to have first a common view of sustainable development, goals, working at ecosystem scale. Governance schemes have to be adapted to promote partnership and cooperation between public and private actors.

New tools and information systems have to be used in support of territorial approaches (e.g. Geographical Information Systems). Such systems need to be fed by spatialized data and indicators. These spatial

indicators should allow evaluating the contribution of fisheries to the coastal economies, in the frame of decentralized local and regional observatories.

Marine Protected Areas, especially coastal ones, are seen here as operational territorial tools to solve the concomitant problems of fishery management and ecosystem conservation. There are in growing number, for instance in the Pacific region where the spatial structure of small-scale fisheries and ecosystems looks particularly important (Chaboud et al, 2008).

Type 4 Integration and responsibility oriented

New type of information is needed to represent multiple aspects of fisheries, related to new orientations concerning responsible fishing, whole life cycle of fisheries products (from extraction to consumers), participatory data collection systems. According to various sustainable development criteria, small-scale or industrial fisheries may be ranked differently (Stilwell et al. 2010).

Case studies

We present here five cases studies. We certainly not pretend to give some exhaustive figure but these five fisheries provide a good illustration of the diversities discussed above.

The Senegalese Small-scale Fisheries

Although the exploitation of the industrial sector is far from negligible, the Senegalese fisheries management is particularly concerned by the importance of the small-scale fisheries (artisanal fisheries) which is responsible of more than three quarters of the total landings. The number of canoes, now about 13 000, has strongly increased by doubling during the two last decades (Thiao, 2009). Fishing effort is also characterized by a significant rise of fishing power. Indeed, in order to insure a greater autonomy at sea and exploit the farther fishing zones (sometimes outside Senegalese EEZ), fishermen acquired more powerful engines and used on board ice boxes.

The development of this small-scale fishery was supported by the capacity of the fishermen to adapt their strategies and tactics to the evolution of the ecological, economic and social contexts which affect the fisheries (Fréon and Weber, 1983; Chauveau et al, 2000). Moreover, the climate drought of the Seventies and the structural difficulties of the agricultural sector induced significant rural migrations towards the coast, encouraging additional manpower to join fishing activity..

During these last years, considerable efforts were made to improve research and governance of the Senegalese small-scale fishery. However, those efforts did not contribute to build a better ability to control of the small-scale fishery dynamics according to the exploitation state of fish resources. Some demersal resources, like groupers, seem heavily overexploited, and the fishery seems to depend now more and more on a limited number of pelagic species (e.g. sardinellas). In a perspective of sustainable development of the Senegalese fisheries, it looks evident today that the small-scale fishery require priority research actions to better understand its main trajectory factors and stakes of its governance, and contribute in a more effective way to its sustainability.

The Peruvian anchoveta fishery

The Peruvian anchoveta fishery is the largest national fleet worldwide targeting a single species, with catches averaging six million tons over the last four years (PRODUCE, 2009). Fish are targeted by both an industrial fleet, whose landings are directed nearly exclusively at fishmeal and fish oil production, and by an artisanal fleet (GRT < 32 t), whose catches are, in principle, mostly used for direct human

consumption (canned, frozen, fresh or smoked). In practice, however, a great deal of anecdotal evidence indicates that most of the artisanal fleet's catch in recent years is also destined for fishmeal production. As a result, supply chains for direct human consumption (DHC) appear to only receive < 1% of total anchoveta landings. Although DHC of anchoveta has apparently increased over the last 10 years, the continued low overall rate of DHC constitutes a paradox in a country where severe malnutrition continues to affect a substantial portion of the population. Furthermore unemployment is high in Peru, especially for unqualified or poorly qualified people that could benefit from changes in the present exploitation and transformation of the anchoveta supply chains. Although the present situation seems to be economically sustainable, socio-economic aspects need to be considered more fully to understand this paradox.

The Peruvian fishmeal and fish oil production is aimed at producing primarily animal feedstuffs (about 30% of the world production; IFFO, 2008). Despite the relative conversion efficiency of many culture systems (e.g. poultry, fish, etc.) cycling anchoveta meal and oil through other species is not as effective a means of providing highly nutritious animal protein to humans than the DHC of anchoveta. In addition, previous research suggests that substantial energy inputs are required throughout the meal/oil mediated supply chain when inputs to fish harvesting, reduction, transport etc. are accounted for (Pelletier et al., 2009).

Since Thomson's work in 1980 (Thomson, 1980), several authors have compared artisanal and industrial fisheries using rough global estimates of number of employees, capital cost per fisher, fuel consumed and discards. These estimations often – but not always – reveal previously unappreciated benefits of artisanal fisheries in terms of employment, food security and poverty alleviation, all points that deserve more detailed study.

These issues indicate that a proper integrated, quantitative and comparative study of food supply chains founded on anchoveta is needed. Indeed a fishery is one of the nodes of a larger network that includes up and downstream processes or activities such as fluxes of energy and biomass in marine ecosystems, boat and gear construction, fuel provision, fish processing, marketing and transport, aquaculture uses and impacts.. Some studies have previously been performed to determine the life cycle environmental impacts of fisheries. However, little is known about the environmental effects of the entire life cycle of anchovy production including the different impacts resulting from industrial and artisanal fleet activities and from indirect and direct human consumption alternatives.

A new research project on environmental and socio-economical impacts of the Peruvian anchoveta supply chains was launched at the end of 2009 by IRD (French Institute of Research for Development) and IMARPE (Instituto del Mar del Peru) with the input of external experts in various fields (Fréon et al., 2010). The aim of the study is to quantify and compare the environmental and socio-economical impacts of the Peruvian anchoveta supply chains for direct and indirect human consumption, from end to end (Fig. 2). Life cycle assessments of the extraction phase will be performed, along with analyses of employment (direct and indirect) and economical rent in order to provide decision makers with a broader and multidimensional understanding of this complex sector. The project is challenging due to its scope along with technical and scientific issues such as the unification of energy units according to their sources and diversity of the conversion processes from ecosystems to human driven systems.

Life Cycle Assessment (LCA) is a tool which provides a useful framework to identify potential contributions to a wide range of global scale environmental concerns that result from various production systems. It is used to inventory the physical inputs, production materials, energy requirements along with the resulting emissions (to air, land, fresh water and oceans) associated with each stage of each production chain: from anchovy capture through production, transport, use and disposal. The functional unit will be 100 g of animal protein of anchoveta or derivative product on the plate of a consumer according to his / her location on earth (Peru or other countries) and according to the type of protein: anchoveta (fresh,

frozen, canned, dried and smoked), cultivated fish, chicken or pork. Material Flow Analysis and conventional micro-economics approaches will be used to complement LCA and study rents and employment (but not environmental costs).

This study will help us understand the above - mentioned food security paradox of Peru. It will also provide direction on how to best support people dependent on fisheries as it will assess and compare the socio - economic implications of each stage of the anchovy production system in terms of indirect and direct jobs, and use of the rent and wealth redistribution. As such this study on the anchoveta fishery clearly falls in the above-mentioned Type 4, although the ongoing information system implemented by IMARPE (Instituto del Mar del Peru (Peruvian Marine Institute) of the whole Peruvian small-scale fisheries started in 1996 (Estrella Arellanoa and Swartzman, 2010) is more conventional and falls primarily into Type 1 and secondarily into Type 2.

Quantifying natural resource use, together with the social and environmental factors of exploitation represent a novel approach which could lead to improvements of the management and a more environmentally and socio-economic sustainable anchovy supply chain. It aims at providing stakeholders and policy makers with a basis upon which to jointly decide further research and development perspectives in the sector and generate the necessary information to inform consumers about the aggregated environmental impacts of each anchovy derived product, in addition to socio-economics aspects. The information generated during this study will provide us with necessary data to predict the best possible adjustment of the current structure of the anchovy production systems for the future, while maintaining the most social benefits and in compliance with climate change objectives.

Evolution of artisanal fisheries approaches in the « Golfe du Lion » area.

Research questions and studies about the small-scale fisheries in the Mediterranean “Golfe du Lion” area illustrate the evolution of points of view. If there is a chronology in the appearance of a new problematic, none supersedes the previous ones. There is no overlap but rather a progressive complexity. In the sixties the artisanal fishing increased with the opening of markets related to tourism development and export. This kind of small-scaled fishery was very poorly known by institutions in charge of the management (Affaires Maritimes administration), but also by researchers. Most of the studies concerned the trawl fishery, of which the number and the size of units were increasing due to the arrival of fishermen repatriated from Algeria. The research was mainly devoted to the knowledge of the fishing effort. The most characteristic study about this phase corresponds to surveys in the lagoon and sea by Farrugio and Le Corre (1984) to monitor the outputs of both professional and recreational boats. These surveys funded by the European Union showed that the actual effort was 40% higher than the official one. The data collected were not specific to artisanal fisheries. There was a will, so that modernization would lead to a new type of artisanal unit: the offshore fishing boats. Subsequently the aim of surveys and data collection was to estimate this artisanal fishing effort measured in units of standardised fishing effort defined in reference to these offshore fishing boats.
The contribution of social science research and studies funded by CEPRALMAR to support the development of fisheries did allow new questions to be addressed and an widening of the issues. Their purpose was be to characterize the operating units and to show the complexity of their strategies (Rey, 1989). They were initially very descriptive approaches which were followed by multidisciplinary programs. The European Seminar supported by the European Union at Ancona (Fontana and Rey, 1993) recognised this complexity in several Mediterranean areas. This impulse was followed by researches carried out in partnership with professionals, in order to obtain more efficient management measures. They were an opportunity to strengthen the capacity of professional organizations. The creation of the “Maison des Pêcheurs” in Sète is a significant consequence of these efforts for better governance.
More recently, a new orientation towards territorial integration of fisheries has to be underlined, according to the principles of Integrated Coastal Zone Management (ICZM). This integration is achieved

locally through maritime SCOTS (Schéma de Cohérence Territoriale), but is also advocated by the national framework documents (Ferlin and Treyer, 2008) and the guidelines of the "Grenelle de la Mer" agreement. This territorial dimension can be taken in account by ecosystem approaches, and by valuations of the services which are supplied by fishing. The patrimonial role of artisanal fishery looks here important, particularly through the opportunities offered by the Axe 4 of the European Fund for Development. These changes were often initiated by European projects and measures, which so have an important innovation role.

Small-scale fisheries in tropical coral reef Islands

Coral reef ecosystems are among the most diverse in the world and the complexity of coastal fisheries is due to this biodiversity and many other factors of geographical, environmental, technical or socio-economical nature. Thus, the region (ecological or cultural), the type of islands (high island, atoll) or reefs (barrier to fringing reefs), the habitat (coral reef, mangrove, estuary, lagoon) and associated resources, the targeted species (invertebrates, fishes) and gears, the type of fishers (subsistence, recreational, commercial), and the country development level generate a diversity of small-scale fisheries. Facing the degradation of coral reefs due to fishing pressure (overexploitation and habitat destruction), scientists and managers are confronted to the challenge of providing new tools for decision makers because of the lack of data on reef fisheries. Since the early 2000s, IRD and numerous scientific partners have undertaken several research programs in the Pacific and Indian oceans that point out the evolution of frameworks and paradigms in fisheries science. five programs may be underlined which illustrated small-scale fisheries of types 2 and 4:

1- DemEcoFish (funded by MacArthur Foundation) and ProcFish (funded by E.U.) programs aimed to develop a regional reef fishery observatory for the Secretariat of the Pacific Community (http://wwwx.spc.int) based on a comparative and an integrative approach from both ecological and exploitation points of view. For instance, in Fiji and Tonga, twelve fishery systems were compared on the basis of indicators across four components: fish (resource abundance and size spectra), fishing activity (catch, effort and gear), geographical data (lagoon and reef areas, population size and fishing grounds) and households socioeconomics (demographic structure, fish consumption, budget). Each component was observed by specific means adapted to the observation units (underwater visual census, remote sensing or interviews). The analysis of the multidimensional data set produced a typology that discriminated the twelve fisheries in three categories in relation to their ecological, socio-economic and environmental characteristics; the indicator values and the fishery categories provided useful reference states for the other Pacific islands;

2- One of the goals of the CRISP program (funded by AFD, French Development Agency)(www.crisponline.net) was to improve the knowledge, the monitoring, and the management capacity of reef resources to ensure sustainable development of coral reef ecosystems. Experiments have been conducted to develop tools adapted to the Pacific islanders, such as synoptic indicators and fishery or reef monitoring methods. For instance, , the comparison of results of underwater visual census conducted by scientists, non residents NGOs volunteers and villagers in Fiji to assess the effects of a marine protected area (MPA) on reef fish abundance allowed to evaluate pros and cons ofparticipatory monitoring on the basis of six criteria: relevance, taxonomic level of indicator species, skill and training, precision, subjectivity and costs (Léopold et al., 2009).

3- PAMPA program (funded by the LITEAU Program of the French Ministry of Environment) brought together scientists and managers to build a set of indicators to evaluate the effectiveness of height MPA in theFrench Mediterranean and overseas territories using three categories of indicators linked to management goals: biodiversity conservation, uses sustainability and governance. Standardized sampling and survey methods were proposed to study frequentation, fishing activities, and user's perception on resource abundance and to perform statistical analyses to assess MPA performance. For instance in New Caledonia, fish diversity and abundance were evaluated by video systems whereas the informal

recreational reef fishery in Noumea surroundings was studied by aerial surveys and fisher interviews (Jollit et al., 2010) : both data sets were integrated into a geographical information system to analyse the spatial management of the coral reef ecosystem.

4- GAIUS program (funded by French Research Agency) dealt with co-management and governance of MPAs following multi-partnership and a multidisciplinary approach. The governance of MPAs was analysed by two modelling approaches to represent stakeholder behaviour related to such politico-socio-eco-systems, and fishers in particular. Bayesian networks allowed to take into account data uncertainty and expert knowledge is acase study developed in Moorea island (French Polynesia) to explain the impacts of the marine management plan established in 2004 (Badie et al., 2009). In La Reunion Island (Indian ocean), , managers and scientists develop together a role-play to analyse the relationships between and strategic responses of fishers, other reef users and local managers to help to design the management plan of a marine reserve.

Small-scale fisheries in the South West of Madagascar (Toliara Bay)

Coastal marine zones play a crucial role in the economic, social and political development of developing countries as they are a major source of goods and services for the local populations. Madagascar, for example, recognizes the need for better and more effective management of its coastal and marine resources and advocates sustainable development and conservation of the marine environment by implementing protective measures on the whole shoreline in a context of great poverty of rural populations (Chaboud, 2007). But fisheries have an impact on the target resources and can also cause severe damages on non target species, habitats, structures and functions of the marine ecosystem. Thus there is a critical need to manage fisheries in a way that allows maximizing individual species yield on the long term while minimizing the effects on the ecosystem securing fisheries sustainability. In order to achieve this objective, information on the status of exploited resources and ecosystem components sustaining resources are needed to undertake an ecosystem-based management. Assessing the biological sustainability of reef fisheries is a very difficult task because of their inherent complexity. In addition governments do not spend a lot of money for the management of fisheries with not great economic value. Monitoring and evaluation programs are neglected because of their cost and ecosystem-based management implies intensive data requirements. Do deal with such challenges, the local communities involvement of in assessment of reef fisheries sustainability have proved to be useful. Participatory assessment methods have the potential of increasing the number of collected data at low cost, while taking advantage of the lacal traditional ecological. In order to investigate the reef fishery of Toliara bay(southwest of Madagascar) we used participatory fishery survey and on site interview data collected. These methods included: i/ catch landings monitoring during six months by fish merchants, ii/ household survey conducted by students on fishing catch and effort and fish consumption ts, iii/ semi-structured interviews of reef users. 1586 fishing trips were sampled between September 2006 and February 2007, 326 households were surveyed by students in January 2007, 70 reef users were interviewed in July-August 2006. Data collected by participants have been analyzed and compared to reference values when available, allowing to assess the sustainability of the reef fishery. Results of this study suggest an unsustainable biological exploitation and underline need for quick management responses to reverse this trend. It also highlights the great potential of participatory assessment programs to obtain relevant information on the status and evolution of the ecosystem while also promoting education and awareness regarding protection and sustainable use of natural resources (Brenier, 2009).

Floodplain fishers: an assessment of the vulnerability face to hydro-climatic changes.

In the Basin of Niger, the communities of fishers constitute one of the largest socio-economic groups, with about one million people. They use two types of ecosystems: (i) lakes, which are now mainly man-made reservoirs, and (ii) large floodplains such as the Inner Niger Delta. Because of the climatic

variations and the construction of large dams, the floodplain fishers nowadays undergo strong environmental changes.
Floodplain fishers have diversified productive activities and great capacities of mobility, one wonders if such livelihoods strategies (i.e. multi-activity plus migration abilities) confer to them adaptive capacities which enable them to face efficiently to hydro-climatic changes.
One of the main (and well known) treats of inland fishing is the dependence of the fish abundance and catches according to the intensity of the flood preceding the annual fishing campaign (Laë, 1992). We thus wondered whether fishers would adapt their intensity of fishing to hydrological conditions and fish abundance. Our data show that fishers do not respond to weak flood and declining yields by diminishing their fishing activity and, conversely, they do not respond to high yields by increasing their fishing activity. At inter-annual scale, fishing activity always involves a relatively constant and high level of labour time, whatever the yields and the hydro-climatic conditions are.
When addressing the same issue with regards to the secondary activity of fishers, which is the rain/flood-fed traditional rice farming, we observed that farming is put into practice every year by most fishers even though the results are highly uncertain and highly variable from year to year, because of the environmental conditions.
In order to explain such above strategies, one has to highlight that rice farming is primarily a subsistence activity, and under no circumstances can it replace fishing, which brings in steady, substantial cash income for much of the year (Fay, 1994). Thus fishers cannot adopt a strategy of shifting from one to the other, accounting for the low observed flexibility of their producing livelihoods.
At last, when addressing mobility and settlement strategies, we observed that IND fishers have a very limited choice between remaining in their home village and undertaking seasonal migration to fishing camps following the same path as in previous years. Fishermen thus have little freedom of movement within the NID to help them cope with environmental changes.
In sum, although migration and diversification are often presented as strategies adopted by rural households to reduce their vulnerability (Ellis, 1998), the present case of IND fishers communities demonstrates that such strategies do not systematically lead to high adaptive abilities face to heavy environmental changes.
Regarding the future of the IND fishers' communities, the end result will probably be the increase of what happened since the 1980s: the departure of young fishers for other regions of West and Central Africa offering scope for their occupational skills (Jul-Larsen & Kassibo, 2003). Fishers from the IND do well in these fishing areas in terms of putting their original skills to use, but as "foreigners" they also encounter new factors of vulnerability (Morand et al., 2005).

Conclusion: toward a revisited multi-disciplinary research framework for small-scale fisheries

As said above the interest of this presentation was to show the diversity of situations of small-scale fisheries with a reduced sample of five fisheries in different ecological, socio economic and governance contexts. This illustrate how much the sentence of the 1989 symposium "*the complexity of small-scale fisheries calls for applying knowledge from many fields in combined studies that can take advantage of a whole range of information*" was pertinent, even if these characteristics are not really specific to small-scale fisheries and may be found also in a lot of industrial ones. But we may consider that the presence of these small-scale fisheries made it necessary to put in place or reinforce specific research programs as those presented in the cases studies section above. Therefore small-scale fisheries may be considered at the origin of a specific research domain.

We would like to use this presentation in a more ambitious way to contribute to the construction of a multidisciplinary research network dedicated to small-scale fisheries. The objectives of such a network could include a more complete presentation and definition of the types of fisheries (resources, exploitations, contexts, societal objectives) in order to address the specific questions research that may provide a better contribution to sustainability and governance.

Such a network could be made effective through the organization in a few years of a further symposium on “research and small-scale fisheries”…

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