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FISHERIES RESEARCH IN WESTERN MEDITERRANEAN: INTERDISCIPLINARY APPROACH

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Non-specialist summary

Fishery activity is a form of interaction between natural systems and social systems which inherits a dynamic and complex character. It is for this reason that the contribution of different scientific disciplines is indispensable in order to understand the interrelationships of the systems involved and to focus correctly on the problems that their management creates.

In recent years, there has been a growing interest in developing integrated approximation within the limits of the rational exploitation of live marine resources, with the scientific community recognising the necessity of establishing links between the biological, economical and social aspects of fisheries management. It can also be stated that, within the sector of the renewable natural resources, this orientation has been particularly more marked in the fisheries world.

Until now, the whole practice of the international organisations and administrations in charge of the management has been to carry out their work based on a "reductionist" policy. Consequently, they have had great difficulties in facing up to the appearance of new problems and the numerous crises that have arisen in recent decades in the fisheries world. Although necessarily biased, the points of view of the biologists have been the only advisory elements that have been based on data and evaluations with a more or less regular basis, despite the imperfection of such data. In order to try to overcome this situation, the European Union introduced the economic element into the Scientific and Technical Fishing Committee in 1992.

The Mediterranean is not outside this scheme. Consequently this project was set up with the principal objective of establishing an interchange of ideas and experiences between the 10 participating institutions from Spain, France and Italy, as well as to co-ordinate the methodology in order to direct it towards multidisciplinary projects. In practice, this study has been established from a synthesis of different themes, by holding four thematic working groups and a final seminar. The end result is the proposal of lines and objectives of investigation for future co-operative projects, with the aim of advancing the knowledge of the "fishing system" as support for an adaptive management of the exploited resources.

Summary

Recent trends in fisheries research have shown that the degree of our understanding significantly improves when the problems to be solved are approached in a multidisciplinary way. It has also been progressively recognised that hierarchical approaches are particularly fruitful and that for a better understanding of fish population dynamics we need to persistently look for the mechanisms behind the observations. Hierarchy is not meant in the sense that one discipline is better or more adapted than others for solving a given problem, but in the sense that the different disciplines should be applied in a logical and progressive way. Studies which focus on highly specialized problems are, of course, very important and should never be neglected, but the finest comprehension of a biological aspect is only poorly rewarding if it has to be placed in the context of limited knowledge of the dynamical system.

Most of the researchers within this project from 10 institutions of Spain, France and Italy have made international co-operation in fisheries research within the Mediterranean area of the EU a reality. The interest in pursuing existing co-operation and co-ordinating research activities between member states has been underlined in several Commission reports and working groups. With the aim of continuing in the future with this co-operation, four thematic working groups and a final seminar were held. The topics covered were the environment and fisheries, modelling, fleet dynamics and effort and fisherIies socio-economy. From the subsequent discussions, the priority lines of investigation and specific objectives for future projects were established in a multidisciplinary framework.

1. Objectives

The future implementation of a new fisheries management system in the Mediterranean should serve as a guideline for this project.

The main objective is to set up a network of researchers who would contribute ideas on the various components of the system, based largely on results of work already carried out in the area or other regions.

This action should lead to proposals for specific multidisciplinary projects for the study of ecosystem dynamics and socio-economic dynamics within the current Framework Programme.

The project consists, in practice, of sharing the results of scientific and methodological research from the various participating institutions, and in co-ordinating prospective thematic thinking towards the development of new common regional programmes.

2.-Environment and Fisheries Working Group

2.1.-*General discussion*

It seems that the anchovy landings in the Alboran Sea are actually recovering. These collapses occur after a peak of maximum catches, the same as occurred in Peru.

It is commented that the same process is being observed in the Ligurian Sea where the yields fell before recovering in the last three years. In the Adriatic a similar process for sardine and anchovy took place and it was studied by different evaluation methods: acoustic, VPA and ichthyoplankton evaluation, with different results for biomass estimation being obtained, possibly due to methodological reasons.

Apparently, the acoustic evaluation cruises have not detected recovery signs for the Alboran stock. It would be interesting to prove if these processes happen at the same time in different areas, Mediterranean or not. It does not seem that the Alboran collapse will occur in Catalonia, whereas it was registered in Algeria. This could be explained by differences in the structure of the populations. The Alboran collapse could be explained by an extraordinary recruitment in 1981 that has not been repeated since and is not related to exploitation.

It cannot be discarded that the Alboran anchovy could come from the spawning of Atlantic broodstock. But does evidence actually exist for the existence of this reproductive stock in the Atlantic and of an important contribution from eggs and larvae?. Perhaps a correlation could be looked for between the fluctuations in the quantity, the way the Atlantic water enters and the fluctuations in populations of small pelagic fish.

The interpretation of the fluctuations of the landings as a biomass fluctuation index for the populations should be treated with caution. It is suggested that historical series of the differences in sea level between the Atlantic and the Mediterranean could be used, since data exist that go back to the past century in some cases. This would allow them to be used as an index of the Mediterranean production and to attempt to correlate them with the fluctuations in the Mediterranean populations.

In 1991 a coincidence in the increase of the hake landings in different areas of the Mediterranean was noted that could be due to the existence of some favourable factor that occurs in such zones.

In Italy it is recognised that in recent years a reduction of the fishing effort has occurred, because of the introduction of fishing management measures, although a considerable recovery of the resources has not happened. The rainfall in the last three years has increased in the studied zone (Ligurian Sea) and an increase of the mean temperature has been observed both for the sea and the air, before stabilising in recent years. An attempt is being made to correlate these parameters with the abundance of the resources. Equally a recruitment maximum has been noted, the same as occurred in the Baleares, Northern Spain and the Gulf of Lions at the end of 1990.

In any case a specific measurement for the fishing effort should not be confused with the mortality by fishing that is actually the factor with which the behaviour of the population is correlated. Perhaps variable climatic measurements could be used as indirect indicators. A seasonal climatological pattern and its variability could be established in order to attempt to correlate them with the fluctuations of the marine populations. Therefore, a series of tasks should be carried out:

1. The recovery of historical series on catches and landings in different areas, together with environmental and climatic parameters, in order to try to identify any trends.

2. Based on previous results, or independently, to establish a hypothesis on the connection or interaction between some key physical factors and biological aspects, such as the spatial distribution of eggs and larvae, the state of the larval condition, growth (first stages of the life cycle in general).

3. The estimates of the adult population and the juvenile population (less than 25 cm) for hake and other species derived from the landings by weight from the Sete trawlers between 1970 and 1993, show a very close correlation. It is suggested that this aspect be investigated in other areas.

4. In the Alboran Sea a great abundance of some species, such as *Capros aper* or myctophids, which are not exploitable or not exploited, was observed and this would be analysed in relation to both the existence of similar phenomenon in other zones and to the carrying capacity of the system. It must be taken into account that modifying the specific composition of the population can also modify the carrying capacity of the system.

5. It was commented that the intrinsic growth capacity of the species (r) that follows a logistic model must be taken into account. Theoretical studies indicate that for high values of r, the curve shows a chaotic trend in the asymptotic zone independent of the environmental conditions. In this context, which value can we give to the estimates of maximum fishing production from the primary production estimates of an area?. Without doubt they have a certain indicative value.

Alternatively in relation to pollution, how can the influence of a pollutant's affect, such as mercury, on the population dynamics of exploited species be studied?. It is actually difficult. Some tests exist for toxicity and, for example, the study of fecundity in relation to the level of some pollutants. The relationships between the cause pollutants and the effects on the ecosystem or on the biology of the species are probably not linear.

The substitution of species in the system could be limited to zones where the water column is greater or less than 1500 m. This is based on the Ligurian Sea where it is observed that the distribution of the adult anchovy does not go beyond this depth. This community would not contain the anchovy whereas it would include its own mesopelagic species. However, in Catalonia large concentrations of anchovy larvae, mixed with other mesopelagic fish have been found on bottoms of more than 1000 metres. This separation of communities in the Ligurian Sea has also been observed in relation to other species such as crustaceans and cephalopods.

Finally, aspects related to a project on the ecology of the first stages of life of the hake were generally discussed, as well as the state of the art for the anchovy being presented

2.2 *Recommendations*

1. Several documents were analysed and presented to the meeting that referred to research projects that have carried out interdisciplinary studies between oceanographers and fishery biologists. In addition, previous recommendations of meetings and international organisations were considered. As a result, the group reaffirmed the necessity to incorporate environmental studies into the fishery research projects carried out in the western Mediterranean in the future.

2. As a summary and seeking a practical outcome for the discussion related to the relationship between the environment and the resources, it is considered a priority need to identify hydrodynamic phenomenon (local upwellings, topographic conditions such as submarine canyons, formation of small scale eddies, etc). These have a contributory influence on the development of the different life stages of the species of commercial interest and certain experimental evidence of their importance is known.

3. Taking into account the advances obtained in some areas of the western Mediterranean (Alboran Sea and Gulf of Lions), it is recommended to continue with the lines of collaboration established for the investigation of biotic and abiotic factors and biological aspects of the different life stages of the principal species (hake, anchovy, red shrimp, etc.), as well as to develop research projects in the immediate future. The group is still open to consider any suggestion originating from the other meetings within this project, so that they can be included in relation to the themes of environment and resources.

4. In relation to the anchovy, the activities carried out were presented and the previous experience was emphasised in relation to the identification of certain common oceanographic processes in the ecosystems where the European anchovy lives. In addition, there is a need to deepen the knowledge of the ecological aspects of its life cycle, concentrating on those worst known (for example, the behaviour of adult shoals in relation to the water masses, availability of food and larval survival, etc.). All this should be undertaken by using a comparative approach in the different areas, which will allow common patterns to be characterised.

3. Modelling Working Group

3.1 *General discussion*

A common problem in fisheries biology is the estimation of parameters for their utilization in the application or production of models. The usefulness of the bayesian approximation has been established, since it allows as many variances and variabilities as necessary to be introduced in the errors. It refers to the models that relate size and age to obtain a probabilistic result, for which a sensitivity analysis is carried out by modifying the parameters that conform to their correlations. It is suspected that the

bayesian model is more adequate since it allows all these parameters to be altered together.

It was stated that in classical statistics the estimation of parameters has a normal multivariant distribution in which simulations can be made by varying the estimations themselves. The bayesian model makes this simulation by directly varying the parameters and not their estimations. The modelling is easier because it acts directly on the parameters. The probable maximum point has to be converted in a distribution.

The possibility of incorporating more errors besides those of the method is very interesting. But how are these errors incorporated?. It is understood that to deal with a hierarchical model the initial steps that are added determine the rest of the parameters. They are a priori distributions from aspects that are always known. It has to be emphasized that this methodology is growing and widely used nowadays.

The use of the bayesian methodology is proposed, which until now has been used very little analytically, instead of the VPA analyses that are deterministic. As a specific example, mortality could be treated as a parameter with an a priori distribution and not as a fixed value, in order to run a VPA later. In general, it adequately predicts the incorporation of the uncertainties better, although they will have more errors.

In relation to spatial modelling, geostatistical techniques are considered in possible sampling applications, from a hake survey in the Gulf of Lions with stratified and random sampling. The sample size is a function of the area of each stratum and assumes that the distribution of the resource is selective with respect to the bathymetry. The variogram was obtained with a good fit and a kriging was made simulating samplings. When a compilador is used in order to obtain random data for the simulation, although they are really pseudorandom, a high correlation coefficient exists between both axes and also of autocorrelation in each axis. The random numbers technique cannot be applied to spatial data, therefore a programme that generates random spatial data was created.

The geostatistical estimation and its variance were undertaken for all sample sizes, with 50 simulations for each one. The representation of the interval for the mean, shows that the variance is established from a certain sample size. Thus other types of samples can be simulated.

Nevertheless, on many occasions the distribution of the individuals does not depend on the depth but on other factors such as the temperature. For example, in the case of the Gulf of Lions where a group of species varied with the east-west salinity and substrate gradient. The type of sampling will depend on which factors affect the resource. The new localization techniques such as GPS are very precise, although it is necessary to have previous knowledge and to distinguish between actual biomass and exploitable biomass.

The concept of time is also introduced. In the classical models space does not exist, whereas in the spatial models time does not exist. The existence of some time incorporation examples is indicated but applied to forests.

Moreover, the behaviour of the fishermen does not agree with the behaviour of the biomass of the resources. The impact of the publication of distribution charts for the fishing resources was studied, but they were not accepted by the fishermen and it was much later when the impact was observed.

A demonstration of a model that takes into account the spatial distribution of sedentary species in cells, that are considered as elementary units of resolution and are non variables, is commented on and carried out. Actually work is starting with demersal species of a certain mobility. The migration of juveniles that are distributed randomly in the zone where the adults occur, when they reach the age of maturity, is also incorporated. The procedure for using the decision tables is also explained, applying an economic theory in order to decide which risks are taken. However, at the moment, the limitations of the model have an effect on migration and multispecificity.

One of the principal problems of the Mediterranean fisheries is to model the decision making by the fishermen. These are guided by decisions in the short term with regard to the catches.

As an experience of modelling in the Mediterranean, a bioeconomical model (HEURES, Lleonart et al, 1996) is presented for discussion, that constitutes a first attempt at a simulation mechanism capable of being used on the basis of understanding the working of the western Mediterranean fishing system, to evaluate management measures and analyse the possibilities of starting adaptive management. Essentially, the model consists of the interaction of three cases that simulate the behaviour of each one of the agents that control the fishery: the resource, the market and the fisherman. The main idea of the model is that the fisherman directs his investments to maximize the mortality and increase the catchability based on the capital invested. It assumes that the capital-catchability relationship is asymptotic, since catchability cannot increase indefinitely.

Although the model is unispecific, it is considered a very promising multidisciplinary approach for applying in the area, but it is waiting for its confirmation with actual data and precise estimations of the parameters.

The possibility of combining the temporal with the spatial models is evaluated. The intention exists to combine the model of differential equations in short specific periods with the bioeconomical model, in which the relation between layers is at longer time intervals, through the classical equations of population dynamics. In addition, the production of maps using the Geographical Information System methodology, is one of the more useful tools used by managers. In any case, the limitations of global modelling will have to be identified in the whole Mediterranean, due to the multispecificity and large variety of systems. Once they are identified, the generalities common to the others should be found in order to be able to arrive at a global model.

3.2 *Recommendations*

1. It is recommended that the bayesian inference statistical methodology be introduced within the field of Mediterranean fisheries research, fundamentally for the estimation of the most relevant parameters in this area (growth, selectivity, etc.).

2. It is recommended that the relevant phenomena in fisheries be considered as dynamic processes whose evolution develops within the framework of interactions between their elements and with effects of spatial-temporal autocovariance.

3. It is recognised that the use of methodologies that incorporate spatial reference and provide description and analysis of the distribution and spatial abundance of the resources and the activity of the fleets are potentially very useful for management of the fishery resources. These methodologies complement, in a heuristic way, the classical approach of exploited population dynamics that take into account time but not space.

4. It is recommended that effort modelling be carried out. This would incorporate the heterogeneity of the spatio-temporal distribution of the resources and the fleets that exploit them and their interactions. These should contain the ecological and technological interdependence of the fisheries studied.

5. Given the uncertainties and inherent risks in the study of fisheries, it is recommended to include a precautionary approach in fisheries analysis. This focus could include decision tables with and without mathematical probabilities.

4. Working Group on Fleet Dynamics and Effort

4.1 *General discussion*

There is a question based on which are the relationships between the explicative causes of resource variability, the exploitation and the environment. Examples were presented demonstrating clearly that the problems of commercialisation, availability of resources and the influence of meteorological conditions have a direct impact on the behaviour of the fleets. Therefore it is necessary to take these microvariations into account. In parallel, the seasonality tied to the displacement of the species allows the problem of sequential fisheries to be considered.

On the other hand, the usefulness of data analysis from cruises of stratified trawling is established in order to investigate the association of stable species and their relationships with the environment. Factors such as the coast-open sea gradient and the influence of river mouths can be considered. The objective would be to put a consistent order to these relationships in a very synthetic way. The application of techniques such as factorial analysis, canonical analysis, contingency tables and others allow these associations, their persistence and resistance to elasticity (resilience), to be identified. These are aspects with relevance to the management, for example, of trawl fisheries.

Given the multispecificity and multigear characteristics of the Mediterranean fisheries, the utility of the application of multivariant, correspondence analysis and cluster statistical techniques have been discussed. Ungrouped fleet catch data for species/boat/day/zone can be used to identify components of the fleet and types of activity, as well as their development. In this way, the pattern of exploitation followed by the fleet can be understood. Moreover, they can also be classified according to technical aspects, with a clear association being able to be found between the types of activity and types of fleet. In this sense, the *métier* concept is used as a coherent

functional entity in terms of vessel type and size, gear, target (group of) species, spatio-temporal fishing pattern, which can be summarised by a consistent array of catchabilities by species and ages.

In parallel, the specific efforts for the principal objective species can be estimated as a function of the type of activity in which they are caught. The relationships between the catch and the new estimated specific effort, provides estimations of the resource abundance, analysing its intra and interannual variations.

It was considered that this approach has a high applicability in Mediterranean fisheries, as has been shown in an area such as the Gulf of Cádiz (southwestern Iberian peninsula) whose exploitation characteristics are very similar.

The availability of ungrouped data from the activity of a fleet also allows a series of standardised estimations of the catch per unit of effort (cpue) to be obtained. This analysis can be undertaken by applying the statistical technique of Generalised Linear Modelling (GLM). These models admit both continual variables, such as the catches of other species, and discrete variables, such as months, categories of boats and years. The suitability of this approach has been examined and discussed, based on data from a trawl fleet and its daily hake catches. On the other hand, obtaining these indices would allow them to be contrasted with the direct estimations available.

On the other hand, the problem of catchability in the framework of the bioeconomical HEURES model (Lleonart *et al.*, 1996) has been considered. It is assumed that the fisherman invests part of his profits to increase the catchability because the effort is limited. In this sense, the catchability is tied directly to the capital of the fleet and its estimation will have to be considered in relation to technological progress. No investment would mean the decrease of the capital in the medium-term, followed by the effort and, finally, the withdrawal of the fishery. Therefore, it is necessary to prepare general data on the fleets, including their typology, fuel consumption, economic data, etc., as well as the development of these data with time.

The concept of Geographical Information Systems (GIS) and their potential in the field of the study of fisheries has been presented and discussed. The GIS methodology covers the ideas of conceptual approximation and of an information technology tool. Its advantage lies, fundamentally, in the integration of heterogeneous data that have a georeference. Time and the representation of two or three dimensions also have to be taken into account. An on going application is the spatial distribution of the fishing effort and fleet dynamics. A clear consensus exists concerning its great utility in the more or less immediate future.

The first priority agreed at recent international meetings dealing with the management of mediterranean fisheries was for the control of the level of fishing applied to several stocks in many parts of the Mediterranean. This implies the need for a common approach to improve the knowledge on fishing effort, given that several key resources are straddling stocks lying across the boundaries between territorial seas and international waters where open access conditions apply. The living resources of extensive international shelf areas fall into the category of straddling stocks, as discussed by the Conference on Straddling and Highly Migratory Stocks.

The life history of most of the Mediterranean species does not occur across extensive areas, so they can be considered as stock units, and it seems clear that a particular management framework is needed for the national fringing shelves that separate them, which are matters that fall entirely under national jurisdiction. Even in cases where management can be done entirely at local or national levels, the setting up of common methodologies for the studies on fishing effort would be desirable, given the advantages that can result from the exchange of experiences in the implementation and enforcement of management actions.

In principle, the relationship between the fishing effort of a particular fleet and the fishing mortality, generated by this fleet, is a linear one. However, in practice such linear relationships can seldom be demonstrated from existing time series. This is because the fleet structure, the directivity of the fleet and the fishing conditions may have changed in the time period. The effects of changes in these parameters are generally not included in the effort measure of this fleet but do also affect the fishing power exerted by this fleet

4.2 *Recommendations*

1. To identify relationships between exploitation strategies and natural inter- and intra-annual variations of the exploited resources in order to go from description to interpretation, including the information coming from field observations.

2. Fishery activity affects the ecosystems. Therefore, it is considered very relevant to have information for marine populations concerning the distributions and their spatio-temporal development, by applying the methodologies presented (statistical and GIS methods) that also evaluate the response of the populations to the impacts.

3. Given the multigear and multispecific nature of the majority of the Mediterranean fisheries, it is considered necessary to identify the different fishing strategies, in order to quantify the corresponding efforts and determine the part of the catchability corresponding to technological advance. These studies could use methodologies such as multivariant analyses (PCA, GLM, etc.) that allow the interactions to be quantified and the standardized abundance indices based on ungrouped fishery activity data to be obtained. These indices could be compared or calibrated with direct indices.

4. In general, the group noted that the geographical regional scale of the projects is a key element at the point of validating methodologies, to identify fishing strategies in order to establish similarities or differences between areas and to be able to analyse the effect of management measures on the effort at a regional level.

5. Socio-economy Working Group

5.1 *General discussion*

Among the fisheries science community, the need for change in current approaches to fisheries management has been recognized. It is significant that most suggestions for this change still retain a strict organizational gap between biological evaluation of the

fish stock and aspects of fisheries operations, e.g. the socio-economic performance, including the actual process of decision making.

The objective of this Working Group has been to bring together and present recent initiatives in order to interlink the socio-economic and biological aspects, as well as to discuss the relevance of variables not considered until now in the study of the fisheries in the area, such as for example the consumption habits of fish products.

From the official statistics of the Ministry of Agriculture, Fish and Food, the quantities of fish products consumed in Spain and their trends have been studied. Moreover, the results of an analysis of the socio-demographic variables with an influence on consumption were collected. It was observed that consumption was not carried out in a homogeneous way in all sections of the population, therefore it is necessary to identify the characteristics of the households where the consumption of these products have importance. Thus, there is a higher concentration of the demand in households where the size of the family is smaller. On the other hand, the responsible age for these purchases is a variable that differentiates between distinct levels of consumption, with this being greater in the families where those responsible for the purchases are older.

In parallel, this consumption has undergone, in recent years, a process of homogenization in relation to the different socio-economic strata of the population. For this reason there has been a qualitative reduction of this variable. On the other hand, it has been observed that the consumption is higher in larger population groups and that the quantity bought is greater in those households in which the person responsible for the purchase does not work outside the home. However, these differences are reduced if frozen or preserved products are considered. In addition, the contrasts between zones of maximum and minimum consumption have been evaluated.

The information as a whole has its importance if it is recognised that knowledge of the market is scarce. This leads to an important separation between the fishing enterprise sector and the agro-food and fishery politics with respect to the final consumer of the products. In some way, the feeding habits and international commercial relations affect the demand and the fishery activity should adapt to this in a continual process of adjustment.

In another line of study, from a static model the potential additional earnings of the different boats or countries that compete by exploiting a stock were studied, from the basis that they decide to co-operate in order to reach an efficient and individually satisfactory solution. The starting point would be to consider that the catches of each company affect the profit of the other companies during the same time period. The classical assumption is not considered, then, of the interdependence of the fishery companies and the available stock for all of them in the future. For this, different catch functions and conditioning factors have been considered, such as the symmetry or asymmetry between boats or countries. The results also depend on these. Thus, it is concluded that the lower the actual salary, the greater is the incentive to co-operate on behalf of the fishery companies, although in this case the total minimum catches, that guarantee any individually efficient and rational solution, can be very high. On the other hand, the greater the productivity of the companies, the greater are the incentives to co-operate, but again in this case the total minimum catches can be very high. Therefore, a

negative relation is established between the incentives to co-operate on behalf of the companies and the level of total catches that leads to any individually efficient and rational income to be reached. In this sense, if the limitations on the catches are important, then co-operation may lack incentives for the companies.

On the other hand, in the asymmetric cases it was observed that the incentives to co-operate on behalf of the most important company in catch terms diminish when the actual income is greater. In any case, however, the maximum earnings related to co-operation for the most productive company are very small, since the asymmetry in the catches place this company very close to the limit of possible profits. In this way, in the asymmetric cases it can be very difficult to establish any type of agreement, especially if this is expensive.

In short, the incentives to co-operate on behalf of the companies can be very small, especially if the actual salary is high. In addition, if the restrictions on catches are raised, co-operation can lack incentive.

The use of the methodology based on neural networks have also been presented and discussed. Due to the complexity that decision taking is acquiring in the field of fisheries, models are necessary that deal with the greatest possible number of variables, which are to a large extent qualitative. The neural networks are a new way to analyse the data, based on the capacity that they have to understand complicated patterns and trends in the data, which is a characteristic ability of this methodology. One of the attractions of this approach would be its capacity to consider the subjective aspects of the economy associated with the fishery activity, simulating biological systems and not conventional calculation techniques. In relation to conventional methodology, the neural networks could demonstrate their usefulness when algorithms do not exist or those that are available do not meet the necessary requirements. On the other hand, there are proposals for a combination of the learning ability of the neural networks and the processing of imprecise information for unclear logic.

This approximation is considered interesting, bearing in mind that it is currently applied in fields such as the recognition of patterns and trends, stock market risk analysis and in prediction of demands, among others.

An alternative has also been presented and discussed, applicable in cases in which little or no biological information exists on the stock to be analysed, such as occurs frequently in the Mediterranean. It is divided into a production model for the biomass estimation at the beginning of each fishing season, which uses bayesian estimation in order to assess the state-measurement model, and the economic objective in order to maximize current and future profits. An application example is the purse seine fishery for anchovy in the Gulf of Cádiz. The results are particularly sensitive to the quality of the available statistical information. However, it is considered an interesting approximation and an example of information integration concerning the resource and economic variables.

On the other hand, the HEURES bioeconomical model (Lleonart *et al.*, 1996) was also presented and discussed (see Modelling Working Group).

5.2 *Recommendations*

1. To encourage a mechanism of feed-back between the proposed models.

2. To advance the modelling by means of the Strategic Administration methodology.

3. The effective development of the mentioned points requires the most independent information possible for the basic variables considered in the distinct models.

4. To take the management of specific cases and areas as a reference study.

The group has established suitable contact mechanisms in order to encourage closer collaboration in the future. Likewise, the usefulness of publishing the presentations, as soon as possible, was established.

6. Final Seminar

From the start of this project, other research activities have been developing in parallel, both at an international and a national level, that tried or try to cover in part some of its proposed objectives. With the aim of revising these activities, they are commented on below, taking the different areas of action as a reference.

6.1 *Databases*

The increasing interest in environmental research will best be served by a consideration of long-term data series concerning renewable natural resources and studies on interactions. Data collection is expensive and time-consuming, since it diverts budgets and manpower from other tasks so there is a conflict between this necessary routine activity and the undertaking of long term strategic research. This long term research, however, essentially depends on the availability of good databases, particularly in the field of biological sampling. In fact, no fisheries research, whether for immediate application for the purposes of management or to find answers to some main scientific questions, such as the relationship between stocks and their environment, can be carried out without the collection of basic data, at the appropriate level, over a constant period according to a rigorous plan.

For many years there has been a trend for the production of common Mediterranean databases which can constitute reliable working tools. Here the various International Organisations go on playing an important role, to which is added the federating action of the European Union through several bilateral or multinational programmes. ICCAT is managing an international database on tuna fisheries which is regularly updated, FAO has developed common databases on biological information (SPECIESDAB) and on parameters of population dynamics and management measures (POPDYN), while ICSEM is implementing a bibliographic database on Mediterranean marine sciences, including the Black Sea area. ITAFISH is an on-going joint ICRAM/FAO Project for the Development of a DataBase System for Fishery and Aquaculture in Italy as a Mediterranean model. ITAFISH contains and integrates several databases covering most of the information areas needed for fishery and aquaculture monitoring and planning.

One of these, already completed at the database level, is the Research and Development Module that deals with aquaculture and fishery co-ordination and monitoring.

Some EU programmes (e.g. FARWEST, Farrugio et al, 1994) have already allowed the conception of some sampling strategies and multipurpose international interactive databases including landings, their biological characteristics, fishing efforts and economical parameters. In addition, as output processes, interfaces have been developed with population dynamics, yield per recruit and catch-effort mathematical assessment models. Another kind of international database, based on experimental trawling surveys at sea, is currently designed for regional studies on abundance and ecological behaviour of fish populations (MEDITS programme in progress).

The knowledge of the demographic structures of exploited populations (which derive basically from the size frequencies of the species caught) is a main condition for the assessment of the stocks and the monitoring of the fisheries exploitation patterns. While significant progress has already been achieved in several areas of the Mediterranean to collect this type of biological data regularly, it is not on a sufficiently large scale and the geographical coverage is still poor.

The definition of a strong large-scale global sampling scheme is thus of paramount importance, even if the management could later be operated on a regional if not a local basis. The idea of the establishment of these basic information networks has been repeatedly pointed out and projected at different meetings. Amongst these above all stand out both the annual meetings that have been held since 1989 with the Directors of the Fishery Research Organisations from the European Union and the second conference on the management of fishery resources in the Mediterranean, held in Venice (27-29 November, 1996).

6.2 *Environment and resources*

In recent years projects (Garcia *et al.*, 1994) and studies (Garcia Lafuente *et al.*, submitted) of international collaboration have been carried out that have considered the possible interdependencies of key biological aspects in the life cycle of species of fishery interest (e.g. the anchovy) and certain abiotic factors such as currents and upwellings. It is considered relevant to continue these studies, taking as an example the Concerted Action (Palomera *et al.*, 1997) that recognises all the available bioecological information on the anchovy in the western Mediterranean and in the north-eastern Atlantic.

On the other hand, initiatives exist in order to widen this type of study to other species with demersal habitats, such as for example the relationship between spatial distribution and the mouths of important rivers (e.g. the Rhone), as well as to determine the recruitment processes of the hake.

The participants of the present project consider that the scientific approach for the evolution of the fishing field in the Mediterranean should take into account the indisputable effects of the agricultural, industrial, urban and touristic developments. Whether they are harmful in one place, or beneficial in another, they, among other factors, have an influence over the environment, the biological productivity and the

exploitation strategies in this sea whose hydric renewal rate is low and where fishing remains greatly dependent on the condition of the coastal edges and the artisan's practices. These aspects are acquiring more and more importance, since at a world level there is a general tendency to redirect the target of fisheries science from resources to the equilibria of entire ecosystems.

6.3 *Stock Unit*

The delimitation of stocks, their definition as a genetic unity and their management was an identified objective in the development of the FARWEST project. Subsequently, collaboration with a team from the University of Gerona that made the techniques of fish genetics available, allowed the achievement of distinct genetic analyses for various species, in particular the hake (Roldan, 1995) and the anchovy (Tudela, 1996). The studies relative to these species were carried out within the framework of the FAR anchovy project (Garcia *et al.*, 1994). The results demonstrate that a unique genetic population exists in the western Mediterranean for both species. Nevertheless, it is clear that the genetic definition of the populations does not coincide with its demographic definition which constitutes the management base. For the moment, the genetic populations in general are delimited at a higher scale than the management units. However, their definition should be reconsidered in light of recent evidence and within the framework of a conception of less regionalised local fishery management, such as is outlined for the immediate future in the Mediterranean. The definition of the management units of the Mediterranean resources could eventually progress within the framework of the FIGIS project which is in progress. In whichever case, it is necessary, as an essential reference for all previous evaluation studies, to establish an agreement which refers to the delimitation of the management units in the western Mediterranean.

6.4 *Fishing System*

The simulation of management strategies within the Mediterranean framework, where the tools of economic management are as, or more, important than the measurement techniques, have been and are being developed in two projects: HEURES, financed by D.G. XIV, and M5 exclusively at the Spanish level. This model was refered and commented above.

6.5 *Models*

The application of indirect evaluation models had an important boost thanks to the FARWEST project, from which various studies of application of VPA models to the stock were suggested, shared by Spain and France for hake from the Gulf of Lyons (Aldebert *et al.*, 1993; Aldebert & Recasens, 1996). In the FAR anchovy project (Garcia *et al.*, 1994) three methods of evaluation were compared: the direct methods of acoustic evaluation and daily egg production and the indirect models. The INTERART project (Sanchez *et al.*, 1995) represented an application of models related to the competence of gears for the same resources, which was also derived from FARWEST. In this sense, it is advisable to encourage the DYNPOP Work Group (CIESM/CIHEAM) with the objective that the evaluation system of the Mediterranean will be brought more and more in line with the ICES philosophy, basically in its aspects of effective international co-operation and the annual frequency of its evaluation.

7. Proposals for objectives of new projects

Besides the conclusions and recommendations established in each Working Group in relation to areas and/or objectives for collaboration projects, those in which a main common interest is reached in their short or medium term achievement are identified and outlined below.

7.1 *Artisanal Fisheries*

For the small scale sector, official statistics from 1989-90 suggest that in EC countries, artisanal fleets made up of 41,930 units were actively operating, of which some 46%, 39%, 8%, 7% are registered for Greece, Italy, Spain and France respectively, and they use some 45 different gear types for at least 100 target species.

The numbers of small boats mentioned above are probably underestimated, but since many of the border countries have particularly well developed small-scale fisheries, an order of magnitude which estimates that some 100,000 small scale units are operating in the Mediterranean as a whole, is not an exaggeration.

The description and quantification of these important fisheries was carried out in some areas of the western Mediterranean about a decade ago (Llabres and Martorell, 1984; Camiñas *et al.*, 1989; Lleonart *et al.*, 1990; Farrugio and Le Corre, 1991). In reality there is reliable evidence that suggests that there were qualitative and quantitative changes that affected the composition and activities of these fisheries, from which it is proposed, based on the methodology already developed in these projects, to produce up to date databases on artisanal fishing within the framework of a collaboration project, that will cover the widest possible part of the western Mediterranean.

This project would also allow comparative analysis of the development in this sector to be carried out, that is assumed to be sensitive to socio-economic changes in other relevant areas such as the work market in relation to agricultural, tourist and other activities, including semi-industrial fishing (purse seine and trawl).

7.2 *"White Book" on fishing.*

In the last decade, there have been diverse initiatives for lines of research in relation to the different fields tied to the study of the fishing system in its widest sense. These initiatives, in the form of both national and international projects, have produced a volume of knowledge that, in many cases, have been disperse and not very well known by the scientific community associated with these themes.

With the aim of: a) obtaining a united and synthetic view of what has been undertaken, b) avoiding duplicates, c) evaluating its potential use in relation to the management of the fishing resources of the area and d) orientating the future efforts in a co-ordinated and coherent way with this knowledge, it is considered important to establish a "white book".

This "white book" would collect the already mentioned activities and would propose lines of future action with the aim of serving as a "corner stone" for the researchers and calls for meetings considered appropriate.

7.3 *Catchability (q)*

In diverse meetings, but in particular during projects of bioeconomical model development, the necessity for catchability estimations has been made evident. The stock control parameter is the instantaneous rate of mortality by fishing. This is composed by the effort, which is relatively easy to measure and control, and catchability (that would be the probability that a stock unit has of being caught by a single unit of effort). This parameter is difficult to estimate and is affected by many biological and anthropogenic factors. Effectively, in the classical application of the models, the catchability is considered constant, although obviously this is not certain. Diverse hypotheses of variation for q exist, with time and with capital (Lleonart *et al.*, 1996). The direct measurement of q would be very important in order to understand and to bring ourselves closer to the actual dynamic of the fishery, which would also fully include the fisherman.

7.4 *Methodology of classical and bayesian estimation in aspects of population dynamics, spatial distribution of resources and resource-environment interaction.*

The actual simplicity of resolution for complex calculation problems, has allowed access to the bayesian statistic, formally confined to theoretical aspects or to estimation in very simple models. The possibilities of the bayesian approach, as opposed to the classical or frequentialist, are increasingly important, and constitute a line of continual progress. Given that we are conscious of the importance of this line, and thanks to the inclusion of a group of statisticians in the University of Alicante, capable of studying and overcoming the possible theoretical and technical problems, the development of a project applying the bayesian methods is proposed. This would undertake its comparison with the frequentialists, the estimation of parameters and the adjustment of models in exploited marine population dynamics.

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