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Integration of fishers' ecological knowledge in fisheries biology and management. A proposal for the case of the artisanal coastal fisheries of Galicia (NW Spain)

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Abstract

The fisheries crisis of the last decades and the overexploitation of a great number of stocks have revealed that the scientific knowledge available about the dynamics of the marine ecosystems and needed for the management of the fisheries is inadequate. This problem is critical when the management of coastal ecosystems and artisanal fisheries is involved. These systems show a great complexity due to the high number of human factors that influence their functioning (related directly to the exploitation of fisheries resources, but also to other types of activities that originate modifications and destruction of habitats) and to the number of components involved in the fishing activity (usually multispecific, multigear, with a diversified fleet that shows a complex spatial pattern of activity). Moreover, a great number of stocks exploited by coastal artisanal fisheries are invertebrates with a population dynamics that no fits in the finfish models. The efficient and sustainable management of these resources is in general not possible using models designed to finfish stocks exploited by industrial fleets.

We analyze the present state of the coastal fisheries in Galicia (NW Spain), paying special attention to the state of the art of the scientific knowledge available, the socioeconomical context, and to the management policies in use. In this sense, the main problems of the present policy directed to the achievement of scientific data and to the management of resources will be identified. We propose to modify the strategies of research in the fishery sciences to introduce the traditional ecological knowledge of the fishers in the management process. This kind of information should constitute a complimentary source to get new knowledge, and for this goal we propose to process it using the mechanisms and tools of the Artificial Inteligence to formalize, objectify and integrate it in the fisheries biology and marine ecology. Some case studies based in this approach will be presented.

1) Overexploitation as a global fishery problem. Scientific opinions about the causes of stock depletions and collapses

World fisheries are in crisis (McGoodwin 1990) due to the overexploitation of a large proportion of the stocks. Thus, Alverson et al. (1994) report that over 90% of the world's fish stocks have been overexploited, while, according to the FAO (1995) 69% of the world's marine stocks are either fully to heavily exploited, overexploited or depleted and therefore are in need of urgent conservation and management measures.

The causes of the collapse of exploited marine populations have been the subject of wide debate, confronting hypothesis that center the problem in an excessive fishing effort which brings about overexploitation, against those that argue that fluctuations in population dynamics are attributable to natural environmental changes. Perhaps the most paradigmatic case of depletion was what occurred in the 90's with the cod fishery in Newfoundland. Myers et al. (1996, 1997) compared different hypotheses on the reason for this collapse and concluded that the high fishing mortality, due to overfishing was what caused the decline of these stocks. This process has been affected by faulty assessments and by difficulties in enforcing the compliance with the established regulations, particularly regarding discards. The above hypothesis is backed by scientific evidences which are much stronger than others related to environmental changes, without the intervention of man, that would cause a decrease in recruitment (Myers et al. 1996). Similarly, it has been proposed that fishing has been the main cause of the depletion of different species of small pelagic fishes, due to the increase in catchability with the decline in the stock as a result of the shoaling habits of these organisms (Beverton 1990). Although these cases are generally much less documented, several invertebrate species, largely coastal benthic organisms with a high unit value and subject to exploitation by the artisanal fleets, have been overexploited, and in some instances, depleted (Jamieson 1993, Jamieson & Campbell 1998). The overexplotation of marine species has led to extinction or near extinction in some extreme cases, which has not been considered as a possible aspect until very recently (Roberts & Hawkins 1999).

It would appear to be evident that the collapse of many stocks constitutes the final stage of overexploiting generated by an excessive fishing effort. This process may be attributed either to a lack of appropriate scientific information or, on occasion, and in spite of suitable assessments, to faulty management systems or failure to enforce the compliance of the fishers. In fact, Roughgarden & Simth (1996) propose that theoretically the collapse of several fisheries (such as cod and other demersal species) is due to the failure of the management system, which is often directed at obtaining the maximum sustainable yield" and not towards the ecological stability of the system.

Fisheries management has been dominated, up until recently, by a school of thought based on the assumption that in-depth scientific research on the biological foundations of the exploited systems would allow for adequate management. Another line of thought, developed more recently, upholds the fact that the spatial and temporal scales of variability of many systems would make research be of limited value in management, while the design of management and monitoring systems would be more beneficial (Hilborn et al. 1995). So the ultimate goal of management systems is not to obtain precise estimates of the population parameters by means of stock assessments carried out by scientists, but rather to design monitoring and management systems that will yield long-term catches without endangering the stock (Ludwig et al. 1993). Moreover, another failure in traditional management systems has been the lack of attention paid to the dynamics or behaviour of the fishers as an integral part of the system (Hilborn et al. 1995).

Fisheries management science appears to have evolved from the early stages during which understanding the biological foundations of the system was considered the key factor in good management, to a state in which the intrinsic complexity of the exploited stocks and ecosystems, along with the technical and socio-economic factors involved, create the need for reorienting research and integrating new sources of knowledge into both the assessment and management processes.

2) COASTAL ECOSYSTEMS AND ARTISANAL FISHERIES: THE CASE OF GALICIA

A definition of artisanal fishery

Even though the offshore industrial fisheries are the most productive on a world-wide level, the small-scale coastal fisheries have a much greater social significance (McGoodwin 1990, FAO 1995, Orensanz & Jamieson 1998). Of the latter type of fisheries, the concept of artisanal fishing is rather ambiguous and variable in terms of the unit of analysis used. We will employ three types of definition to establish the limits of the scope of our study on Galicia:

1) From a political and administrative standpoint, the Autonomous Government of Galicia ("Xunta de Galicia") has defined an inshore fishery (vessels less than 150 GRT; "sector de bajura") which carries out its activity in the waters of the continental shelf and the rías (from the intertidal zone to the start of the slope) (Annex 1). This sector comprises a fleet that fishes on the continental shelf (demersal and pelagic fisheries), and a fleet that operates in the interior waters (rías and shallow oceanic areas). In the latter case, the fishery carried out from a vessel (usually under 12 m in length) can be differentiated from intertidal shellfishers harvesting goose barnacle and some bivalves.

2) From a technological point of view, the artisanal sector uses low or medium level technological equipment, insofar as the operating chain is simple, consisting of gears handled by one or two people (a minimum of manpower is what makes this technique efficient).

3) From a biological standpoint, the Galician artisanal sector harvests, as we see it, ecosystems located in coastal waters that range from the intertidal zone to waters of 60-80 m depth near the coastline.

If we combine the different definitions, it is possible to describe an artisanal sector in the strict sense of the term - within the existing inshore fishery in Galicia - which would cover the fisheries in interior waters. Although we do, on occasion, include the entire inshore sector in our analyses and proposals, we will focus on the artisanal sector in the strict sense, excluding the intertidal shellfishing of bivalves, since in many aspects, this type of fishery is more related to an extensive culture than an actual fishery.

Social, economical and technical aspects

Galicia is a region with an autonomous government located in NW Spain (Northeast Atlantic) and with a population of approximately three million inhabitants. It boasts an extensive, irregular coastline (1,295 km) with a series coastal embayments ("rías"), which in many instances take the form of wide, gentle incoming bodies of water, such as the Rías Baixas (in the south) and at other times are smaller in extension and have a more rugged appearance, such as the Rías Altas (in the north).

The Galician coast supports a large number of human settlements directly related to the sea due to its great length, its unique morphology, the biological richness of its waters and its strategic situation. At the present time, there are over 80 communities whose economies depend largely on harvesting fish and shellfish resources. They range from large cities (Vigo, A Coruña, ...), to towns (Riveira, A Guarda, Malpica, Burela, ...) or small villages that oftentimes have under 200 inhabitants (Barizo, Arou, Oia, ...).

According to the official census of the Galician fishing fleet in 1994 (Xunta de Galicia 1995), there were 8,811 vessels with 28,014 fishers. However, these data only reflect legally registered fishers. In practice, the number of people who carry out fishing activities is substantially higher, since we must also consider, those individuals who are not full-time fishers, but who, during certain times of the annual fishing cycle, do carry out specific fisheries as a supplement to their incomes (e.g. retired persons, taxi drivers, shopkeepers, unemployees, etc). Although they are difficult to quantify, they must be considered in the artisanal sector as harvesting agents who also have an effect on coastal ecosystems.

In Galicia the so-called inshore fishery accounted for almost 2/3 of the human contingent that made up the fishing crews in 1989 (Xunta de Galicia 1992). The overall figures taken from the 1994 census (Xunta de Galicia 1995) present a similar situation: 70% of the fishers work in the inshore sector in vessels less than 9 meters in length (72%). Moreover, 49% of this fleet (4,329 vessels) pertained to productive units consisting of only one fisher. From an economical point of view and taking only official data into account (data provided by the Xunta de Galicia), the fresh weight of fish landed in 1998 amounted to 171,000 mt with a first sale value of over 57,000 million pesetas (346 million euros). These figures do not include landings channelled through other commercial routes. This is, then, a very heterogeneous fleet (mainly longline vessels, trawlers, gillnets and traps) operating in different areas of the continental shelf and Galician rías, harvesting a total range of over 100 different species.

Within the inshore fishery, the artisanal sector is the most numerous. This usually consists of productive units made up of very few fishers who are usually related to each other. In fact, the generic makeup of these types of vessels tends to constitute ideal models such as father-son(s); father-in-law-son(s)-in-law; cousins, brothers-in-law; etc, completing the crew with people who are not related, when the various family households are unable to supply new members (García-Allut 1998).

The following characteristics provide some of the most important arguments in favour of the social importance of the artisanal sector in Galicia, particularly when other, more attractive economic alternatives are not available:
1) demographical (over 70% of the inshore fishers are artisanal),
2) social (they usually consist of mostly small owners whose main economic goal is to reach a level of capitalisation that will facilitate the social reproduction of the household), and
3) socio-economical, providing employment and energising a complex economic sector (fishing-handling-marketing-transport-processing, etc.) There are in fact populations that are almost totally dependent on fishing activity (Malpica, Muxía, Burela, ...), and significant changes in these fisheries would have a considerable effect on other sectors of production. Moreover, fishing activity is also a source of supplementary income for other groups (unemployees, small shopkeepers, retired persons, ...).

The artisanal fisheries are characterised by the use of fishing strategies involving diversification (Annex 2). The annual fishing cycle can be described basically by the use of different gears and methods depending on the seasonality of the resources and the regulations and legislation of the different administrations (Ministerio de Agricultura, Peca y Alimentación [Ministry of Agriculture, Fisheries and Food] of the Spanish Government and the Xunta de Galicia). However, depending on the ecological characteristics of the areas where vessels from each seafaring village operate, there is usually a primary fishery which is more profitable targeting one or two species (octopus, velvet swimming crab, spider crab, bib, conger eel, queen scallop, etc.) and other fisheries which supplement the primary one (wrasses, sea bream, sea bass, etc.).

Population dynamics of coastal exploited species

From a biological viewpoint, the traditional fisheries operating off the Galician coast are multispecific and multi-gear, exploiting a diverse array of species, mainly sessile benthic invertebrates sessile or having a low mobility with life-cycle phases that occur in shallow waters close to the coastline. It possible to list around 50 species that are harvested for commercial purposes (Annex 3). They include a diverse group, both in terms of taxonomy as well as life styles. Among the most important species from an economical point of view are the crustaceans (the velvet swimming crab, spider crab, prawns and goose-barnacle); bivalve molluscs (several species of clams, razor clams, scallops and cockles); cephalopods (octopus, cuttlefish and squid); and fish (a number of species are exploited but catches are generally low; there are no specific fisheries except in cases such as the bib or conger). Harvesting of new groups has begun recently, i.e. the gastropods (abalones) and echinoderms (sea urchins). In some cases in species presenting migratory processes between coastal and offshore waters (such as the squid, bib, etc.), the artisanal fishery only exploits one stage of the life cycle, while the demersal and pelagic fisheries that carry out their activity on the continental shelf, exploit other stages.

As was commented above, of all the species harvested only a few (consisting, on a global level in Galicia, basically of octopus, spider crab, velvet swimming crab and goose barnacle) support fisheries that target one species (excluding bivalve semi-culture in intertidal areas). For the remaining species, the strategy of the fishers is directed at catching diverse species using a specific gear, given that the abundance and commercial value of the other species do not allow for the development of unispecific fisheries. The current situation is partially the result of the state of overexploitation or depletion of many of the harvested stocks. It is difficult to analyse the level of exploitation that these species are subjected to as the assessments carried out to date are either non-existent or highly fragmentary (this aspect will be reviewed later in more detail). However, there are a number of indicators that reveal that many of the target stocks of artisanal fisheries in Galicia are being overharvested:

1) The virtual depletion and collapse of several stocks (for example lobster, spiny lobster, sea bream) whose catches are irrelevant today but historically were important in the area.
2) The time series of catches (despite the problematic interpretation of these statistical data due to a lack of quality control) show that there has been a decline in many cases from the 1940's-60's to the present time, such as in crustaceans (unpublished data).
3) Specific assessments, such as on the spider crab in the Ría de Arousa (Freire et al. in press) and the Artabro Gulf (unpublished data), reveal exploitation rates of >>90% per fishing season.

The regulations used in the management of artesanal fisheries have been based implicitly on analytical models of finfish population dynamics developed according to the seminal research of Beverton & Holt (1957) (see Hilborn & Walters [1992] for a review) used in the management of industrial fisheries. However, from a biological standpoint, the species harvested by the artisanal coastal fleet of Galicia, and particularly the great majority of invertebrate species, present a number of characteristics which render the above-mentioned analytical models useless in understanding their population dynamics. In short, these species have a persistent spatial structure (in the sense of Orensanz & Jamieson [1998]) and are characterised by the following (in Jamieson & Campbell [1998] appear a number of papers which analyse specific examples and general theoretical aspects of these types of organisms):

1) complex life cycles (planktonic larval stages and benthic or demersal postlarval stages);

2) a spatial distribution characterised by the existence of aggregations pods which are evident on different scales;

3) the stock-recruitment relationship (due to density-dependent processes, which is the focal point of population regulation in classical models) is absent or present only in very low stock levels. The processes of physical transport of larvae to appropriate habitats for recruitment has been recently defined as a key (density-independent) process in recruitment of invertebrates; and

4) a population structure that could be defined as meroplanktonic metapopulations in which the postlarval stages make up a chain of local populations along the coast with low migration and dispersal levels and interconnected by a planktonic larval stage. This aspect determines a decoupling between the local stocks of adults and the subsequent recruitment in the same local population. In some cases there is even evidence of source-sink dynamics in which only some of the local adult populations contribute reproductively to the next generation depending on the whether or not the existing local oceanographic conditions favoured the larval transport.

In reality, all marine populations have, to a certain extent, some of the characteristics described as typical of coastal invertebrates. However, there are two aspects which make the classical models more appropriate for industrial finfisheries: 1) the fishes harvested (in many cases pelagic or demersal) are generally more mobile than the benthic invertebrates, which is why the spatial structure is less persistent; and 2) in industrial fisheries, the spatial scale of exploitation is similar to the spatial scale of the population (or metapopulation) [a homogeneous fleet exploits most or all of the distribution area], whereas in artisanal coastal fisheries the fleet is heterogeneous and each sector (defined from a geographic point of view or by gear) exploits specific segments of the population, so the spatial scale of the population structure and the scale of the fleet do not coincide. Therefore management measures must take the existing spatial heterogeneity into account.

Another problem with management systems based on classical models lies in the fact that they have focused on regulating fishing effort, which has been considered as the only relevant human impact on the system. In coastal ecosystems, in contrast, there are a number of activities that give rise to changes or the destruction of key habitats (e.g. Rothschild et al. 1994), and these may have a greater effect on population abundance than fishing mortality.

3) Management of the Galician artisanal fisheries

Institutions involved and regulatory measures used

The artisanal fisheries of Galicia are legislated almost entirely from the administration of the Autonomous Government of Galicia (Consellería de Pesca, Marisqueo e Acuicultura [Ministry of Fishery, Shellfishery and Aquaculture] of the Xunta de Galicia) in that it has legal authority from the national government over "territorial" waters (the straight line connecting the tips of the capes) and jurisdiction over activities related to the capture of crustaceans and bivalves.

In essence, the regulatory measures are aimed at species (minimum landing sizes, protection of ovigerous females, maximum catch limits, ...); gears (number of gears per vessel and fisher, maximum length, minimum mesh size, ...); spatial and temporal closures (specific zones and depths for concrete gears and species).

The different resolutions, regulations, guidelines, etc. arising from the administration are circulated through newsletters to the fishers' guilds ("Cofradías de Pescadores"; fishers' associations under the auspices of the Xunta de Galicia) in each port and they are under the obligation to provide this information to affected parties.

These rules, regulations, laws, etc. are drawn up by the autonomous administration based "theoretically" on scientific criteria (although, as will be commented on below, there is a considerable lack of data and biological knowledge on the stocks of the coastal ecosystems of Galicia) and mainly political criteria (political forces and lobbies: the central Government, guilds with opposing interests, fishery sectors [longline vs.drift net; bib trap vs. octopus trap; tangle-net and longline, etc.]). The fact that the management of the coastal fisheries in Galicia are, in practice, more politically than scientifically oriented is a direct consequence of the current state of knowledge on these fisheries.

Biological knowledge of exploited stocks

Based on the above description of the situation of the artisanal fleets in Galicia, it is important to analyse the biological information available on the exploited species and ecosystems as well as the assessment methods that have been applied up to the present. We do not intend to carry out a thorough review of the biological research done on coastal fishing resources in Galicia, but rather, we will try to make a diagnosis, in synthesis, of the state of our current knowledge of the exploited resources.

In Galicia there is a basic knowledge of the biology and life history of some of the species of interest, e.g. in fishes (bib), crustaceans (goose barnacle, velvet swimming crab, spider crab), cephalopods (squid) or bivalves (clams and cockles) [detailed bibliographical references have been omitted, but are available from the authors]. These papers provide important information for adapting the present management measures (e.g. minimum landing size depending on size at sexual maturity; seasonal temporary closures depending on reproductive or moult cycles; growth rates and, in some cases, mortality in order to estimate yield per recruit). There has not, however, been an attempt to gain an in-depth understanding of the processes that determine the population dynamics of these species such as recruitment, spatial structure or density-dependent processes (although at the present time, some efforts are being made in this direction, as is the case of the spider crab).

In synthesis, we are faced with only partial information, both in terms of the species analysed and the study topics. In this sense, it would be fitting to go back to the issue raised in the introduction concerning the possibility of acquiring "complete" scientific knowledge that would be suficient for appropriate resource management. In an industrial fishery, for instance, the relationship between the economic benefits obtained by the fishery and its biological and social complexity is high, which would make it possible to develop intensive lines of research (and assessment methods). In terms of the artisanal coastal fisheries of Galicia, the economic yield of each one of the species harvested does not appear to be able to support specific lines of research (and even less so if data on the geographic variability of each stock is needed, which appears to be the case).

In view of this situation, we must seek out alternative ways to acquire information applicable to fisheries management. So, first of all, we must find new sources of knowledge that will be able to supplement or broaden our scientific knowledge (this aspect is the central topic of this paper, which will be discussed in detail in subsequent chapters). Secondly, we believe that the species and ecosystems exploited by the Galician artisanal fleet (and by artisanal coastal fleets in general) have a number of similarities, which should be used, as far as possible, to make generalisations based on the fragmentary information available. In order to meet this goal, it will be necessary to develop research lines that will carry out an in-depth analysis of the mechanisms that regulate the population dynamics of the species of interest, in terms of their fishery value as well as their value as biological models. Secondly, using the available data for all the ecosystems and stocks, they must be classified according to their affinities with the model systems for which detailed information is available. This process will allow strategies for adequate management to be designed (a topic which will not be discussed in full in this paper).

Assessment methods

The idea proposed above concerning the relationship between economic yield and the biological and social complexity of the fisheries as determining factors in the capacity for the development of scientific research may be applied to the development of assessment systems that will involve intensive biological work or compiling statistical data. Therefore, it would not seem appropriate to use the methods based on the direct assessment of stocks from biomass estimates in research cruises or recruitment monitoring as a proxy variable of the future biomass of the stock, due to the considerable economic and human effort involved (considering the number of species and stocks of each species to be assessed).

An alternative based on the use of statistical data on catches has made it possible to carry out retrospective stock assessments of species such as squid (Simón et al. 1996), in order to estimate total catch, or the spider crab (Freire et al. in press), to estimate the biomass harvested and fishing mortality (using methods based on stock depletion, due to the high exploitation rate). The indirect methods for the reconstruction of stock abundance based on fishery data (such as VPA and similar analyses) would not be appropriate for use in this situation because the underlying biological model does not fit the exploited resources and in general, the needed statistical data are not available, although some attempts have been made in this direction (e.g. González-Gurriarán 1995 did a preliminary analysis on yield per recruit of the velvet swimming crab).

4) FISHERS' ECOLOGICAL KNOWLEDGE

Definition and historical development of research

The FEK (Fishers' Ecological Knowledge) is a specialised branch of TEK (Traditional Ecological Knowledge). However, only recently has it generated interest as a topic of study focused on resource management. TEK has not been taken into account by those responsible for the management of fisheries. Rather, it has always been considered as part of the traditional knowledge that a "people" (culture) acquire about their environment, and so, would be a type of knowledge limited in scope (local) and lacking abstract thought. The declaration of Río recognised, however, the importance of indigenous knowledge in the sustainable management of the environment. And, in keeping with this belief, investigators at the Memorial University of Newfoundland have carried out interdisciplinary research, owing to the crisis in the cod fishery in Newfoundland and Labrador, to develop new methods for incorporating FEK into the management of fisheries resources (Neis 1992, Hutchings et al. 1996), particularly when these fisheries were the object of very important attention from a scientific and institutional standpoint. A case in point is the crisis of 1990, which the fishers had predicted, in opposition to the opinion of the scientists (Finlayson 1994).

Although there has been very little previous research dealing with the use of FEK in resource management, there have been important reports in the field of anthropology -specifically within the ethnoscience-, in which an attempt has been made to systemise and carry out a taxonomic classification of the different aspects of the traditional knowledge of many of the cultures of the world. In the field of fisheries anthropology, the first contributions were made in 1967 by Morril on the classification of coral-reef fishes exploited by the Cha-Cha people and by Forman on methods of locating fish in a Brazilian fishing community. In 1981 Johannes included a glossary of terms in Paluam used to designate fishing instruments, behaviour of the fishes, parts of the marine environment, and different fish species. Similarly, Eythorsson (1993) provided an example of Sami taxonomy (Norway) for the different types of cod. But it was not until the 1980's that the concept of TEK (Traditional Ecological Knowledge) began to be used on a more regular basis and with a view to its application in resource management.

Lacking a definition of the concept, it was Mailhot (1993), who gave us the first explanatory definition: "the sum of data and ideas acquired by a group of human beings, related to the settlement and use of a region for many generations". This definition also laid the foundations for the construction of a methodological framework with the possibility of carrying out applied work.

A comparison of traditional and scientific knowledge

Unlike the credibility and respect afforded to the knowledge generated by normal science, other types of knowledge, pertaining to certain trades, receive little or no consideration outside the setting in which they are used. There are clearly important differences between the two, especially in terms of ways of formulating statements about the world of experience. The basic difference lies in the formal point of view. In this sense, we may say that in the specific case of fishers' traditional knowledge, the know-how that emerges in this environment lacks method, terminology and syntax proposed in a consensual manner; it lacks the universal scope established as a criterion for truth; it does not have systematised historiography and lacks the socio-political and economical support for generating more and better knowledge. However, both types of knowledge are born analogously in an attempt to resolve the problems stemming from the fields of experience in which they move and both use this experience to verify the truth and reliability of their statements.

The fact of the matter is that they are two different cultural domains that are asymmetrical and have different degrees social impact. However, each type, in its own right, pursues similar goals: to exercise a certain "control" over nature, but one case seeks the form of explanations with reasons framed in complex, long- and medium-term theories and the other case, resorts to other explanatory strategies that require a rapid interpretation in order to make effective decisions.

Our approach endeavours to highlight the importance that fishers' TEK should be understood not only as a history of practices, whereby work techniques are learned and transmitted (Delbos & Jorion 1984), but they must also be regarded as a history of the representation and comprehension of the environment in which they live. In this way, in addition to being linked to practice, knowledge is also linked to a conceptual network of spatial and environmental information as -or even more- essential than manual and technical culture (García-Allut 1995).

Besides being proven by the information acquired over generations, the fishers' knowledge on what occurs in the marine environment is an updated understanding that includes the latest changes occurring in the local marine environment. And it is precisely in this relationship where the affirmation that the fishers themselves are the ones who "know" the ecological environment of their community best is a fact. However, those who plan management policies are politicians working in collaboration with technicians from the administrations, and they do so unilaterally, entirely disregarding the knowledge of the fishers concerning their field of experience. Some examples that occurred in Galicia in recent years may serve as an illustration: in the late 1980's, the autonomous government encouraged the use of a type of trap (different from the traditional one that captured both octopus and velvet swinmming crabs) to catch octopus. This resulted in an economical setback for the artisanal fishers or the opening of the fishing season for the velvet swimming crab at a critical time of its reproduction

<u>Why has FEK been ignored as an interesting source of new knowledge for marine biologists up to now</u>?

Science and technical progress are invariably cited as the reason for the "success" of our culture. A direct consequence of this is that the social recognition of this knowledge is accepted by the public and therefore enjoys privileged status. The same is not true, however, of other types of knowledge, such as that of the fishers. The social image of the latter is largely conditioned by the social position of the productive activity from which this knowledge stems. Therefore, the social credibility regarding what the fisher *says* is affected by what the fisher *is* in relation to the other interlocutors.

It is our understanding that this stratification of knowledge is a *factum* that conditions behavioural attitudes among individuals, and this certainly has major consequences. In fact, we believe that relationships of inequality between individuals and social groups are the result of the differences perceived in the types of knowledge that each person may possess – in addition to economic factors. And this difference will always hurt those who have knowledge which is located socially on the lowest branch of the "tree of knowledge". Therefore, it is our opinion that this feature of structural character may be one of the reasons that could partially explain why scientists (who assess the institutions where fisheries policies are designed) refuse to recognise that fishers' knowledge is an interesting source of information.

Another argument, stemming from the one discussed above, is related, first of all, to the training fishers are supposed to have. In other words, fishers cannot be in possession of reliable knowledge because they have not received the necessary training. So, this knowledge cannot have true value because it is not derived from the use of a scientific method. At the most, it may be considered a type of know-how constructed on a foundation of naive empiricism (Popper 1962), the exclusive result of causal perceptions carried out with no control in the observation process (Kaplan 1964, cf. Wallace 1976). This leads to a situation where many scientists who are experts in marine ecosystems are convinced that they know more than the fishers. Moreover, they believe that the idea fishers have of marine ecosystems is plagued with errors and inconsistencies and that it would be practically impossible for them to contribute any worthwhile information.

Another reason is that some biologists and economists do not trust the information provided by the fishers. This mistrust of the reliability of the information is specifically founded on the old belief (Hardin 1968, Gordon 1953) that the fishers' main objective is to maximise his economic yield on a short term, with little concern for the future, so that the data and explanations he may be able to offer would be biased by his own interests. This conception, we must not forget, has been largely refuted by the wealth of anthropological literature that appeared starting in the 1980's, in which many examples are presented regarding the capacity of the artisanal fishers to create strategies regulating the resources (Farmer 1981, McGoodwin 1990, García-Allut 1993). But this wariness is likewise present in the opposite direction: fishers being mistrustful of biologists. There is a deep-rooted mistrust among the community of fishers - a reflection of how they see their relationship with official institutions- which they must comply with in terms of legislation, and the experts are looked upon as a prolongation of these (Collet 1996).

Our main argument is based on the premise that fishers have an in-depth understanding, as a result of a number of observations verified over the generations, of the marine environment that they exploit (Forman 1967, Cordell 1974, Orbach 1977, Warner 1983). But, we also uphold that, prior to the implementation of any management measures, it is essential to investigate how this knowledge is generated and used (McGoodwin 1990, Palsson & Helgason 1996, Symes 1996) taking into account that this is what directs the productive behaviour of the fishers.

In order to carry out this task, we are faced with the question of how and for whom to do it. In other words, although there are very few anthropologists in agencies that make decisions on fisheries management (Fricke 1988, McGoodwin 1990), it would seem obvious for us to realise that this type of research should not just be included in the literature that circulates almost exclusively through channels for the dissemination of maritime anthropology, but rather it should also be a part of a basis for analysis capable of improving the knowledge of others - namely the biologists, anthropologists and fishers. The ultimate goal would be to design fisheries policies that are more in touch with the social situation and identity of the fishers. Therefore, if anthropologists could present this knowledge more formally and systematically, through their research, they could become valid communicators and mediators between the fishers and the experts.

Along these lines, we brought up a number of reasons that are found in the very foundations of our society which restrain any dialogue with other sources of knowledge. However, the barrier of prejudice could be broken down if we could somehow open up communication between the fishers and experts. In fact, many scientists do not ask any information of the fishers because they do not know how to use or explore this type of knowledge in an appropriate fashion.

5) A Proposal for the integration of FEK in the research and management of Galician artisanal fisheries

Objectives of the use of FEK in Galician artisanal fisheries

Our main objective is to acquire new knowledge for application to the sciences that are involved in designing management models for artisanal fisheries in Galicia, specifically focusing on marine biology. In order to attain this main goal we have set five sub-objectives:

1) Verification of concepts already used in biological science: traditional knowledge could be integrated into the development of ecological concepts that can be verified within the science of biology. There are already examples of this approach (i.e. in research on the cod and capelin fisheries in Newfoundland, Rose & Leggett 1993). The hypotheses proven within a standard scientific framework are based on a considerable number of observations. Our research on the traditional knowledge of fishers provides a means of acquiring a wealth of relevant information which has been accumulated over many generations of fishers so that it may be used in the verification of hypotheses in the field of biology.
2) The traditional knowledge of the fishers may be integrated into the fisheries sciences insofar as the fishers include stock assessments in their decisions related to fishing. In other words, fishers do not arbitrarily select fishing grounds and zones, but rather they are guided by an estimate of the resources that might be found in space and time (annual fishing cycle).
3) To put forth new hypotheses able to be investigated in the future.
4) To perfect standardised concepts
5) To generate new knowledge

We plan to attain these sub-objectives by slecting the knowledge that the fishers have in their field of experience. Moreover, the type of knowledge obtained will be even richer the more variety there is in harvesting techniques, since each fishing technique and method determines a specific type of knowledge. We must remember that Galician fishing communities, for example, tend to use different methods of harvesting (trap, tangle-net, gill-net, hook/glass box, etc) and different fishing techniques ("de meixoada", "ós lances", ...) to catch velvet swimming crabs, spider crabs and octopus.

The more generic scope of knowledge that we will need to achieve the above goals will be centred, in turn, on acquiring knowledge and information on: a) coastal ecosystems, b) population dynamics, c) descriptions of habitats and bottom types, d) interactions and relationships between species, e) behaviour and feeding habits, f) reproductive zones and seasons, g) climate (atmospheric and oceanic) influences on the species, h) stock assessment of fishes, crustaceans and molluscs, i) reconstruction of the history of marine ecosystems in relatively short periods, etc. After filtering, systemising and formalising all this type of information and knowledge, we will be able to broaden our understanding of the exploited species.

As an example, we will present some concepts used by the artisanal fishers in Galicia, that would provide useful knowledge for the biologist such as:
a) "veirada": these are borderline areas between rock and sand (relatively narrow strips). These "veiradas" are generally dotted with small stones ("ollados") and are ideal habitats for different species (bib, sea bream, sea bass, velvet swimming crabs, etc).
b) "ajuas lodas (nejras, quentes,...)": these terms designate a type of upwelled water mass, which, according to the fishers, usually approaches the coast in August. It usually brings crustaceans ("small shrimps") and fishes that feed on them; some of the fishes attract others (sardine, pollack). When these waters reach the coast it is possible to catch sea bass, sea bream, etc.
c) types of rocks, for example for each type of rock that they recognise, a cognitive model will be constructed including aspects such as the type of fish or seaweed species, and seasons when they are most productive.

Methodology

The TEK of the fishers is a system made up of practical aspects and beliefs that are implicated in a social context which is different from normal science. One of the methodological obstacles associated with combining science and traditional knowledge is finding ways to integrate both types of data and information. If TEK is to be used in the development of sciences involved in fisheries and resource management, we will require a framework within which to gather this knowledge and to blend it with normal science in order to optimise its use in resource management policies. First of all, this knowledge should be compiled in a language used by the people in order to analyse the way in which the population codifies and organises its knowledge. Secondly, we must realise that traditional knowledge is internally differentiated by a number of factors that include fisheries technologies (gears, ..), fishing techniques ("embalo", "lances", ...). age, gender etc. Lastly, a focal point of research on TEK should be the identification of the most appropriate types of information.

In order to acquire traditional knowledge, methodologies and research techniques must include: a) analysis of discourse, b) selection of information, c) semi-guided open interviews, d) surveys on specific points of knowledge, e) analysis of the distribution maps of the resources and habitats drawn up by the fishers, and other documents of a functional nature that they may have (notebooks, graph interpretations (depth sounder, radar), notes, etc).

The ultimate goal of processing the information obtained following the methods described above is to acquire new knowledge that can be integrated into fisheries biology. This processing would be made possible with the help of the mechanisms and methodological tools of the computer science (the development of a terminological system and mechanisms for sharing knowledge). These tools would provide us with the formalism necessary to express this knowledge (descriptive logics) and a tool based on this formalism (terminological system), in addition to formal and computer mechanisms for collaboration between the experts (anthropologist/biologist) (resource discovery mechanisms). The authors are collaborating with specialists in Artifical Inteligence (Computing Department, Universidade da Coruña) with experience in in the processing and representation of knowledge (Barreiro et al. 1997, 1998, 1999) to acomplish this objetive.

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Annex 1. Characteristics of the fishery sectors operating in inshore waters (continental shelf and rías) of Galicia (NW Spain) corresponding to the political and administrative category of inshore fisheries ("bajura") (boats of <150 GRT). Only the main gears used are included.

Gears	Fishing zones	Distance to the coastline	Depth
Fishing lines (pelagic and demersal)	- Limit of continental shelf - Continental shelf	15 - 40 miles 7 - 12 miles	100 - 400 m
Trawl (semipelagic and demersal)	- Continental shelf	4 - 12 miles	150 - 300 m
Gill-nets	- Limit of continental shelf - Continental shelf - Coastal areas	Shoreline to 15 miles	1 - 400 m
Traps	- Coastal areas	Shoreline to 8 miles	1 - 60 m
Intertidal shellfishers / divers	- Coastal areas		0 - 20 m

Annex 2. Main artisanal fisheries operating in coastal waters of Galicia. The target species corresponding to each gear are indicated.

Gears	Target species
Traps	Octopus Velvet swimming crab Bib (Spider crab)
Glass-box / Hook	Octopus Spider crab
Tangle- and gill-nets	Spider crab (Cuttlefish) (Fishes)
Fishing lines	Conger Bib
Intertidal shellfishers / divers	Bivalves Goose barnacles

Annex 3. Main invertebrate species exploited by the artisanal fisheries operating in coastal waters of Galicia (intertidal to 60-80 m) Official total landings (mt) and value (in millions of pesetas) are presented for 1997 and 1998 (data provided by the Conselleria de Pesca, Marisqueo e Acuicultura) Several species with low official catches are omitted The official data do not distinguish catches obtained from different fleets; in the case of invertebrates most of the landings for the major part of species correspond to the artisanal fleet. In the case of the fishes (not showed), many species are exploited in Galicia but artisanal catches constitute only a small part of total catch and only some ones are target of the artisanal fisheries (as the bib *Trisopterus luscus* and conger *Conger conger*)

Common name			1997		1998	
Galician	English	Scientific name	Landings	Value	Landings	Value
CRUSTACEANS						
Nécora	Velvet swimming crab	*Necora puber*	119	166	66	128
Centola	Spider crab	*Maja squinado*	117	178	126	206
Boi	Edible crab	*Cancer pagurus*	38	20	3	3
Camarón	Prawn	*Palaemon serratus, P elegans*	68	278	57	232
Percebe	Goose barnacle	*Pollicipes cornucopia*	319	903	365	1087
CEPHALOPODS						
Pulpo	Octopus	*Octopus vulgaris*	3886	2533	3570	2209
Choco	Cuttlefish	*Sepia officinalis, Sepia elegans*	778	381	626	313
Calamar	Squid	*Loligo vulgaris, Loligo forbesi*	1245	739	924	544
BIVALVES						
Ameixa babosa	Clam, pulled carpet shell	*Venerupis pullastra*	2114	2257	2554	2613
Ameixa fina	Clam, grooved carpet shell	*Venerupis decussatus*	794	1512	914	1794
Ameixa rubia	Clam, banned carpet shell	*Venerupis rhomboides*	326	292	306	260
Ameixa xaponesa	Short necked clam	*Venerupis japonica, Venerupis semidecussatus*	285	225	2452	909
Berberecho	Common cockle	*Cerastoderma edule*	2957	876	2452	909
Navalla	Razor clam	*Ensis directus, Solen marginatus, S.vagina*	115	148	97	169
Longueirón	Sword razor shell	*Ensis siliqua*	50	20	68	55
Vieira	Scallop	*Pecten maximus*	77	74	35	48
Volandeira	Queen scallop	*Aequipecten opercularis*	34	21	38	21
Carneiro	Wart venus shell	*Venus verrucosa*	83	58	116	81
Relo		*Dosinia exoleta*	1281	135	1309	141
Cadelucha	Wedge shell	*Donax trunculus, D variabilis*	39	75	36	71
ECHINODERMS						
Ourizo	Sea urchin	*Paracentrotus lividus*	585	47	525	58